Robert T. Jackson

DEPARTMENT OF THE INTERIOR.

REPORT

OF THE

UNITED STATES GEOLOGICAL SURVEY

OF

THE TERRITORIES.

F. V. HAYDEN,
UNITED STATES GEOLOGIST-IN-CHARGE.

VOLUME XII.

WASHINGTON:
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1879.

LETTER TO THE SECRETARY.

OFFICE UNITED STATES GEOLOGICAL AND
GEOGRAPHICAL SURVEY OF THE TERRITORIES,
Washington, D. C., January 1, 1879.

SIR: I have the honor to transmit herewith, for your approval and for publication, Volume XII of the Final Reports of the Survey under my direction.

This volume has been prepared by Prof. Joseph Leidy, the eminent comparative anatomist and microscopist, who is well known as one of the most valued collaborators of the Survey, and the author of the first volume of the quarto series of Reports, entitled "Contributions to the Extinct Vertebrate Fauna of the Western Territories."

Professor Leidy spent the greater portion of two seasons in the West under the auspices of the Survey. During this time he made a careful exploration of the country about Fort Bridger, Uinta Mountains, and the Salt Lake Basin, in search of the materials for this memoir.

The use of the microscope in all branches of natural science has become so universal that the publication of the present volume in connection with the Survey needs no explanation. It is intended as a guide and aid to students in this new or little-known field of observation. The facility with which these small objects for study can be obtained all around us will render the work still more timely and useful to the students of this country. There are also a number of closely allied fields of inquiry, as the Diatoms, Desmids, Infusoria, Rotifera, Entomostraca, and Aquatic insects, etc., which, when pursued with the same skill and devotion, will prove equally fruitful in results.

The Rhizopods are the lowest and simplest forms of animals, mostly minute, and requiring high power of the microscope to distinguish their structure. While most of them construct shells of great beauty and variety, their soft part consists of a jelly-like substance. This the animal has the power of extending in threads or finger-like processes, which are used as organs of locomotion and prehension, often branching. From the appearance of their temporary organs, resembling roots, the class of animals has received its name of Rhizopoda, meaning literally root-footed.

In compensation for the smallness of these creatures, they make up in numbers, and it is questionable whether any other class of animals exceeds them in importance in the economy of nature. Geological evidence shows that they were the starting-point of animal life in time, and their agency in rock-making has not been exceeded by later higher and more visible forms.

With the marine kind, known as Foraminifera, we have been longest familiar. Their beautiful many-chambered shells—for the most part just visible to the naked eye—form a large portion of the ocean-mud and the sands of the ocean-shore. Shells of Foraminifera likewise form the basis of miles of strata of limestone, such as the chalk of England and the limestones of which Paris and the pyramids of Egypt are built.

Fresh-water Rhizopods, though not so abundant as marine forms, are nevertheless very numerous. They mainly inhabit our lakes, ponds, and standing waters, but they also swarm in sphagnous swamps and even live in moist earth. Professor Leidy has devoted several years of study to the Fresh-water Rhizopods of the eastern portion of our country, and his especial object in his western expeditions was to investigate those which are to be found in the elevated regions of the Rocky Mountains.

The beautiful plates which illustrate this volume were engraved by Messrs Sinclair & Son, Philadelphia, and to this firm the thanks of the Survey are due for their care and skill.

Very respectfully,

F. V. HAYDEN,

United States Geologist.

To the SECRETARY OF THE INTERIOR.

UNITED STATES GEOLOGICAL SURVEY OF THE TERRITORIES.

FRESH-WATER

RHIZOPODS

OF

NORTH AMERICA.

BY

JOSEPH LEIDY, M. D.,

PROFESSOR OF ANATOMY IN THE UNIVERSITY OF PENNSYLVANIA, AND OF NATURAL HISTORY IN SWARTHMORE COLLEGE, PENNSYLVANIA.

WASHINGTON:
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1879.

LETTER OF TRANSMITTAL.

PHILADELPHIA, *January* 1, 1879.

DEAR SIR: On several occasions you have expressed a desire, that, in my trips to the Western Territories, I should undertake the investigation of the microscopic forms of life which inhabit the waters. During the last four years I have studied one important class—the Rhizopods, as they occur in all fresh waters of the country, from the Atlantic border to an altitude of 10,000 feet in the Rocky Mountains. The marine forms of Rhizopods, in all times, have extensively contributed to the construction of stratified rocks The determination of the living fresh-water forms may serve as a guide to the discovery and determination of fossil forms in the vast lacustrine formations in the interior of our continent. Herewith, I transmit my report for examination and publication, trusting it may meet with your approbation.

Respectfully,

JOSEPH LEIDY.

Dr. F. V. HAYDEN,

U. S. Geologist, Washington, D. C.

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INTRODUCTION.

The revelations of the microscope are perhaps not exceeded in importance by those of the telescope. While exciting our curiosity, our wonder and admiration, they have proved of infinite service in advancing our knowledge of things around us. The present work, founded on such revelations, I have attempted to prepare in a manner to render it easy of comprehension, with the view of promoting and encouraging a taste for microscopic investigation.

Dr. Carpenter, the eminent English physiologist and naturalist, in his treatise 'The Microscope and its Revelations', remarks that "it is a tendency common to all observers, and not by any means peculiar to microscopists, to describe what they *believe* and *infer*, rather than what they actually witness."

There are certainly peculiar difficulties in arriving at a faithful interpretation of microscopic observations, arising from many causes, of which a common one is the difficulty of handling minute objects, especially active living animals, so as to examine them from every point of view. While I have endeavored to describe things as they appeared to be, I am conscious of having been unable to avoid the usual proportion of errors, for which I beg indulgence, and which I leave for others who shall pursue the same path of investigation to correct.

What are Rhizopods? is a question that will be asked by perhaps most persons whose attention may be directed to the present work. They are the simplest or lowest forms of animal life, constituting the first class of the Protozoa (Greek, *protos*, primitive; *zoön*, animal).

The Rhizopoda (Gr. *rhiza*, root; *pous*, foot:—root-footed animals) are mostly microscopic beings, rarely just visible to the naked eye; though some are sufficiently large to appear as conspicuous objects. Their minuteness is amply compensated by their multitude and world-wide distribution;

essentially aquatic, they occur wherever there is moisture. Commencing from one's own doorstep, they may be found in almost every damp nook and crevice, savanna and marsh, pool and ditch, pond and lake, sea and ocean, and from the greatest depths of the latter to the snow-line of mountains. By far the greater proportion are marine, and their tiny shells enter abundantly into the composition of the ocean mud and abound in the sands of every ocean shore. They appear to have been the first representatives of animal life on earth; and if there is any truth in the theory of evolution, they represent our own remotest ancestors. Having existed for ages, their remains have largely contributed to the formation of the marine sedimentary rocks.

The particular Rhizopods which form the subjects of the present work are those usually designated as the 'Fresh-water Rhizopods', living mainly in comparatively still fresh waters, in the mud of bogs, among algæ and mosses, and even on the ground in damp, shaded places. My investigations were commenced four years ago, and have been continued during that time, in intervals of leisure from teaching and ordinary business pursuits, until last summer, when I began the preparation of my report for publication. In the study of the Rhizopods, my attention has been more particularly directed to the discovery and determination of the various forms occurring in this country, rather than to the elaboration of details of structure, habits, modes of development, and other matters pertaining to their history, though these have not been entirely neglected. In the latter respects, my researches fall short of those of some of the able naturalists of England and Germany:—Wallich, Carter, and Archer of the former, and Hertwig and Lesser, Greeff, Cienkowski, and Schulze of the latter country.

The illustrations accompanying the work, done in chromo-lithography, are not equal in execution to my desire, though they represent the characteristic appearance of the subjects in all cases, I believe, sufficiently well to enable the student to recognize these when found. The original drawings, made by myself, I think may be fairly viewed as approximating accuracy, at least so far as relates to the outlines, which have invariably been drawn to a scale of measurements, so as to preserve the proportions of all parts. Faults in perspective and other qualities are partially due to my own want of ability as an artist, and partially to the difficulty of correctly interpreting the views of objects as ordinarily seen through the microscope. Many of the illustrations exhibit various degrees of imperfection in some of the details, due to exaggeration of defects in the original drawings, which the artists, without any knowledge of the subjects, have attempted closely to imitate. It has long been a matter of regret to me that I have not been able to secure the services of accomplished artists, educated for the special purpose to give us faithful and beautiful representations of natural-history subjects, such as we so frequently see in the scientific periodicals and other works especially of Germany and France.

I think it worth while to embrace the opportunity of informing students that microscopic observations, such as those which form the basis of the present work, do not require elaborate and high-priced instruments. Such a microscope as is made by Zentmayer of Philadelphia, Beck of London, or Hartnack of Paris, and sold at prices ranging from $50 to $100, answers all ordinary purposes. The instrument should be furnished with two objective powers, of which the higher should be at least $\frac{1}{4}$th or $\frac{1}{5}$th of an inch focus. A still higher power being occasionally required, I have found an $\frac{1}{8}$th or $\frac{1}{10}$th objective of great service. I have now in use a little instrument of Beck, called the Economic Microscope, with 1-inch and $\frac{1}{4}$-inch object-glasses and two eye-pieces, sold by W. H. Walmsley, No. 921 Chestnut street, Philadelphia, for $50. An important addition to the instrument, for measuring, is a micrometer, divided into fractions of a millimetre, which may be purchased for a couple of dollars.

I give the above statement, not with any disposition to detract from the value of the various magnificent microscopes so much in vogue, but with the object of dispelling a common impression widely prevalent, at least among those with whom I habitually come into contact, that the kind of work such as I now put forth can be done only with the help of elaborate and expensive instruments.

In aid of my researches among the Rhizopods of the Rocky Mountain Region I acknowledge the services of my friend Dr. J. Van A Carter, formerly of Fort Bridger, now of Evanston, Wyoming Territory. It was not only under his hospitable roof that I was enabled to pursue my investigations, but he conducted my expeditions into the Uinta Mountains and other places to collect materials, and withal defrayed the expenses of our trips Dr. Carter, in his appreciation of scientific matters, has been of eminent service to geologists and other naturalists visiting his region of country.

Some of my most delightful recollections are associated with expeditions into the Uinta Mountains conducted by Judge W. A. Carter, of Ft. Bridger, or his son-in-law Dr. J. Van A. Carter. At an elevation of from eight to ten thousand feet the mountains are covered with forests, chiefly of Fir and Pine, with a most wonderful profusion of beautiful flowering plants beneath. The forests here and there enclose bright, grassy meadows and ponds, favorite resorts of deer, and in these I obtained rich materials for my investigations.

Whatever may be thought of the pertinence of publishing such works as the present one with the Reports of the Geological Survey of the Territories, to remove any misapprehension in the matter I deem it proper to state that my contribution has been given without pecuniary recompense. In my own judgment, Prof. Hayden has acted with the most enlightened view in authorizing and encouraging such natural-history investigations as would be facilitated by explorations of the country in which his geological surveys were conducted. With the exception of the cost of publishing the present Report, the only additional expense to which I put the Survey during my explorations in the West amounted to about $222. Much expense was saved through the liberality of various railroad companies in giving me the privilege of free travel and travel on half-fare.

GENERAL REMARKS ON THE RHIZOPODS.

The simplest kinds of Rhizopods are unprovided with a protection or support of hard parts of any kind, possessing, at least in their ordinary active condition, neither a shell nor an investing membrane. In all kinds, the soft substance of the animal mainly consists of a fluent, viscid, albuminoid jelly, endowed with an extensile and a contractile power, by which the creature is enabled to execute all those movements which ordinarily distinguish animal life.

The motile jelly of the Rhizopod is regarded to be of the nature of the common elementary basis of organic bodies in general, and, like it, is called the protoplasm (Gr. *protos*, first; *plasso*, I mould:—the primitive material from which organic bodies are moulded). Its resemblance in motive power to muscular tissue, or the flesh of more complex animals, led the French naturalist Dujardin, who was the first to indicate the true nature of the Rhizopods, to give it the name of sarcode (Gr. *sarx*, flesh; *eidos*, form).

The soft mass of protoplasm, or sarcode, forming the essential part of the body of all Rhizopods, has no internal cavity like the body-cavity of higher animals, neither has it a mouth like the higher Protozoa, nor has it stomach or intestine. Without trace of nerve elements, and without definite, fixed organs of any kind, internal or external, the Rhizopod,—simplest of all animals, a mere jelly-speck,—moves about with the apparent purposes of more complex creatures. It selects and swallows its appropriate food, digests it, and rejects the insoluble remains. It grows and reproduces its kind. It evolves a wonderful variety of distinctive forms, often of the utmost beauty, and, indeed, it altogether exhibits such marvelous attributes, that one is led to ask the question in what consists the superiority of animals usually regarded as much higher in the scale of life.

In this relationship, Dr. Carpenter remarks of the Rhizopods, "If the views which I have expressed as to the nature and relations of their living substance be correct, that substance does not present any such differentiation as is necessary to constitute what is commonly understood as 'organization' even of the lowest degree and simplest kind; so that the physiologist has here a case in which those vital operations which he is accustomed to see carried on by an elaborate apparatus, are performed without any special instruments whatever,—a little particle of apparently homogeneous jelly changing itself into a greater variety of forms than the fabled Proteus, 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, propagating itself without genital apparatus,—and not only this, but in many instances forming shelly coverings of a symmetry and complexity not surpassed by those of any testaceous animals."*

Through the motile power of the Rhizopod, it projects or extends portions of its protoplasm, which act as temporary organs of locomotion and prehension, and it again withdraws or contracts them so that they melt away in the mass and leave no trace of their previous existence. From their function, the extensions of protoplasm have received the appropriate name of pseudopods (Gr. *pseudos*, false; *pous*, foot). These appear, in general, in different kinds of Rhizopods, in the condition of threads of extreme

* Introduction to the Study of the Foraminifera. Preface, vii.

delicacy, of coarser finger-like processes, or of rounded lobes. They often branch and assume a more or less root-like appearance, whence Dujardin gave the class the name of Rhizopods.

As previously intimated, the simplest kinds of Rhizopods are unprovided with hard parts, or even a membranous investment, and they present to the outside medium in which they live nothing but the naked mass of protoplasm of which they consist. By far the greater number of the class are protected and supported by some kind of skeleton of hard material, consisting of spicules or a trellis-work of silex, or a shell of chitinoid membrane, of limestone, or of the former material. Mostly the hard part is intrinsic, or pertains to the inherent structure of the animal, but frequently is also more or less extrinsic. In the latter instances, the shell usually consists of siliceous particles, commonly hyaline quartz sand, diatom cases, and sponge spicules.

Besides some general differences in the character of the soft parts, the sustaining skeleton, or protective shell, of the Rhizopods, exhibits a great variety in form, construction, and arrangement of structure; frequently is highly intricate and often remarkable for beauty of apparent design.

On the general differences observed in the soft body-mass and its pseudopods, and on the absence or presence of hard parts with their form and constitution, the ordinal and other subdivisions of the Rhizopods are founded. It however appears from the researches, especially of British authorities, such as Carpenter, Williamson, Wallich, Brady, Parker, and Jones, that the members of the class are infinitely variable, and that indeed no absolute distinctions of species and genera exist, such as appear more definitely to characterize the higher forms of animal life. My own investigations rather confirm this view, and, under the circumstances, we can only regard the more conspicuous and prevailing forms as so many nominal species, in likeness with the species of higher organic forms, more or less intimately related, and by intermediate forms or varieties merging into one another.

As is the case with all other groups of organic beings, few authorities agree in the classification of the Rhizopods; and it is for convenience rather than from studied opinion that I have adopted the following ordinal arrangement

Class. RHIZOPODA.

Order I. Protoplasta; II. Heliozoa; III. Radiolaria; IV. Foraminifera; V. Monera.

The distinguished French naturalist Dujardin, who first recognized the nature of the Rhizopoda, and applied to them this name, included in the class the Foraminifera and the group of Protoplasta, excepting only the genus Amœba, although he fully understood the relationship of this with the former. The Heliozoa he viewed as another division of the Protozoa, and in his day the Radiolaria were not sufficiently known to hold a recognized position in zoological systems.

Prof. Haeckel, one of the latest and highest authorities on all that concerns the lowest forms of life, includes in the class the Foraminifera, the Heliozoa, and the Radiolaria. The Protoplasta and the Monera, which names originated with him, he regards as two distinct and additional classes in his proposed kingdom of Protista (*protiston*, primordial).

Prof. Carpenter includes all the ordinal groups above indicated as Rhizopoda, but associates the Heliozoa in the order of Radiolaria.

Dr. Wallich* divides the class into three orders: the Herpnemata, the Protodermata, and the Proteina. In the first are included the Gromida, Foraminifera, and Polycystina; in the second, the Thalassicollidæ and Acanthometrina; and in the third, or highest order, the Actinophryna, Lagynidæ, and Amœbina.

Prof. Huxley drops the name of Rhizopoda altogether, and distributes the groups into two divisions of the Protozoa: the Monera and the Endoplastica To the former he refers the Monera of Haeckel and the Foraminifera; to the latter he refers the Radiolaria, including the Heliozoa, the Protoplasta, the Gregarinidæ, the Catallacta, and the Infusoria. The essential character of the Monera, according to Haeckel, the founder of the order, is the absence of a nucleus, but this has recently been shown by Hertwig and Schulze to exist in the Foraminifera. Carter, Greeff, and others, speak of the Heliozoa as fresh-water Radiolaria. Hertwig and Lesser, who gave the name of Heliozoa to the ordinal group, regard them as of a distinct class from the Radiolaria, and, excluding these, they associate the former together

* Annals and Magazine of Natural History, 1863, xi, p. 438.

with the Foraminifera, Protoplasta, and Monera, as Rhizopoda, but propose for this class to substitute the name of Sarcodina.

In my studies of the Protozoa, or animals of the lowest subkingdom, I have habitually viewed as Rhizopods the five ordinal groups indicated in the above classification. This accords with the views of Prof. F. E. Schulze, an able investigator of the class. In a recent number of the Archiv für Mikroscopische Anatomie for 1877, p. 21, he remarks, that his researches led him to consider as pertaining to the Rhizopods, as an essentially harmonious whole, all those low forms which, during the greater part of their life, and especially during the period of their highest perfection, hold intercourse with the exterior world, move about, and obtain food, by means of extensile processes of the viscid body-substance, which are again capable of flowing back completely into the latter.

The first two orders of the Rhizopods—the Protoplasta and the Heliozoa—are those which are commonly designated as the 'Fresh-water Rhizopods'; the Radiolaria and the Foraminifera, with part of the Monera, are marine.

Fresh-water Rhizopods are to be found almost everywhere in positions kept continuously damp or wet, and not too much shaded. They are especially frequent and abundant in comparatively quiet waters; clear, and neither too cold, nor too much heated by the sun, such as lakes, ponds, ditches, and pools. They are also frequent in wet bogs and savannas, among mosses, in springy places, on dripping rocks, the vicinity of waterfalls, springs, and fountains, and in marshes, wherever the ground is sufficiently damp or moist to promote the growth of algæ They are also to be found in damp shaded places, among algæ, liverworts and mosses, about the roots of sedges, rushes and grasses, or those of shrubs and trees growing in or at the borders of bogs and ponds or along ditches and sluggish watercourses. They are likewise to be found with algæ in damp shaded positions in the depressions and fissures of rocks, in the mouths of caves, among decaying logs, among mosses and lichens, on the bark of growing trees, and even in the crevices of walls and pavements about old dwellings and in cities.

The favorite habitation of many kinds of Rhizopods is the light superficial ooze at the bottom of still waters, where they live in association with diatoms, desmids, and other minute algæ, which form the chief food of most of these little creatures. They never penetrate into the deeper and usually black mud, which indeed is almost universally devoid of life of any kind.

Rhizopods also occur in the flocculent materials and slimy matter adherent to most submerged objects, such as rocks, the dead boughs of trees, and the stems and leaves of aquatic plants. A frequent position is the under side of floating leaves, such as those of the Pond-lily, *Nymphæa odorata;* the Spatter-dock, *Nuphar advena;* and the Nelumbo, *Nelumbium luteum.* Certain kinds of Rhizopods, especially the Heliozoa, or Sun-animalcules, are most frequent among floating plants, such as Duck-meat, *Lemna;* Hornwort, *Ceratophyllum;* Bladderwort, *Utricularia;* and the various Confervas, as *Zygnema*, *Spirogyra*, *Oscillatoria*, and the Water-purse, *Hydrodictyon.*

In no other position have I found Rhizopods of the kind under consideration in such profusion, number, and beauty of form as in sphagnous bogs, living in the moist or wet Bog-moss, or *Sphagnum.* Sometimes I have found this particular moss actually to swarm with multitudes of these creatures of the most extraordinary kinds and in the most highly developed condition. A drop of water squeezed from a little pinch of Bog-moss has often yielded scores of half a dozen genera and a greater number of species. Frequently, however, the Sphagnum of many localities contains comparatively few Rhizopods, though I have rarely found them entirely absent from this moss. Other mosses and liverworts I have not observed to be specially favorite habitations of the Rhizopods, not even such aquatic kinds as the *Fontinalis.*

Notwithstanding the experience of four years' exploration and observation, I have not been able to determine the exact conditions under which particular Rhizopods are to be obtained with certainty and in any considerable numbers. In general, they are to be found in greatest number and variety under the peculiar conditions favorable to them, in old established ponds, bogs, etc., which are not liable to become completely dried up in the summer season. At times, however, I have found a profusion of one or two forms in some localities, in which, in another season, I could find but few or none. Sometimes I have found many individuals of a particular kind in a shallow pond of recent origin, which, after drying up in the summer and being renewed the following spring, yielded no more of the same. Sometimes the most unpromising places have produced an unexpected and occasionally a surprisingly rich supply of Rhizopods, and repeatedly the most promising places have yielded exceedingly few.

The Rhizopods may be found at all temperate seasons of the year; and even in winter, when out of the influence of a freezing cold, a few may be discovered, though mostly in a comparatively inactive state. Frost or a freezing temperature appears to destroy them.

They do not live among actively decaying vegetal matter, nor are they to be found in foul water. I have further not been able to discover them in brackish waters on the sea-coast, though I detected a few forms in feebly saline or alkaline waters in the Bridger Valley of Wyoming Territory.

The Fresh-water Rhizopods appear to inhabit indiscriminately almost any kind of country, no matter what may be its rocky constitution, except it be limestone. According to my experience, they are comparatively rare in limestone districts, and I have repeatedly been disappointed in my expectation of finding them in some large limestone springs in which grew a profusion of Anacharis, Chara, and other aquatic plants. This has appeared the more surprising when it is considered that the allied marine order, the Foraminifera, have so largely contributed to the formation of the limestone rocks.

The mode I have habitually adopted for collecting Rhizopods, which is also equally well adapted for collecting many other microscopic organisms, plants, and animals, is as follows:

For ponds, ditches, or other waters, I use a small tin ladle, or dipper, such as is commonly employed for domestic purposes Into the handle I insert a stick of convenient length, and for this I usually carry with me a jointed pole of two or three pieces, each about five feet. The dipper is used by slowly skimming the edge along the bottom of the water so as to take up only the most superficial portion of the ooze, which is then gently raised from the water and transferred to a glass jar. A small hole in the bottom of the ladle favors the retention of the collected material, but care should be taken that it is not so large as to permit the material to stream through. After the collecting-jar is full, if more of the material is wanted, after allowing that in the bottle to settle, I pour off a portion of the water and supply an additional quantity from the locality.

Usually, I have proved more successful in obtaining Rhizopods from the ooze near the shores of lakes and ponds than I have in deeper water;

but this I suspect was mainly due to the circumstance that near the shore I could see the ooze at the bottom of the water, and could much better manage to collect the desired material.

Aquatic plants, if rooted in the mud, should be carefully cut off and gently lifted from the water so as to disturb as little as possible the adherent materials. A sufficient quantity being placed in a tin preserving-can or other vessel, water from other portions of the plants may be squeezed upon that which is retained.

Wet Sphagnum may be collected and put in tin preserving-cans, and the water of other portions may be squeezed upon the portion preserved. The same process may be pursued with other mosses.

From the surface of the ground in wet places, to collect the Rhizopods, it is sufficient to scrape up, with the broad blade of a knife, the green algous material with which the animals are usually associated.

The materials collected from waters I have preserved, for convenient examination from time to time, by putting them in dishes about three inches in depth, filling them with fresh water, and placing them in the window where they obtain an abundance of light, but without receiving the direct rays of the sun. If exposed to the sun, the water becomes unduly heated, and all living things speedily die and decompose. Care should also be observed not to have too much material in the same dish; and I have found it best to preserve a stratum of ooze which, when settled, is not more than from a line to the eighth of an inch in depth. Some Duck-meat, *Lemna*, Bladderwort, *Utricularia*, Spirogyra, or other plant, collected, and placed in the water, greatly promotes its freshness and continued purity. The dishes should be covered with panes of glass to exclude the dust and prevent evaporation. A day or two after the materials have been placed in dishes, the sediment has deposited and the water become clear. In this condition, there may usually be observed on the surface of the sediment a continuous thin film, or patches of a yellowish, yellowish-green, or green color. The film, or patches of the same material, is more tenacious than the deposit beneath, and consists of the various living organisms, especially diatoms, desmids, rhizopods, etc., which have extricated themselves from the ooze to occupy the most favorable position to continue their functions. Indeed, it is a remarkable phenomenon to observe with what ease and rapidity these extremely minute living creatures can free themselves from the depths of the mud in which they had been buried, to occupy a position on its surface, where they receive the full benefit of the conditions necessary to their life.

From the living film, as it might not inappropriately be called, the desired objects for examination are to be obtained. Portions may be lifted with a glass tube closed at the upper end by the finger, and then with the other end brought into contact gently with the surface of the ooze. By raising the finger, the pressure of the water forces a portion of the ooze into the tube, when, the finger being replaced, a drop of the contents of the tube may be transferred to a glass slide or an animalcula cage for the field of the microscope.

The materials collected and disposed of in the manner above described may be preserved in a good condition for examination for weeks together, and indeed without any further care in this way I have kept a stock of Rhizopods alive during the winter.

The Rhizopods collected with wet Sphagnum, or other mosses, or on damp earth, may be readily kept in good condition for examination in glass cases, for which purpose common wide-mouthed candy-jars answer. They should be kept in the light in the same manner as the dishes of water. With Sphagnum I have retained its peculiar Rhizopods alive the whole year through.

To examine the Rhizopods of Sphagnum or other mosses, or from the algous film of damp places, wet a fragment, teaze it with a knife and forceps, and press the water from the pulpy mass into a watch-crystal. A drop of the sediment collected is then to be transferred to the field of the microscope.

The different forms of fresh-water Rhizopods are not generally restricted to different localities or positions, but are commonly found more or less in association together. Usually the naked forms, and especially the larger ones, the Difflugias and the Arcellas, are found most frequently, abundantly and best developed, in the ooze of bodies of water. The Euglyphas, Nebelas, and their nearer allies, are in like manner most frequent in the moist Sphagnum of bogs; and the Heliozoa in the positions previously indicated.

The chief localities from which I have myself collected the materials of the present work are as follows:

Ponds, springs, and marshes in the vicinity of Philadelphia, but especially the ditches which traverse the great meadows below the city, in the alluvial triangle called the Neck, between the Delaware River and the mouth of the Schuylkill River.

Ponds, marshes, etc , along the course of the Delaware River, both in Pennsylvania and New Jersey, from Philadelphia to the Delaware Water Gap.

Sphagnous bogs, pools, and ponds on the Pokono Mountain, Monroe County, and on Broad Mountain, Schuylkill County, Pennsylvania

The lower part of the State of New Jersey, along the course of the Camden and Atlantic City Railway, and along the course of the Camden and Cape May Railway. Throughout this broad region materials were collected from many localities: ponds and pools, sphagnous bogs, cedar swamps, savannas, and cranberry lands. Also Lake Hattacawana, or Budd's Lake, on Schooley's Mountain, Morris County, New Jersey.

The vicinity of Noank, on the coast of Connecticut, and of Newport, Rhode Island.

Bridger Valley, in the southwestern corner of Wyoming Territory, and the Uinta Mountains to the height of 10,000 feet, in the same region.

Partridge Island, at the head of the Bay of Fundy, Nova Scotia.

Before entering in detail upon the special subjects of my studies, the Fresh-water Rhizopods, nearly all of which pertain to the orders of the Protoplasta and the Heliozoa, some remarks on the characters of the other orders of the class may not be out of place.

The **Radiolaria** (*radiolus*, a little ray) are the subjects of an elaborate and magnificent work by Dr. Ernst Haeckel, Professor of Natural History, in Jena.* They are exclusively marine Rhizopods, comprising many wonderfully beautiful forms, living and swimming in vast multitudes in the superficial waters of the ocean. They are generally minute, and are the most complex in their constitution of any of the Rhizopods. They are commonly furnished with a siliceous or flinty skeleton, which, in variety of form, symmetry, and intricacy of construction, is a marvel of beauty. The material of the skeleton is derived from the exceedingly small proportion

* Die Radiolarien (Rhizopoda Radiolaria), Berlin, 1862.

of silex contained in the sea-water. After death, the skeletons of the Radiolaria sink to the bottom of the ocean, where they accumulate as an abundant component of the mud.

In the island of Barbadoes, extensive rock strata of the Tertiary period, 1100 feet in thickness, consisting of marls, tripoli, and ferruginous sandstones, are largely composed of the siliceous skeletons of Radiolaria. Material from these strata called 'Barbadoes earth' is well known to microscopists, and is highly prized for the perfection and beauty of the forms it supplies. Likewise, in the Nicobar Islands, of the Indian Archipelago, the solid nucleus of the islands, consisting of clays, marls and arenaceous marls of Tertiary age, 2000 feet in thickness, is largely composed of the remains of Radiolaria.

According to Haeckel, the soft body of the Radiolaria is more highly organized than that of the Foraminifera and Heliozoa. It contains a central capsule of firm membrane enclosing masses of minute cells. The exterior protoplasm commonly contains numerous yellow cells enclosing starch-grains, and in some forms also large vacuoles, and from it emanate in all directions countless pseudopodal rays.

Most Radiolaria possess a highly complex skeleton composed of silex, exhibiting in different kinds a wonderful variety of the strangest and most elegant forms. Sometimes it consists of a simple trellised ball, sometimes a series of several such balls enclosed concentrically in one another, and connected together by radial bars. Generally delicate spines, often branching, radiate from the surface of the balls. In other instances, the skeleton consists of a star mostly composed of twenty spines, arranged in definite order and united in a common centre. In some Radiolaria, the skeleton is a delicate, many-chambered shell, as in the Foraminifera. Indeed, says Prof. Haeckel, 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 **Foraminifera** (*foramen*, an aperture; *fero*, to bear) constitute by far the most important order of the Rhizopods, especially from the vast quantities in which they have existed in all times from the earliest known appearance of life on earth until now, and from the enormous extent in which their remains have contributed to the formation of rocks. They are marine shell-bearing animals, mostly living at the bottom of oceans and seas, some attached, but generally free, and creeping on the surface of sea-weeds, on the mud, the sands and rocks, or on dead shells and corals, or the lifeless fixed hard parts of other living animals, as the shells of mollusks, corals, sertularians, and sponges. Large numbers are pelagic, or live on the high seas, swimming in the superficial water, while their dead shells form an incessant rain, and contribute largely to the formation of the ocean mud.

Of their class, the Foraminifera have been longest and best known, and their tiny and beautiful shells have been the subjects of many descriptions and illustrations. The characters of the order have been especially elaborated in more recent works, among which may be mentioned the "Organization of the Polythalamia" by Dr. Max S. Schultze, and the "Introduction to the Study of the Foraminifera" by Dr. William B. Carpenter.

The Foraminifera, though generally too minute to be distinguished by the naked eye, are readily detected with a good pocket-lens. They are commonly largest in tropical seas, and even the same species are better developed in warmer than in colder latitudes. A few, the giants of their kind, are conspicuous for their size, and range even to the diameter of several inches. In former ages they frequently reached a greater growth, so that fossil forms are commonly larger than those now living. Some of the extinct species exceed in size double that of any known existing ones.

The Foraminifera are provided with a shell, mostly calcareous, but often partially calcareous with incorporated siliceous sand, or it is composed of sand-grains alone cemented together. With few exceptions, the shells are partitioned into many chambers, and the most common forms, which are spiral, so nearly resemble the shells of the Nautilus and Ammonite, that until a comparatively late period all were classed together as Polythalamia (Gr. *polus*, many; *thalamos*, chamber) or Cephalopoda (the Cuttle-fishes). D'Orbigny, recognizing in the shells of the Nautilus and Ammonite that the chambers were traversed by a tube, while in the shells of the so-called microscopic Cephalopods the chambers communicated by one or more holes, called the former Siphonifera (*siphon*, a tube; *fero*, I carry) and the latter Foraminifera. In a systematic arrangement of the Cephalopods in 1825, D'Orbigny still retained the Foraminifera as an order. Dr. Carpenter remarks that "no suspicion appears at that time to have crossed the mind of M. D'Orbigny that the place of these organisms might be among the lowest instead of among the highest of the Invertebrata."

The true nature of the Foraminifera, and their relationship with *Amœba*, *Difflugia*, and other animals of the kind, was first recognized by the accurate observer M. Dujardin.

In the Annales des Sciences Naturelles for 1835, there are two articles from M. Dujardin, entitled "New Observations on the Microscopic Cephalopods" and "New Observations on the pretended Microscopic Cephalopods". The author remarks that he has observed several genera of these animals from the Mediterranean in a living condition, notably Miliola, Rotalia, etc. The segments of the shell successively augment in volume, and are occupied with a red or orange-colored animal matter, of the consistence of thick mucus, very contractile, and susceptible of lengthening into threads. In conclusion, the author remarks that "if one wishes to assign to these animals their place in the animal kingdom, in considering the absence of organs, the homogeneity and simplicity of their material—a sort of mucus endowed with spontaneous movement and contractility—one is led to place them in the lowest rank I first designated them under the name of Symplectomères, only having in view the succession of similar parts rolled together, in the known species; but the observation of Gromia has led me to prefer the name Rhizopods, to express their singular mode of creeping by means of threads, which extend and branch like roots."

Dr. Carpenter divides the Foraminifera into two suborders: the Imperforata and the Perforata, founded on the circumstances that in the former the shell has mostly but a single orifice of communication with the exterior for the emission of the pseudopods, while in the latter the shell has its outer walls everywhere minutely perforated for the same purpose

The sarcode of the Foraminifera consists of a viscid protoplasm, usually more or less colored yellowish, brown, or red; the color being deepest in the earlier formed chambers of the shell, and becoming less towards the last one, in which it is very feeble or absent altogether. The protoplasm contains granular matter, and vacuoles, or drops of more liquid matter than that of the general mass of the sarcode. Nuclei have commonly been supposed to be absent, but recent researches of Hertwig* and Schulze† have proved their existence. The pseudopods of the Foraminifera extend as

*Jenaische Zeitschrift, x, 1876, 41. †Archiv f. Mikros. Anat. 1877, 9.

exceedingly delicate threads, often in large number, from the one or several mouths or numerous pores of the shell. They divide and subdivide into finer and finer threads, which inosculate freely where they come into contact with one another, so as to produce an intricate net. From this condition, Dr. Carpenter has applied to the order the name of Reticularia. The pseudopods exhibit continual changes in their arrangement, and an incessant circulation in their course. In the larger threads, two streams are observed at the same time, passing in opposite directions; in the finest threads, a single stream moves outward or inward. The currents carry along granules of the protoplasm, and also convey particles of food which may be caught in the way of the pseudopods.

Sea-sands contain as an important constituent the dead shells of recent Foraminifera, though in very variable proportions. They are generally most abundant in the sands of warmer latitudes, and especially on shores profusely furnished with sea-weeds.

Plancus,* who, according to D'Orbigny,† was the first to describe and figure the shells of Foraminifera, counted 6000 individuals in an ounce of sand from the Adriatic. D'Orbigny estimated that there were 160,000 in a gramme of selected sand from the Antilles. Schultze ‡ gives 1,500,000 as the number he found in fifteen grammes of sand from Gaeta on the coast of Sicily.

Even on the comparatively barren shores of New Jersey, consisting of quartz sand, foraminiferous shells occur in notable quantity. In a portion scraped from the surface between tides, at Atlantic City, I estimated that there were 18,700 shells to the ounce avoirdupois, all of a single species of *Nonionina* In another sample, from Cape May, I obtained 38,400 shells to the ounce, likewise of the one species.

In sand collected by scraping up the long white lines on the bathing beach at Newport, Rhode Island, occupying an indenture of the rocky coast, covered with sea-weeds, foraminiferous shells were found to be much more numerous, but, excepting in the case of some examples of Miliola, of smaller size. In an ounce of the sand, I estimated that there were about 280,000 shells, of several genera and species.

It would appear as if the deep-sea mud almost universally was mainly

*Ariminensis de conchis minus notis. Venice 1739.

†Foraminifères: La Sagra, L'isle de Cuba. Paris, 1839. Introduction, vii.

‡Organismus d. Polythalamien, 1854, p. 25.

derived from the shells of Foraminifera. The sediment of the Atlantic Ocean is so largely constituted of one kind of foraminiferous shell, the *Globigerina bulloides*, that the mud is now frequently spoken of as the 'Globigerina ooze'; and this material is likewise found in the Pacific and other oceans and seas.

In speaking of the composition of the ocean mud, Mr. Thomson remarks: "The dredging at 2435 fathoms at the mouth of the Bay of Biscay gave a very fair idea of the condition of the bottom of the sea over an enormous area, as we know from many observations which have now been made, with the various sounding instruments contrived to bring up a sample of the bottom. On that occasion the dredge brought up about one and a half cwt. of calcareous mud. The matter contained in the dredge consisted mainly of a compact 'mortar', of a bluish color, passing into a thin—evidently superficial—layer, much softer and more creamy in consistence and of a yellowish color. Under the microscope the surface layer was found to consist chiefly of entire shells of *Globigerina bulloides*, large and small, and fragments of such shells mixed with a quantity of amorphous calcareous matter in fine particles, little fine sand, etc. Below the surface layer the sediment becomes gradually more compact, and a slight grey color, due probably to the decomposing organic matter, becomes more pronounced, while perfect shells of Globigerina almost entirely disappear, fragments become smaller, and calcareous mud, structureless and in a fine state of division, is in greatly preponderating proportion.

"One can have no doubt, on examining this sediment, that it is formed in the main by the accumulation and disintegration of the shells of Globigerina—the shells fresh, whole and living in the surface layer of the deposit, and in the lower layers dead and gradually crumbling down by the decomposition of their organic cement, and by the pressure of the layers above—an animal formation in fact being formed very much in the same way as in the accumulation of vegetal matter in a peat bog, by life and growth above, and death, retarded decomposition and compression beneath."*

When we are thus informed of the constitution of ocean mud, we are fully prepared to learn that vast rock-formations of past ages are composed of the shells of Foraminifera. D'Orbigny observes that the 'calcaire grossier' of the Paris basin, a coarse limestone of Tertiary age, is chiefly com-

* The Depths of the Sea, p. 410.

posed of the shells of these animals. As this rock is employed for building, he remarks that it is no exaggeration to say that Paris, as well as the towns and villages of some of the surrounding departments, are almost built up of Foraminifera.

The limestones of early Tertiary age of Southern Europe and Asia and of Northern Africa are largely constituted of Nummulites (*nummulus*, a small coin),—foraminiferous shells resembling money in shape, and ranging from the size of a pin-head to that of a dollar. This 'Nummulitic Limestone' attains a thickness of several thousand feet, and contributes to form those great mountain chains, the Pyrenees, Alps, Apennines, Carpathians, and the Himalayas, often including their snow-clad peaks. It extends through the Mediterranean basin, Asia Minor, and Persia, into India. In Egypt, it furnished building-stone for the great Pyramids.

The chalk of Europe, a soft limestone of an earlier time than the former, is also chiefly composed of the shells and their decomposed remains of Foraminifera. The so-called green-sands, like those of our neighboring States, New Jersey and Delaware, of the same and other periods, from the earliest to the latest times, have been largely due to Foraminifera. Prof. Bailey has further shown that a similar material to the green-sand is now in process of formation in the Gulf of Mexico, through the same agency.

The fossil-bearing rocks of earliest time present illustrations of the same character. Limestones of the Carboniferous age have been largely due to foraminiferous shells, and one kind has been specially named 'Fusulina Limestone', from the abundance of shells it contains of the foraminiferous genus Fusulina.

The group of organic beings designated as **Monera** (Gr. *moneres*, simple) was first definitely characterized by Prof. Haeckel, who describes it in his Monograph as follows:

Organisms without organs, which in the perfectly developed condition consist of a freely movable, naked body, composed of a completely structureless and homogeneous sarcode (protoplasm). Never differentiating nuclei within the homogeneous protoplasm. Motion occurs through contractions of the homogeneous body-substance, and through extension of variable processes (pseudopods), which either remain simple, or branch and anastomose. Nourishment occurs in various ways, mostly after the manner of Rhizopods. Reproduction takes place only in an asexual manner, through division. Often, though not always, the free moving condition interchanges with one of rest, during which the body excretes and encloses itself in a structureless investment.*

Though Prof. Haeckėl has indicated and described a number of fresh-water species of Monera, I am not sure that I have had the opportunity of finding any of them, excepting perhaps the genus Vampyrella of Cienkowski, which he ascribes to the same order.

In his History of Creation, Prof. Haeckel observes: "In a state of rest most Monera appear as small globules of slime, invisible or barely visible to the naked eye, and at most about the size of a pin-head. When the Moner moves, there are produced on the surface of the little slime ball, finger-like processes or very fine radiating threads, the so-called false feet or pseudopods. The latter are simple continuous processes of the structureless albumen-like mass of which the body consists. We are unable to perceive different parts in it, and we can obtain direct proof of the absolute simplicity of the semi-fluid mass of albumen, for with the aid of the microscope we can follow the Moner as it receives its nourishment. When minute bodies suitable for food, as, for instance, small particles of decayed organic bodies or microscopic plants and infusoria, accidentally come into contact with the Moner, they remain hanging to the sticky surface of the semi-fluid mass of slime, and here produce an irritation, which is followed by a strong afflux from the slimy mass of the body, and they become finally completely enclosed by it, or they are drawn into the body of the Moner by displacement of the several albuminous particles and there digested, being absorbed by simple diffusion (endosmosis).

"Just as simple as is the nourishment, is the mode of reproduction of these primitive beings, which one cannot positively call animal or plant. All Monera propagate themselves only in an asexual manner by self-division. When such a speck, for example, a Protamœba or a Protogenes, has attained a certain size by the assimilation of foreign albuminous matter, it falls into two pieces; there is formed a constriction around the middle, which finally leads to the separation of the two halves. Each half becomes rounded, and then appears as an independent individual, which commences anew the simple play of the vital phenomena of nutrition and propagation. In other Monera (*Vampyrella*) the body in the process of propagation

* Biologische Studien, 1870, 68.

instead of two, falls into four equal parts, and in others again (*Protomonas*, *Protomyxa*, *Myxastrum*) at once into a large number of small globules of slime, each of which again by simple growth becomes like the parent body." *

Sir Wyville Thomson, in the Voyage of the Challenger, briefly describes certain Rhizopods, which he refers to a new order. On page 341 of the work indicated, he says: "In the investigations with the towing-net, made by Mr. Murray during the latter part of the cruise, at all depths, about thirty species or more were procured of a beautiful group of minute forms approaching, but in many important points differing from the Radiolarians. This order have apparently hitherto escaped observation, and I retain for the type genus the name *Challengeria*, and for the Order that of 'Challengerida'. As a rule these forms are extremely minute, although some of them approach in size the smaller Radiolarians. They consist usually of a single chamber of silica varying greatly in form, sometimes triangular, sometimes lenticular, and frequently globular or flask-shaped; with a single opening usually guarded by a beautifully formed and frequently highly-ornamented lip. The contents of the shell consist of a mass of granular sarcode, with one or more large well defined granular nuclei, and a number of dark brown, sometimes nearly black, rounded compound granular masses. The Challengerida are essentially Rhizopods with monothalamous siliceous shells; and their zoological position may be not very far from such forms as Gromia."

Nothing is said of the characters of the pseudopods; but should they be of the same kind as those of Gromia, this, with the new forms, might conveniently be associated in the same order.

* Natürliche Schöpfungsgeschichte, 1872, 166.

FRESH-WATER RHIZOPODS.

PROTOPLASTA.

Protos, first; *plasso*, I form or mould.

The **Protoplasta** comprise by far the greater number of the Fresh-water Rhizopods, and include nearly all the known forms except the Heliozoa, or Sun-animalcules. They are divisible into two sub-orders, the **Lobosa** and the **Filosa,** founded mainly on the difference of the pseudopods, which in the former are comparatively thick, finger-like or lobose, and in the latter filamentous and of extreme delicacy.

Some of the Protoplasts are naked, usually have no real distinction in the relative position of parts, and emit pseudopods from any portion of the body-mass, though even most of these when in movement, for the time being, may have the body more or less differentiated into an anterior and a posterior region.

The greater number of the Protoplasts are provided with an exterior shell, commonly of a more or less flask- or vase-like shape, and, with few exceptions, having a single orifice, from which the pseudopods are projected. The shell is an excreted membrane, chitinoid or siliceous in character, or it is constructed of siliceous sand or particles of similar constitution, but, so far as known, appears never to be composed of carbonate of lime.

PROTOPLASTA LOBOSA.

The **Lobose Protoplasts,** represented by the familiar Amœba, Difflugia, Arcella, as well as by many other less known genera, are principally characterized, as indicated in the name, from the comparatively thick, lobe-like, or blunt finger-like form of the pseudopods.

In the Lobose Protoplasts, more than in any other Rhizopods, the sarcode mass of the body exhibits a tendency to differentiate an exterior, usually more consistent layer of protoplasm, which, though actually continuous with the interior, ordinarily more fluent protoplasm, seems like an investing membrane, preventing the escape of the latter. For convenience, the two portions of protoplasm, differently related in position, have been appropriately termed the Endosarc and the Ectosarc (Gr *endon*, within; *ektos*, outside; *sarx*, flesh).

The ectosarc appears as the exterior clear protoplasm; the endosarc as the interior granular protoplasm, though high powers of the microscope generally reveal an infinitely fine granular constitution also to the former.

Dr. Wallich regards the endosarc and ectosarc as temporarily distinct portions of the sarcode, mutually convertible into one another. The ectosarc becomes differentiated from the endosarc by contact with the outside medium in which the animal lives, and from time to time reverts again to the condition of the more fluent endosarc within.

From this view, as intimated by Dr. Wallich himself, the ectosarc is due to a temporary and partial coagulation of the endosarc coming into contact with the water in which the animal lives, and again reverts to the condition of the more fluent endosarc as it retreats to the mass of the latter within the body. The process reminds one of the cooling of a molten mass of metal at the sides of a crucible, and the melting-away again of the crust as it is stirred from the sides into the remainder of the molten mass within.

In the movements of the sarcode mass of the body, as exemplified in an Amœba, a temporary increase of the ectosarc may occur in one or more positions, accompanied with a proportionate flow or drain of hyaline protoplasm from the contiguous endosarc. A reduction in thickness of the ectosarc follows an absorption of the clear protoplasm among the more visible granular constituents of the endosarc.

The pseudopods of the Lobosa commence as projections of the clear ectosarc, and may continue as such in their extension unless unusually prolonged or thick. In the latter cases they are accompanied to a variable extent with an influx of the endosarc. They are mostly digitiform or finger-like processes, or, in other words, are cylindrical, with rounded ends, variable in number and length, often simple, frequently more or less ramose, but almost never anastomosing. Sometimes they are pointed, and indeed in the same species under different circumstances they may be either blunt or pointed.

The endosarc is essentially granular; that is to say, it consists of a motile hyaline protoplasm, not differentiated from the ectosarc, except in its less consistence and in the thorough diffusion of conspicuous granular elements. These occur in all gradations of size, from those which are immeasurably fine and indistinct up to the largest granules which are more or less darkly defined, and resemble oil-molecules. Besides the more generally diffused granular constituents, the endosarc contains variable proportions of larger spherical corpuscles, clear or finely granular, and mostly colorless or pale yellowish, but in some species usually of a bright green color, and apparently of the nature of chlorophyl.

An important element of the endosarc is the nucleus, a comparatively large spherical or compressed spherical corpuscle, colorless, and mostly clear, but sometimes finely granular, or more distinctly coarsely and uniformly granular. In the naked forms of the Lobosa, while in motion, the nucleus usually occupies a position at the posterior part of the body, or at least is placed back of the centre In most of the shell-covered forms it occupies a corresponding position; that is to say, in the part most remote from the mouth of the shell,—in the fundus or upper part of the body. In some forms, as in Arcella, there are two or more nuclei occupying a position on each side of the fundus.

Another element of the endosarc, usually situated at its confines and encroaching on the ectosarc, is the contractile or pulsating vesicle. This appears as a clear, colorless, or pale roseate sphere, which is observed very slowly to enlarge, then rather abruptly to collapse and for the moment disappear, again to reappear, commonly in the same position. The successive movements of the vesicle occur with a certain degree of regularity, or rhythm, whence the name of pulsating vesicle. It appears to be due to a gradual concentration of water from all parts of the sarcode mass of the body, forming a drop, which when it reaches a certain size excites contraction and is expelled. The phenomenon is remarkable, and is in a measure subservient to a respiratory as well as to an excretory function.

In the naked Lobosa, the contractile vesicle usually occupies a position posterior to the nucleus or at the back of the body near the surface. In the shell-covered kinds of flask- or vase-like shape, there are commonly several contractile vesicles situated at the periphery of the body adjacent to the nucleus. In Arcella, the greatest number of contractile vesicles occur, and are ordinarily seen, as the animals are viewed from above or below, along the border of the sarcode mass.

Food swallowed by the Lobosa and other Rhizopods, and indeed by most of the Protozoa, appears in the endosarc, commonly in spherical balls, mingled with the other constituents. These balls, or rather the spaces occupied by them, have been called vacuoles, and are usually regarded as of temporary character. Ehrenberg supposed them to be actual stomachs, and hence the name of Polygastrica (Gr. *polus*, many; *gaster*, stomach), which he applied to all the Protozoa, including other forms now generally regarded as pertaining to the vegetal kingdom.

Dr. Wallich considers the so-called vacuoles, or food-vesicles, not in the light of mere spaces, but as temporary vesicles of ectosarc, due to inversion of portions of the exterior ectosarc at the time of the inception of the food, or to the contact of water with portions of the endosarc. The food-balls commonly appear with some degree of uniformity in size, and they vary in color and constitution according to the nature of the food and the changes it undergoes during digestion in the endosarc. The solid food in the balls often appears surrounded with a more translucent area than the contiguous endosarc, due to water swallowed with the food Frequently, however, the solid food appears without the translucent area, and in direct contact with the endosarc, in which cases liquid originally ingested with the food and altered in some way has probably been drained off into the contiguous endosarc.

Among the food constituents of the endosarc there frequently occur solid bodies of different forms and extremely different sizes, with or without surrounding liquid, such as diatoms, desmids, fragments of vegetal tissues, and even other Rhizopods included in their shells.

Associated in like manner with the ordinary food-balls, there are frequently to be noticed drops of liquid, clear and colorless, or colored, mingled with the other materials of the endosarc. These particular liquid drops, water-vacuoles or vesicles containing liquid, are due to water swallowed in drops, or imbibed and accumulated in drops, or they are the result of more consistent food liquefied in the process of digestion.

The food appears to be swallowed by the Lobosa, not by a mere adherence of the material to a viscid substance, and a gradual entanglement and sinking of the food into the body, but through an active extension or flowing of the ectosarc over it, with or without the aid of the pseudopods. In the naked forms, the inception may occur in any position of the exterior surface of the body, but, according to the researches of Prof. Duncan,* would appear ordinarily to take place at the posterior extremity, where the endosarc is nearest to or actually reaches the surface. Some of my latest observations apparently confirm this view.

Whatever may be the position of ingestion in the naked Lobosa, excreta are ordinarily discharged at the posterior extremity of the body adjacent to the position of the contractile vesicle. Although there is no true vent, like the positions of the contractile vesicle and nucleus, the position of discharge of excrement maintains a certain degree of constancy.

In the shell-covered Lobosa, the food and water are ingested at the mouth of the shell, usually through the agency of the pseudopods, and the egesta are discharged in the same position at the base of the pseudopods, if these happen to be protruded.

Many of the Lobosa exhibit, among the constituents of the endosarc, variable proportions of clear, colorless or yellowish oil-globules, and also starch-granules. The latter are no doubt often swallowed as part of the food; but in many cases they appear as if they were an intrinsic element of the endosarc.

Most of the naked Lobosa frequently contain in the endosarc more or less angular particles of quartz sand; sometimes a few grains, sometimes in large and truly astonishing quantities. The shell-covered Lobosa usually do not contain this material, at least in any obvious quantity.

Another frequent constituent of the endosarc, especially in some of the Amœbæ, consists of minute crystals, often quite distinct, though it is not easy to make out their exact form and constitution. They sometimes appear as octahedrons, rhombohedrons, and hexagonal tables. Auerbach† supposes them to be of a fatty nature; Carter ‡ describes them as octahedrons, or modifications of the same, and as probably consisting of oxalate of lime; and Wallich § speaks of them as rhombohedrons, probably of car-

* Popular Science Review, 1877, 217.

† Zeitschrift f. wis. Zoologie, 1856, 309.

‡ Annals and Magazine of Natural History, 1863, xii, 33.

§ Ibidem, 1863, xi, 434; xii, 135.

bonate of lime, and again he refers them to the hexagonal system. The crystals sometimes occur in notable quantity, even in young specimens of Amœba, and are quite conspicuous; at other times, even in what appear to be the same species, they are few and small, or not clearly evident. The crystals, unlike the quartz sand, appear to be an intrinsic element of the animal.

There is yet little positively known in relation to the modes of reproduction of Rhizopods, though it is certain that a common mode is by division, as has been observed in some of the naked Lobosa, Heliozoa, and Monera. The opportunities for observing the process have appeared to me to be by no means frequent; for in all the four years of my study of the Fresh-water Rhizopods, I met with an Amœba in the state of division in but few instances, and the common Sun-animalcule, *Actinophrys sol*, but rarely.

The shell-covered Protoplasts are frequently found in pairs, with the shells mouth to mouth. When the shells are sufficiently translucent to allow the soft parts within to be seen, at times it is observed that these become confluent in one mass, which flows to and fro from one shell to the other. The mass finally dividing again into two, the individuals with their shells become separated without apparent change from the original state. This condition of union of a pair is commonly named 'conjugation', and has been supposed to hold a relation with the act of reproduction, though it has not been positively proved to be so.

From certain appearances, hereafter to be considered in the special cases, I have suspected that many of the supposed examples of conjugation are really due to reproduction through division. From the appearances alluded to, there is reason to suspect that from time to time the shell-covered Protoplasts, under appropriate conditions,—such as are induced by being well fed, so that the animal is in a highly active condition, and the shell is surcharged with sarcode,—quickly project one half the mass of sarcode, which as quickly assumes the shape and size of the parent. The exuded mass at the same time may be supposed to rapidly secrete a shell; or, if this is composed of foreign matters, as in the case of a Difflugia, it may be immediately formed by the adherence of particles to the exuded sarcode. If such shall be proved to be one of the modes of reproduction of the shell-covered Protoplasts, it is one which we may suppose would assure comparative uniformity of character in the shape, size, and constitution of the shell, just as buds of the same plant ordinarily assure the same varieties of flowers and fruit. On the other hand, reproduction of the Rhizopods from germs or spores would probably furnish a partial explanation of the multitudinous varieties of form.

The naked Protoplasts, as represented by species of Amœba, etc., at times which are apparently related with circumstances unfavorable to activity, even of an opposite character, as extremes of temperature, cold or heat, assume a condition of complete quiescence, reminding one of the winter or summer sleep of higher animals. The condition is preceded by retirement into the deeper part of the ooze in which these lowly creatures live, or by concealment in dirt and other materials accumulated around and adherent to them. Contracted into a globular form, they are purged of all remains of food and other materials, such as sand, etc., swallowed with the former. They then become gradually invested with a structureless membrane consisting of one or several layers, apparently the product of exudation and coagulation of a portion of the protoplasm of the sarcode mass of the body. In this encysted condition, the Protoplast remains an indefinite period, and perhaps usually undergoes transformation into reproductive germs or spores. Often, however, if the circumstances are changed for one favorable to activity, the creature bursts its envelope and creeps forth to feed in the ordinary manner, as if it had been passing a time in sleep.

The shell-covered Protoplasts are frequently found with the sarcode mass contracted into a ball commonly defined by a membrane of variable thickness, and apparently due to the coagulation or condensation of the ectosarc, or of an exterior more clear and homogeneous layer of the soft structure. In the formation of these quiescent balls, they are purged of all remains of the food which is often seen occupying the space between the ball and the mouth of the shell. Frequently, also, in the quiescent or encysted condition of the sarcode, the mouth of the shell is closed by an operculum apparently formed by the accumulation of successive layers of matters discharged from the sarcode ball.

The encysted ball of the shell-covered Protoplasts in many instances appears to be resolved into globules, or coarse granules of nearly uniform size, which are probably to be viewed as germs or spores.

From the researches of Mr. Carter* it would appear that in Amœba

*Annals and Magazine of Natural History, xviii, 1856, p. 226.

and Euglypha, representatives of the Lobose and Filose Protoplasts, the endosarc becomes resolved into nucleated cells, which are of the nature of ova, while the nucleus is resolved into granuliferous non-nucleated cells, finally breaking up into their constituent granules, which are of the nature of spermatozoids.

AMŒBA.

Greek, *amoibos*, changing.

Volvox: Linnæus, 1760. *Chaos:* Linnæus, 1767. *Proteus:* Müller, 1786. *Vibrio:* Gmelin, 1788. *Amiba:* Bory, 1824. *Amœba:* Ehrenberg, 1831.

Animal, when at rest, a spherical or oval mass of soft, hyaline, colorless, homogeneous, pale granular protoplasm, possessing extensile and contractile power, and in the active condition devoid of an investing membrane, or any kind of covering. In motion, mostly of exceedingly variable and ever-changing form, and with no absolute distinction of parts, though frequently exhibiting more or less disposition to differentiation into an anterior and a posterior region. Ectosarc hyaline, crystal-clear, but, with high magnifying power, exhibiting more or less of an infinitely fine granular constitution. Endosarc continuous with the former, finely and coarsely granular, mingled with corpuscles of intrinsic and varied character, together with various ingesta, consisting of food, water-drops, sand, etc. Containing also a nucleus and a contractile or pulsating vesicle, or sometimes more than one of either or both of these constituents.

Body with no external appendages of a fixed or permanent character. Pseudopods digitate, simple or branching, cylindroid and blunt, or more or less tapering and pointed, or short and broadly lobate, consisting of extensions of the ectosarc with variable proportions of the endosarc, or of the former alone.

Animal in the quiescent state, purged of food and other ingested matters, globular in form, and invested with a structureless membrane, apparently produced by coagulation of a portion of the ectosarc.

AMŒBA PROTEUS.

PLATES I, figs. 1–8; II, figs. 1–13; IV, figs. 22–25; VII, figs. 13–19; VIII, figs. 17–30.

Der kleine Proteus. Rösel: Insecten Belustigung, 1755, iii, 621, tab. ci.
Volvox Chaos. Linnæus: Systema Naturæ, ed. x, 1760, i, 821.
Volvox Proteus. Pallas: Elenchus Zoophytorum, 1766, 417.
Chaos Protheus. Linnæus: Systema Naturæ, ed. 12 et 13, 1767, i, 1326.
Volvox Sphærula. Müller: Verm. Terres. Fluviat. 1773, 31.

Proteus diffluens. Müller: Animalcula Infusoria, 1786, 9, tab. ii, figs. 1–12.—Surriray: Dict. Sci. Nat. 1826.
Vibrio Proteus. Gmelin: Lin. Syst. Nat., ed. 13, 1788, 3899.
Amiba divergens. Bory: Dict. Clas. Hist. Nat. 1822, 261.
Amiba Rœsili. Bory: Encyc. Méth., Hist. Nat. Zoophytes, 1824, 46.—Dujardin: Hist. Nat. Zoophytes, Infus. 1841, 232.
Amiba Mülleri. Bory: Encyc. Méth., Hist. Nat. Zoophytes, 1824, 46.
Amœba princeps. Ehrenberg: Abh. Ak. Wis. Berlin, 1831, 28, 79; Infusionsthierchen, 1838, 126, Taf. viii, Fig. x.—Perty: Kenntniss kleinst. Lebensformen, 1852, 188.—Auerbach: Zeitsch. wissens. Zool. 1856, 407, Taf. xxii, Fig. 1–10.—Leidy: Pr. Ac. Nat. Sc. 1874, 14, 143.
Amiba princeps. Dujardin: Hist. Nat. Zoophytes, Infus. 1841, 232, pl. i, fig. 11.
Amœba ramosa. Fromentel: Études Microzoaires, 346, pl. xxviii, fig. 2.
Amœba communis. Duncan: Pop. Sc. Review, 1877, 233.
Amœba chaos. Leidy: Pr. Ac. Nat. Sc. 1878, 99.
Amœba proteus. Leidy: Pr. Ac. Nat. Sc. 1878, 99.

Species comparatively large, nearly colorless, or more or less black by transmitted light, pale yellowish by reflected light; spheroidal or ovoidal when at rest; very variable and ever changing in shape when in motion, ordinarily ramose, palmate, or radiate; comparatively active, creeping, with a disposition to differentiate into an anterior and a posterior region. Pseudopods digitate, simple or branching, and blunt, sometimes tapering and pointed. Posterior part of the body in contraction receding in the advancing pseudopods, sometimes assuming a mulberry-like appearance. Nucleus usually single, discoid, habitually posterior. Contractile vesicle usually single and large, habitually behind the former. Ectosarc thinly differentiated. Endosarc finely and coarsely granular, with many and varied elements, contributing in its flow to the extension of the pseudopods.

Size, in the globular form to 0.2 mm.; in the ovoidal form to 0.3 by 0.15 mm.; extended in a dendroid form, occupying a space of 0.5 mm. in length by 0.4 mm. in breadth; in a palmate form 0.5 mm. long by 0.35 mm. broad; in a radiate form from 0.2 mm. to 0.5 by 0.4 mm.; in an irregularly cylindroid form to 1 mm. long. The largest observed occupied a space of 0.6 by 0.2 and 0.35 mm.

Locality.—Common in the superficial ooze of ponds and ditches almost everywhere, though rarely in large numbers. Ditches below Philadelphia and brick-ponds in the vicinity. Ponds in the neighboring counties, including Delaware, Chester, Montgomery, Bucks, Berks, and Northampton; Broad Mountain, Schuylkill County; Pokono Mountain, Monroe County, Pennsylvania; at Absecom, Hammonton, Woodstown, Vineland, Cape May, and other places in New Jersey; Newport and Narragansett, Rhode Island; and lakes of the Uinta Mountains, Wyoming Territory.

A large **Amœba** is the subject of the earliest notice of a Fresh-water

Rhizopod. It was discovered by Rösel, and described in a work entitled "Insecten Belustigung", or Recreation among Insects, published in Nurnberg in 1755. Rösel calls the animal the little Proteus, and accompanies his description with nineteen well-executed and colored figures engraved by himself.

Linnæus, in the Systema Naturæ, referring to Rösel's animal, named it *Volvox Chaos,* and subsequently *Chaos Protheus.* Pallas called it *Volvox Proteus.* Müller afterwards named it *Volvox Sphærula*, but later, after having himself observed the animal, described and figured it under the name of *Proteus diffluens.*

As the generic name of Proteus had been previously appropriated for the well-known Salamandroid of Adelsberg, Bory de St. Vincent substituted that of Amiba for the animal of Rösel and Müller, calling it by the various names of *Amiba divergens*, *A. Rœsili*, and *A. Mülleri.*

Ehrenberg, in the Transactions of the Academy of Sciences of Berlin for 1830, indicated and figured a comparatively small Amœba, the $\frac{1}{24}$th of a line (pp. 39, 75, pl. I, figs. 5), under the name of *Amœba diffluens*, regarding it as the same as the *Proteus diffluens* of Müller.

In the Transactions of the following year, Ehrenberg described what he considered to be a new species with the name of *Amœba princeps.* The characters given of this are as follows: Diameter $\frac{1}{6}$th of a line; body transparent, yellowish, with many easily and voluntarily movable blunt processes; four times larger than the Proteus.

This description is accompanied with one of *Amœba diffluens* (*Proteus diffluens*, Müller), as follows: Diameter $\frac{1}{24}$th of a line; body transparent as water, mostly with only three or four variable processes; four times smaller than the preceding species.

In his great work, the Infusionsthierchen, 1838, Ehrenberg described *Amœba princeps* as "large, yellowish, equalling $\frac{1}{6}$th of a line, provided with a variable number of cylindrical appendages, thick and rounded at the end." The accompanying figures (Taf. VIII, Fig. X) accord with the description, and agree with the familiar common large Amœba.

In the same work, *Amœba diffluens* is described as "rarely surpassing the $\frac{1}{24}$th of a line, hyaline; processes variable, moderately long and robust and subacute." Under this species, Ehrenberg places as synonyms the names of all forms of Amœba previously described by others, including the one first discovered, the little Proteus of Rösel

In the earlier description of *Amœba princeps*, Ehrenberg says it is four times larger than the Proteus, meaning the *Proteus diffluens* of Müller and his own *Amœba diffluens*, but not the Proteus of Rösel; for this, according to the actual representation of the latter, is four times larger than *Amœba princeps*, and sixteen times larger than *Amœba diffluens*, according to the measurements of these given by Ehrenberg.

In the remarks on *Amœba princeps*, in the Infusionsthierchen, Ehrenberg says "it is true that Rösel described a larger species of Proteus of which the dimension accords with this, but the blunt processes, of the species occurring in Berlin, do not agree well with those of Rösel's figures, but rather approximate those of larger individuals of *Amœba diffluens*."

It is natural to suppose that an Amœba discovered by the earliest microscopic observers would be one of the more common large forms, and that such was the case appears to be fairly proved by figures and descriptions.

Rösel, in referring to one of his figures of the little Proteus, remarks that in its natural size it looked like A. Now, this figure A represents the animal in its quiescent state, in globular form, and the figure measures just four fifths of a line. No Amœba has since been recorded, in the same condition, so large as this, and it is not unfair to suppose that the figure is somewhat exaggerated, which could readily occur in absence of the accurate means of measurement which came subsequently into use.

Rösel refers to his having held his little Proteus at rest with a pointed feather, which is alone sufficient to prove that he had under his observation one of the largest forms of Amœba.

In size, according to the actual measurements given, Rösel's Proteus is as much larger than *Amœba princeps* as this is than *Amœba diffluens*.

In all other characters ascribed by Ehrenberg to *Amœba princeps*, it appears to the writer to agree with the Proteus of Rösel, and this without doubt better than does the *Amœba diffluens* as described by Ehrenberg.

Amœba princeps is said by the latter to be yellowish, while the *Amœba diffluens* is said to be clear as water. Though Rösel says nothing of the color of the Proteus, his figures, carefully colored, exhibit the granular contents yellowish, and the exterior investment colorless, just as our large common Amœba appears under partially reflected and transmitted light.

Most of Rösel's figures exhibit the characteristic changes of form of the Proteus, and these certainly agree with those of our common large Amœba, and better with those of Ehrenberg's figures of *Amœba princeps* than with those of the same author's figures of *Amœba diffluens.* Of the figures of Rösel, one he likens in its branching to the antler of a deer, a resemblance which all must have seen who are familiar with the large Amœba commonly regarded as the *Amœba princeps.*

As regards both size and color of the Proteus of Rösel, it might refer to other large Amœbæ than *A. princeps*, as for instance the *A. villosa* of Wallich, or the *Pelomyxa palustris* of Greeff; but the changes of form and the extension and shape of the pseudopods rather approximate it to the former.

Müller's description and figures of *Proteus diffluens*, which that author regarded to be the same as Rösel's Proteus, appear to apply to the same animal as Ehrenberg's *Amœba princeps*, rather than to the *Amœba diffluens* of the latter.

From the review thus presented, I think it will be admitted that the little Proteus of Rösel, the *Proteus diffluens* of Müller, the *Amœba princeps* of Ehrenberg, and our large familiar Amœba, are to be regarded as one and the same animal.

It has been suggested that all forms of Amœba may eventually be found to be transitory phases of the same species; but even this view does not render the determinations of Ehrenberg and those who follow him in relation to *Amœba princeps* and *Amœba diffluens* any the less incorrect.

Having arrived at the conclusion that our common large Amœba, usually called *Amœba princeps*, is the same as Rösel's Proteus, the question arises as to its appropriate name.

Ehrenberg changed the name of Amiba of Bory into Amœba; and had it not been that the latter mode of spelling the word had come into such common use, I would have dropped the ugly diphthong, and resumed the word Amiba, as employed by Bory and Dujardin.

Of the specific names employed for the little Proteus, that of *chaos* in *Volvox Chaos* of Linnæus is oldest; but that of *proteus* in *Volvox Proteus* of Pallas appears more appropriate, and would at the same time serve to perpetuate the name given to the animal by its discoverer. I therefore suggest that the name of *Amœba proteus* should be employed for the common large Amœba, recognizable as the Proteus of Rösel and the *Amœba princeps* of Ehrenberg; otherwise, according to the strict rules of scientific nomenclature, it should be *Amœba chaos*.

Amœba proteus (pls. I, II) is one of the largest forms of the genus, and is the one which is perhaps the most familiar to those who are accustomed to the examination of the microscopic life abounding in fresh waters. It is commonly found in the superficial ooze of clear and comparatively quiet waters, such as ponds, lakes, and ditches. It also occurs among Duck-meat and on the under surface of leaves of aquatic plants floating on the surface of water. In some instances, in certain localities, it may be found in profusion; but frequently in similar places, or even at other seasons in the same place, I have failed to obtain it after the most diligent search. Specimens often vary, especially in different localities, to such a degree that it is difficult to decide whether to regard them as really pertaining to this or some other described species.

The habitual appearance of characteristic forms as they have come within my notice may be described as follows:

The Amœba, if observed immediately after having been transferred from the material in which it lived to the object-glass of the microscope, appears as a globular or ovoidal, granular ball, translucent and of a blackish hue by transmitted light, or faintly yellowish white by reflected light. Often, however, from the first moment of observation, the animal appears of irregular shape, with projected pseudopods already in movement, apparently as if it had been little affected by disturbance.

The globular or ovoidal quiescent Amœba after a little while puts forth from every part of the body a multitude of clear, rounded extensions of the ectosarc, which give one the impression that the creature had suddenly exuded, or, if I may use the term, sweated, numerous drops of liquid. These quickly elongate, and assume the form of digitate pseudopods, in which condition the animal may present the appearance seen in fig. 1, pl. I. A number of the pseudopods continue to elongate and become thicker, not only from an extension of the ectosarc, but by the attendant influx of the endosarc. The greater number of the pseudopods originally seen are withdrawn and altogether disappear. The growing pseudopods are cylindrical or digitate, with blunt extremities. They extend in all directions, are usually more or less curved, and frequently branch. In this condition, the Amœba may present the appearance represented in fig. 2.

Occasionally the rounded or ovoidal mass composing the body of the Amœba, after putting forth numerous processes in the manner above described, withdraws the most of these, while a few others rapidly elongate, and diverge on each side, and the animal may assume a shape reminding one of a great spider. A specimen in this condition is represented in fig. 1, pl. II.

Commonly, while one or two, and occasionally more, of the pseudopods, continue to extend and branch, others shorten and disappear, and the principal mass of the body is diminished at the expense of the growth of the advancing pseudopods, and it may to a greater or less extent merge into them. As the Amœba advances through the extension of one or more principal pseudopods in a particular direction, the whole together becomes more or less differentiated into an anterior and a posterior region. The posterior extremity of the body, in its contraction through the flow of its endosarc into the advancing pseudopods, frequently assumes a more or less mammillary appearance. In this condition, the Amœba, in its form and branching, may remind one of the antler of an elk, and such specimens are represented in figs. 3, 4, pl. I.

In the continued extension and branching of one or more of the chief pseudopods, the Amœba progresses more or less rapidly, the body appearing incessantly to exhaust itself in the continued growth or elongation of the pseudopods and in the production of new ones, while it is as incessantly replenished by the contraction and melting-away of pre-existing pseudopods. While the animal moves along, its direction may change at any moment by the more active prolongation of any one of the pseudopods.

The changes of form produced by the extension and branching of certain of the pseudopods, with the recession, melting-away, and total disappearance of others, is endless. Sometimes the animal creeps onward in a flowing manner with comparatively simple cylindroid form, occasionally emitting a single pseudopod, on one side or the other. More commonly in movement it assumes a dendroid or palmate form, or sometimes, diverging from the directly onward course, it becomes more radiate in appearance.

Not infrequently it assumes more or less grotesque shapes, in which almost every conceivable likeness may be imagined.

Usually *Amœba proteus* creeps along surfaces, mainly extending its pseudopods, and advancing in the same general direction. The pseudopods may, however, be extended or produced in any direction, and in their production the direction of motion of the animal may be completely reversed, or it may occur in the direction of extension or production of any pseudopod. There is no fixed distinction or differentiation of parts or regions, and any point of the animal may become central or peripheral, forward or backward, or lateral.

In the movements of *Amœba proteus*, as certain of the pseudopods are extended, and the mass of the body is proportionately reduced, other pseudopods may more or less gradually recede and merge into the advancing ones, or they may become shriveled and mammillary in appearance, as is frequently the case with the posterior extremity of the body itself, and as represented in figs. 3–7, pl. I.

The mammillary appearance assumed by the posterior extremity of the animal may persist for a considerable time, though undergoing continued variation. Any of its processes may become the source of new pseudopods, and the whole may, at any moment, contract and merge into the general mass of the body.

When *Amœba proteus* is free and floating or suspended in water, it often assumes a more or less radiate or stellate appearance, with the pseudopods more or less tapering, and it then looks like a giant form of *Amœba radiosa*, as represented in fig. 2, pl. II.

When creeping on flat surfaces, the body and pseudopods of the *Amœba* are more or less depressed; but when the animal is floating, they are more rounded.

The ordinary shape of the pseudopods is digitate or finger-like, or depressed cylindroid, with blunt rounded ends. They may be straight or more or less curved, even or crimped, and simple or branched. Sometimes they are more or less tapering and bluntly pointed, or they may be clavate, or thicken in approaching the end.

The projection of the pseudopods is always preceded by a flow of the more hyaline portion of the protoplasm of the body, or of the ectosarc, followed closely and incessantly by an influx of the endosarc. The flow of the endosarc proceeds from the interior of the body, and is continuous through the axis of the latter, back of the source of the pseudopod; and if this forms the fore part of the body, the current may be continuous its entire length. If a growing pseudopod proceeds from an intermediate position, currents of endosarc may flow from opposite directions to promote its extension.

The flow in the current of endosarc is always most active axially, both within the body and the pseudopods. As it approaches the end of a pseudopod, formed by the advancing ectosarc, it usually enters to one side and turns upon itself, as represented in fig. 11, pl. II.

New pseudopods start more or less abruptly, and give one the impression as if they proceeded from a sudden escape of a portion of the contents of the body, through an accidental rupture of its surface. In their extension they appear to flow onward like a liquid stream, as previously intimated, always preceded by a portion of the clear ectosarc, followed by an incessant influx of the endosarc. In the precedence of the ectosarc, it looks as if it were a clear liquid, incessantly drained from the endosarc, and flowing off in a stream; but apparently before the ectosarc has a chance of accumulating to any considerable extent, it is constantly followed by granular endosarc, as if this was forced into it from behind by contraction of the body.

The progress of the animal may continue steadily for a time, induced by the equally steady extension and advance of one or more pseudopods, accompanied with a more or less brisk flow of the endosarc of the body, continuing in one stream, or dividing into several, according to the number of the advancing pseudopods.

While there is no absolute distinction between the ectosarc and endosarc, the two being continuations of the same protoplasmic mass, in the movements of the animal the endosarc appears to flow within walls, more or less thick, formed by the ectosarc. With the exhaustion of the endosarc from behind, the including ectosarc contracts, and melts away into the advancing portion of the body.

Amœba proteus, while steadily pursuing its course, may slacken its speed and altogether cease its onward movement; and after a brief interval, a new pseudopod may start forth, and with its extension in the same direction the course of the animal may be entirely changed from the former one.

Not unfrequently during the extension of one or more pseudopods in advance, another may originate, and extend in a widely divergent or even opposite direction from the former. In such instances, after a little while, the previously advancing pseudopods become retarded in their course, then recede, and go to contribute to supply the new pseudopod moving in another direction.

Occasionally clearer and wider expansions than usual of the ectosarc appear at the root of a pseudopod, or like a web in the crotch of a pair of pseudopods, as seen in figs. 3, 5, 7, pl. I. Similar expansions at times extend as longitudinal folds along the body and principal pseudopods, as represented in fig. 7.

Sometimes a pair of pseudopods start together from near the same point, extend side by side, and, as they advance, become confluent from their root onward. Very rarely do contiguous pseudopods, approaching one another and coming into contact at the ends, become connate, or fused together, though I have observed this to occur in the capture of an animalcule, as represented in fig. 5 *c*, pl. I.

The fundamental structure of *Amœba proteus* consists of a thin, colorless, jelly-like, pale, and finely granular protoplasm, or sarcode, endowed with extensile, contractile, and other less well defined attributes, in which, however, a chemical or digestive power may be included. The exterior clearer portion of the protoplasmic mass constitutes the ectosarc, while the interior portion, mingled with various elements, intrinsic and extrinsic, constitutes the endosarc.

The clear ectosarc, examined by the higher powers of the microscope under favorable conditions of light, appears never to be perfectly structureless, but exhibits an infinitely fine granular constitution.

The endosarc, with its mingled coarser elements in its relationship with the ectosarc, may be compared with the circulating blood in the capillaries of the higher animals. The endosarc is comparable to the rapidly flowing current of blood, mingled with its corpuscles, in the axes of the vessels, while the ectosarc is comparable to the slower moving blood-liquor next the walls of the vessels.

The ordinarily distinguishable elements of the endosarc of *Amœba proteus* have appeared to me to be as follows:

1. Granules, from those of the finest, most diffuse, and scarcely per-

ceptible kind, such as are commonly to be detected in a favorable light and with the highest microscopic powers, in the clear limiting ectosarc, to such as are distinct, darkly defined, and resemble the finest molecules of oil.

2. Variable quantities of rather large, spherical, homogeneous, or indistinctly granular corpuscles, usually colorless or faintly yellowish, apparently liquid or semi-liquid.

3. Different proportions of round, oval, or irregularly oval bodies of various sizes, clear, colorless, and highly refractive, apparently of the nature of starch-granules, and resembling them in their chemical reaction.

4. Variable quantities of round or oval globules darkly defined and highly refractive, clear and colorless, or of different shades of yellow, passing at times into brown, apparently oleaginous in character. These are often altogether absent.

5 Widely different proportions of food-balls, mostly spherical and of pretty uniform size, and very variable in composition and color, according to the nature of the food and the changes it has undergone through digestion. The colored balls are commonly pale yellow, passing to darker yellow and different shades of brown, even sometimes approaching to blackness. Often some of the balls appear bright green or yellowish green, and are frequently recognizable as being composed of round single-celled algæ.

Generally the food-balls appear surrounded with a clear halo indicating the presence of liquid enclosing the more solid matter, and consisting of water swallowed with the food. Often the balls exhibit no vestige of such a halo, in which cases we may infer that the water which may have been swallowed with the food and had surrounded the ball, in an altered condition, has been imbibed by the including endosarc.

Besides the more solid food-balls, there are frequently to be observed globules of colored or colorless liquid or semi-liquid matters, which may consist of water-drops swallowed as such, and of dissolved food resulting from digestion.

Sometimes large numbers of clear water-drops are not only seen within the endosarc, but are actually observed to be developed as if from a concentration of the more liquid part of the protoplasm, and these are again often seen slowly to disappear as if gradually absorbed by the contiguous protoplasm.

Independently of the food-balls, which ordinarily are formed from soft and readily yielding materials, the endosarc is often observed to contain other food of a more consistent character, greatly differing in the size of the morsels and frequently more or less readily recognizable from their form. Such materials commonly consist of the various diatoms, desmids, green unicellular algæ, and zoospores of the filamentous algæ. Considerable fragments of the latter, such as Oscillaria, Zygnema, etc., are also often seen among the food contents. Occasionally animal forms may be detected in the food materials of the endosarc, among the most common of which are the Rotifers, and in several instances I have observed with them an unfortunate Arcella, a Difflugia, or a Trinema.

These more consistent and persistent food materials, like the food-balls, are often observed included in water-drops swallowed with the food, but they also frequently appear without any such liquid investment.

Other materials related with the food, and frequently forming part of the endosarc-jumble, consist of fragments of various vegetal tissues, such as portions of cellular tissue of macerated leaves, vessels, ligneous fibres, and hairs. In some fine large vigorous specimens of *Amœba proteus* collected from a pond in the vicinity of a saw-mill, the endosarc contained multitudes of particles of sawdust.

In addition to the food materials and other elements of the endosarc of *Amœba proteus*, it frequently contains variable proportions of quartz-sand in irregular angular particles.

6. A remarkable and pretty constant element of the endosarc, apparently of an intrinsic character, consists of minute crystals, as seen in fig. 11, pl. II. They have been observed in this and other Rhizopods by many investigators. Though very evident, I have generally failed to determine their exact form or the system to which they belong.

7. An important element of the endosarc is the nucleus, seen in most of the figures of pls. I and II. It usually occupies a position posterior to the middle of the body, but may be shifted to almost any other position in the movements of the animal. Mostly it appears as a rather conspicuous compressed spheroidal, or thick discoid body, with the broad surfaces somewhat convex, flat, or slightly depressed, and the border rounded. It is often surrounded by a clear halo, apparently consisting of a globular envelope of clear protoplasm. In different Amœbæ of various sizes, and from dif-

ferent localities, the nucleus presents considerable range in size. In a number of characteristic individuals it measured about $\frac{1}{500}$th of an inch in width and from one half to two thirds the thickness of the width. In others it ranged from half the size indicated to one fifth greater diameter.

The nucleus is colorless, homogeneous, indistinctly and finely granular, or more coarsely, uniformly, and distinctly granular. I did not at any time distinguish a distinct membranous wall to the nucleus; and a distinct nucleolus, if present, escaped my notice.

In several instances I have seen two nuclei in the same individual, as represented in fig. 2, pl. I. More frequently I have failed to detect a single one, though it is probable that in most cases, if not in all, it was hidden from view by other elements of the endosarc. Occasionally, however, even in large specimens of unusual transparency and unobscured by the presence of food and other materials, as in the individual represented in fig. 7, pl. II, I was unable to discover a nucleus.

8. Almost invariably there may be seen in the vicinity of the nucleus, and approximating it in size, the clear liquid globule, which constitutes the contractile or pulsating vesicle. It usually occupies a position just back of the nucleus, but not unfrequently, in the movements of the endosarc, is shifted to a position in advance. The contractile vesicle is ordinarily observed very gradually to enlarge, and then rather abruptly to collapse, so as to disappear altogether from view. After a brief interval it again reappears in the same or nearly the same position. Starting as a minute spherule, the vesicle gradually increases as before, until it reaches its former size, when it once more abruptly collapses. The increase, collapse, disappearance, and reappearance of the contractile vesicle occur successively and incessantly in a rhythmical manner, reminding one of the regular action of the heart in higher animals.

The gradual expansion of the contractile vesicle is slow and more or less variable in the time it takes to reach the full size; the collapse ordinarily occupies about a second of time.

The contractile vesicle appears to be due to the accumulation or concentration of water from the surrounding endosarc, which water appears then to be expelled from the body in the collapse of the vesicle. It is perfectly clear, and of a pale, though decided roseate hue, which becomes more pronounced with the expansion of the vesicle. The same hue is to be observed in the contractile vesicle, and all clear water-vacuoles of the endosarc, in other Rhizopods and Protozoa in which these constituents occur.

Sometimes two contractile vesicles are seen in *Amœba proteus*, as represented in fig. 6, pl. II. They occupy the usual position back of the nucleus, or may be temporarily separated by one shifting in advance of the latter, or indeed both may be transferred to any other position. Rarely a greater number of contractile vesicles occur, usually in such cases smaller and often more or less scattered.

Sometimes after the disappearance of the contractile vesicle, two or three minute ones appear simultaneously in its place, and, as they gradually augment in size, break into one another until all become one.

In the progressive movements of *Amœba proteus*, and the extension of its pseudopods, the flow of the endosarc is accompanied with a more or less thorough mingling of all its constituents. The smallest elements are hurried along most briskly, while the largest exhibit more or less inertia; the nucleus and contractile vesicle almost always being hindmost in the race. Occasionally, a more than ordinary impulse drives the nucleus in advance of its habitual position, and even carries the contractile vesicle beyond it, but in a little while they again assume their usual place.

A remarkable fact in the streaming of the endosarc, with all its varied constituents rolling among and jostling one another, is the circumstance that the food-balls with their liquid envelope, the water-vacuoles, the contractile vesicle, and all else, retain their integrity, as if they were solid, or contained each within a membranous sac. Never are the materials observed to break and run together, as a result of the continued jar to which they are subjected.

As previously intimated, Dr. Wallich expresses the opinion that the endosarc and ectosarc of the Rhizopods are mutually convertible into one another. When endosarc comes into contact with water, it undergoes a sort of temporary coagulation, or conversion into ectosarc, and when the latter is transferred into the interior after a time it again undergoes resolution into the more liquid endosarc. In the taking of food he supposes that each portion when swallowed becomes enveloped with a film of ectosarc, which forms a vesicle enclosing the food and water-drop in the interior of the endosarc. As the food undergoes digestion, and the water, altered in condition, is imbibed from the vacuoles into the contiguous endosarc, the vesicles of ectosarc which contained the food and water undergo resolution into endosarc.

As the soft structure of *Amœba proteus* is totally unprotected, even by the thinnest membrane, one would expect to find the animal exceedingly irritable, though such appears not to be the case in a marked degree. In its wanderings it frequently comes into contact with more actively moving Infusorians and mailed Rotifers without in the least being affected by their rude shocks. On one occasion I happened to have beneath the microscope a large individual of *Amœba proteus*, together with a multitude of the active ciliated Infusorian, the *Coleps hirtus*. The Amœba moved about, entirely indifferent to the frequent buffets of the Coleps. In attempting to readjust the cover of the object-glass, a portion of the Amœba was crushed off; but notwithstanding the accident, the larger portion of the creature, still retaining its nucleus and contractile vesicle, moved away, apparently unmindful of its injury. The smaller portion of the Amœba was attacked by half a dozen Coleps, and the escaping granules of the endosarc, exhibiting lively molecular movement, were greedily swallowed by the Infusorian. One would further suppose from the structure and semi-fluid character of the Amœba that it must be sticky and that materials would adhere as they came into contact with it. This is, however, so far from being the case, that *Amœba proteus* is frequently observed traversing mud with algæ and other materials, without anything adhering to its surface even for a moment. Not unfrequently, however, various matters are observed attached to the posterior extremity of the body, and dragged after the animal in its movements.

Amœba proteus, like most others of the genus and its allies, is essentially herbivorous, though its choice of vegetal food is perhaps largely due to the fact that it is more readily attainable than animal food. Judging from the materials usually observed among the constituents of the endosarc, the favorite food consists chiefly of the one-celled algæ, diatoms, desmids, zoospores, and portions of filamentous algæ, besides fragments of the tissues of higher plants. The Amœba evidently possesses a power of discrimination and selection in its food, for although it appropriates with the latter many particles of dead vegetal tissues, and even abundance of sand-grains, it commonly rejects dead diatom shells and the empty cells of other algæ.

I have rarely had the opportunity of directly observing *Amœba proteus* swallow food, mainly from the circumstance that I did not sufficiently often watch the animal a proper length of time for the purpose.

Mr. Duncan, in a recent publication,* intimates that the usual position in which the Amœbæ take their food is at the posterior extremity of the body, which I am inclined to think, from some later observations I have made on the allied genus Dinamœba, is correct.

On the other hand, I have repeatedly observed *Amœba proteus* discharge the remains of its food; the usual position being at the posterior extremity of the body, in the vicinity of the nucleus, as represented in figs. 3, 4, pl. I. The excrementitious matters commonly consist of brownish or colorless balls and granules, empty cells of algæ, or others with the brownish, shriveled remains of their contents, diatom shells, etc. The discharge is rather sudden, and is often accompanied with the escape of some viscid liquid. The temporary orifice abruptly closes, leaving no trace of its previous existence.

From the concurrent testimony of observers, it would appear that the Amœbæ may take food at any point of the surface of the body; and the discharge of matters may likewise occur in any position.

I have had but few opportunities of seeing *Amœba proteus* capture living animals. In one instance I saw an individual, as represented in fig. 5, pl. I, containing, within a large vacuole, an active Infusorian, a Urocentrum, and having a second victim of the same kind included in the fork of a pair of pseudopods, the ends of which were brought into contact, so as to imprison the animalcule within a circle. The latter moved restlessly about within its prison, but after a time became motionless, and shortly after the ends of the pseudopods which enclosed it fused together, as seen at *c* in the figure just indicated. Films of ectosarc extended from the body of the Amœba towards the fused ends of the pseudopods, and finally the Urocentrum was enclosed in a vacuole like that in the interior of the body of the Amœba. Having carefully watched the latter for some time, the two vacuoles containing the captured Urocentrums were seen gradually to diminish in size, the contents were reduced to the usual size of ordinary food-balls of the endosarc, and all trace of the previous character of the victims was completely lost.

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* Popular Science Review, 1877, 217.

The food of *Amœba villosa* and other Rhizopods appears always to be swallowed together with some water, which subsequently is commonly observed as a clear area surrounding the food within the endosarc. Soft food, vegetal and animal, assumes the form of spherical balls; but more consistent food, such as diatoms, retains the original form according to its degree of resistance. The distinctive character of soft articles of food rapidly disappears after being swallowed. The different food materials undergo chemical changes as a result of digestion in the endosarc, and colors become changed in a striking manner. The bright-green chlorophyl of algæ becomes brown or yellow and shriveled within the colorless cells, and the endochrome of diatoms becomes browner in hue and shriveled into two narrow strings within each shell.

Some ooze gathered in the month of September from a mill-pond, in which grows a profusion of the magnificent Nelumbo, *Nelumbium luteum*, near Woodstown, New Jersey, contained many large specimens of *Amœba proteus*, like the one represented in fig. 7, pl. I This individual occupied a space of about one fourth of a line in length by one sixth of a line wide in front, where three large finger-like pseudopods diverged. The nucleus, if present, escaped my notice. The contractile vesicle usually occupied a position at the posterior extremity. The endosarc contained numerous large, round or oval, yellowish, granular balls, supposed to consist of food, but not visibly included in water-drops. Many of these were darkly outlined, and appeared to have an oil-like consistence. With them were also mingled many clear colorless globules, granules, and crystals. When the specimen was first noticed, it contained, just in advance of the position of the contractile vesicle, a Brachionus, which finally assumed the appearance of an ordinary food-ball, resembling the abundance of yellowish balls with which it was associated.

In movement, the main trunk and larger pseudopods of the same Amœba assumed more or less the appearance of being longitudinally folded. The endosarc axially flowed as if in the interior of thick-walled canals, of which the walls appeared to be composed of finer granular matter with scattered imbedded crystals. In the flow, all the contents did not move with the same rapidity, and usually the smaller particles were swept quickly by the larger ones. Other matters, including some of the largest elements, appeared to stick to the inner surface of the extemporaneous tubes, but successively became detached to be carried along with the rest of the contents. As the posterior part of the body became exhausted of its axial contents, it contracted, shriveled, and kept up continuously the mulberry-like aspect of this region, as seen in the figure.

Mostly in the contraction of the posterior part of the body of Amœba, or of its pseudopods, as they exhaust themselves through the flux of their endosarc, the ectosarc closes up more or less evenly with the latter. In the Amœba under consideration, in similar contraction of parts, the ectosarc appeared to be slower in its closing-up, so that they became more or less shriveled processes in their shrinkage.

Another large individual, in general form like the letter Y, measured 0.64 mm. long, with one of the divergent arms 0.4 mm. long by 0.04 mm. thick. The two arms continued to diverge until they divided the main stalk of the body, and became extended together, in nearly the same line, so as to measure two millimetres in length. I supposed the two limbs were about to divide, but subsequently one reversed the direction of its motion and flowed into the other, and the animal then assumed a palmate appearance.

Another specimen, when first observed, covered a space in both directions measuring about 0.6 mm. It appeared to be in the act of division, consisting of two portions connected by an isthmus; but subsequently one portion flowed into the other, while this extended three divergent pseudopods. The contracted pseudopods of the former portion shriveled into beaded cords, and then melted-away in the progressing body-mass.

This specimen, retained under observation during two days, with the idea that it was about to divide, finally appeared as a quiescent oval ball 0.46 by 0.38 mm., closely covered with small round pseudopods of clear ectosarc, looking like dew-drops, measuring 0.012 to 0.016 mm., and occasionally containing a few granules or a minute crystal.

The largest individual observed among the Amœbæ, from Woodstown pond, extended into two arms from a posterior mulberry-like mass, which measured 0.2 by 0.16 mm., with one arm 0.8 mm. long by 0.08 mm. thick, and the other arm 0.6 mm. long by 0.06 mm. thick. The contractile vesicle occupying the interior of the mulberry-like end of the body was 0.06 mm. diameter. The crystals of the endosarc, apparently octahedral in form, appeared to reach 0.075 mm by 0.0375 mm.

Certain specimens met with from time to time, and regarded as pertaining to *Amœba proteus*, but presenting either more or less peculiarity, or some point of special interest connected with the history of the animal, may here be described.

A specimen obtained in the spring of the year from the ooze of a ditch when first seen had the appearance represented in fig. 25, pl. IV. It was globular, about 0.2 mm. in diameter, and projected a number of digitate pseudopods in different directions. Besides the usual contents, in the vicinity of the large contractile vescicle, there were observed half a dozen granular balls from 0.016 to 0.024 mm. in diameter. The granules within the balls exhibited an active swarming motion, reminding one of the rapid movements of spermatozoids in higher animals. The nature of these granular balls I failed to determine, but suspected they might really constitute male elements of the Amœba. The individual after a little while moved off in the manner usual with *Amœba proteus*, assuming a dendritic form. The nucleus was distinctly, coarsely, and uniformly granular. The contractile vesicle expanded to the extent of $\frac{1}{12}$th of a millimetre in diameter, and would collapse in two seconds of time. Sometimes it would reappear as two, which, after expanding to a certain extent, would unite into a single one. After keeping the specimen the greater part of a day, it was finally lost without my having learned anything further in regard to the granular balls contiguous to the contractile vesicle.

I have repeatedly met with Amœbæ, which I have supposed to pertain to the species under consideration, though they presented sufficient peculiarity to make the reference uncertain.

A not unfrequent form is such as are represented in figs. 22, 23, and 24, pl. IV. Comparatively active, in creeping on flat surfaces, the animal commonly presents a prolonged, somewhat triangular outline; straight or curved, with the broader extremity in advance, and spreading into a variable number of conical-pointed pseudopods. These undergo frequent, but slow change, and in their extension do not receive so much of the coarser constituents of the endosarc as usual in more characteristic forms of *Amœba proteus.* The posterior end of the body is narrow and blunt, simple or papillose, and sometimes is produced into a brush or fringe of rather long villous processes. The animal is greedy in habit, and usually contains much food, consisting of algæ, mingled with other constituents of the endosarc. The nucleus and contractile vesicle exhibit the usual characters and relative position, as in more common forms of *Amœba proteus.*

An individual of the kind just described I had the opportunity of seeing swallow and digest one of another species, the *Amœba verrucosa.* The steps of the process I have attempted to represent in figs. 13–19, pl. VII, and they occurred as follows:

In a drop of water squeezed from mud adhering to the roots of the plant Ludwigia, collected in a half-dried marsh, in the month of August, I noticed an active Amœba, as seen in fig. 13. It was of elongated triangular, snail-like form, with the anterior broader extremity extended into a number of conical antenna-like pseudopods. The posterior end was somewhat coarsely papillose, and from the left side projected two conical pseudopods like those in front. Observing an *Amœba verrucosa*, fig. 12, in its usual sluggish condition, lying almost motionless, directly in the path of the former, I was led to watch whether the two would come into contact and what would be the result.

The *A. proteus* contained a number of large food- and water- vacuoles, together with a single diatom. The contractile vesicle occupied the usual position and exhibited the usual changes. The *A. verrucosa*, besides the granular protoplasm, appeared to contain nothing but a conspicuous contractile vesicle, and this remained unchanged.

The snail-like Amœba reached the *A. verrucosa*, and turning with tail end towards the right, the body shortened, and a pair of digitate pseudopods extended from the head and embraced the latter in the manner represented in fig. 14. The conjoined ends of the pseudopods fused together, and the animal reversed its direction of movement, while the *A. verrucosa* gradually sank deeply within its body, and assumed the appearance of a large sphere, still retaining its contractile vesicle unchanged, as represented in fig. 15. The snail-like *A. proteus* assuming nearly the original shape, as first noticed, then moved about after a while and presented the appearance seen in fig. 16. The tail end of the body was elongated and papillose, and the swallowed Amœba, reduced in size, had lost its contractile vesicle and become oval in shape. Later, the *A. proteus* appeared more slug-like, while its victim had become pyriform and striate, and was then included within a large water-vacuole, as represented in fig. 17. Subsequently, the *A. proteus* was observed to discharge the diatom, previously noticed in the endosarc, from the side of the posterior narrow end; and the *A. verrucosa*, within its now globular water-vacuole, had become bent upon itself, as seen in fig. 18. Still later, the body of the *A. verrucosa* appeared to have become broken up into five spherical, granular balls, as seen in fig. 19, which rolled about among the other constituents of the endosarc of the *A. proteus.* These observations were conducted through about seven hours. What finally became of the five balls resulting from the destruction of the *A. verrucosa* I did not ascertain, but supposed that they were digested, to contribute to the nutrition of the *Amœba proteus.*

In my studies of *Amœba proteus* I have not been so fortunate as to trace its history from an early period, nor to discover its modes of reproduction. In association with the more characteristic forms, I have seen many which I have suspected to be the young; but it is quite as probable that they may have pertained to other described species.

Comparatively small Amœbæ are frequently to be met with, which, though exhibiting considerable variety, are yet commonly and habitually clavate, or more or less slug-like in shape. Similar Amœbæ have been described under the names of *Amœba Gleichenii, A. limax, A. guttula,* etc.

Some of these I have suspected to be the young of *Amœba proteus,* though with equal probability they may be considered to belong to some other species. They are usually quite active, and glide along with the thicker extremity in advance, with comparatively little change of form. The posterior extremity is more or less tapering, and terminates bluntly, and mostly without any process, though the end is apparently in some degree prehensile, as it is occasionally observed with adherent materials dragged after the animal in its movements.

Progression commonly is due to an incessant, more or less even, or interrupted, flow or roll of the ectosarc of the head end forward, followed closely by an influx of the endosarc and a concurrent contraction of the body behind. The precession of the ectosarc at the head end appears as a clear watch-crystal-like extension of variable thickness, into which the endosarc flows from one side and spreads towards the other. Frequently the onward movement of the animal is promoted by the projection of hemispherical pseudopodal lobes, alternately and in succession, at the sides of the head end, which are produced in the same manner as the latter itself.

The endosarc of the small Amœbæ presents a basis of pale, indistinct, granular matter, merging into the almost vanishing granular constitution of the hyaline ectosarc. Scattered through it are coarser granules with variable proportions of fine oil-like molecules and darkly defined particles, which in many instances appear to be crystalline in form. A conspicuous contractile vesicle commonly occupies a position posterior to the middle of the body, and not unfrequently two or more of such vesicles occur. With the more characteristic contractile vesicle, variable numbers of water-vacuoles frequently occur, undistinguishable from the former in appearance, but with less regular or no evident rhythmical movements. A round nucleus, of homogeneous granular structure, and surrounded by a clear halo, is a common constituent.

In the smallest or youngest Amœbæ, food in balls or other conspicuous form is commonly absent, though occasionally an individual may be seen containing a single small diatom.

Examples of Amœbæ, viewed as probably pertaining to the young of *Amœba proteus*, are subjects of the following notices.

Some water scooped from a cow-track in a marshy place, in the month of March, contained an abundance of Amœbæ, together with diatoms. The smallest Amœbæ, as represented in figs. 21–23, pl. VIII, were ovoid, and ranged from 0.036 to 0.048 mm. in length. They moved actively by repeated hemispherical bulgings, first on one and then the other side of the broader end, though at times the bulgings occurred elsewhere.

In structure, they consisted of delicate granular endosarc invested with clear ectosarc. The endosarc contained coarser granules, among which some appeared to be of crystalline form. There were also present a nucleus surrounded with a faint halo, and a contractile vesicle. Often there were two of the latter, and sometimes a greater number. None of the specimens contained distinct food-balls.

The larger Amœbæ ranged in size from the former up to 0.125 mm. in length. These were active and slug-like in shape, as seen in fig. 29. They moved with the thicker end forward through the agency of hemispherical pseudopodal lobes, bulging alternately at the sides of the head end. They proceeded straight forward or often curved to one side or the other. The endosarc contained many scattered, darkly outlined granules, which appeared indistinctly to be crystalline. It also contained many clear globules which appeared to be water-vacuoles. These larger Amœbæ generally contained a considerable quantity of food, mainly consisting of diatoms of the kind which abundantly occurred in the water with the animals. In several instances I observed individuals in the act of discharging dead shells of diatoms, as represented in the figure just indicated. The expulsion occurred at the posterior end of the body; nothing escaped except the remains of the food, and subsequently all trace of the temporary vent disappeared.

None of these Amœbæ exhibited anything like a posterior villous process, though the end of the body appeared in some degree prehensile, as several individuals were observed with adherent diatoms trailing after them.

Some water with growing Nitella gathered in the autumn was preserved during the winter In January, the surface of the sediment contained multitudes of minute Amœbæ, such as are represented in figs. 17–20, pl. VIII. In their movements they exhibited considerable variety of form, but were commonly more or less ovoid or clavate, and moved with the broader extremity forward. They were composed of pale delicate endosarc, preceded by thick watch-crystal-like extensions of clear ectosarc. The endosarc contained a round or oval nucleus, two or three contractile vesicles, and a few scattered, darkly outlined granules, but no conspicuous food. They ranged from 0.03 to 0.04 mm. in length. The posterior extremity was prehensile, but exhibited no clear trace of a villous process.

Some ditch-water, with ooze and portions of the root of the Arrow Arum (*Peltandra virginica*), collected in autumn and examined the following April, contained many small Amœbæ in association with large and characteristic ones of *Amœba proteus*. The small Amœbæ were habitually ovate, more or less pyriform or clavate in shape, figs. 24–25, and ranged from the $\frac{1}{25}$th to the $\frac{1}{12}$th of a millimetre in length. They moved actively onward in a sort of rolling manner, with the broader extremity forward; and the posterior tapering end was devoid of any appearance of a villous process. The endosarc contained many fine, irregular granules, which appeared to be starch-particles; and among them were others which appeared indistinctly to be crystalline. A small nucleus and a contractile vesicle were constantly present Among the little Amœbæ a number were observed, apparently of the same kind, but containing a large spherical, granular nucleus, reaching

$\frac{1}{35}$th of a millimetre in diameter. The granules of the nucleus were coarse and uniform. In some specimens, the nucleus was simple, but in others presented a tripartite division, as represented in figs 27, 28. I failed to trace the further history of these Amœbæ.

Rarely have I had the opportunity of seeing *Amœba proteus*, or any other species, multiplying by division. On one occasion, in the month of February, while examining some material collected the previous autumn, I observed a pair of small Amœbæ connected by a narrow isthmus in the manner represented in fig. 30. Each individual was of oval form, and measured about $\frac{1}{20}$th of a millimetre long by $\frac{1}{25}$th of a millimetre wide. Each contained a contractile vesicle and two large globules looking like oil, but apparently no nucleus. The endosarc presented the usual character of that of *Amœba proteus*, and contained, besides minute crystals, a number of algæ, some of which were green, and others, changed by digestion, were brown. After about ten minutes from the time the Amœbæ were first seen they separated by rupture of the isthmus. Subsequently, one individual became constricted transversely across its middle, and in the mean time, while watching it, the other individual moved away and was lost to view. The individual under observation became gradually more constricted, and finally divided, as in the former case, into two. One division, larger than the other, retained the contractile vesicle and both oil-like globules. The smaller division, of rounded form, measured $\frac{1}{30}$th of a millimetre; but after a short interval a contractile vesicle appeared within it, and the little creature assumed a clavate shape and moved out of the field of vision. The larger division likewise assumed a clavate shape, and as it moved away it measured $\frac{1}{12}$th of a millimetre long.

AMŒBA VERRUCOSA.

PLATE III.

Amœba verrucosa. Ehrenberg: Infusionsthierchen, 1838, 126, Taf. viii, Fig. xi.—Dujardin: Infusoires, 1841, 236.—Perty: Kennt. kleinst. Lebensformen, 1852, 188.—Carter: An. Mag. Nat. Hist. 1857, xx, 37, pl. i, figs. 12, 13.—Leidy: Pr. Ac. Nat. Sc. 1876, 198; 1878, 158.

Amœba natans. Perty: Kennt. kleinst. Lebensformen, 1852, 188, Taf. viii, Fig. 14.

Amœba quadrilineata. Carter: An. Mag. Nat. Hist. 1856, xviii, 243, pl. v, fig. 3; 248, pl. vii, fig. 81.—Barker: Quart. Jour. Mic. Sc. ix, 1869, 94.—Leidy: Pr. Ac. Nat. Sc. 1874, 167.

Thecamœba quadripartita. Fromentel: Études Microzoaires, 346, pl. xxviii, fig. 3.

Animal in the maturer stages, as ordinarily observed, more or less sluggish, and often nearly motionless, commonly appearing of an irregularly oval, round, or quadrately rounded form, with wart-like expansions and a more or less wrinkled condition of the surface; pseudopods short, broad, blunt lobate extensions of the ectosarc; outlines of the body, wrinkles of the surface, and pseudopodal extensions more or less sharply defined, and often appearing with double lines. Endosarc pale granular, and mostly, excepting food materials, with few or no coarse granules. Ectosarc copious, very hyaline, and broadly extended. Contractile vesicle large and conspicuous. Nucleus mostly distinct. Size ordinarily ranging from 0.08 by 0.072 mm. to 0.18 by 0.16 mm., or from about $\frac{1}{12}$th to $\frac{1}{6}$th of a millimetre.

Animal in the younger stages active and incessantly in motion; body oval or pyriform, usually moving with the broader pole in advance; surface comparatively smooth, but marked with four longitudinal lines or delicate folds, sometimes with a greater or less number or none. Fore part of the body appearing as a broad, clear pseudopodal expansion thinning away laterally and posteriorly. Contractile vesicle posterior; nucleus in advance of the latter. Size ranging from 0.04 by 0.02 mm to 0.12 by 0.09 mm.

Locality.—Very common, and found almost everywhere with moisture and algæ. Pennsylvania, New Jersey, Rhode Island, Connecticut, Maine, Nova Scotia, Colorado, Wyoming, and Utah.

Ehrenberg described, in the 'Infusionsthierchen,' a species of Amœba with the above name as follows: "In the extended condition small, not exceeding $\frac{1}{20}$th of a line, hyaline, sluggish, with variable processes which are very small, obtuse, and wart-like." He remarks that he never saw the processes reach even half the extent of the body. The animal remained a long time motionless, but appeared voracious, as it invariably contained Oscillariæ or Naviculæ mostly half digested. It also contained a nuclear body and a contractile vesicle. The short, wart-like processes were always blunt.

Dujardin refers a small Amœba to the same species, and describes it as globular or ovoid, with short, cylindrical, obtuse, divergent expansions frequently appearing like warts, with very slow motion, and measuring from 0.014 to 0 055 mm

Perty indicates *Amœba verrucosa*, and describes a small Amœba with the name of *Amœba natans*, which is probably the same, for he says this is like the former, but smaller, being only the $\frac{1}{67}$th of a line.

An Amœba agreeing with the description of *Amœba verrucosa* of Ehrenberg I have frequently obtained from various localities. I have found it in the ooze of ponds, ditches, and river shores, in the mud of marshes, in wet sphagnum, among the confervæ of fountains and dripping rocks, and in company with Rotifers, about the roots of mosses, in the yaid attached to my house.

Amœba verrucosa is exceedingly sluggish, and often, during the time of its observation, remains stationary, or nearly so. In this condition it usually appears as an irregular quadrately round or oval and more or less wrinkled mass, with short lobate pseudopods or wave-like expansions of the surface. The pseudopods are slowly projected, apparently in a hesitating manner, and the wave-like expansions slowly but incessantly change. In motion, the Amœba glides along with extreme slowness, advancing by wave-like expansions, while short lobate pseudopods project in any direction, apparently without object. The whole surface of the Amœba often appears delicately wrinkled. See figs. 5–7, 28–36, pl. III.

A striking peculiarity of *Amœba verrucosa* is that the outlines of the body, the pseudopodal expansions, and the wrinkles of the surface often appear defined with partial or interrupted double lines, as if the animal were invested with a delicate membrane. See figs. 1, 2, 7, 28, 29.

Amœba verrucosa is highly transparent and colorless, and it commonly exhibits an unusual degree of extension or differentiation of the ectosarc from the endosarc The former appears homogeneous, but under high powers of the microscope is seen to be extremely finely granular.

The endosarc presents a diffused pale granular appearance gradually merging into the ectosarc. It often contains but a scanty supply of food materials, and sometimes these appear to be absent, or at least they are not recognizable, as exemplified in figs. 5, 9–11, 35. Commonly, more or less food is visible as pale granular, colorless or yellowish balls scattered through the endosarc, as seen in figs. 6, 7, 28–34. Not unfrequently algæ are present, such as protococci, oscillarias, diatoms, and desmids, as seen in figs. 1–3, 12–14, 30–32. In several instances I observed specimens of the Amœba containing a Trinema, or a Difflugia, or both, as seen in fig. 38.

Generally, a nucleus is included in the endosarc, but frequently I have been unable to detect one.

A contractile vesicle is nearly always present and sometimes two or three. In several instances I was able to satisfy myself that the Amœba under observation was alive only by seeing the usual changes of the contractile vesicle. Otherwise the animal appeared motionless, although close watching would lead to the detection of an exceedingly slow change in the wrinkling of the surface

From the inactive character of *Amœba verrucosa*, and the frequent comparative deficiency of food in the endosarc, I have suspected that the animal might express an exhausted state of *Amœba proteus.*

One of the most common and well marked amœboid forms, represented in figs. 12–18, pl. III, was originally described by Mr. Carter under the name of *Amœba quadrilineata.* Of all the varieties or species of the genus it is that which at any time I have been able to find with most certainty. I have frequently observed it in association with other named forms, especially *Amœba radiosa* and *A. verrucosa.* I have also repeatedly noticed intermediate forms, which have led me to view *A. quadrilineata* as the young of *A. verrucosa.* It was not until after this determination, in examining the literature of the subject, that I learned Mr. Carter had arrived at the same conclusion from a different point of view. In an article "On the Freshwater Infusoria of Bombay" (An. Mag. Nat. Hist. 1857, xx, page 37), he remarks: "I have also met with another species of Amœba undergoing ovular development, viz. *A. verrucosa*, Ehr., precisely like that which I have already described; the Amœba perishing as the ovules are developed and ending in becoming a mere ovisac." He adds: "This Amœba appears to me—for I have watched the development of a group for many months together—to be the adult of my *A. quadrilineata*, and therefore the latter is not a new species. The formation and development of the ovules took place in April, and the organism appears to require at least nine months to come to maturity."

The young of *Amœba verrucosa*, figs. 12–27, as ordinarily seen, appears as a small hyaline pyriform body, usually actively moving, with the broader extremity in advance The clear ectosarc forms a thick or broad expanse in front, gradually thinning away posteriorly to a narrow border. It is remarkable for retaining persistently fixed, in nearly the same relative position, four equidistant narrow longitudinal folds or doubly contoured lines. These extend from the back end of the animal, but do not reach its front, ceasing shortly in advance of the visible mass of endosarc. The latter is pale granular, and it extends from the posterior extremity ordinarily about three-fourths to four-fifths the extent of the animal.

The creature does not put forth distinct pseudopods; but in progression the ectosarc rolls forward, appearing at the moment as if it were being drained off from the endosarc, while this as incessantly streams on and maintains the same relative position.

The contractile vesicle habitually occupies a position at the posterior extremity of the endosarc, but is sometimes propelled forward, even to the middle of the latter. It exhibits its peculiar movements more frequently and expands to a proportionately greater degree than in the adult. In collapsing it usually closes from within outwardly so as to assume at first a reniform and then a crescentoid appearance; but in other instances it closes so as to appear like a decreasing lens. It is very mobile, and, in the irregular contractions of the posterior part of the animal, often assumes an irregular outline of form. It frequently reappears in a group of from two to half a dozen vesicles of different sizes, and these, as they expand, become irregularly confluent until finally they form together a single large sphere. See figs. 9, 15, 16.

The nucleus appears as a spherical or oval, faintly granular body, often surrounded by a hyaline envelope. Occasionally two such bodies are present. Besides the nucleus and the contractile vesicle, the endosarc frequently exhibits nothing, except some minute oil-like molecules.

The food constituents of the endosarc commonly consist of a few Naviculæ or Protococci; but often a greater number of the same are present, and sometimes considerable portions of Oscillaria. In addition, brownish and colorless food-balls and a few oil-like drops may be present.

Of the young of *Amœba verrucosa* I have observed individuals range from the $\frac{1}{50}$th of a line in length by the $\frac{1}{100}$th of a line in breath, up to the size of mature forms.

The four longitudinal lines, originally supposed to be a distinctive character of *Amœba quadrilineata*, though the usual number, are by no means constant, for I have observed them to vary in different individuals from a single one to half a dozen. As the animal grows they appear to become less evident, and ultimately become obsolete or undistinguishable from the many temporary wrinkles of the surface. See figs. 1–4, 8, 9, 12–27, 30–32, 37.

Individuals of the *Amœba terricola* of Dr. Greeff* bear a near resem-

* Arch. mik. Anat. 1866, ii, 299, Taf. xviii, Fig. 1–11.

blance to *Amœba verrucosa;* but others, in their larger size, ranging from 0.35 to 0.4 mm., and in the possession of a terminal villous process, remind one more of *Amœba villosa.* With the exception of the latter forms, *A. terricola* and *A. verrucosa* agree closely in characters: the exceedingly sluggish habit, the indisposition to move, the great porportionate extent and membrane-like appearance of the ectosarc, the wrinkled condition of the surface, and the short pseudopodal extensions, are the same in both.

The *Protamœba simplex* of Prof. Haeckel* likewise bears a close resemblance to *Amœba verrucosa;* but, according to the character assigned to the former, a contractile vesicle and nucleus are absent, while they are present and more or less conspicuous in the latter.

AMŒBA RADIOSA.

PLATE IV, figs. 1–18.

Amœba radiosa. Ehrenberg: Abh. Ak. Wis. Berlin, 1830, 39; 1831, 80; Infusionsthierchen, 1838, 128, Taf. viii, Fig. xiii.—Dujardin: Infusoires, 1841, 236, pl. iv, figs. 2, 3.—Perty: Kennt. kleinst. Lebensformen, 1852, 188.—Carter: An. Mag. Nat. Hist. 1856, 243, pl. v, figs. 10–18.
Amœba brachiata. Dujardin: Infusoires, 1841, 238, pl. iv, fig. 4.—Fromentel: Études Microzoaires, 347, pl. xxix, fig. 4.
Amœba ramosa. Dujardin: Infusoires, 1841, 239, pl. iv, fig. 5.

Comparatively small, colorless, transparent, inactive. As usually observed floating, habitually stellate, with a spheroidal or oval central mass or body, and from two or three to a dozen or more pseudopods of variable length and form, mostly conical and acute or attenuated and thread-like, commonly simple, straight, curved or flexuose, rarely furcate. In creeping, of a less radiate character, but with the pseudopods mainly divergent from one extremity, and that in the direction of motion of the animal. Usually one conspicuous contractile vesicle or several smaller ones. Nucleus usually distinct. Endosarc with a few oil-like molecules, sometimes more or less replete with water-vacuoles. Food commonly scanty.

Size.—Body 0.012 mm. to 0.045 mm. diameter or rarely to 0.06 mm.; pseudopods to 0.08 mm. long.

Locality.—In the ooze and among aquatic plants of most ponds, ditches, and springs. Pennsylvania, New Jersey, Rhode Island, Connecticut, Maine, Nova Scotia, and Fort Bridger and Uinta Mountains, Wyoming.

Ehrenberg described a small form of Amœba under the above name,

* Studien ueber Moneren u. a. Protisten, 1870, 172, Taf. vi, Fig. 12.

which, he says, approximates $\frac{1}{10}$th mm., and has many variable processes in the form of long, narrow, acute rays. Dujardin has described apparently the same creature as pertaining to three species with the names of *A. radiosa*, *A. brachiata*, and *A. ramosa.*

A small Amœba, of habitually radiate appearance, as usually seen, is common in many situations. The radiate form, however, in a great measure, appears to be incidental to the animal being free and floating, for when it is creeping upon surfaces it loses much of this specific character.

Amœba radiosa is a comparatively small inactive species, and ordinarily is observed suspended in water almost motionless and with its ray-like pseudopods apparently fixed as if they were rigid. It possesses comparatively little irritability, and at times, when it comes into the vicinity of a Stentor, a Vorticella, or a Rotifer, it may be seen whirling about in the currents produced by these animals, with its form unchanged and its pseudopods extended, as if it had no inherent power of motion. On closely watching the Amœba, as it remains quietly suspended in water, it is observed very slowly to undergo more or less change of shape, and the pseudopods are noticed gradually to contract or elongate, to bend from side to side in a gentle oscillating manner, or to become twisted or bent in an angular direction. Sometimes more quickly than usual, a pseudopod will be withdrawn in a tortuous course. While one or two pseudopods are almost imperceptibly shortened or lengthened or entirely withdrawn, new ones will as slowly appear and elongate.

In floating or swimming, *Amœba radiosa* glides along almost imperceptibly, and much in the same manner as the common Sun-animalcule. Perty speaks of its locomotion as being very feeble. Dujardin says of certain specimens, they lived particularly in the flocculent pellicle on the surface of the water, and when detached they floated and were drawn into the eddies produced by Vorticellas. Of others, described by the same author under the name of *Amœba brachiata*, he says they float in the water when agitated; but when after a certain time they become fixed on a surface, they apply themselves to it in extension more or less like other Amœbæ.

Characteristic specimens of *Amœba radiosa* are to be found almost everywhere, and at all times, where other Fresh-water Rhizopods occur.

I have observed them in the proper material, collected from pools, ponds, ditches, springs, bogs, and other situations in all seasons of the year, excepting when that material has been exposed to the cold of winter; and I have found them from the head of the Bay of Fundy to Florida, and from near the ocean level at Cape May, N. J., to an elevation of 10,000 feet in the Uinta Mountains of Wyoming Territory.

Amœba radiosa, figs. 1–18, pl. IV, as commonly observed floating or swimming, has more or less of a stellate form, with pointed conical rays emanating from a common centre, or it appears as a spheroidal body with a variable number of more or less tapering pseudopods. The central sarcode mass or body ranges from 0.018 mm. to 0.06 mm. in diameter. The pseudopods vary in number from one or two to a dozen or more, and consist of extensions mainly of clear ectosarc. They vary greatly in length,—less than the body to three or four times its diameter. Sometimes they extend in long filaments, so as to assume almost the appearance of the rays of the common Sun-animalcule. Usually they are moderately long, tapering, conical, sharp-pointed, straight, bent, or somewhat tortuous. Less frequently they are more cylindroid, blunt, or pointed, mostly simple, and rarely furcate.

The endosarc of the body consists of a fine pale granular protoplasm, with variable proportions, though in comparatively small quantity, of darker molecules. It usually contains one or more food-balls enclosed in water-drops, colored or colorless, and conspicuous for their size. These may be altogether absent, or may be replaced by simple drops of water or other liquid, the result of digestion of food. Sometimes many water-drops or water-vacuoles, are present, as seen in fig. 13, pl. IV, and these at times appear to multiply or decrease, while the animal is under observation.

Among the constituents of the endosarc, a round nucleus is usually to be detected, though sometimes it is much obscured by surrounding materials, and occasionally cannot be distinguished without the action of reagents upon the animal.

The contractile vesicle is constantly to be observed exhibiting all the phenomena noticed in it in most Fresh-water Rhizopods; but frequently, in accordance with the general sluggish nature of this form of Amœba, its movements are exceedingly slow.

Occasionally a diatom or other alga may be observed among the constituents of the food; but I have not seen sand particles or crystals in the endosarc, as in other species.

Large individuals, which I have supposed to belong to *Amœba radiosa*, such as those represented in figs. 9–12, pl. IV, approach in character *A. proteus*, both in shape and in greater activity, especially when creeping, as seen in fig. 11. Quiescent individuals of large size have at times appeared to me to be undistinguishable from *A. verrucosa.*

In creeping on flat surfaces, *Amœba radiosa* becomes more or less differentiated so as to appear to have an anterior and a posterior extremity, from the former of which radiate a variable number of tapering pseudopods. Sometimes these appear to emanate from one or two palmate extensions, as seen in figs. 17, 18, which gradually and incessantly change their shape as the animal slowly glides along. The pseudopods shorten and lengthen, disappear and reappear in the usual manner, and not unfrequently they oscillate from side to side. Sometimes I have observed individuals drag after them adherent particles of sand or other materials, like *Amœba proteus* and *A. villosa*, but I have never detected anything like a prehensile process or a villous appendage. See fig. 18.

There are many organic bodies of very different character which so closely resemble *Amœba radiosa* that they might readily be mistaken for it. Such are the colorless blood-corpuscles and primitive ova of animals.

Dr. Perty* describes and figures bodies resembling *Amœba radiosa* which he found in the mucus of the foot of a fresh-water snail, *Lymnæus.* He remarks that a small portion contained numerous bodies which he viewed as mucus-corpuscles until he saw them exhibit the usual changes of form of an Amœba. He asks whether these bodies are really young Amœbæ, or whether the mucus-corpuscles of snails have the power of contracting and of putting forth processes. The bodies, judging from the description and accompanying figures, were evidently mucus-corpuscles which exhibited the curious phenomenon now so well known as amœboid movement.

Thirty years ago I observed similar movements and changes of form in the blood-corpuscles of *Helix albolabris* and other land-snails, but I was utterly at a loss to account for the phenomenon, and concluded that the movements were due to endosmosis and decomposition.

In our fresh-water sponges, especially the yellow one which I formerly

*Kennt. kleinst. Lebensformen, 1852, p. 188, Taf. viii, Fig. 16.

described under the name of *Spongilla fragilis*,* I have repeatedly observed amœboid corpuscles which I supposed to be parasitic, but which are now regarded to be ova of the Spongilla. These corpuscles bear so close a resemblance to *Amœba radiosa* that it is not improbable isolated ova of Spongilla have at times been mistaken for it.

The Spongilla amœboids, as represented in figs. 19, 20, pl. IV, from specimens taken from the scrapings of a *Spongilla fragilis* obtained from the Schuylkill River, in July, ordinarily resemble *Amœba radiosa* in the swimming condition. They have a stellate appearance with a spheroidal body and a variable number of pseudopods radiating in all directions. They remain suspended, almost motionless, in the water, but feebly vary the shape of the body, and slowly project or withdraw a pseudopod, or change its form or direction. The body consists of a mass of pale granular protoplasm with variable proportions of yellowish grannlar balls looking like food. It contains a nucleus, which is often obscured by surrounding materials. It has also a contractile vesicle, which exhibits the characteristic movements, though comparatively with exceeding slowness. Not unfrequently several contractile vesicles occur. The pseudopods are long, tapering, and pointed, and are composed of ectosarc with only the finer protoplasm of the endosarc. Associated with the amœboids resembling *Amœba radiosa*, are others, as represented in fig. 21, which in their appearance and slow movements resemble *A. verrucosa*, though they are no doubt of the same character as the former.

AMŒBA VILLOSA.

PLATE I, figs. 9, 10; II, figs. 14–16; VIII, figs. 1–16.

Amœba. Wallich: An. Mag. Nat. Hist. 1863, xi, 287, pl. viii.
Amœba villosa. Wallich: Ibidem, 366, pl. ix, 434, pl. x, figs. 5–9.—Duncan: Pop. Sc. Rev. 1877, 217, pl. vi, figs. 38–40.
Amœba princeps. Carter: An. Mag. Nat. Hist. 1863, xii, 30, 44, pl. iii, figs. 1–3.
Trichamœba hirta. Fromontel: Études Microzoaires (*no date*), 345, pl. xxviii, fig. 4.

Animal in motion differentiated into an anterior and a posterior region, ordinarily more or less sausage-shape or irregularly clavate, or palmate in shape, and commonly with few lobate, or short thick digitate, or conical pseudopods, consisting of extensions of the sarcode preceded by more or less thick portions of clear ectosarc, and mostly directed forward; posterior extremity commonly somewhat narrower, and terminating in a villous area

* Proc. Acad. Nat. Sc. 1851, 278; 1874, 145.

or process of variable form, but mostly rounded, knob-like, or discoid. Endosarc as in *Amœba proteus*, and containing usually nearly centrally a single large conspicuous nucleus, and habitually posterior to this a single large and conspicuous contractile vesicle.

Size.—To $\frac{1}{50}$th of an inch (Wallich).

Locality.—England, France.

Amœba villosa, a large and remarkable species, described by Dr. Wallich, was discovered by him in England. It is chiefly distinguished by its habitual more or less clavate or palmate form, differentiated into an anterior broader, and a posterior region terminating in a villous area or in a villous knob. It commonly projects comparatively few short thick digitate pseudopods, which are directed forward and little disposed to branch. Like *Amœba proteus*, it ordinarily possesses a single large nucleus more or less central in position, and behind this an equally large contractile vesicle. Besides these, the granular endosarc contains crystals, vacuoles, oil-like corpuscles called by Dr. Wallich 'sarcoblasts,' and other bodies called 'nucleated corpuscles.' The food materials commonly observed are like those of *Amœba proteus.* Some of the specimens, according to Dr. Wallich, attain a diameter of $\frac{1}{50}$th of an inch.

I have not been so fortunate as to meet with positively characteristic specimens of *Amœba villosa*, though a similar form is frequent in many of our ponds, which appears to be a different animal, and is the subject of a later chapter, under the name of *Pelomyxa villosa.*

Small Amœbæ are frequently to be met, in many positions or different kinds of localities, which I have suspected to be the young of *Amœba villosa*, but of this view I have no certain evidence. They have the same general form, constitution, and habits as the little Amœbæ supposed to pertain to *Amœba proteus*, and differ only in the habitual possession of a terminal villous process.

Some water, with ooze and confervæ, collected from a brick-pond, near Swarthmore College, in the autumn, was preserved during the winter In February, a yellowish green dust-like film covered the surface, consisting of unicellular algæ. With these, and feeding on them, there were numerous small active Amœbæ, such as are represented in figs. 4–10, pl. VIII. They commonly exhibited a clavate shape, often modified by lateral pseudopodal lobes, and were provided with a terminal villous process of variable form. They glided along with the body straight and slightly sinuous, or often curving to one side or the other. Frequently they presented little change of form, the head alone incessantly rolling forward concurrent with contraction of the body behind; but often they projected pseudopodal lobes on each side nearly or quite as thick as the head end itself. Though habitually of the shape described, these little Amœbæ would at times assume a variety of forms. When at rest, they were more or less depressed globular or oval.

The villous process terminating the body had the appearance of a protruding portion of the endosarc. It was often observed with adherent algæ, fig. 4, dragged about in the movements of the animal.

The ectosarc was always thickest at the head end, or in advance of the pseudopodal lobes, and thinned away to nothing at the villous process.

The endosarc was composed of the usual pale granular matter, with variable proportions of coarser granules and sometimes small clear globules. Distinct crystals, likewise in variable proportions, and some of them comparatively large, were always present. A large contractile vesicle was another conspicuous constituent, and occasionally a second occurred. The nucleus was globular, homogeneous, and faintly granular, and was defined by a thin halo.

The Amœbæ commonly contained as food a number of the green algæ among which they lived. Frequently some of these algæ within the endosarc had become bright reddish brown as a result of digestion.

Occasionally individuals were observed to assume a globular shape, and then spread out and remain quiescent, as seen in fig. 11. In this condition, the body was undefined by any trace of clear ectosarc at the border, and the contents were rendered unusually distinct. The contractile vesicle remained unchanged

Among these Amœbæ, I observed several of especial interest. While having the same general features as the others, they contained from one to half a dozen large nuclei, which were coarsely and uniformly granular, as seen in figs. 12–16. When these were in greatest number, together with the pulsating vesicle, which approximated them in size, they occupied the greater part of the body of the animal. In its movements, both the nuclei and the pulsating vesicle would at times exhibit the effects of mutual pressure by change of form (fig. 14), and also exhibit elasticity in the return to the globular shape when the pressure was relieved.

The individuals with the large granular nuclei usually contained little food, though they were quite as active as the others.

On one occasion, while observing an individual of the kind, in an animalcula-cage, but not submitted to pressure, as it moved along in the usual manner it suddenly assumed a spheroidal form. It contained two large granular nuclei together with a large contractile vesicle and other ordinary contents. After a brief interval, the contractile vesicle began to collapse, when at the same moment one of the large nuclei burst, and in an instant its coarse granular contents were expelled from the animal apparently together with the liquid contents of the pulsating vesicle, as seen in fig. 15. The scattered granules were minute globules, exhibiting only molecular motion, and measuring about 0.002 mm. They were probably germs or spores, but their destiny I failed to trace. The little Amœbæ above described, in the usual clavate form, measured from 0.08 mm. long by 0.024 mm. wide at the anterior or thicker end, to 0.14 mm. long by 0.04 mm. wide.

An individual containing three large granular nuclei was 0.1 mm. long by 0.04 mm. wide; the nuclei, of uniform size, were 0.028 mm. in diameter. An individual with six large granular nuclei was of the same length as the preceding, by 0.028 mm. wide; the nuclei were 0.02 mm. in diameter. The granules of the nuclei were about 0.002 mm. in diameter.

Forms closely similar to the above, and containing the same kind of large granular nuclei, are described and figured by Dr. Wallich in his account of *Amœba villosa*.*

Several weeks subsequently to making the above observations, some Amœbæ from the same water and apparently of the same kind, instead of the ordinary minute crystals, contained minute concretionary bodies of varied shape, as seen in figs. 34, *a–l*. These bodies measured from 0.001 to 0.004 mm. Under the action of acetic acid they slowly dissolved, but without any visible evolution of gas.

In some ooze, collected from a pond on Darby Creek, Delaware County, Pennsylvania, in the month of March, there were a number of Amœbæ of the same character as the preceding, as seen in figs. 9, 10, pl. I. They were usually clavate in form, reaching a length of about 0.1 mm. They

*An. Mag. Nat. Hist. 1863, xi, 365, pl. ix.

terminated behind in a conspicuous villous ball, which often exhibited in its interior one or several contractile vesicles. The endosarc contained many crystals and but little food, though it was abundant with the animals. The nucleus appeared unusually small, and such likewise appeared to be the case with the contractile vesicles, of which there were commonly several.

Some moist moss, from crevices of the pavement in the yard attached to my house, collected in June, was placed in a dish with clear water. After a few days a drop of water squeezed from the moss was found to contain some small Amœbæ, in association with the common Wheel-animalcule (*Rotifer vulgaris*), etc. The Amœbæ, figs. 14, 15, 16, pl. II, were usually clavate in shape, though modified incessantly by broad pseudopodal lobes projecting laterally, and they mostly terminated in a minutely villous ball. The endosarc contained the usual constituents. They moved actively, and measured about 0.06 mm. long.

Some water with abundance of diatoms, desmids, etc., collected in an extensive sphagnous swamp on Broad Mountain, Schuylkill County, Pennsylvania, in September, contained many Amœbæ, such as are represented in figs. 1–3, pl. VIII. Commonly they exhibited a sausage-like shape, or an elongated clavate form, and reached the length of 0.25 mm. They glided along with little change, or they often projected one or two, and occasionally more, digitate pseudopods from the sides. Frequently also smaller and narrower pseudopods were projected in a divergent manner at the sides of the back end of the body, which terminated in a villous process of variable form. The pseudopods contiguous to the latter would assume in contraction the form of cylindroid villous processes. A conspicuous nucleus and one or more contractile vesicles were constantly present.

OURAMŒBA.

Greek, *oura*, tail; *amœba*.

Animal possessing the same essential characters as the genus Amœba, but in addition provided with fixed filamentous appendages habitually trailing from the posterior extremity of the body. Filaments flexible, cylindrical, tubular, inarticulate or articulate, resembling the mycelial threads of fungi, perfectly passive, and neither retractile nor extensile.

OURAMŒBA VORAX.

PLATE IX, figs. 1–12.

Amœba villosa (Wallich). Archer: Jour. Proc. Dublin Micros. Club, 1866, 56, 65; Quart. Jour. Mic. Sc. vi, 1866, 190, 267; x, 1870, 305.

Amœba with remarkable posterior linear processes. Archer: Jour. Proc. Dublin Micr. Club, 1873, 314; Quart. Jour. Mic. Sc. xiv, 1874, 212.

Ouramœba vorax. Leidy: Pr. Ac. Nat. Sc. Phila. 1874, 78; 1875, 127, 414.

Ouramœba lapsa. Leidy: Ibidem, 1874, 78.

Proposed genus Ouramœba (Leidy). Archer: Quart. Jour. Mic. Sc. xv, 1875, 202.

Amœba form, plus a cluster of finger-like posterior appendages. Archer: Quart. Jour. Mic. Sc. 1876, xvi, 337.

Animal in all respects resembling the ordinary forms of *Amœba proteus*, but in addition provided with a variable number of permanently fixed fascicles of long filaments, appended to the habitually posterior end of the body. Filaments permanent cylindrical tubes, in each fascicle emanating from a common stalk, simple, or dividing only from near the root, inarticulate, mostly blunt at the ends; fascicles from one to half a dozen or more, often more or less separated, but mostly trailing in a single bunch.

Size.—Small individual in motion 0.14 mm. long by 0.028 mm. where widest, with caudal filaments from 0.04 to 0.18 mm. long. Individual of spheroidal form 0.14 mm. in diameter; in motion, elongated to 0.33 mm., with caudal filaments to 0.2 mm. long. Individual in movement, of palmate form, 0.3 mm. long, with spread of 0.2 mm, with rays to 0.22 mm. of length. Dendroid individuals to 0.33 mm. long, with spread of 0.14 mm.

Locality.—Rare. Found only in two localities, spring and pond, on Darby Creek, Delaware County, Pennsylvania.

The singular amœboid animal to which I gave the name of **Ouramœba vorax** I first noticed in May, 1874. It was obtained from the sediment of a spring, in which grows water-cress, near Lansdowne station, on the Westchester railroad. I found the creature the following year in the same spring, and also in a pond, a mile distant, near Kellyville, which dried up the succeeding summer. I have likewise observed specimens of what I suppose to be a second species, first noticed in January, 1875, in material collected from the same spring, and preserved since the preceding autumn. Elsewhere I have not found Ouramœba.

When first seen I regarded the animal as an *Amœba proteus* dragging after it a bundle of mycelial threads. The recurrence of several individuals led me to examine the animal more attentively, when I came to the conclusion that the threads were part of its structure. See figures of pl. IX.

After publishing a brief notice of Ouramœba in the Proceedings of the Academy of Natural Sciences of Philadelphia for 1874, Mr. Archer, of Dublin, had the kindness to direct my attention to a description of the same animal, by himself, in the Journal of Proceedings of the Dublin Microscopical Club for 1866, page 56, and 1873, page 314. This I was delighted to see, as I felt that it confirmed my observation of the existence of this curious and enigmatic variety, or species

There can be no question but that Ouramœba is the same creature as the one which had been previously discovered and described by Mr. Archer. This able authority, however, regarded the animal only as a remarkable variation from the *Amœba villosa* of Dr. Wallich, and in this light still continues to view it. as we learn from the following report of the Proceedings of the Dublin Microscopical Club, published in the Quarterly Journal of Microscopical Science for 1876, page 337: "Mr. Archer further presented a preparation in Beale's carmine fluid of the curious Amœba form, *plus* a cluster of finger-like posterior appendages = *Ouramœba*, Leidy, which, however, did not cause any contraction of the processes, a fact, so far capable of being urged by Prof. Leidy in favor of his views; but on the other hand the gathering abounds with specimens of the ordinary character, that is, without the faintest evidence of any linear processes—simple *Amœba villosa* (*princeps*),—but, the appendages apart, quite identical with the so-called Ouramœba"

Though none of the individuals of *Ouramœba vorax* which I have observed equaled in size the largest ones of *Amœba proteus*, in all other respects—the possession of the caudal filamentous appendages alone excepted—I remarked no difference.

Mr. Archer speaks of the animal observed by him as a form of *Amœba villosa* of Dr. Wallich, and refers to "the presence of a large and numerous tuft of very long prolongations commonly issuing from just beside the villous patch."

In *Ouramœba vorax* I have at no time observed a villous patch, though in several instances I have seen the posterior part of the body in its contraction assume a mulberry-like appearance which simulated such a patch, as seen in fig. 9, pl. IX.

The filamentary caudal appendages of *Ouramœba vorax* consist of from one to half a dozen distinct tufts, usually collected into a single bundle trailing longitudinally behind the body, as seen in figs. 1–9, pl. IX. Each tuft is composed of from a pair to six or more filaments emanating from a common point or stem, from which they divide and more or less diverge. The filaments are of variable length, not only in the same individual, but also proportionately with the body in different individuals. Sometimes they are few and short or long; more frequently they are numerous and as long as the body or longer. They are straight, curved, and often irregularly bent; cylindrical and blunt, or sometimes acute or swollen at the end. They are mostly simple from their point of origin, but sometimes branch off from near the latter, and rarely elsewhere. Sometimes an individual is seen in which the filaments appear irregularly contracted at one or more points, and bent or twisted, as if in these positions they had been injured and become atrophied, as represented in fig. 5.

In structure, the caudal filaments of *Ouramœba vorax* consist of a colorless membranous tube with pale granular contents, mingled with a variable proportion of oil-like molecules. The latter sometimes increase to considerable drops elongated in the course of the enclosing tube. (Fig. 12.)

The mode of fixation of the caudal filaments is difficult to comprehend. In a detached tuft, the root appeared to be continuous with a ball of homogeneous protoplasm, as seen in fig. 11.

In the movements of Ouramœba, the caudal filaments are entirely passive, and are usually dragged along behind it. Sometimes in varied movements of the animal, the tufts of filaments become more or less separated at their root to a greater distance than usual, and widely diverge from one another, as represented in figs 2, 3.

The caudal filaments present so much resemblance to the mycelial threads of fungi, that I have suspected they may be of this nature, and parasitic in character, due to the germination of spores which had been swallowed as food. I have repeatedly recognized, among the food of various Amœbæ, different kinds of fungus-spores, and it is not unlikely that these lowly creatures may be infested with fungus-parasites, just as we frequently find to be the case with insects. Even the constancy in the extension of the filaments from a particular part of the body is no objection to the conjecture, for in insects we observe certain species of Sphæria growing as constantly from the head. There is, however, perhaps an important objection to this view, and that is, the caudal filaments do not grow from a mycelium within the protoplasmic mass of the body of the animal.

According to Mr. Archer, Ouramœba, with its appendages, which he aptly likens to "a bundle of dipt-candles," may be only a varietal form of what I have considered to be *Amœba proteus*, but the solution of the question remains for future investigation.

One of the specimens of *Ouramœba vorax* which earliest attracted my attention did so on account of the unusual quantity and variety of diatoms and other algæ which it contained, rather than on account of its linear caudal appendages. It was indeed this specimen, fairly represented in fig. 1, that led me to adopt the specific name of the animal. The individual was nearly a third of a millimetre in length, with the caudal appendages one-sixth of a millimetre longer. It moved along in a flowing manner, tongue-like in outline, with the narrower end forward, and without projecting any digit-like pseudopods. The caudal filaments at times trailed behind; at others, more or less diverged to the right and left. There were six tufts, which would become distinctly separated, then would collect into two bundles, and again would combine into a single one. Among the food contents of the endosarc there were four large specimens of *Navicula major*, besides several of Gomphonema, Stauroneis, and other diatoms, a Cosmarium, fragments of a bluish green Oscillaria, etc.

Another individual of Ouramœba, when first seen, formed a mulberry-like mass, as represented in fig. 3. It measured about 0.14 mm. in diameter, and presented five tufts of filamentous appendages projecting from one half the mass. After a little while it elongated, lost its mulberry-like appearance, and projected from the sides long digitiform pseudopods, as seen in fig. 2. The animal in this condition measured about 0 3 mm. long, and the five tufts of caudal filaments were widely separated and divergent posteriorly. The discoid nucleus and contractile vesicle were distinctly visible, and agreed closely in appearance and habitual relative position with those of *Amœba proteus*. Food-balls and water-vacuoles were few.

Another specimen, represented in fig. 4, had a branched appearance, and afterward assumed a stellate form extending over a space of about 0.25 mm. It possessed but two tufts of short caudal filaments.

A specimen from a collection of the following season, represented in fig. 5, had a palmate appearance, which, as usual with the animal, changed at every movement. It measured 0.3 mm. in length, and had a large bundle of filaments trailing behind, which measured up to 0 2 mm. in length. A large

Navicula major at times extended across the back part of the body, and then again was dragged along behind in a pouch-like extension of the same.

Another fine active specimen, observed on the same occasion, is represented in fig. 6. It was much branched, and was 0.2 mm. long. The caudal filaments formed three tufts and ranged from 0.05 to 0.16 mm. in length. The animal dragged after it a considerable amount of dirt, which adhered at the point of origin of the caudal filaments.

Another specimen, with the body ramose, and 0.22 mm. long by 0.2 mm. in expanse, had but a single pair of caudal filaments. It contained two large specimens of *Navicula major*, which at one time extended in separate pouches of the body posteriorly like the single one of fig. 5. A Navicula was discharged, at the posterior extremity of the body, to one side of the insertion of the caudal filaments and the contractile vesicle. The latter measured 0.028 mm. in diameter. The nucleus in advance was 0.02 mm. diameter.

Another specimen, with the body occupying a space of 0.26 mm. in length by 0.2 mm. in width, had also but two caudal appendages. These, when the animal was first seen, trailed backward from the side of a mulberry-like mass formed of the posterior extremity of the body. The measurements of the contractile vesicle and nucleus were the same as in the former specimen.

Fig. 9 represents a smaller specimen, resembling the former in the possession of a pair of short caudal filaments which project in a widely divergent manner laterally from the posterior mulberry-like termination of the body.

Figs. 7, 8, are two views of an individual, a small specimen, with a single pair of long caudal filaments. The contractile vesicle was distinct, but there appeared to be no nucleus present, and the animal was also devoid of visible food.

OURAMŒBA BOTULICAUDA.

PLATE IX, figs. 13–17.

Ouramœba botulicauda. Leidy: Proc. Acad. Nat. Sc. Phila. 1875, 127.

Species comparatively small, colorless, transparent, irregularly angular in outline. Pseudopods short, conical, acute, rarely digitate. Caudal appendages in one or two tufts, each composed of from two or three up to nine acutely divergent, segmented filaments of variable length. A contractile vesicle and a nucleus present.

Size.—Ranging from 0.04 mm. long by 0 032 mm. broad to 0.076 mm. long by 0.02 mm. broad; the caudal appendages from 0.012 mm. to 0.045 mm. long.

Locality.—In the ooze of a broad spring, near Lansdowne station, on the Westchester railroad, about five miles from Philadelphia.

In association with *Ouramœba vorax*, at Lansdowne station spring, three years in succession, I found what I have supposed to be a different and smaller species, for which I have proposed the name heading the present chapter. If Ouramœba be really a distinct genus from Amœba, it is probable that the smaller form under consideration may be the young of *Ouramœba vorax.*

Ouramœba botulicauda (figs. 13–17, pl. IX) ordinarily exhibits an irregularly angulated outline, and often assumes a palmate shape with short angular digit-like pseudopods. The ends of the latter present variable proportions of clear ectosarc, and they move and retract more or less in succession as the animal moves along. The posterior end of the body is somewhat tapering and obtuse, and gives attachment to a variable number of appendages. These form a single tuft divergent from a single point: but occasionally there are two tufts. The appendages are commonly three, but range up to nine. They are of variable length, straight, and consist of series of elongated elliptical bodies, from one to four, also of variable length. They resemble strings of sausages, whence the specific name given to the animal.

The endosarc of *Ouramœba botulicauda* is pale granular, mingled with a few oil-like molecules. Generally the specimens observed of the animal contained but little food in the form of balls. One individual contained a single diatom. One or two contractile vesicles are usually present, as seen in the figures. A distinct nucleus was also commonly present.

PELOMYXA.

Greek, *pelos*, mud; *muxa*, mucus.

Pelobius: Greeff, 1870. *Pelomyxa:* Greeff, 1874.

Animal with the general character of Amœba, naked, of variable and inconstant form, in the quiescent condition spheroidal or ovoidal, in motion commonly more or less leech-like or slug-like in shape, and differentiated into an anterior and a posterior region, habitually with the broader extremity in advance, and progressing through the projection of a wave-like or hemispherical expansion of clear ectosarc, in front or successively upon either side, or from other parts of the body; posteriorly frequently ending in a conspicuous process of clear sarcode, which is prehensile, and often finely villous. Body composed of a clear ectosarc with a finely granular endosarc containing variable proportions of clear vacuoles and other more consistent colorless globules. Nuclei numerous, scattered through the endosarc. Contractile vesicles small and inconspicuous, except in the young. Animal voracious and usually more or less gorged with vegetal and animal materials, together with considerable mud and sand.

PELOMYXA VILLOSA.

PLATE V, with the name *Amœba villosa;* VIII, figs. 31–33.

Amœba sabulosa. Leidy: Proc. Acad. Nat. Sc. 1874, 87.

Animal nearly opaque, except when young, appearing, by transmitted light, brown or black with hyaline border; by reflected light, yellowish white and maculated with other colors dependent on the contained food; spheroidal or ovoidal and somewhat depressed in the resting condition; habitually clavate or botuliform when in motion; straight, curved, or sigmoid; moving with the thicker extremity in advance; with a terminal circular villous patch, which may be projected into a mammillary or ball-like process; villi numerous, minute, papillary or filiform, simple or ramose. Pseudopods usually as one or two broad lobar projections of the fore part of the body, preceded by a thick seam of clear ectosarc, rarely prolonged or branching, sometimes accompanied with a few narrow conical processes of clear ectosarc projecting from any part of the body. Nuclei many, scattered through the endosarc. Contractile vesicles many, small and inconspicuous, usually occupying a position in the vicinity of the villous area. Animal exceedingly gluttonous, usually gorged with algous and other food, dirt, and sand, which more or less obscure from view the intrinsic elements of structure; motion sluggish, flowing, and more or less intermittent; villous extremity prehensile, often seen clinging to fixed objects or dragging after it adherent dirt or food materials.

Size.—In the ordinary resting or spheroidal condition from 0.12 to 1.25 mm., but commonly from 0.25 to 0.5 mm. In the elongated or clavate form, as when in motion, from 0.12 by 0.06 mm., to 0.6 by 0.22 mm., or rarely up to 1.75 by 1 mm. Frequently about 0.33 mm. long by 0.15 mm. at the anterior or broader end.

Locality.—The ooze of ponds, especially those of sphagnous swamps, or of damp mossy forests. In the vicinity of Philadelphia; Delaware County; mountains of Schuylkill and Monroe Counties, Pennsylvania; vicinity of Camden; Hammonton, Franklinville and Absecom ponds; and Budd's Lake, Morris County, and vicinity of Cape May, New Jersey; China Lake, Mount Gilbert, Uinta Mountains, Wyoming Territory.

Under the name of *Pelomyxa palustris*, Prof. Greeff has described one of the largest and most remarkable of amœboid animals, in certain respects like *Amœba villosa*, but in others of more or less peculiar character. In its habitual shape, movements, and gluttonous nature, it resembles the latter; but ordinarily it exhibits no posterior process, and this, when existing, appears to be villous only in young individuals. Instead of one, it possesses many nuclei scattered through the endosarc; and rarely is there a conspicuous contractile vesicle present, but in its place a variable number of small ones. The granular endosarc, besides the food materials and an abundance of sand, contains ordinary vacuoles, and clear globules called by the author 'Glanzkörper' or shining corpuscles. The size of the animal commonly is about one millimetre, but reaches to two millimetres or even more

An amœboid form, represented in pl. V, and closely related to the two forms above indicated, is rather frequent in the ooze of our ponds, especially those of forest swamps. Until recently I ascribed it to *Amœba villosa*, but the weight of evidence appears to me to make it a nearer associate of *Pelomyxa palustris.* I am, however, uncertain whether some of the specimens, especially what appear to be young individuals, which I have viewed as of the same kind or species, do not really belong to the former, while others may pertain to Pelomyxa.

In most respects, the animal under consideration accords with the characters assigned to *Pelomyxa palustris;* but in the frequent and almost constant possession of a posterior villous process, it best agrees with *Amœba villosa.* Under the circumstances I have named it *Pelomyxa villosa*, and have the impression that all the forms may, through later investigations, be proved to be but different stages of the same species.

Pelomyxa villosa ordinarily ranges in its more matured forms from 0.166 to 0.33 mm., though rarely I have seen individuals reaching 1.25 mm. in diameter, or 1.75 mm. in length by 1 mm. in breadth, so that the largest specimens are intermediate in size to the largest of those of *Amœba villosa* and *Pelomyxa palustris*.

Pelomyxa villosa viewed by reflected light, as seen in figs. 1, 11, 13, 14, usually appears cream-colored, yellowish white, or brownish white, often more or less spotted with various colors, green, yellow, and brown, due to particles of the food contents shining through. It is mostly opaque or nearly so, and viewed by transmitted light, as seen in figs. 2–4, 6, 10, 12, 17, appears dark brown or black, with a thin hyaline border, which widens to a more or less prominent meniscus-like thickening in advance of any pseudopodal projection. Small or young individuals are proportionately more and more translucent, as seen in figs. 5, 7–9, 15, 16.

When at rest the animal is somewhat depressed globular or oval, and ordinarily when starting to move it assumes an ovoid, oblong, or clavate shape. In progression it is commonly sausage-like in form, straight, more or less curved or sigmoid, and habitually moves with the thicker end in advance. The posterior—usually narrower—end mostly is more or less finely villous; and this portion frequently projects as a depressed ball or disk, or as a process of variable form and extent.

The animal may move along in a slow steady roll or flow, with little change of shape, preceded at the fore end by a continued or more or less interrupted advance of a meniscus-like extension of clear ectosarc, pursued closely by an incessant influx of the endosarc. Mostly the progressive movement occurs through the alternate projection on each side of the head of a hemispherical portion of the ectosarc followed by a rather abrupt and quick rush of the endosarc into the pseudopodal projections.

Dr. Wallich's remarks concerning the movements of *Amœba villosa* apply equally well to those of the form under consideration. He says that "the rush of granules of the sarcode does not follow upon a previous contractile effort exercised at the posterior portion. As the animal progresses, occasionally altering its course, there are periods during which perfect quiescence is maintained by the granules; and the rush or flow of these seems to take place, as it were, to fill up the vacuum engendered by the sudden projection of a portion of the ectosarc." *

* Annals and Magazine of Natural History, 1863, xi, 369.

In referring to the mutual convertibility of the endosarc and ectosarc, Dr. Wallich exemplifies the process as it appears to occur in the movements of *Amœba villosa*, and the same occurs in a manner exactly similar in *Pelomyxa villosa*. He observes that "in the projection of the ectosarc from some area of the general surface, in the form of a hemispherical mass with a broad base, only a very small portion of the original contour line seems to give way at first, so as to admit the passage of the endosarc and other granular contents into the newly projected part, but its entire floor appears to be gradually dissolved, as it were, and free communication between the main body and the new pseudopodal cavity is not established until the completion of this process. Whilst it is progressing the endosarc-granules seem to rush round a corner into the cavity, the corner gradually receding, so to speak, and ultimately becoming altogether obliterated."*

Sometimes in the projection of a pseudopodal lobe, from the side of the head end of the body, it will continue to be projected, and will gradually receive the endosarc, and with it, as it were, the entire body, when, of course, the animal changes the direction of its movement into that of the pseudopod. This mode of movement is represented in the accompanying woodcut outlines 1–5.

Pelomyxa villosa: mode of motion.

At times, *Pelomyxa villosa* will appear stationary, or nearly so, and comparatively quiescent, and will project from any part of its surface, slowly or more or less rapidly, a variable number of narrow, conical, or somewhat spindle-shaped, pointed pseudopods of clear ectosarc, as seen in figs. 3, 5, 10. These receive none of the endosarc, and are not used as locomotive organs, but perhaps serve a tactile function.

I have not observed *Pelomyxa villosa* assume the branching condition of *Amœba proteus*, but under undue pressure I have seen it project one or more long digitate pseudopods, as in the latter.

The villous area or appendage of the Pelomyxa under consideration resembles that ascribed to *Amœba villosa* by Dr. Wallich. In the resting

*Annals and Magazine of Natural History, 1863, xi, 370.

condition or spheroidal form of the animal it is not obvious, and it appears to be capable of complete retraction and obliteration, as is the case with the ordinary pseudopodal extensions. It is variable in appearance, though as ordinarily seen it forms a discoid or sucker-like process defined from the rest of the body by a constriction. When not projected, it is sometimes visible as a circular patch terminating the posterior extremity of the body, as represented in figs. 1, 13. Sometimes the process appears as a conical or irregularly papillary projection. The villi are very variable; sometimes numerous, minute and crowded; sometimes fewer, thicker and widely separated; at times short and papillary, at others more or less long and hair-like, and occasionally branched. See figs. 1–10, 12, 13, 15–17.

The villous portion or process of the body is highly prehensile, and serves the animal to fix its position in like manner with the sucker of a leech. At times when I have poured off the liquid from the glass on which I was examining a specimen of the *Pelomyxa* to put on it clearer water, it would maintain its place by means of the villous end of the body. As a temporary organ of prehension it is no doubt of importance in obtaining food. Algæ and other materials are often seen adherent to and dragged along after it in the progressive movements of the animal, as represented in fig 14. In structure, the villous process appears as an extension of finely granular homogeneous endosarc without the slightest differentiation of enclosing ectosarc, and when it is of irregular or papillary form it looks as if it were a sort of hernial protrusion of the endosarc through an accidental rupture of the ectosarc.

Sometimes the villous area of *Pelomyxa villosa* appears only as a villous fringe to the posterior extremity of the body. Occasionally I have observed an individual emit a multitude of minute villi near or in conjunction with the usual villous area, or in other positions of the body. These additional or supplemental villi appeared to be less permanent than the others, or at least after a time they were withdrawn and were no longer visible in the same individual.

Pelomyxa villosa I have usually found to be so opaque, except in young specimens, that the different elements of its interior structure are undistinguishable without the animal is submitted to considerable pressure, or it is actually crushed. In habit, like the *Pelomyxa palustris*, it is exceedingly gluttonous, and is remarkable for the manner in which it gorges itself with food and other materials of different kinds. Usually the quantity of the ingesta is so great as totally to obscure from view all the intrinsic constituents of the endosarc except when they rush into pseudopodal projections of the ectosarc.

The food is mainly of vegetal character, consisting of all sorts of algæ, especially diatoms, desmids, and other unicellular forms, oscillarias and other filamentous forms, fragments of higher plants, fibres and particles of wood and leaves, etc., besides flocculent, apparently decaying, vegetal matter. The food in the interior of the animal, as in other amœboid forms, when of soft or yielding character, appears as variously colored balls, mostly yellowish, brownish, or green, often enclosed in water-drops, but often also free from the latter, as indicated by the absence of the clear zone, which usually indicates the presence of surrounding liquid. Much of the food apparently is diffused, as fine yellowish matter, among the intrinsic granular constituents of the endosarc.

In the ordinary process of digestion in *Pelomyxa villosa*, as in other amœboid forms, green vegetal substances gradually assume a yellowish or brownish hue. The insoluble residue of the food of all kinds is from time to time discharged in the usual manner at the posterior extremity of the body, but whether through or to one side of the villous process I did not ascertain.

Quartz-sand is a frequent and abundant material mingled with the food and other constituents of the endosarc. Not only fine but coarse particles are swallowed, but they appear always to be directly in contact with the granular and other matters of the endosarc, and not contained in vacuoles or water-drops, as ordinarily is the case with most solid food. In many individuals, the quartz-sand has appeared to predominate over everything else in the endosarc, and such specimens, which were literally bags of sand, I formerly described as a species, with the name of *Amœba sabulosa*.

Pelomyxa palustris, as described by Prof. Greeff, also swallows a notable quantity of sand; but this appears not to be the case, at least to any remarkable extent, with *Amœba villosa*, as described by Dr. Wallich and Dr. Duncan.

Dr. Wallich describes crystals of rhombohedral form as a constituent of the endosarc of *Amœba villosa;* but these bodies, ordinarily so conspicuous and common in *Amœba proteus*, either do not exist, or they escaped my notice, in the more characteristic or matured specimens of *Pelomyxa villosa.* In some young amœboid forms, which I suspected to pertain to the latter, crystals undoubtedly existed, and perhaps they are likewise abundant enough in mature forms, but ordinarily are obscured from view by the presence of the large proportion of sand particles. Prof. Greeff does not mention them as an element of *Pelomyxa palustris.*

The basis of the endosarc of *Pelomyxa villosa*, as in the latter, consists of a pale and finely granular protoplasm, mingled with more distinct fine oil-like molecules. Besides the food materials and other ingesta, the endosarc contains a variety of other elements. Among these there are variable proportions of clear vacuoles, sometimes numerous, sometimes few, of different sizes.

Another element consists of clear or indistinctly granular corpuscles of albuminoid or oleaginous appearance, mostly colorless, but sometimes more or less feebly yellowish. They range from a small size up to 0.006 mm., though the prevailing size was about one-half this dimension. Under the action of acetic acid they mostly remained unchanged, though many became more distinctly granular, and less distinctly outlined. These corpuscles probably correspond with the 'sarcoblasts' of *Amœba villosa* of Dr. Wallich, and the 'Glanzkörper' or shining corpuscles of *Pelomyxa palustris* of Prof. Greeff.

Mingled with the clearer corpuscles just indicated, there were others, comparatively fewer, and measuring about 0.004 mm. These were more or less homogeneous, with scattered granules superficially situated. Still other corpuscles, about the same size as the preceding, were finely granular, and contained a darker granular nucleolus. I am uncertain whether these corpuscles correspond with the nuclei of *Pelomyxa palustris* as described by Prof. Greeff.

In some crushed specimens of the variety of *Pelomyxa villosa*, originally noticed by me under the name of *Amœba sabulosa*, I further noticed a few comparatively large granular spheres reaching about 0.016 mm., and containing each several scattered nucleoli, some of which appeared clear and homogeneous, while others were granular.

In several instances, in crushed specimens of *Pelomyxa villosa*, I also observed, as one of the constituents of the endosarc, numerous minute rods, from 0.001 to 0.005 mm. in length, and resembling vibrios, but motionless

Under the $\frac{1}{10}$th inch objective power of the microscope, many appeared to be transversely striated. Similar bodies are described by Prof. Greeff as a constituent of the endosarc of *Pelomyxa palustris.*

Dr. Wallich describes a conspicuous nucleus and an equally conspicuous contractile vesicle as present in *Amœba villosa*, having the same essential characters and holding the same habitual position as in *Amœba proteus.* In the figures accompanying Dr. Wallich's memoir, the single large nucleus, and the large contractile vesicle, or in its place several smaller ones, are among the most striking features of the creature.

In *Pelomyxa villosa*, except in those specimens I have regarded as young individuals, I have at no time been able to detect a single large nucleus like that represented in *Amœba villosa*, or such as exists in *A. proteus.* I have, also, at no time observed a single large and conspicuous contractile vesicle in the more characteristic forms of the animal; but in its place there are usually from one to half a dozen small ones, commonly occupying a position in the vicinity of the villous area of the body, or even partly within this area when it is produced as a process. Frequently the small contractile vesicles are more or less obscured from view by other surrounding elements. They commonly remain separate and independant of one another, and while one appears and undergoes enlargement another collapses and disappears.

I have not been able to trace a continuation of the history of *Pelomyxa villosa.*

In one instance I observed a large individual replete with quartz-sand, apparently burst and scatter its softer granular constituents until reduced to about one-half the original size. The remaining portion of the body appeared unhurt, but what the phenomenon meant I did not positively ascertain, though I suspected that it was attendant upon the expulsion of germs.

DINAMŒBA.

Greek, *deinos,* terrible; *amœba.*

Animal with the same essential structure of Amœba; when at rest, spheroidal or oval; when in motion, habitually ovoid or slug-like, and with the broader extremity in advance. Pseudopods few or many, mostly simple extensions of the ectosarc, subulate, or long conical and acute, occasionally furcate. Posterior extremity of the body papillose; papillæ very variable, few or many, simple or compound, retractile. Surface of the body, including the pseudopods and the papillæ, bristling with minute spicules or motionless cils.* Body of the animal often enveloped, even in the active moving condition, with a thick layer of delicate hyaline jelly, defined on the surface by multitudes of minute spicules. Spicules of the surface of the body and the exterior layer of jelly with its spicules sometimes absent.

DINAMŒBA MIRABILIS.

PLATE VI; VII, figs. 1–11.

Deinamœba mirabilis. Leidy: Pr. Ac. Nat. Sc. 1874, 142, 155.
Amœba tentaculata. Leidy: Pr. Ac. Nat. Sc. 1874, 167.
Dinamœba. Leidy: Pr. Ac. Nat. Sc. 1877, 288.

Body round, oval, ovate or limaciform,† commonly more or less depressed when moving on flat surfaces; anterior part broad and blunt; posterior part narrower and more or less tapering; sometimes broader behind; spheroidal when floating. Pseudopods mostly numerous, and usually projecting from the anterior region of the body, consisting of moderately long, conical, or somewhat fusiform, or subulate processes of clear ectosarc. Posterior extremity of the body commonly much papillose, with the papillæ very variable, simple or compound, rounded or elongated. Surface of the body everywhere, including pseudopods and papillæ, thickly bristling with minute spicules, which are, however, in some conditions entirely absent. Body often enveloped with a thick layer of clear protoplasm, which is defined by a minutely ciliated surface, and is penetrated by the pseudopods. Endosarc mostly with abundance of oil-like molecules, large clear globules, and multitudes of food-balls. Nucleus and contractile vesicles commonly obscured from view by the other constituents.

Size.—Spheroidal form 0.064 to 0.16 mm. diameter. Creeping forms 0.152 mm. long by 0.06 mm. broad, to 0.34 mm. long by 0.22 mm. broad.

Locality.—Ponds of the cedar and sphagnous swamps of New Jersey, commonly among the desmids *Didymoprium* and *Bambusina*, which appear to be its favorite food.

Dinamœba mirabilis in its quiescent condition is globular or oval, and often appears indisposed to move. It is a sluggish animal, though much

* From the word '*cilia*,' anglicized into '*cils*'—minute linear appendages, in rows reminding one of the eyelash, whence the name.

† Shaped like a Limax, or slug.

less so than *Amœba verrucosa.* When about to move, it commonly assumes an oval and then an ovoid or a pyriform shape It slowly glides with the thicker end in advance, usually projecting from the front a conical eminence of hyaline ectosarc. At the same time it quickly projects from one or both sides of the head a long subulate pseudopod. Simultaneously, or more or less successively, a variable number of similar pseudopods may be projected from other portions of the body. The pseudopods are more frequently confined to the fore part of the body. There may be but one or two, or they may be numerous and project everywhere except at the posterior extremity. The latter is covered with papillæ, differing from the pseudopods in being short and blunt. See pl. VI.

The pseudopods present considerable uniformity both in shape and size. They are composed of the ectosarc alone, except that a few molecules of the endosarc extend a little way within their base. They are elongated conical, with an expanded base, slightly swollen near the middle, and tapering to a sharp point. Occasionally one or two are forked. They make their appearance from the ectosarc, suddenly, as short conical projections, which run outwardly some distance with a blunt extremity, and then rapidly extend in a tapering point, as exemplified in the group of pseudopods to the right of the head in fig. 2, pl. VII. They are projected quickly even to such a degree as to require special attention to see them produced, and they are also as quickly retracted.

The papillæ of the back end of the body are variable in number and appearance. Sometimes they are comparatively few; at others, numerous and thickly crowded. Not unfrequently they are themselves papillose. Their usual form is mammillary, often enlarged at the end, or they may be conical and pointed. They are composed of the ectosarc, but commonly receive more of the endosarc than the pseudopods. They appear to be retractile, like the latter, and often diminish or increase; often and quickly change their aspect, and frequently disappear altogether.

A remarkable feature of Dinamœba (pl. VI) is seen in every part of the surface, including the pseudopods and posterior papillæ, bristling with exceedingly minute spicules, or rigid cils, which are directed perpendicularly to the surface. Not unfrequently these minute cils are absent, figs. 2, 3, 5–9, pl. VII; and in several instances in which they were abundantly present, after some hours, on the same individuals, they had disappeared.

In several cases also I have seen minute molecules replace the spicules, as represented in fig. 11, pl. VII.

Another character of Dinamœba, even more remarkable than the former, as represented in figs. 2, 7, pl. VI, is the occurrence of a thick investment of hyaline jelly, resembling in appearance that which envelopes certain algæ, as commonly seen in the desmid *Didymoprium grevillii.* This transparent cloak is borne by the active, moving animal, and is no evidence of the creature being ready to pass into a quiescent or an encysted condition. The free surface of the jelly-like cloak is defined by innumerable exceedingly minute rods, standing perpendicularly, which give to the animal the appearance as if it were surrounded by a nimbus of bacteria. Sometimes through the stratum of jelly there are to be observed variable numbers of linear bodies resembling the former; but these have usually appeared to me to be endowed with motion, and to be really true bacteria.

In the movements of Dinamœba, its jelly-like cloak appears to be no obstacle, and the subulate pseudopods shoot through and beyond it as if it did not exist.

Like the bristling spicules of the body and appendages of Dinamœba, the jelly-like envelope with the bacteria-like cils may be absent; but, according to my experience, it is present in the greater proportion of cases.

Dinamœba is commonly cream-white or greenish white and more or less spotted with green and brown, or it is yellowish or brownish white spotted with yellow and brown. The colors, with the exception of the white, are mainly dependent on the food-balls shining through from the interior. The pseudopods, papillæ, and jelly-like envelope are hyaline and colorless.

Dinamœba mirabilis, like *Pelomyxa villosa*, is a gluttonous feeder, and is commonly so gorged with food that it greatly obscures the intrinsic elements of the endosarc and renders the animal more or less opaque. The food-balls, mostly included in water-drops, are globular, and variable in color according to their original nature and the changes they have undergone in digestion.

The basis of the endosarc consists of hyaline protoplasm, with a pale, faintly granular constitution, as in other amœboids. It is generally mingled with a large quantity of fine oil-like molecules, which are especially well seen where the endosarc merges in the ectosarc, and also within the roots of the pseudopods.

Occupying the central portion of the endosarc, and mingled with the food-balls, in different individuals, there is a variable quantity of other globular elements of different kinds. Frequently a large proportion of these globules consist of clear oil-like drops of homogeneous liquid resembling similar globules in *Pelomyxa villosa.* Others appear faintly granular in structure, and may be either nuclei and food-balls, or perhaps both. Many globules also are simple water-vacuoles, varying greatly in number and size.

I have not been able to detect in Dinamœba, except perhaps in a few young individuals, a distinct nucleus, such as is usually so conspicuous in *Amœba proteus.* It is not improbable that a nucleus like that of the latter may ordinarily be present, and be completely obscured by the abundant food and other constituents of the endosarc.

A conspicuous contractile vesicle, like that habitually present in *Amœba proteus* and other species, is rarely to be seen in Dinamœba. Mostly several small clear globules, up to half a dozen, may be seen from time to time at the posterior extremity of the animal, which appear to substitute the usual single contractile vesicle of other amœboid forms. These globules remain separate, slowly enlarge, and collapse more or less successively, in the manner of the ordinary contractile vesicle. Perhaps also as a substitute for the more conspicuous contractile vesicle, in Dinamœba we observe the frequent displacement, from the central mass of the endosarc, of one or more large vacuoles, which appear within the posterior extremity, and after a little while discharge from the body their mingled liquid and solid contents, the remains of the food.

Though indefinite granular matter, apparently derived from decaying vegetal substances, is taken with other food, Dinamœba appears not to swallow sand or other conspicuous inorganic particles.

Crystals also appear not to be present as a constituent of the endosarc of Dinamœba, nor did I ever detect within it minute rods or vibrio-like bodies, such as are frequently observed in some forms attributed to *Pelomyxa villosa.*

As before intimated, Dinamœba is a gluttonous animal, and, when found under favorable circumstances, is usually observed gorged with food. It appears mainly to feed on algæ, and its favorite food consists of the common desmids *Didymoprium grevillii* and *Bambusina brebissonii*, especially the former. Where these two desmids thrive luxuriantly, in ponds of the deep sphagnous and cedar swamps of New Jersey, I have found the favorite haunts of Dinamœba. Less frequently among its food contents I have observed diatoms, closteria, and the brownish flocculent matter common in some of the ponds indicated.

The green spots so generally observed in Dinamœba are mostly due to the presence of scattered cells of Didymoprium and less frequently of Bambusina, scattered as food contents through the endosarc. As a result of digestion, the green endochrome of the desmids loses its color, at first becoming paler and then yellowish green, then ochreous yellow. The discharged cells of the desmids appear with the yellow shriveled remains of the endochrome in the centre.

The figures of pl. VI represent individuals of Dinamœba, feeding on Didymoprium, and containing in their interior multitudes of food-balls mainly consisting of joints of that plant, of various shades of green, and others rendered brown or yellow as the result of digestion.

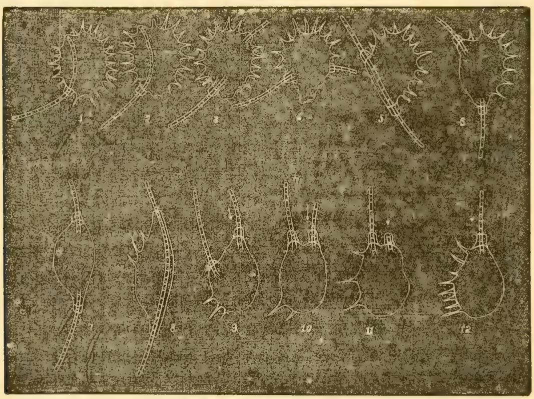
As is intimated, by Prof. Duncan, to be the case in Amœba, I suspect that Dinamœba habitually takes its food at the posterior part of the body. I have not seen the animal in the act of seizing its food, so that I am unable to say whether it does so through the aid of the terminal papillæ. My observations, however, lead me to believe that in swallowing the food it first enters to either side of the papillary extremity.

In one instance in which I detected Dinamœba in the act of swallowing, the animal presented the appearance represented in fig. 1, pl. VI, and had been but a few minutes previously transferred to the animalcula-cage. It was a fine vigorous specimen, broadly oval, 0.18 mm. long by 0.16 broad, with its characteristic subulate pseudopods projecting in every direction. All parts bristled with spicules, and the body was enveloped in its hyaline jelly-cloak. A long filament of Didymoprium had one end bent and swallowed by the Dinamœba, entering from the front, on the left side, in advance of the middle. At the position of entrance it was enclosed for some distance by a thick papillary protrusion of clear ectosarc, which clasped it so tightly as to constrict the jelly-envelope of the Didymoprium completely through to the cellular axis of the plant.

A little later the animal slowly expanded so as to measure 0.24 mm. in length, and retaining the original breadth. At the same time, the Didymoprium was broken, the detached portion pushed off, and the retained portion drawn in, and with this the large papilla of ectosarc. A moment after, a large protrusion of the body occurred to the left of the posterior extremity, followed by an abrupt discharge from it of twenty-four cells, mostly of Didymoprium, with a few of Bambusina. The discharged cells contained the yellow shriveled remains of the endochrome. A view of the animal in the condition just described is represented in fig. 2.

Later, as the animal slowly glided along, it presented the appearance seen in fig. 3. The body was depressed pyriform, with the posterior narrow end crowded with long papillæ. In this condition it measured 0.28 mm. long. Eight hours subsequently, the same individual measured 0.24 mm. long by 0.16 mm. broad.

In another instance I observed an active, well-fed Dinamœba in the act of swallowing a filament of Bambusina. The successive steps of the process are represented in the woodcuts 1–12.



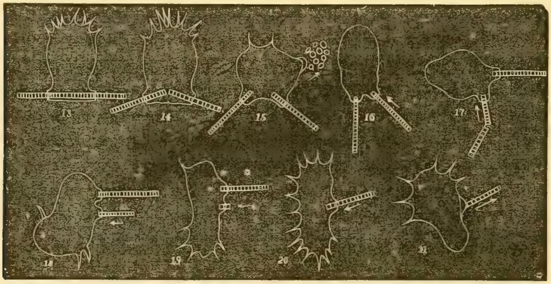
Successive changes observed in *Dinamœba mirabilis* while in the act of swallowing a filament of the alga Bambusina. The arrows indicate the course of movement in the swallowing of the alga.

When first seen, the animal was oval, 0.22 mm. long by 0.16 mm. broad. The alga was 1.12 mm. long, and a portion of it was immersed in the Dinamœba, entering to the left of the posterior extremity, and extending along the left side, the fore end causing a slight protrusion of ectosarc at the head (1). A little later the animal slightly elongated, remaining of the same breadth (2). Gradually moving with an inclination to the left, the relative position of the alga was changed so that it crossed in a slant, and the anterior end protruded to the right of the head (3). The relative position of the alga continued to change, so that it became transverse (4), then gradually slanted in the opposite direction (5), and at last assumed nearly its original position, as seen in cut 6. It next acquired a median position, extending through the length of the animal, as seen in cut 7. The creature now extended in both directions along the alga, as represented in the succeeding woodcut (8), until it became 0.36 mm. long by 0.128 broad. The movements up to this moment had been slow and uniform, but now the animal rather suddenly doubled upon itself, bending the alga with it, as seen in cut 9. The two extremities of the alga were bent more closely together until they were parallel, and their ends protruded together from the same pole of the animal, as represented in cuts 10, 11. In this condition the animal measured nearly the same as originally, that is, 0.24 mm. long by 0.16 mm. broad. Subsequently the right extremity of the alga was drawn into the animal, leaving but one protruded, as seen in cut 12, and after a little while this also disappeared, and the animal moved away, with the lower part, as seen in the woodcut, in advance. As the alga was three times the length of the animal after it was swallowed, it must have formed a coil; but this was entirely obscured from view by the abundance of food and other constituents of the endosarc. During the process of swallowing the alga, as may be noticed in the outline figures, the number and position of the pseudopods incessantly varied. In the beginning they were numerous; at one time none, and later but two or three. From the creature doubling upon itself, in the manner represented, it would seem as if the head and papillary end of Dinamœba were not permanently differentiated, for both subsequently appeared together to become the tail end, while an intermediate portion of the body assumed the relative position of the head.

Indeed, no portions of the exterior of Dinamœba are constant, although they usually seem to be so Head and tail appear to be mutually interchangeable, and such also is the case with the processes I have for convenience distinguished as pseudopods and papillæ.

Some hours later, on examining the same Dinamœba, which had been preserved in the animalcula-cage, it presented the appearance represented in fig. 6, pl. VI. It was oval in shape, 0.272 mm. long by 0.16 mm. broad, and sitting, as it were, on a Didymoprium. From the head projected a number of pseudopods. The posterior extremity clasped the alga by means of a transverse cylindrical process of greater length than the breadth of the body. The ends of the process on each side were extensions of the ectosarc fringed with papillæ. The cylinder embraced the alga so tightly as to contract its gelatinoid sheath close to its green cellular axis

While watching the Dinamœba, without any suspicion of what was to follow, and with the impression that the animal was holding a resting position, as seen in the woodcut 13, the Didymoprium suddenly broke within its clasp, as represented in the following woodcut 14.



Successive changes observed in *Dinamœba mirabilis* while in the act of swallowing a filament of the alga Didymoprium.

The animal subsequently passed through the successive changes seen in cuts 15–21. The Dinamœba gradually shortened, the pseudopods in front diminished to two, the two portions of the alga were made to approach each other, and the right side of the body projected in a nipple-like prominence, from which there were suddenly discharged upward of twenty cells of Bambusina (15). These were probably derived from the filament swallowed, as previously described. The cells were nearly all separated, and contained only the shriveled remains of the endochrome.

The Dinamœba again became elongated, all pseudopods disappeared, and the two portions of the alga approached so as to project from the animal at an acute angle, while at the same time the right portion was observed slowly to sink into the interior (16). The animal next turned to the left, the two portions of the alga assumed a position at a right angle, and the left portion broke into two (17). The animal then turned until the head was directed backward, and the two portions of the alga remaining in connection with the animal assumed a parallel position close together on the left of the tail end (18). What had been the left portion of the alga sunk gradually into the body and disappeared (19). Subsequently what had been the head of the animal shrunk and became the tail end furnished with pseudopods, while the previous tail end projected pseudopods and moved in advance as the head end (20). The projecting extremity of what had been the right portion of the alga broke off close to the animal and was rejected (21), while the retained portion sunk out of sight.

Some days later I had the opportunity of observing another Dinamœba in the condition represented in fig. 4, pl. VI. It was a fine, large specimen, of ovate form, the third of a millimetre long by the fifth of a millimetre broad. From the left of the posterior part of the body projected two divisions of a Didymoprium, which no doubt had been broken apart, as in the former instance. The two divisions of the alga assumed a symmetrical position at the tail end, and afterward portions of each were successively broken off, and the retained pieces were swallowed.

Habitually Dinamœba rejects excrementitious matters at one side of the posterior papillary extremity; but I have repeatedly observed the animal discharge the remains of food not only from other parts of the body, but in two or three widely separated positions at once, as represented in fig. 7.

Though *Dinamœba mirabilis* is a more sluggish animal than *Amœba proteus*, it appears to be more irritable. Disturbance generally causes it to withdraw its pseudopods and contract its body, though slowly. A slight shock, I have also noticed, will frequently cause it to discharge a portion of its food contents, and this several times and at several points at once.

An active specimen of Dinamœba, from Atco, New Jersey, when first noticed, was oval, 0.3 mm. in length by 0.2 mm. in breadth. After a moment, from disturbance, it discharged a few cells of Didymoprium, at the same time, from the right of the head and the left of the tail, and in a few seconds afterward upward of twenty cells of the same alga from the former position, and a series of four cells, still connected together, from the latter position. The animal then became globular and quiet, and measured 0.2 mm. in diameter.

On the same occasion, in the same drop of water, I observed another fine Dinamœba, with an oval body 0.25 mm. long by 0.2 mm. broad, with numerous subulate pseudopods projected in all directions. It exhibited a thickly papillose tail-like appendage 0 12 mm. long by 0.06 mm. broad. The tail was filled with fine granular matter, a multitude of darkly defined oil-like molecules, clear globules, and three cells of Didymoprium. The animal afterward discharged a group of cells of the latter alga from the body to the left of the tail, and subsequently assumed a long clavate shape 0.4 mm. long by 0.18 mm. broad at the thicker end.

In one instance I observed a Dinamœba, which contained, with other food, a desmid, the *Closterium didymotocum*, as represented in fig. 1, pl. VII. When first seen, the alga held a transverse position causing a considerable protrusion of the body on the left side. The alga had evidently been seized just after it had parted from another;—for one-half of the cell was comparatively tender and doubled upon the older and more rigid half. With the Closterium, smaller algæ, and other ordinary materials, there was an unusually large vacuole, which discharged itself several hours after first observing it. About eight hours after seeing the Dinamœba, the minute spicules of the surface had disappeared, and two hours later the Closterium was discharged, but without my having seen the act. The following morning the animal presented the appearance represented in fig. 2. It was 0.21 mm. long by 0.12 mm. broad at the fore part. The pseudopods were remarkably long, up to 0.12 mm., and projected in every direction. The posterior extremity ended in a number of compound papillæ. The endosarc, besides colored food-balls, contained a multitude of colorless globules. Three smaller ones of these appeared within the tail end as contractile vesicles. No trace of the minute spicules, usual in Dinamœba, was to be seen on any part of the surface of the animal.

In the Proceedings of the Academy of Natural Sciences for 1874, page 167, I described an amœboid, under the name of *Amœba tentaculata*, as follows: Body spheroidal, oval, or limaciform, projecting a multitude of long conical or fusiform pseudopods of clear ectosarc, into which no granules of the endosarc enter; posteriorly finely papillate, or with a discoid papillate subdivision. Exterior of the body colorless and transparent; interior yellowish and spotted brown or green from the food contents. When moving, the animal resembles a sea-slug, Eolis, in its shape and from its many long pointed pseudopods. At the fore part of the body, in progression, a large extent of perfectly clear ectosarc precedes the endosarc, equal to about one-sixth of the length of the body. This is blunt in front, and with its divergent pseudopods resembles the head of a slug. When floating, the animal looks like a large Actinophrys with thick conical rays.

This amœboid, which I now suspect to represent only another condition or stage of *Dinamœba mirabilis*, I have repeatedly found, in the autumn, in the same localities. It agrees in habitual shape and size, in the kind of pseudopods, and the possession of the posterior papillary organ, with the more characteristic form. We have seen that both the minutely spiculate condition of the surface and the gelatinoid coat of Dinamœba may be dispensed with, so as to reduce it to the condition of the amœboid form under consideration.

This amœboid seems as if it were Dinamœba which had passed the actively feeding stage, as it contains but comparatively little food and the endosarc is much reduced. The large proportion of ectosarc in relation with the endosarc reminds one of *Amœba verrucosa.*

In motion, the creature advances slug-like in manner and general appearance. The body is composed of a central mass of granular endosarc enveloped with a thick layer of clear ectosarc, of which a still thicker portion forms the head, as seen in figs. 5, 7, and 10, pl. VII. The pseudopods, usually numerous, form subulate processes of clear ectosarc occupying mostly the anterior region of the body. The posterior papillæ are variable in number and size, and in advance show more or less disposition to merge into pseudopods.

Figs. 5–7 represent three successive views of the same individual as observed at intervals during thirty-six hours. As first seen, fig. 5, it was elongated elliptical with prolonged blunt poles, both of which, as well as the exterior layer of the intermediate body portion, appeared to be composed of clear ectosarc. The central mass of granular endosarc was mingled with diffused brownish material, and contained a few clear globules or vacuoles, various articles of food, and a large pale granular nucleus surrounded by a clear halo. Pointed conical pseudopods of clear ectosarc projected everywhere from the head and body, while the tail was minutely and profusely papillose.

When next examined, the animal appeared as in fig. 6, oval in outline, with the anterior half covered with pseudopods, and the posterior half with numerous short blunt papillæ. The nucleus was concealed from view.

Later the body was elongated, with the posterior part most expanded, as in fig. 7. The nucleus was nearly central and quite distinct. In the first and last views, several small contractile vesicles were observed at the posterior extremity of the animal.

Among the articles of food there was a long colorless thread, apparently a cotton or ligneous fibre, coiled among the other constituents of the endosarc. A bright green desmid, as seen in figs. 5, 6, finally assumed a brown hue, as seen in fig. 7.

Fig. 8 represents an individual of the same kind as the preceding, in the act of floating or swimming. The body of globular form, and with numerous pointed pseudopods radiating in all directions, gave it the general appearance of a Heliozoan, except in the character of the rays. The usual posterior papillæ did not appear in this condition, but subsequently were seen, when the animal assumed the elongated creeping position. The size of the central body was much reduced in its proportions, from the multitude of pseudopodal rays, and measured 0.065 mm. in diameter.

The endosarc of the amœboid under consideration is usually pale granular, and apparently mingled with brownish matter, which I have suspected to be derived from the brown flocculent material usually so abundant in the locality in which the creature is found. It also contains variable proportions of fine oil-like molecules, water-vacuoles, brownish and colorless granular food-balls, diatoms, and other food materials, but rarely a particle of quartz-sand. Mostly the fine oil-like molecules are very few or are altogether absent, and frequently also water-vacuoles appeared not to be present except in the nature of contractile vesicles. Of these there are apparent a variable number situated within the villous extremity of the body, often small and comparatively numerous, at other times few and larger.

Commonly a nucleus may be detected in the movements of the animal, as seen in figs. 5 and 7. It is of large size, pale granular, and surrounded by a clear ring. In fig. 10, an individual is represented, in which the nucleus appeared to be a sphere containing large granules of uniform size. The specimen was quiet, remained nearly stationary, and occasionally emitted here and there a small conical pseudopod. In a similar specimen the nucleus presented the appearance of including exceedingly delicate coiled filaments, but the time did not permit me to investigate further the nature of these.

Dinamœba mirabilis, in size, habitual form, and some other characters, approaches *Pelomyxa villosa*, and after recognizing *Amœba tentaculata* as representing another stage of the former, I began to suspect that it might likewise be the same. When, however, we take into consideration the usual abundance of pseudopods in Dinamœba, their paucity or absence in *Pelomyxa villosa*, the difference in the character of the villous and papillary processes, and the difference in habits, with other occasional peculiarities, we may regard them as distinct unless further investigation shall prove otherwise.

Dinamœba mirabilis bears considerable resemblance to *Mastigamœba aspera*, described by Prof. Schulze.* This animal is broad, fusiform, about 0.1 mm. long, provided with many pseudopods and a general investment of minute bacteria-like bodies, but is particularly distinguished by the possession of a long flagellum, projecting in front, from an ovate corpuscle enclosing a nuclear body. When I first saw the figure of Mastigamœba, it occurred to me that Dinamœba was the same, and that the flagellum in the latter had inadvertently escaped my notice. I waited rather impatiently until the following season, that I might again have the opportunity of examining what I had described as Dinamœba. I have since seen an abundance of specimens in a variety of conditions; but in none did I ever see a flagellum.

Dinamœba further differs from Mastigamœba in other respects: in the habitual form of the body; in the pseudopods, which are digitiform in the latter; and in the relative position of the minute spiculate bodies investing the animal, which in Mastigamœba are described as generally placed parallel with the surface.

Dinamœba seems also quite distinct from *Dactylosphærium vitreum* of Hertwig and Lesser,† which appears to be related with *Mastigamœba aspera*,

* Archiv f. mikroskopische Anatomie, 1875, 583, Taf. xxxv.

† Archiv f. mikroskopische Anatomie, 1874, Sup. 54, Taf. ii, Fig. 1.

but, like the former, is devoid of the flagellum. Dactylosphærium is a smaller animal than Dinamœba, of irregularly rounded form, and from 0.012 to 0.06 mm. in diameter. The pseudopods projecting in all directions are somewhat conical and blunt. Two varieties are described, in one of which the endosarc is occupied with multitudes of bright-yellow corpuscles; in the other, with green corpuscles. In most examples of the variety with green corpuscles, the body is covered with minute villi of protoplasm, which, though simulating the minute spicules investing Dinamœba, are clearly of a different character.

HYALODISCUS.

Greek, *hualos*, crystal; *discos*, a quoit.

Hyalodiscus: Hertwig and Lesser, 1874. *Plakopus:* Schulze, 1875.

Body naked, discoidal, consisting of a colored granular endosarc, with nucleus and vacuoles, and a clear colorless ectosarc, which in motion of the animal extends in a broad zone beyond the colored mass of endosarc, and projects pointed conical processes mostly few in number.

HYALODISCUS RUBICUNDUS.

PLATE XLV, figs. 17, 18.

Hyalodiscus rubicundus. Hertwig and Lesser: Arch. mik. Anat. 1874, x, Supl. 49, Taf. ii, Fig. 5.
? *Plakopus ruber.* Schulze: Arch. mik. Anat. 1875, xi, 348, Taf. xix, Fig. 9–16.

Endosarc brick-red in color.

Size.—0.03–0.06 mm. diameter.

In the outset of my studies of the Fresh-water Rhizopods, I met with several specimens of what I suppose to be the curious colored amœboid form described by Hertwig and Lesser under the name of **Hyalodiscus rubicundus,** but I have since seen no others. They were found in the ooze of Cooper's Creek, New Jersey, in the month of May.

One of the specimens, shortly after being noticed, exhibited the appearance seen in fig. 17, pl. XLV. It had an irregularly circular outline, measured about 0.0625 mm. in breadth, and consisted of two portions. One of these was an orange or light brick-red body with a variable number of conical pointed processes; the other was a thin, delicate, broad, crescentic band of clear colorless ectosarc embracing more than half the circumference of the former. The animal slowly glided in an amœba-like manner, in the direction of the pseudopodal expansion of ectosarc. In its movements the red mass underwent more or less change of shape, the surface at different points would rise and fall, and here and there the pointed processes would be withdrawn and others would be projected. The band of ectosarc also moved in a wave-like manner, extending and receding in different positions.

The red mass of endosarc was composed of a basis of fine red granules with a few larger ones of the same color but darker, and a few scattered oil-like molecules. The central portion of the endosarc, from time to time, exhibited a clearer circular spot, apparently indicating the presence of a nucleus. There were also to be seen two or three small vacuoles, but I failed to detect any movement in them.

Another specimen, found at the same time with the preceding, represented in fig. 18, was about half the size. It was of the same color, but the endosarc contained a multitude of conspicuous globular colored corpuscles mingled with the finer granular basis. The clear colorless ectosarc extended around the border of the colored endosarc, and projected a few conical processes, into which none of the colored granular matter of the latter reached. The movements of the animal were of the same character as in the former specimen.

Plakopus ruber, described by Prof. Schulze, is probably identical with *Hyalodiscus rubicundus*, as suspected by this author, though it is a very much larger animal, and contains several nuclei. Prof. Schulze gives as the size of the former from 0.2 to 0.6 mm.

DIFFLUGIA.

Latin, *diffluo*, to flow.

Difflugia: Leclerc, 1815. *Arcella:* Ehrenberg, 1841. *Lecquereusia:* Schlumberger, 1845. *Homœochlamys; Heterocosmia; Exassula:* Ehrenberg, 1871.

Shell very variable in shape, usually composed of extraneous angular particles of hyaline quartz-sand, sometimes mingled with other bodies, such as diatom-cases, sponge-spicules, etc.; the same forms sometimes composed of chitinoid membrane incorporated with scattered extraneous particles or composed in part or entirely of intrinsic particles of peculiar character. Mouth inferior, usually terminal, rarely sub-terminal. Sarcodic mass commonly occupying the greater part of the capacity of the shell, attached by threads of ectosarc to the interior of the fundus and sides, and by a prolongation to the margin of the mouth. Nucleus single, situated near the fundus of the endosarc. Contractile vesicles several, situated at the periphery of the latter, contiguous to the nucleus. Pseudopods usually up to half a dozen or more, cylindrical, simple or branching, commonly rounded at the ends, sometimes spreading and pointed.

DIFFLUGIA GLOBULOSA.

PLATES XV, figs. 25–31; XVI, figs. 1–24.

Difflugia globulosa. Dujardin: An. Sc. Nat. 1837, viii, 311, pl. ix, figs. 1 *a*, *b*; Hist. Nat. Infusoires, 1841, 248, pl. ii, fig. 6. Pritchard: Hist. Infusoria, 1861, 554, pl. xxi, fig. 10.
Difflugia proteiformis. Ehrenberg: Infusionsthierchen, 1838, 131, Taf. ix, Fig. i; Micrographic Dict. 1860, 232, pl. 23, fig. 39.—Pritchard: Infusoria, 1861, 553.—Leidy: Proc. Ac. Nat. Sc. 1877, 307.
Difflugia globularis. Wallich: An. Mag. Nat. Hist. xiii, 1864, 241, pl. xvi, figs. 1, 2, 17, 27.—Leidy: Proc. Ac. Nat. Sc. 1877, 307, 321.
Difflugia proteiformis, subspecies *D. globularis.* Wallich: Ibidem.
Difflugia acropodia. Hertwig and Lesser: Arch. mik. Anat. 1874, x, Supl. 107, Taf. ii, Fig. 6.

Shell spheroidal or oval, with the oral pole more or less truncated. Mouth inferior, terminal, circular, usually truncating the shell; sometimes more or less protruding or bordered by a short neck, rarely more or less inverted. Shell commonly composed of quartz-sand, sometimes of diatoms, and sometimes of chitinoid membrane usually incorporated with more or less sand and diatoms. Sarcode, independent of the food, colorless.

Size.—Smallest specimen, with shell of sand, 0.036 mm. long by 0.03 mm. broad; with the mouth 0.015 mm. wide. Chitinoid specimens, with diatoms and sand, from 0.024 mm. long by 0.032 mm. broad; with the mouth 0.016 mm. wide, to 0.108 mm. long, 0.12 mm. broad; with the mouth 0.06 mm. wide. Largest specimens, of sand grains, 0.26 mm. long, 0.184 mm. broad, with the mouth 0.08 mm. wide.

Localities.—In the ooze of ditches and ponds frequent, in the vicinity of Philadelphia, Pennsylvania, New Jersey, Maine, Rhode Island, Connecticut, Florida, Alabama, Nova Scotia, Utah, and near Fort Bridger and in the Uinta Mountains, Wyoming Territory. Small forms are not unfrequent on moist earth in bogs, meadows, and even, with algæ and mosses, in the crevices of the brick pavements of the city of Philadelphia.

Dujardin, in 1837, described a species with the name of **Difflugia globulosa,** in which he says the shell is corneous, globular, and 0.1 mm. long. Of the accompanying figures, one is ovoid, with the mouth at the narrower end; the other is represented as an upper view, and is oval, so that, if strictly correct, the shell would be compressed ovoid. Later, he describes the shell as brown, globular, or ovoid and smooth; and the accompanying figure is circular in outline, with pseudopods directed from one pole.

Ehrenberg, in 1838, described an oval form, the shell of which is composed of quartz-sand, as *Difflugia proteiformis*, and attributes this name to Lamarck. To the same he refers one of the three different forms described by Leclerc as characteristic of the genus *Difflugia*. Lamarck, however, applied the name of *D. proteiformis* to all the forms indicated by Leclerc, without discrimination.

Of the three different forms noticed by Leclerc, one is readily recognizable as *Difflugia spiralis;* a second, as *D. acuminata;* while the third, referred to *D. proteiformis* by Ehrenberg, from its shape would appear rather to associate itself with the *D. pyriformis* of Dr Perty.

Dr. Wallich describes a more or less globular form, the shell of which is composed of quartz-sand, or this together with diatoms, as a subspecies of *D. proteiformis*, with the name of *D. globularis.* This name he attributes to Dujardin, evidently in mistake for that of *D. globulosa.*

Difflugia globulosa, as I have supposed it to be, is not uncommon in the ooze of ponds and ditches, and the smallest examples are frequent among moss, algæ, and other plants in damp shaded places.

The shell varies in shape from oval to ovoid and subpyriform, and to spheroidal and oblate spheroidal, as seen in figs. 25–31, pl. XV, and figs. 1–24, pl. XVI. The oral pole of the shell is more or less truncated, and the mouth is large, circular, entire, inferior, and commonly terminal. Mostly it forms the truncation of the oral pole, but sometimes the latter is more or less inflected, and the mouth becomes elevated above the level of the bottom of the shell. Less frequently, the mouth is more or less projected, so as to produce a short neck to the shell. Oval or ovoid varieties of the shell merge into forms which may be regarded as pertaining to *Difflugia pyriformis.*

Oblate spheroidal shells, with the oral pole more or less inflected to the mouth, resemble in shape the shell of a sea-urchin, Echinus.

In structure, the shell, as usual in other species of Difflugia, is composed of particles of quartz-sand, as represented in most of the figures above indicated. The smallest specimens frequently consist of chitinoid membrane incorporated with variable proportions of sand grains, as seen in figs 13–17, pl. XVI. Specimens, found in sphagnous swamps, sometimes consist of chitinoid membrane incorporated with variable proportions of diatoms, or fragments of the same, with sand grains and other particles of a less determinate character, as represented in figs. 9, 10, 18, 19, pl. XVI. Specimens are also found, in the same situations, composed almost entirely of diatoms, as represented in figs. 21, 22. The larger shells of *Difflugia globulosa*, composed of quartz-sand, are commonly colorless, but may be more or less yellowish or brownish, apparently due to ferruginous staining. Occasionally specimens are seen, like those of figs. 23, 24, in which the cementing material of the sand particles exhibits a deeper stain of the same kind. The smallest shells are more commonly of a yellowish hue.

In my experience it has occurred to meet with dead shells of *D. globulosa* more frequently than with living specimens.

The sarcode of *D. globulosa*, independent of food contents, is colorless.

Difflugia globulosa through intermediate forms merges into *D. pyriformis*, and I suspect also into *D. lobostoma*. The small oblate-spheroidal forms, with inflected base, especially when mainly composed of chitinoid membrane, are scarcely distinguishable from Arcellas. I have also seen specimens in which the mouth was more or less eccentric, and I was uncertain whether to refer them to the species under consideration, or whether to regard them as pertaining to *Difflugia constricta*, or the spineless form of *Centropyxis aculeata*.

The range of size is considerable. The smallest specimens, found among moist earth, measured about 0.036 mm. long by 0.03 mm. broad, with the mouth 0.015 mm. The largest specimens, from the ooze of a pond, measured 0.3 mm. in diameter, with the mouth 0.16 mm.

DIFFLUGIA PYRIFORMIS.

PLATES X; XI; XII, figs. 1–18; XV, figs. 32, 33; XVI, fig. 38; XIX, figs. 24–26.

Difflugia. Leclerc: Mém. Mus. Hist. Nat. 1815, ii, 474, pl. 17, fig.

Difflugia pyriformis. Perty: Mittheil. Naturf. Gesells. Bern, 1848, 168; Kennt. kleinst. Lebensformen, 1852, 187, Tab. ix, Fig. 9.—Pritchard: Hist. Infusoria, 1861, pl. xxi, fig. 17.—Carter: An. Mag. Nat. Hist. xii, 1863, 249; xiii, 1864, 21, pl. i, fig. 1.—Wallich: An. Mag. Nat. Hist. xiii, 1864, 240, pl. xvi, figs. 9, 10, 39, 40.—Ehrenberg: Ab. Ak. Wis. Berlin, 1871, 264.—Leidy: Pr. Ac. Nat. Sc. 1874, 14, 79; 1877, 307.

Difflugia proteiformis. In part of Lamarck and Ehrenberg = Leclerc's figs. 2, 3, pl. 17, Mém. du Mus. d'Hist. Nat. ii, 1815.

Difflugia ——— ? Carter: An. Mag. Nat. Hist. xiii, 1864, 29, pl. i, fig. 11.
Difflugia proteiformis, subsp. *D. mitriformis*, var. *D. pyriformis*. Wallich: An. Mag. Nat. Hist. xiii, 1864, 240.
Difflugia compressa. Carter: An. Mag. Nat. Hist. xiii, 1864, 22, pl. i, figs. 5, 6.—Leidy: Proc. Ac. Nat. Sc. 1874, 14; 1875, 307.
D.: Corticella pyriformis. Ehrenberg: Abh. Ak. Wis. Berlin, 1871, 247.
Difflugia entochloris. Leidy: Proc. Ac. Nat. Sc. 1874, 79; 1875, 307.
Difflugia vas. Leidy: Pr. Ac. Nat. Sc. 1874, 155; 1875, 307.
Difflugia nodosa, var. of *pyriformis*. Leidy: see following pages.
Difflugia cornuta, var. of *pyriformis*. Ibidem.

Shell pyriform, flask-shaped, or ovoid, with the narrower pole prolonged into a neck of variable length, of uniform transverse diameters, or more or less compressed; fundus obtusely rounded or subacute, or more or less expanded and variably produced into from one to three conical processes; neck gradually and evenly narrowed to the oral end, cylindroid, sometimes constricted; mouth inferior, terminal, circular, or slightly oval. Structure of the shell usually of angular particles of quartz-sand, sometimes mingled with diatoms; less frequently composed of chitinoid membrane, with variable proportions of diatoms and sand. Sarcode mostly with the endosarc bright green, from the presence of chlorophyl grains, but often colorless, except as modified by the presence of food.

Size.—Ranging from 0.06 to 0.58 mm. long, 0.04 to 0.24 mm. broad; mouth 0.016 to 0.12 mm. wide.

Locality.—Everywhere in the ooze of ponds, ditches, and bogs.

Observed in Pennsylvania, New Jersey, Rhode Island, Connecticut, Florida, Alabama, Nova Scotia, Colorado, Utah, Fort Bridger, and Uinta Mountains, Wyoming.

VARIETY 1.—*D. pyriformis;* the ordinary characteristic form, with the opposite diameters uniform. See pl. X.

VARIETY 2.—*D. compressa;* like the preceding, but more or less compressed. See pl. XI, figs. 1–6; pl. XII, figs. 10–16.

VARIETY 3.—*D. nodosa;* usually a large form like the latter, but with the fundus variably produced into from one to three eminences. See pl. XI, figs. 7–22.

VARIETY 4.—*D. cornuta;* pyriform, with the fundus provided with one or two pointed conical processes. See pl. XII, figs. 17, 18.

VARIETY 5.—*D. vas;* like the ordinary form, but with the neck defined from the body by a constriction. See pl. XII, figs. 2–9.

Difflugia pyriformis is one of the most common species, and it presents much variety of shape and size.

The shell is ordinarily flask-like or baloon-form, or, as indicated by the specific name, pear-shaped, with an oval or ovoid body more or less gradually prolonged into a neck, which tapers to the mouth or is cylindroid, and of variable proportionate length. Usually the shell is of uniform diameters, but is sometimes more or less compressed so as to be wider in one direction. Occasionally specimens occur exhibiting some want of bilateral symmetry. The fundus of the shell is mostly regularly rounded, but sometimes is more or less subacute. The mouth is inferior, terminal, and circular or oval.

Characteristic specimens of the ordinary forms, exhibiting considerable variety in exact shape, size, and structure, are represented in pl. X.

Specimens of *Difflugia pyriformis* of the ordinary kinds have a wide range in size. Some of the smallest measure only the $\frac{1}{400}$th of an inch, while large ones reach ten times that length.

Compressed forms of *D. pyriformis*, constituting what I have viewed as the variety—and agreeing with Mr. Carter's species—*D. compressa*, are unfrequent compared with those with more uniform diameters. Intermediate conditions occur, showing the gradation of one form into the other. In *D. compressa*, the shell exhibits variable degrees of compression, sometimes comparatively little, at others to such an extent that the shell is twice the breadth in one direction that it is in the other. The length usually exceeds the greater breadth, but rarely the latter actually exceeds the former. Specimens exhibiting various degrees of relative breadth are represented in figs. 10–16, pl. XII.

The size of compressed specimens I have found to range as follows: Length $\frac{1}{125}$th to $\frac{1}{66}$th of an inch; greater breadth $\frac{1}{164}$th to $\frac{1}{104}$th of an inch; lesser breadth $\frac{1}{284}$th to $\frac{1}{156}$th of an inch; with the oral end $\frac{1}{520}$th to $\frac{1}{208}$th of an inch in the greater width.

A striking variety of *D. pyriformis*, certainly not distinct from this as a species, I have named *D. nodosa*. It is not an unfrequent associate with the more ordinary form, and is distinguished by its usually large size, its more or less compressed form, and its broad fundus, which is produced into from one to three knobs or conical eminences, varying greatly in degree of development.

In the summer of 1874, I found this variety in extraordinary profusion in Swarthmore brick-pond, and all the specimens of pl. XI were derived from this locality. The subsequent two seasons I could find none of the kind in the same pond, but in 1877 it again appeared in moderate quantity.

When first discovered, the specimens were so abundant that a drop of ooze, in which the animal lived, would often contain several dozen individuals.

They were remarkable for their large size, and the bright green color and activity of the animal. Notwithstanding the great number of individuals, scarcely two could be found in all respects alike. The general shape was that of the ordinary *D pyriformis*, usually more or less compressed; but the proportions varied considerably. Commonly the breadth was nearly or quite double in one direction what it was in the other; but sometimes the compression was trifling, when the shell presented the ordinary form of *D. pyriformis*. Commonly the greatest breadth occupied the upper third or fourth of the shell.

In the view of the specimens from the narrower side, the shape was pretty uniformly pyriform. In the view from the broader side, the lateral border varied from an inclined plane to a concave line, while the fundus varied exceedingly; sometimes from evenly convex to obtusely angular; sometimes from horizontally straight to concave; sometimes with a single median eminence, a pair of lateral eminences, or a transverse row of three, and all variable in their proportions. Unsymmetrical forms also occurred, in which the knobs or eminences on one side of the shell were disproportionately produced.

The size of the knobby specimens, from Swarthmore pond, ranged as follows: the smallest specimen was $\frac{1}{62}$d of an inch long; $\frac{1}{89}$th of an inch in the greater, and $\frac{1}{156}$th of an inch in the lesser breadth. A large specimen measured $\frac{1}{44}$th of an inch long; $\frac{1}{89}$th of an inch in the greater, and $\frac{1}{138}$th of an inch in the lesser breadth, with the oral end $\frac{1}{178}$th of an inch wide

In my early observations on the variety *D. nodosa*, I was led to view it as a species distinct from *D. pyriformis*, and from the bright green color of the endosarc I named it *D. entochloris*.

Another variety of *Difflugia pyriformis*, which I formerly supposed to be a distinct species, I named *D. vas*. It has the shape of the more characteristic specimens of *D pyriformis*, but has the neck defined from the body by a narrow constriction, as seen in figs. 2–9, pl. XII. I think there can be but little doubt that this variety and the ordinary more familiar form of *D. pyriformis* merge into one another; and I have met with various intermediate forms. See figs. 24–26, pl. XIX.

The specimens vary greatly in size, and this is also the case in the proportions of the body and neck of the shell. Ordinarily those from Absecom pond range from $\frac{1}{80}$th to $\frac{1}{60}$th of an inch in length. The smallest specimen observed, from Swarthmore brick-pond, was $\frac{1}{90}$th of an inch long and $\frac{1}{297}$th of an inch broad. The largest one, from Absecom pond, was $\frac{1}{56}$th of an inch long by $\frac{1}{90}$th of an inch broad.

Still another variety which I have occasionally seen is represented in figs. 17, 18, pl. XII. It may be distinguished as *D. cornuta*, and has the characteristic form of *D. pyriformis*, but has the fundus provided with one or two conical spines. This variety I have observed to approximate by intermediate forms the more characteristic ones of *D. acuminata*.

The shell of *Difflugia pyriformis* is commonly composed of coarse, irregular grains of hyaline quartz-sand, and is often the roughest of its kind; though sometimes, considering the coarseness of the materials, the shell is wonderful for its evenness. The shell may be composed altogether of comparatively large stones, or it may be partly constructed of these more or less uniformly distributed, with the intervals filled in with smaller ones. Sometimes the larger stones especially occupy the fundus or the greater part of the body, and the neck is composed of smaller ones; sometimes the arrangement is reversed, and sometimes the largest stones are arranged contiguous to the mouth. Not unfrequently one or several stones greatly exceed the others, and produce conspicuous unsymmetrical projections in the shell, as seen in figs. 6–9, 12–15, pl. X; figs. 37, 38, pl. XVI.

It may not be unworthy of remark, that the coarsest and most uneven specimens are found together in association with the smoothest, in the same localities and apparently under the same circumstances.

Less frequently the shell of *Difflugia pyriformis* is constructed of an intermixture of quartz-sand and diatoms in varying proportions, usually the former predominating, but sometimes the latter. Large naviculas are often conspicuous among the building materials, and occasionally spicules of the fresh-water sponge are noticed with them. Such specimens are represented in figs. 13, 15, 18–21, pl. X. Sometimes the shell of *D. pyri-*

formis consists of chitinoid membrane, colorless or straw-colored, and having incorporated variable quantities of diatoms and sand, as seen in figs. 22–26, pl. X. Specimens of this kind, of the smallest size, occasionally met with, are remarkable for the great proportionate size of the adherent diatoms, as seen in figs. 22, 23, reminding one of the cases of the basket-worm (*Thyridopteryx*), often seen suspended from the branches of the arbor-vitæ and other trees.

Rarely I have seen a Difflugia, referable to *D. pyriformis*, in which the shell appeared to be composed of chitinoid membrane incorporated with flocculent black matter, apparently from the sediment of the locality in which the creature was found. Such a specimen is represented in fig. 27, pl. X.

The shell of *D. pyriformis*, in all the specimens included as varieties under the names of *D. compressa*, *D. nodosa*, *D. vas*, and *D. cornuta*, as seen in the various figures of these, in plates XI and XII, was composed exclusively of angular particles of quartz-sand. Rare, indeed, is it to see a rounded particle of quartz-sand entering into the construction of the shell of any Difflugia; but an example of one such shell, pertaining to *D. pyriformis*, exhibiting several rounded sand grains, is seen in fig. 15, pl. X.

The interior sarcode of *Difflugia pyriformis*, as usual in the genus from the nature of the shell, is greatly obscured from view. Commonly, the greater portion of the mass occupying the body of the shell is of a bright green color due to the presence of an abundance of chlorophyl granules, which appear to be an intrinsic element of structure of the endosarc. Less frequently the sarcode appears to be in greater part or even entirely colorless, except that the central portion may be more or less colored by the presence of food contents.

The expressed sarcode of *D. pyriformis* usually exhibits a faintly granular and colorless basis mingled with variable proportions of bright green chlorophyl granules, and others which are colorless and darkly defined and resemble starch. Besides these, there may be seen a large and clear or faintly granular nucleus, together with the varied constituents of the food. In individuals with uncolored sarcode, the chlorophyl granules are absent, and such also appears to be the case with most of the starch-like granules. Sometimes, in the bright green specimens, the expressed nucleus exhibits a uniform and distinct granular appearance. Mr. Carter, in an account of the structure of the sarcode of *Difflugia pyriformis*, indicates two different conditions or stages as above described. The chlorophyl granules, when present, he regards as part of the structure of the animal, as much so as the same colored element is, in the green fresh-water polyp (*Hydra viridis*). Colorless granules, in association with the green ones, he determined to be of the nature of starch, and these he also regards as part of the structure of the animal. In the colorless stage of the latter he further intimates the absence of the chlorophyl and a diminution in the quantity of the starch.*

According to the same able investigator, the green condition of the sarcode is associated with greater activity of the animal, and is especially common in the spring season; while the colorless condition, indicative of more passive habit, occurs in autumn. The changes in color he supposes to be connected with changes in the nucleus, and to be related with the reproductive process.

The Swarthmore specimens, above mentioned, found in such profusion in the summer of 1874, were all possessed of a bright green endosarc, and were in the most active condition. Neither before nor since have I met with any form of Difflugia which exhibited more lively movements, and such varied changes in the appearance of the pseudopods Extreme extension of the latter was accompanied by an influx of more or less of the endosarc with chlorophyl and starch-like granules. Of the many changes presented by the pseudopods, examples are given in the figures of pl. XI.

While it has occurred to me to see multitudes of *Difflugia pyriformis* in all its varieties of the ordinary form, and of *D. compressa*, *D. nodosa*, and *D. vas*, with the sarcode in a bright green condition, at all temperate seasons of the year, I have also observed them in the colorless condition in variable, but comparatively small, proportion, at the same times and in the same localities. The animal is also to be seen of every grade, from that in which the body of the shell appears in greater part to be occupied by a bright green endosarc, to that in which all color is absent except what is due to the presence of food. Commonly, when the bright green specimens of *D. pyriformis* are abundant, the uncolored ones are comparatively few. I have further observed bright green specimens of *D. pyriformis*, in which the sarcode was not only in a passive condition, but was contracted into a central

* Annals and Magazine of Natural History, xii, 1863, 249.

ball occupying the body of the shell. Not unfrequently specimens appear as if the color of the sarcode, as it is ordinarily seen, had undergone a change into a yellowish or brownish hue.

Difflugia pyriformis was first described with this name by Perty,* from specimens collected in Switzerland. Two of the figures accompanying Leclerc's original description of the characters of the genus Difflugia appear to belong to the same.† These figures Ehrenberg‡ refers to his own *D. proteiformis*, attributing the name to Lamarck,§ who, however, applied it without discrimination to all the forms, comprising three distinct ones, described by Leclerc as representing the genus. Ehrenberg's figures and description of *D proteiformis*,‖ as I have before intimated, appear rather to apply to the *D. globulosa* of Dujardin.¶ Ehrenberg remarks of *D. oblonga*, described and figured in the 'Infusionsthierchen' as a form with a purely chitinoid shell, that if it is the same as the *D. pyriformis*, of Perty, deprived of its incrusting material, as intimated by Claparède and Lachmann, the latter name should be disused.** This would be just, if we could be positive of the relation of *D. oblonga* with *D. pyriformis;* but in its shape it appears rather to be related with *D. acuminata* without its point. Carter†† and Wallich‡‡ describe *Difflugia pyriformis* as occurring both in England and India. The latter author refers the more ordinary form, as a variety, to a subspecies which he names *D. mitriformis.* Figures of the latter, with one or two points to the fundus, he refers to *D. acuminata* as another variety of *D. mitriformis.*§§

Lang describes a form under the name of *D. triangulata,* the figures of which remind me of the knobby variety of *D. pyriformis.* The shell is described as triangular, flat, membranous, and reticulated.‖‖

Difflugia pyriformis by gradual transition merges into *D. globulosa, D. acuminata*, etc.

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* Kennt. kleinst. Lebensformen, 187.

† Mém. Mus. Hist. Nat. ii, 1815, pl. 17, figs. 2, 3.

‡ Infusionsthierchen, 131.

§ Animaux sans Vertèbres.

‖ Infusionsthierchen, Taf. ix, Fig. i.

¶ An. Sc. Nat. 1837, viii, 311, pl. ix, fig. 1; Hist. Nat. Infusoires, 248, pl. ii, fig. 6.

** Abh. Ak. Wis. Berlin, 1871, 256.

†† An. Mag. Nat. Hist. xii, 1863, 249.

‡‡ Ibid. xiii, 1864, 240.

§§ Ibid. pl. xvi, figs. 7, 8, 12 *b*.

‖‖ Quart. Jour. Mic. Sc. v, 1865, 285.

DIFFLUGIA URCEOLATA.

PLATES XIV; XVI, figs. 32–34; XIX, figs. 28, 29.

Difflugia urceolata. Carter: An. Mag. Nat. Hist. xiii, 1864, 27, 37, pl. i, fig. 7.—Leidy: Pr. Ac. Nat. Sc. 1877, 307.
Difflugia lageniformis. Wallich: An. Mag. Nat. Hist. xiii, 1864, 240, pl. xvi, figs. 15, 16.—Leidy: Pr. Ac. Nat. Sc. 1874, 14.
Difflugia proteiformis, subspecies *D. mitriformis,* var. *D. lageniformis.* Wallich: Ibid.
Difflugia amphora. Leidy: Proc. Ac. Nat. Sc. 1874, 79.
Difflugia olla. Leidy: Proc. Ac. Nat. Sc. 1874, 156; 1877, 307.

Shell amphora-form; body spheroid, ovoid, or ovate, with the fundus obtusely and evenly rounded, or more or less acute, or acuminate, and rarely furnished with several usually blunt spines; neck short, more or less contracted; mouth large, circular, terminal, with or without a rim of variable breadth, usually reflected and terminating in a thin delicate edge. Structure of the shell commonly of hyaline quartz-sand; rarely of chitinoid membrane with variable proportions of diatoms and sand. Sarcode colorless; pseudopods many, digitate, simple, and branching.

Size.—Of the spheroid forms, from 0.18 mm. to 0.44 mm. long by 0.14 mm. to 0.38 mm. broad; of the ovoid forms, 0.2 mm. to 0.52 mm. long by 0.14 mm. to 0.36 mm. broad.

Locality.—Ditches and ponds in the vicinity of Philadelphia; ponds of sphagnous swamps in New Jersey; pools and ponds at Fort Bridger, on Bridger Butte, and in the Uinta Mountains, to an elevation of 10,000 feet, Wyoming Territory.

Difflugia urceolata was originally described by Mr. Carter from specimens found in England. It is represented as of oval form, slightly prolonged to form a short neck, and with a rim slightly reflected. Its size is stated at $\frac{1}{83}$d of an inch in length and $\frac{1}{92}$d of an inch in breadth.

The species was described the same year by Dr. Wallich, likewise from specimens found in England, under the name of *Difflugia lageniformis.* It is represented of oval form, with a short contracted neck and a strongly reflected lip.

Difflugia urceolata is the largest species of the genus, and is common in the ooze of ditches traversing the meadows below the city of Philadelphia, and communicating with the Delaware and Schuylkill Rivers. It is also frequent in the ponds of sphagnous swamps, such as those of Atco, and

Absecom, and Lake Hatacawanna, New Jersey; and I also found it abundantly in ponds of the Uinta Mountains, Wyoming Territory.

Ordinarily the shell of *Difflugia urceolata* strikingly resembles the ancient Roman amphora. The body of the shell varies from a globular shape to a more or less ovoid form. The upper extremity, or fundus, is obtusely rounded or more or less acute, and sometimes it is rounded and more or less acuminate.

The neck is a short and slight cylindrical constriction from the body. The mouth is large and circular, and frequently truncates the neck; but, mostly, it is surrounded by a lip of variable breadth, usually more or less reflected, and terminated by a thin delicate edge. Sometimes the neck is more or less everted, and terminates at the mouth without extending in a circular lip or rim. Pl. XIV, figs. 1–8; pl. XVI, figs. 33, 34.

The size of the spheroidal forms of *D. urceolata* ranges from about the $\frac{1}{180}$th to the $\frac{1}{60}$th of an inch in diameter; the ovoid forms measure from the $\frac{1}{120}$th to the $\frac{1}{48}$th of an inch in length.

In the ponds of sphagnous swamps of New Jersey, a variety of *D. urceolata* is common, in association with the more ordinary forms, in which the fundus of the shell is provided with usually from three to half a dozen nipple-shaped spines. This constitutes the variety I formerly named *D. olla.* The shell is commonly of the shape of the spheroidal form of *D. urceolata.* The spines are mostly blunt, and often terminate in a single stone flake of greater width than the spine at its point of attachment. They are arranged in a circle, more or less regular, around the fundus, usually unaccompanied by a central spine, though occasionally also there is one in this position. They are mostly shorter, less acute, and less eccentric than the conical spines in a similar position in *D corona.*

Examples of the variety named *D. olla* are represented in figs. 10–13, pl. XIV; fig. 32, pl. XVI; and figs. 28, 29, pl. XIX.

The shell of *Difflugia urceolata* is composed, as is generally the case in other species of the genus, of colorless angular particles of quartz-sand, mostly of larger ones scattered with some appearance of regularity, while the intervals are occupied with smaller ones. The surface of the shell, though often uneven, is less so commonly than in some of the smaller species of Difflugia. Frequently larger stones occupy the neck of the shell, but passing thence they gradually become smaller approaching the edge of the rim or reflected lip.

Only in the variety with spines to the fundus, previously indicated as *D. olla*, from the sphagnous ponds of New Jersey, have I seen a few specimens in which the shell was composed of colorless chitinoid membrane, incorporated with diatoms and fine sand grains, as seen in fig. 29, pl. XIX.

The interior sarcode of *D. urceolata*, in all its variety of forms and in all seasons, I have found to be colorless, independently of the hues given to the central portion of the endosarc by the varied nature of the food. The pseudopods are ordinarily from two or three to half a dozen, and of the usual simple digitate kind.

Difflugia urceolata by transitional forms merges into *D. acuminata.*

DIFFLUGIA CRATERA.

PLATES XII, figs. 19–21; XVI, fig. 35.

Difflugia cratera. Leidy: Proc. Ac. Nat. Sc. 1877, 307.

Shell goblet-shape, with oval or spheroidal body and wide cylindroid neck; fundus obtuse; mouth terminal, large, circular, truncating the neck, or with a reflected rim. Composed of colorless chitinoid membrane, incorporated with minute particles of sand and dirt.

Size.—Length 0.056 mm. to 0.066 mm.; breadth of body 0.036 mm. to 0.042 mm.; breadth of neck 0.028 mm. to 0.036 mm.

Locality.—Among Ceratophyllum and other aquatic plants. Canal at Bristol, Berks County, Pennsylvania; Buffalo, New York.

Difflugia cratera is one of the smallest species of the genus, and, though apparently rare, may be common enough, but have escaped frequent observation from its diminutive size. I first found it among hornwort, collected in the canal at Bristol, Pa., August, 1876, and noticed about a dozen individuals. I have since met with it recently, August, 1878, in some sediment from the water-supply of Buffalo, New York. The sediment sent to me, on a glass slip, for examination, consisted mainly of the curious four-spined infusorian, *Ceratium longicorne*, and with it I detected two individuals of *Difflugia cratera.* All the specimens observed appeared to be empty shells, though it is not improbable some of them may have contained the living sarcode, which, being contracted and transparent, escaped notice.

Later, October, 1878, in an additional supply of sediment, received from Buffalo, in association with *Ceratium longicorne*, I observed a number of specimens of the same little Difflugia.

The Bristol specimens of *Difflugia cratera* varied but slightly in any respect. The shell, as represented in figs. 19, 20, pl. XII, was goblet-shaped, with the body and neck of nearly equal length. The body, a little longer than the neck, was ovoid, with the narrower pole forming the fundus of the shell. The neck was wide, cylindroid, and slightly expanded approaching the mouth, which was large, circular, and terminal.

The Buffalo specimens differed considerably from the former, as well as among themselves, as seen in fig. 21, pl. XII, and fig. 35, pl XVI. The beautiful goblet-shaped shells varied in the proportionate length of the body and neck. The former was more or less oblately spheroidal, and the latter longer or shorter than the body, and expanded in variable degrees approaching the mouth.

In all the specimens, from both localities, the shell was composed of colorless chitinoid membrane, which exhibited a minutely wrinkled appearance, and sparsely scattered over the surface there were a few minute sand grains and fine particles of dirt.

The Bristol specimens measured about 0.056 mm. in length; the Buffalo specimens ranged from 0 066 mm to 0.072 mm. in length.

Since the above was written, it has occurred to me that the minute shells, referred to *Difflugia cratera*, may perhaps pertain to a species of ciliated infusorian, of the genus *Tintinnus*.

DIFFLUGIA ACUMINATA.

PLATE XIII.

Difflugia. Leclerc: Mém. Mus. Hist. Nat. ii, 1815, 474, pl. 17, fig. 5.
Difflugia acuminata. Ehrenberg: Infusionsthierchen, 1838, 131, Taf. ix, Fig. iii.—Perty: Kennt. kleinst. Lebensformen, 1852, 187.—Leidy: Pr. Ac. Nat. Sc. 1874, 14, 79; 1877, 307.
Difflugia acuminata, var. *acaulis.* Perty: Ante, 187, Taf. ix, Fig. 6.
Difflugia bacillariarum. Perty: Ante, 187, Taf. ix, Fig. 7.
Difflugia pyriformis. Carter: An. Mag. Nat. Hist. xii, 1863, 251; xiii, 1864, 36, "acuminated variety," pl. i, fig. 1 *l*.
Difflugia proteiformis, var. *acuminata.* Wallich: An. Mag. Nat. Hist. xi, 1863, 453, pl. x, fig. 13.
Difflugia ——? Carter: An. Mag. Nat. Hist. xii, 1864, 29, pl. i, fig. 10.
Difflugia proteiformis, subspecies *D. mitriformis*, var. *D. acuminata.* Wallich: An. Mag. Nat. Hist. xiii, 1864, 240, pl. xvi, figs. 11, 12.
D. Corticella acuminata. Ehrenberg: Abh. Ak. Wis. Berlin, 1871, 247.

Shell amphora-form or oblong oval, pyriform, or cylindroid with the upper part more or less inflated; fundus acute, acuminate, or prolonged into a nipple-shaped process, rarely with two or three points; neck long, short, or none; mouth large, terminal, circular; lip usually straight. Composed of angular quartz-sand, sometimes with intermingled diatoms, rarely of the latter altogether, sometimes of chitinoid membrane with scattered sand and diatoms. Sarcode colorless; pseudopods as usual in the genus.

Size.—Smallest specimens with shell of sand were 0.1 mm. long, 0.048 mm. broad, and 0.032 mm. wide at the mouth; large pyriform specimens of sand, 0.4 mm. long, 0.184 mm. broad, and 0.064 wide at the mouth; largest cylindroid ones of stones, 0.520 mm. long, 0.12 mm. broad, and 0.1 mm. wide at the mouth. Smallest specimens with the shell of diatoms measured about 0.084 mm. long, 0.036 mm. broad, and 0.024 mm. at the mouth.

Locality.—Ditches near Philadelphia, Swarthmore pond, Darby pond, Pennsylvania; Absecom pond, and ponds of Atco, Kirkwood, and other sphagnous swamps of New Jersey; ponds at Fort Bridger and Uinta Mountains, Wyoming Territory. France, Leclerc; Berlin, Ehrenberg; Switzerland, Perty; England, Carter and Wallich.

The shell of **Difflugia acuminata** in shape is like an ancient Roman amphora, or is oblong oval, gradually narrowing toward the oral extremity, and acute or tapering at the summit; or it is pyriform, with the fundus in the latter condition; or it is cylindroid, more or less inflated above, and tapering at the fundus. See pl. XIII. The mouth is terminal, circular, and large, with the lip straight or slightly contracted and rarely slightly everted. In one instance only, as seen in fig. 12, have I seen it surrounded by a projecting rim. The shell either narrows from the body gradually and regularly to the mouth, or more or less abruptly, forming a neck of variable length, sometimes short, sometimes long, and of every intermediate degree. The longer-necked varieties present us with the pyriform and drop-tube-like shells.

The fundus of the shell presents various degrees of acuteness, passing into a more or less acuminate condition or prolonged into a nipple-like process, which may be short and thick, or long and narrow. The process is usually straight, but is often bent to one side, and sometimes occupies a position unsymmetrically to one side. Rarely there are two or three processes to the fundus, as seen in figs. 25–29, pl. XII.

The amphora-like specimens of *Difflugia acuminata* graduate into *D.*

urceolata, and the pyriform varieties into *D. pyriformis*, while the drop-tube-like forms are the most peculiar or characteristic.

The shell of *Difflugia acuminata* is ordinarily composed of clear quartz-sand, as in *D. pyriformis*. Occasionally I have seen particles of garnet mingled with the former, as represented in figs. 14, 15, pl. XIII. Sometimes the quartz-sand is mingled with variable proportions of diatoms.

Not unfrequently the shell is composed of colorless chitinoid membrane, incorporated with quartz-sand alone or with this and intermingled diatoms. In this kind usually the grains of sand are closely placed in juxtaposition at and near the mouth of the shell, but are elsewhere scattered and separated by wide intervals. In some cases, the shell is more or less covered with large diatoms, generally adherent in the length, and diverging upward beyond the boundary of the shell, as seen in figs. 21, 22.

Certain specimens found among sphagnum consisted entirely of diatoms, as seen in figs. 23–26, in most cases (which is unusual) still retaining portions of the endochrome.

The sarcode of *Difflugia acuminata* is colorless, excepting the usual coloring in the endosarc dependent on the presence of food, though I have met with an individual, as seen in fig. 15, in which the endosarc was bright green. In this case the color may have been due to the food, as the specimen was obtained from among an abundance of green algæ. It should be mentioned, however, in this relation, that most of the specimens from which drawings were made were empty shells, chosen on account of their comparative translucency and distinctness of structure.

The range of size of *Difflugia acuminata* is considerable. The smallest ones observed are those composed of diatoms, from sphagnum. These are about the $\frac{1}{285}$th of an inch in length by the $\frac{1}{625}$th of an inch in breadth.

One of the smallest amphora-like shells, composed of sand, measured the $\frac{1}{200}$th of an inch long by the $\frac{1}{300}$th of an inch broad. One of the largest amphora-like shells, composed of sand, measured the $\frac{1}{60}$th of an inch long by the $\frac{1}{140}$th of an inch broad; and one of the largest pyriform shells had nearly the same measurement. The largest drop-tube-like shell measured nearly the $\frac{1}{20}$th of an inch long by the $\frac{1}{250}$th of an inch in breadth.

Difflugia acuminata is one of the commonest of the genus, and is found almost everywhere with other familiar kinds of Difflugia. It is one of the three forms originally indicated and figured by Leclerc as characteristic of the genus. It was described and figured by Ehrenberg in the 'Infusionsthierchen,' and was first specifically named by him. It was also figured and described under the same name by Perty, and subsequently likewise by Carter and Wallich.

Perty represents a specimen in which the shell appears to be composed of chitinoid membrane incorporated with scattered quartz grains. He also figures and describes another under the name of *Difflugia bacillariarum*, which appears to be a variety of *D. acuminata* in which the shell is composed of diatoms.

DIFFLUGIA LOBOSTOMA.

PLATE XV, figs. 1–24; XVI, figs. 25–29.

Difflugia proteiformis. Carter: An. Mag. Nat. Hist. xviii, 1856, 128.
Difflugia tricuspis. Carter: An. Mag. Nat. Hist. xviii, 1856, 221, pl. vii, fig. 80.—Ehrenberg: Ab. Ak. Wis. Berlin, 1871, 264.
Difflugia oblonga. Fresenius: Abh. Senckenb. Naturf. Gesells. ii, 1856–8, 225, Taf. xii, Fig. 43–45.
D. Exassula tricuspis. Ehrenberg: Abh. Ak. Wissens. Berlin, 1871, 246.
Difflugia lobostoma. Leidy: Pr. Ac. Nat. Sc. Phil. 1874, 79; 1877, 307.
Difflugia crenulata. Leidy: Pr. Ac. Nat. Sc. Phil. 1874, 79.

Shell ovoid, oval, or nearly spherical, usually composed of quartz-sand, rarely in part or wholly of diatoms or of chitinoid membrane with a few quartz particles; mouth terminal, usually from three- to six-lobed, occasionally more; fundus obtusely rounded. Sarcode colorless, or with the endosarc colored green from the presence of abundance of chlorophyl granules; pseudopods to half a dozen or more, and exhibiting the usual shape and changes as in other species.

Size.—Ordinarily about 0.12 mm. long and 0.1 mm. broad, with the mouth 0.032 mm. wide. Ranging from 0.08 mm. long by 0.06 mm. broad, with the mouth 0.024 mm. wide, to 0.14 mm. long by 0.128 mm. broad, with the mouth 0.048 wide.

Locality.—Ponds and ditches in the vicinity of Philadelphia; Swarthmore brick-pond, and ponds on Darby Creek, Delaware County; Morrisville pond, Berks County; ponds in vicinity of Easton, Northampton County, Pennsylvania; ponds in New Jersey; Spencer pond, Maine; vicinity of Jacksonville, Florida; Fort Bridger and Uinta Mountains, Wyoming Territory. Bombay, Carter; Germany, Fresenius.

Difflugia lobostoma is one of the most common species, and may be found more or less abundantly in the ooze, or among algæ, in ponds and ditches where other kinds occur. As usually observed, it is seen lying on the side, and it often requires patient manipulation to make it turn in such a way as to obtain a view of the mouth, on the peculiar character of which its specific distinction mainly depends. As ordinarily seen, it bears so close a resemblance with the corresponding views of *Difflugia proteiformis*, as described and figured by Ehrenberg,* that it may not only be readily taken for the same, but I have suspected that Ehrenberg may have actually had this animal under observation when he described *D. proteiformis.* Ehrenberg, however, makes no allusion to the character of the mouth of the latter, and subsequently, in referring to one of the varieties of *D. lobostoma*, described by Mr. Carter, first as *D. proteiformis*, and then, from the trilobate condition of the mouth, as *D. tricuspis*, he does not even hint that the latter is synonymous with his *D. proteiformis.* †

The name of *Difflugia proteiformis* is exceedingly indefinite in its application. It was originally applied by Lamarck, ‡ without discrimination, to all the forms figured and described by Leclerc as characteristic of the genus Difflugia.§ Ehrenberg, attributing the name to Lamarck, applied it to a new form, and ascribed one of the forms represented by Leclerc to the same species. ‖ Dr. Wallich uses the name of *Difflugia proteiformis* in a sort of generic sense, and regards all other forms of the genus ordinarily recognized as transitional subspecies and varieties.¶

As previously intimated, Mr. Carter applied the name of *D. proteiformis* to a species, and subsequently, from the trilobate form of the mouth, named it *Difflugia tricuspis.***

The late Prof. Bailey, of West Point, New York, in his Microscopical Observations made in South Carolina, Georgia, and Florida, mentions the occurrence of *D. proteiformis*, but gives no clue as to the particular form he viewed as this species.††

Ehrenberg's description of *D. proteiformis* is too incomplete to determine whether it applies to what I have viewed as the *D. globulosa* of Dujardin, or the present species, which I have named, from the peculiar character of the mouth, *D. lobostoma.* I was led to reject Mr. Carter's name of *D. tricuspis*, evidently applied to the same, as it is objectionable, if we include

* Infusionsthierchen, 131, Taf. ix, Fig. i.
† Abh. Ak. Wis. Berlin, 1871, 238, 264.
‡ Animaux sans Vertèbres, ii, 1816.
§ Mém. Mus. Hist. Nat. t. ii, 474, pl. 17.
‖ Infusionsthierchen, 131.
¶ An. Mag. Nat. Hist. xiii, 1864, 215.
** Ibid. xviii, 1856, 128, 221.
†† Smithson. Contrib. ii, 1850.

with the species all the varieties in which the number of cusps, or rather lobes, to the mouth, varies from three to half a dozen or more. A variety of the same species, with a five-lobed mouth, is figured and described by Fresenius, and referred by him to the *D. oblonga* of Ehrenberg.* The reference is, however, improbable, for Ehrenberg, in speaking of the *Difflugia tricuspis* of Carter, remarks that Fresenius regards it as *D. oblonga*, but adds that he had not perceived a three-lobed mouth to the latter,† from which it may be suspected that no lobes whatever were present, as appears to be the case, if we may found an opinion on the figures of that form in the 'Infusionsthierchen.'

The shell of *Difflugia lobostoma* is commonly ovoid, with the mouth situated at the narrower pole. Less frequently it is oval or nearly spherical, or the ovoidal form may be more or less prolonged at the narrower pole, so as to assume a sub-pyriform shape. The mouth may truncate the shell, or it may not interfere with the curvature of the oral pole, or this may more or less protrude so as to form a short neck or rim.

Usually the mouth is trilobed, or is bordered with three rounded lobes or sinuses separated by angular points, and resembles the trefoil opening employed in architectural decoration, as seen in figs. 1, 3, pl. XV. The number of lobes of the mouth may, however, vary from that given to half a dozen or more. Next in frequency to the trilobate mouth, according to my experience, is the six-lobed mouth, as seen in figs. 10, 12, and after this comes the quadrilobate mouth, as seen in figs. 5, 8, 16.

Large specimens, with a many-lobed mouth, approximate *Difflugia corona*, and indeed I have observed so many of intermediate condition in all respects, that there is little doubt that the two species merge into one another.

The shell of *Difflugia lobostoma* is usually composed of angular quartz-sand, in common with other species of the genus. Rarely it is composed of diatoms, or diatom-like plates, together with fragments of others, sometimes with variable proportions of quartz-sand. Small shells occasionally occur composed of chitinoid membrane with quartz particles incorporated. Individuals in which the shell is composed wholly of quartz-sand are represented in figs. 1–15, pl. XV.

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* Abh. Senckenb. Naturf. Gesells. ii, 1856–8, 225.

† Abh. Ak. Wis. Berlin, 1871, 238, 239.

Specimens in which the shell is composed of thin angular siliceous plates, consisting at least in part of diatoms and fragments of others, found usually in sphagnous swamps, are represented in figs. 18–20.

In several instances I have found specimens of large size, especially in ponds of the Uinta Mountains, as represented in figs. 16, 17, in which the shell was composed of rectangular and oval plates defined by interrupted or dotted lines, the nature of which I did not determine.

Another variety, observed in a few instances, from Woodstown pond, Gloucester County, New Jersey, had a mammillated shell, as represented in figs. 21, 22. The mulberry appearance of the shell reminds one of the figure of a form designated by Dr. Wallich as *Difflugia tuberculata.* The specimen had a six-lobed mouth with a short rim, but the composition of the shell I failed to make out.

In several instances, once at Morrisville pond, Berks County, and the other in the ditches below Philadelphia, I found peculiar translucent pale yellowish specimens, such as are represented in figs. 25, 26, pl. XVI. The ovoid shell, with trilobate mouth, appeared to be composed of a cancellated membrane, as in the genus Nebela.

Rarely, also, I have seen a specimen with trilobate mouth, in which the shell appeared to be composed of flocculent dirt, as represented in fig. 29.

A small specimen, such as I have occasionally seen, with trilobate mouth, and with the shell composed of chitinoid membrane, incorporated with a few scattered quartz particles, is represented in figs. 27, 28. This specimen, from Swarthmore brick-pond, accords with the *Difflugia tricuspis* of Mr. Carter, described as a smaller and less incrusted species than *D. proteiformis*, with trefoil opening of the test, measuring $\frac{1}{320}$th of an inch, from Bombay. Ehrenberg regards it as a distinct species, and the name has certainly precedence of the one under which it is here included, but has appeared to me inappropriate for adoption.

In perhaps most cases in which I have observed *Difflugia lobostoma*, especially the ordinary form with trilobate mouth, the endosarc has appeared bright green from the presence of chlorophyl corpuscles; but in many instances all color except that derived from the food has been absent.

Difflugia lobostoma commonly ranges in size from the $\frac{1}{300}$th to the $\frac{1}{175}$th of an inch.

A large specimen, referable to *D. lobostoma*, from Jacksonville, Florida, is represented in fig. 8, pl. XVII. It had a six-lobed mouth, with deep sinuses, separated by angular points. In all respects it closely resembled one, of which the mouth is represented in fig. 12 of the same plate, of *D. corona*, from Lake Hattacawanna, New Jersey, except that it was devoid of spines to the summit. At the side of the latter it might be regarded as a spineless variety of the same species.

Another specimen, from Hammonton pond, Atlantic County, New Jersey, represented in figs 18, 19, pl. XV, may be regarded as a transitional form from *D. lobostoma* to *D. corona* or *D. urceolata.* The shell is larger than usual in *D. lobostoma,* is nearly spherical, provided with a short neck and a feebly crenulated mouth, in which the crenulations are seen to be about eleven. It is composed of thin angular plates, apparently consisting of diatoms and fragments of others.

As before intimated, *Difflugia lobostoma* is the commonest of our species, and is found in the superficial mud and flocculent matter of most fresh-water ponds and ditches. I have also frequently found it among the filamentous algæ and the materials adherent to aquatic plants. When first noticed after removal to the field of the microscope, it is usually seen lying on the side. Protruding its finger-like pseudopods, commonly about half a dozen, after some apparent struggling it rises on end, generally with the mouth downward. On tapping the slide upon which it is examined, it either firmly maintains its position, or withdrawing the pseudopods it falls again on the side, and usually much labor and patience are required to get the creature in such a position as to see the mouth. From the common occurrence of *D. lobostoma,* with the circumstance that, as ordinarily seen, it so much resembles the *D. proteiformis* of Ehrenberg, I have been led to suppose that it is the former, which is usually regarded as the latter by authors.

I have repeatedly seen *Difflugia lobostoma* in conjugation, mostly two individuals, but in several instances three together, so as to give a view in outline comparable to the trefoil-shape of the mouth of the commonest variety.

DIFFLUGIA ARCULA.

PLATES XV, figs. 34–37; XVI, figs. 30, 31.

Shell hemispheroidal; fundus convex; base inverted, shallow infundibuliform; mouth inferior, central, trilobed. Structure of shell usually of yellowish chitinoid membrane, mostly with more or less adherent dirt or scattered particles of quartz-sand or diatoms, especially occupying the fundus.

Size.—From 0.112 mm. to 0.144 mm. broad by 0.06 mm. to 0.08 mm. high; mouth 0.028 mm. to 0.04 mm wide.

Locality—Sphagnum of Atco and Absecom, New Jersey; of Tobyhanna, Pokono Mountain, Monroe County, and Broad Mountain, Schuylkill County, Pennsylvania.

Difflugia arcula is perhaps an extreme variety of *Difflugia lobostoma.* It is not unfrequent, and appears to be confined to sphagnous swamps. In shape, color, and material of structure, its shell resembles that of an Arcella, as seen in figs. 34–37, pl. XV. Usually it is nearly hemispheroidal; but the height is commonly a little greater than half the breadth. The top is evenly rounded and dome-like. The bottom is a broad, shallow, inverted funnel with reflected border. The mouth is central and trilobed; the lobes or sinuses being variably narrowed in degree. See figs. 34–37, pl. XV; figs. 30, 31, pl. XVI.

In structure, the shell is composed of chitinoid membrane of different shades of straw-color, often with irregular darker spots, apparently as if due to adherent dirt. Frequently, also, it has incorporated particles of hyaline quartz-sand mostly scattered on the sides, or more especially accumulated on the fundus. Sometimes a few diatoms or fragments of these are mingled with the quartz-sand.

The specimens observed were always dead, so that I did not ascertain the appearance of the sarcode.

The smallest specimen measured $\frac{1}{223}$d of an inch broad and $\frac{1}{223}$d of an inch high; the largest was $\frac{1}{173}$d of an inch broad and $\frac{1}{312}$th of an inch high.

Difflugia arcula probably merges into *D. globulosa*, *D. lobostoma*, *Centropyxis*, and *Arcella.*

DIFFLUGIA CORONA.

PLATE XVII.

Difflugia corona. Wallich: An. Mag. Nat. Hist. xiii, 1864.—Leidy: Pr. Ac. Nat. Sc. 1874, 14, 79; 1877 307.
Difflugia proteiformis, subsp. *D. globularis*, var. *D. corona.* Wallich: Ibid.

Shell spherical or spheroidal, composed of clear angular quartz-sand; fundus with a number of conical spines of the same composition as the rest of the shell; mouth terminal, circular, with the border multidentate or crenulate. Sarcode colorless; pseudopods many, of the usual form in the genus.

Size.—Ranges from 0.14 mm. to 0.32 mm. in diameter; mouth 0.06 mm. to 0.18 mm. wide; spines 0.04 mm. to 0.06 mm. long.

Locality.—Ditches near Philadelphia, ponds on Darby Creek, and Swarthmore brick-pond, Delaware County, Morrisville pond, Berks County, Pennsylvania; Atco pond, Woodstown pond, Hammonton pond, Absecom pond, and Lake Hattacawanna, New Jersey; Spencer pond, Maine; Jacksonville, Florida. England, Wallich.

Difflugia corona, as represented in the figures of pl. XVII, is the most remarkable and beautiful species of the genus. It was first indicated by Dr. Wallich from specimens found in England It is a common American species, and is frequent in the vicinity of Philadelphia.

The shell of *Difflugia corona* is usually nearly spherical, but frequently is slightly prolonged approaching the mouth. It is commonly one of the smoothest of the genus, though composed of angular particles of quartz-sand in the usual manner. The mouth is circular, and commonly truncates the spheroidal shell, or it continues its curvature, or it is somewhat projected. The lip or border of the mouth is dentated or crenulated. The denticles are thick, angular processes, more or less acute, sometimes blunted, concentric, or slightly everted. They range in number from six to sixteen; but the most frequent number is twelve, and usually a larger rather than a smaller number prevails. The intervening notches are thick-edged, as deep as they are wide, and rounded at bottom.

The fundus of the shell is furnished with a variable number of acute conical spines. Generally there are from three to seven; but they range in number from one to eleven. Mostly they form an eccentric circle, widely divergent, nearly equidistant, and usually occupy a position at the upper third of the shell. Often there is a central spine, sometimes longer than the others. Often this is absent, and sometimes it is the only one existing. The spines are straight or slightly curved, sharp-pointed, hollow processes of the shell, with the same composition.

The shell is composed of colorless angular quartz-sand, usually with the larger particles scattered, with some appearance of uniformity, and with the intervals occupied by smaller ones. Often, too, larger stones are ranged near the mouth, and sometimes form a nearly unbroken row. The denticles of the mouth and the spines of the fundus are likewise made up of sand. Not unfrequently the spines end in a single sharp splinter, or flake, which, in many instances, is of so marked a character that one cannot avoid the impression that it has been specially selected. Mostly the denticles and the tips of the spines are colored ferruginous brown, while the rest of the shell is uncolored.

As usual in Difflugias, the shell has an uneven surface, varying in this respect mainly according to the proportionate quantity of large and small sand grains entering into its composition. Nevertheless, the grains are united in such a manner that, as before intimated, it is comparatively one of the least uneven in the genus.

Irregular variations from the usual forms of *D. corona* are occasionally found. In several instances I have seen specimens somewhat compressed and unsymmetrical, probably from accident. Such a one is represented in fig. 11, pl. XVII. In this, also, the spines were disproportionately large compared with their ordinary condition. Sometimes the spines may be more irregularly disposed, out of the usual proportions, more curved, much reduced in size, and rarely nearly obsolete. I have occasionally met with a specimen in which the mouth was more or less oblique or subterminal, and with a single spine terminating the fundus, as seen in fig. 7.

This matter brings us to what may be viewed as transitional forms. Fig. 12 represents the mouth of a shell of *Difflugia corona*, from Lake Hattacawanna, New Jersey. In all respects, the specimen accords with the commoner forms, but has only six denticles to the mouth. It differs only from the large specimen of *Difflugia lobostoma*, of fig. 8, from Jacksonville, Florida, in the possession of spines to the fundus. As we have seen that the number of the spines in *D. corona* may be reduced from eleven to one, we may regard the specimen of *D. lobostoma*, just indicated, as a spineless form of *D. corona*. Thus, no positive character separates *Difflugia corona* from *Difflugia lobostoma* as an independent species.

The interior sarcode of *D. corona*, as visible through its stony wall, appears colorless, with a more or less brownish tinge and darker spots of the same, centrally in the endosarc, dependent on the food. The pseudopods present the usual appearance, digitate and palmate, or long and cylindrical, simple or branching, and ever changing in length and form They are sometimes extended upward even to the ends of the spines projecting from the fundus. Mostly perfectly clear, under high powers of the microscope they appear uniformly and exceedingly finely granular. When much extended, they often exhibit the entrance, along their axis, of coarser granules from the endosarc.

Dr. Wallich, who first described *D. corona*, views it as a variety of what he calls the subspecies *Difflugia globularis*.

In the original notice of the latter,* as *D. globulosa*, Dujardin describes the shell as corneous and nearly globular, and accompanies the account with figures, one of which, representing a side view, is ovoid, with an oval mouth without crenulation. In the 'Histoire Naturelle des Infusoires,' he describes the shell as brown, globular or ovoid, and smooth.

In the 'Proceedings of the Dublin Microscopical Club,' 1866, p. 53, it is stated that Mr. Archer, among other Rhizopods exhibited one that he "would refer somewhat doubtfully to *Difflugia corona*." He remarks, "If this be *D. corona*, Dr. Wallich's figure is too regular and symmetrical, too diagrammatic, the adherent foreign particles too accurately adapted, and too much of one size, and the horns too short." According to my experience, Dr. Wallich's figure is a fair representation of the species, and Mr. Archer's criticism leads me to suppose that he had under comparison an irregular specimen, and not one of the usual character.

Difflugia corona ranges from the $\frac{1}{175}$th to the $\frac{1}{75}$th of an inch. It is one of the most characteristic and beautiful forms, and is also common in many localities. It is found living in the surface mud at the bottom of ponds and ditches, or among the dirt adherent to submerged aquatic plants. It feeds on algæ and apparently also on decaying vegetal matter.

DIFFLUGIA CONSTRICTA.

PLATE XVIII.

Arcella constricta. Ehrenberg: Abh. Akad. Wis. Berlin, 1841, 410, Taf. iv, i, Fig. 35, Taf. v, Fig. 1.
Arcella lunata. Ehrenberg: Ibidem, 1841, 410; 1871, 259, Taf. iii, ii, Fig. 3, 4.
Arcella Arctiscon. Ehrenberg: Microgeologie, 1854, 108, 171; Abh. Ak. Wis. 1871, 258, Taf. iii, ii, Fig. 17.
Arcella guatimalensis. Ehrenberg: Microgeologie, 1854, 364; Ab. Ak. Wis. 1871, 259, Taf. iii, ii, Fig. 16; Nordpolarfahrt, 1874, Taf. iii, Fig. 35.
Difflugia marsupiformis. Wallich: An. Mag. Nat. Hist. xiii, 1864, 241, 244, pl. xvi, figs. 3–5.—Leidy: Pr. Ac. Nat. Sc. 1877, 307.
Difflugia proteiformis, subspecies *D. marsupiformis.* Wallich: Ibidem.
Difflugia marsupiformis, variety *D. cassis.* Wallich: Ibidem, fig. 6.—Leidy: Pr. Ac. Nat. Sc. 1877, 321.
A. Homœochlamys constricta. Ehrenberg: Ab. Ak. Wis. 1871, 244.

* An. Sc. Nat. viii, 1837, 311, pl. 9, fig. 1.

A. Homœochlamys lunata. Ehrenberg: Ibidem, 244, 274.
A. Heterocosmia Arctiscon. Ehrenberg: Ibidem, 245, 274.
A. Heterocosmia guatimalensis. Ehrenberg: Ibidem, 245, 274.
Arcella borealis. Ehrenberg: Nordpolarfahrt, 1874, Taf. iii, Fig. 29.
Arcella laticeps. Ehrenberg: Ibidem, Fig. 30.

Shell laterally ovoid, with the fundus posterior and more or less prolonged obliquely upward, obtusely rounded and simple, or in the largest forms often provided with from one to half a dozen conical spines. Mouth antero-inferior, large, circular or oval, and inverted, with the anterior lip often prominent. Shell as usually seen (lying on the front, by transmitted light) more or less pyriform, with the narrower part downward and including the mouth, which appears as a clearer transversely oval or somewhat reniform or circular space; sometimes in the shorter forms nearly circular or even transversely oval in outline.

Shell composed of hyaline quartz-sand, or of chitinoid membrane, usually with variable proportions of scattered mineral particles. Colorless, yellowish, or brown. Interior sarcode transparent and colorless.

Size.—Spineless specimens range from 0.09 mm. long by 0.078 mm. broad, to 0.232 mm. long by 0.16 mm. broad. The spine-bearing forms range from 0.18 mm. long by 0.12 mm. broad, to 0.34 mm. long by 0.18 mm. broad.*

Locality.—The smaller spineless forms are found almost everywhere in moist places; the larger forms, including those bearing spines, are found commonly in the ooze of ponds. New Jersey, Pennsylvania, Maine, Florida, Alabama; and at Fort Bridger and in the Uinta Mountains, Wyoming

Difflugia constricta, of which many forms are represented in pl. XVIII, is one of the most common species. It holds a slanting position in comparison with that maintained by others; that is to say, when the animal is erect, as in its ordinary movements, the long axis, corresponding with a line passing from the centre of the mouth to the summit of the shell, is oblique instead of being perpendicular. The inclination of the axis ranges between 30° and 60°.

Commonly the shape of the shell is slightly compressed pyriform or ovoid, with the narrower end downward and forward. It is of variable

* The length is taken from the anterior lip to the fundus, as the specimens are usually seen lying on the object-glass of the microscope. The true length would be from the centre of the mouth in the axis of the shell to the fundus.

length, and wider from side to side than from before backward. In the lateral view, with the plane of the mouth or bottom of the shell on a level, it appears obliquely ovoid, with the fundus directed backward and upward, and with the fore part of the base or anterior lip usually more or less prominent.

In the front or back view of the shell, as it is ordinarily seen, lying on the object-plate of the microscope, by transmitted light, it appears pyriform, ovoid or spheroid in outline, with a clearer transversely oval or somewhat reniform or round space included within the lower or narrower part and produced by the mouth. See figs. 2, 5, 7, 15, 22.

The bottom of the shell is concave, and the nearly circular or oval mouth is inflected and situated above the level of the border of the base. The fundus is usually obtusely rounded and simple, and viewed from behind is transversely oval and flattened below, as seen in fig. 13.

In the largest and most elongated forms, the fundus is often provided with from one to half a dozen acute, conical spines. A single spine produces a central, rather abruptly tapering point; a pair surmount the sides, and a greater number are ranged in a usually more or less regular row.

Unsymmetrical forms of *Difflugia constricta* are not unfrequent, especially in the larger specimens, both in the shape of the shell and in the arrangement of the spines, when these exist.

The shell is ordinarily composed in the usual manner of other species of the genus; that is to say, of angular particles of quartz-sand. Sometimes the particles have more or less uniformity; sometimes heavier grains surround the mouth, and not unfrequently also occupy the top of the fundus. When spines are present they have the same composition as the body of the shell; but a remarkable circumstance is the frequent termination of these spines with a single sharp-pointed and trenchant splinter, as if specially selected for the purpose, and as represented in figs. 56, 57.

Rarely the shell is composed of chitinoid membrane incorporated with variable proportions of scattered quartz particles, in the form of minute grains or thin plates. Occasionally minute oval pellets, and sometimes diatoms, enter into the constitution of the shell.

The sarcode of *Difflugia constricta*, independent of any food contents, is transparent and colorless, and the animal is so very sensitive and indisposed to protrude its pseudopods, that in most cases it is difficult, in consequence of the structure of the shell obscuring the interior, to determine whether the specimens under examination are dead or alive.

Difflugia constricta, in its various forms, is one of the most abundant of species, and appears to be found almost everywhere where moisture and algæ are present.

Small spineless specimens, cap-like in form, of the variety named by Dr. Wallich *Difflugia cassis*, such as represented in figs. 8–34, pl. XVIII, are very common with algæ, on the surface of moist earth, in marshy places, in meadows, and in forests. I have found them constantly, in association with the common wheel-animalcule and several other rhizopods, about the roots of mosses, and with algæ, in the crevices of the pavements in shaded places in the city of Philadelphia. I have even found them among mosses and lichens high up in trees. They also occur frequently among sphagnum.

The small spineless forms are frequently of various shades of brown, while the larger ones are usually colorless.

The largest varieties and the spine-bearing forms are found in the ooze of ponds. These appear to constitute the variety named by Dr. Wallich *Difflugia marsupiformis*. See figs. 35–55.

A somewhat peculiar variety, represented in figs. 37–44, I have not unfrequently found among sphagnum. The shell is cap-like in shape, yellowish brown in color, and composed of chitinoid membrane, usually incorporated with variable proportions of scattered sand particles. In the view from the front or back, the shell appears transversely oval, but flat beneath. The mouth is deeply inflected, or forms the smaller opening of an inverted funnel, of which the base of the shell forms the greater opening. Sometimes the fundus of the shell is loaded with comparatively large stones, and rarely the shell is almost devoid of sand particles. This form of shell approximates closely, if it does not really merge into, the spineless variety of Centropyxis.

Either of the names *Difflugia marsupiformis* or *D. cassis*, given by Dr. Wallich, better applies to the species than that of *Arcella constricta*, given originally by Ehrenberg. The apparent constriction, often absent, is due to the narrowing of the shell, as seen in the front view, opposite the position of the mouth.

The form of *Difflugia constricta* repeats that of *Trinema enchelys*, but

I have not been able to ascertain whether these actually merge into each other.

The range in size of *Difflugia constricta* is considerable. The smallest measured was $\frac{1}{520}$th of an inch long from the anterior lip to the fundus, the breadth was slightly less than the length, and the thickness or fore.and aft diameter of the fundus $\frac{1}{780}$th of an inch, and the mouth was $\frac{1}{890}$th of an inch wide. The largest was $\frac{1}{100}$th of an inch long from anterior lip to fundus, $\frac{1}{156}$th of an inch broad, $\frac{1}{200}$th of an inch thick, and the mouth $\frac{1}{250}$th of an inch wide. The spines of the fundus reach a length of $\frac{1}{625}$th of an inch.

DIFFLUGIA SPIRALIS.

PLATE XIX, figs. 1–23.

Difflugia. Leclerc: Mém. Mus. Hist. Nat. 1815, ii, 474, pl. 17, figs. 1 and 4.
Difflugia spiralis. Ehrenberg: Monatsb. d. Berlin. Akad. d. Wissens. 1840, 199; Abhand. Akad. Wissens. Berlin, 1871, 274, Taf. iii, Fig. 25–27.—Bailey: Micros. Obs., in Smithson. Contrib. 1850, 41.—Fresenius: Abhand. Senckenb. Naturf. Gesells. ii, 1856–8, 224, Taf. xii, Fig. 37–42.—Pritchard: History of Infusoria, 1861, 553.—Carter: An. Mag. Nat. Hist. xiii, 1864, 18, pl. i, fig. 9.—Wallich: An. Mag. Nat. Hist. xiii, 1864, 215.—Leidy: Pr. Ac. Nat. Sc. 1874, 79; 1877, 307.
Lecquereusia jurassica. Schlumberger: An. Sc. Nat. 1845, 255.
Difflugia proteiformis, monstrosa. Perty: Kenntniss kleinster Lebensformen, 1852, 187, 214, Taf. viii, Fig. 22.
Difflugia Helix. Cohn: Zeitsch. f. wissens. Zoologie, 1853, 261.
Difflugia proteiformis, var. *septifera.* Wallich: An. Mag. Nat. Hist. 1853, xi, 1853, 453, pl. x, fig. 12.
Difflugia proteiformis. Wallich: An. Mag. Nat. Hist. 1863, xii, 456.
Difflugia proteiformis, subspecies *D. mitriformis*, var. *β. D. spiralis.* Wallich: An. Mag. Nat. Hist. 1864, xiii, 1864, 240, pl. xvi, figs. 24, 25.
D. Corticella spiralis. Ehrenberg: Abh. Ak. Wis. Berlin, 1871, 247.

Shell retort-shaped, usually with a laterally compressed spheroidal body, and a short, wide, cylindroid neck, obtuse fundus, and terminal circular or slightly oval mouth. A partition occupying the interior of the shell, defining the neck from the body, and giving to the shell by transmitted light the appearance of a single turn of a spiral. Structure of the shell variable; frequently of quartz-sand, often of peculiar elements, or of chitinoid membrane incorporated with various extraneous particles. Sarcode colorless; pseudopods as usual in the genus.

Size.—Length 0.096 mm. to 0.188 mm.; breadth of body 0.068 mm. to 0.164 mm.; thickness 0.068 mm. to 0.136 mm.

Locality.—Lakes, ponds, and ditches. Pennsylvania, New Jersey, Rhode Island, South Carolina, Georgia, Florida, Alabama, and the Uinta Mountains of Wyoming Territory.

Difflugia spiralis, a common and pretty species (figs. 1–23, pl. XIX), is one of the most remarkable forms of the genus, and is also the most variable in the structure of its shell. It is one of the original forms described by Leclerc, in 1815, under the generic name alone. Though not strictly correct to call it spiral, the construction of the shell, especially when viewed by transmitted light, gives rise to such an impression, and thus led Ehrenberg so to name it, and likewise Bailey after him, apparently without knowing that the former had done so.

In *Difflugia spiralis* we may recognize one of the enigmatic rhizopods, described, without illustrations, by Schlumberger, in 1845, in the 'Annales des Sciences Naturelles.' I refer to the *Lecquereusia jurassica*, described as having "a somewhat depressed ovoid-globular retort-shaped shell with a short, wide neck and a terminal circular aperture, from which project thick, cylindrical, blunt pseudopods."

The shell of *Difflugia spiralis* is retort-like or flask-shaped, with a usually compressed spheroidal body, and a short, wide, cylindroid neck, which is commonly produced a little more from one side than the other of the shell. The body and neck are, however, quite variable in their exact form and proportions. Commonly the larger specimens with a stony structure accord with the general form indicated. Smaller specimens usually have a proportionately, and often absolutely, longer neck and a more spherical, uncompressed form of body. The neck is mostly straight, but is sometimes slightly bent or curved. Generally it is evenly expanded where it joins the body, but is frequently inflated more to one side. The mouth is terminal, circular, or slightly oval, and is neither contracted nor expanded at the border.

The shell, as ordinarily viewed lying on one of the usually broader surfaces, exhibits a dark line, indicating the presence of an interior partition, which starts from the bottom of the neck on one side and extends in a more or less oblique direction or curve upward toward the opposite side. In some specimens, the partition appears to extend from one half to two thirds way across the shell, and in others nearly or quite completely across in a sigmoid line to the opposite side. The partition apparently continues inwardly the curvature of one side of the body of the shell, and thus gives rise to the impression that the latter makes a spiral turn.

Ordinarily the structure of the shell so obscures the partition from view that a satisfactory idea of its exact form and relations cannot be obtained. In most instances in smaller and more translucent specimens, in which the partition could be distinguished, it appeared to be a crescentoid plate, with a large circular aperture between its upper part and the contiguous portion of the shell. In other instances, the aperture seemed to pass through the upper part of the partition itself.

In many specimens, the neck is more or less defined from the body of the shell by a narrow constriction in the line of the partition, especially in those in which the latter extends completely across.

The structure of the shell of *Difflugia spiralis* is of more variable character than in any other species of the genus. Frequently it is entirely composed of angular, colorless quartz-sand, as in the species of Difflugia generally, and as seen in figs. 1–3, 6, pl. XIX. In these specimens, also, the usual varieties in arrangement occur, some being constructed of particles of some uniformity of size, small or large, while others are composed of scattered coarser particles, with the intervals filled in with smaller ones. Sometimes there is an accumulation, especially of larger stones, centrally on the broader surfaces of the shell, as seen in figs. 4, 5.

The former figure represents a large specimen, in which the shell was mainly composed of thin, narrow, rectangular plates, mingled with some diatoms, and the central portion of the broader surfaces of the body was occupied by large particles of quartz-sand.

A singular variety is that in which the shell is composed of short vermicular bodies closely laid together, as represented in figs. 7, 9–11. The same form is described by Dr. Wallich as occurring in England. The vermicular bodies are transparent and colorless, but when viewed by reflected light present a silvery white lustre. Dr. Wallich calls them chitinous pellets.

Occasionally I have found specimens composed of similar bodies separated by marked intervals, and apparently imbedded in a homogeneous membrane, as represented in fig. 8.

Other varieties of shells, related with those last indicated, consisted of a net-work of apparently the same nature as the vermicular bodies, as seen in fig. 12, or of minute scattered corpuscles, as seen in fig. 13. With these shells, as represented in the two figures just referred to, there were incorporated scattered particles of quartz-sand.

Another interesting variety observed is one in which the shell was mainly constituted in the usual way of a stone-work masonry, but had the neck composed of vermicular bodies, as seen in fig. 5.

A singular variety is represented in figs. 14, 15, in which the shell is composed of narrow plates or rods mostly in small parallel groups of twos and threes or more, and laid closely together in every direction. This is probably the kind to which Schlumberger refers in his account of *Lecquereusia jurassica*, in which he says the shell is composed of a paste of minute bacillar bodies.

Small forms of *Difflugia spiralis* are not uncommon in which the shell is composed of transparent chitinoid membrane incorporated with variable proportions of linear bodies, diatoms, and sand particles, as represented in figs. 16–22.

A curious specimen, of large size, represented in fig. 23, was composed of irregularly rounded or oval bodies containing a central nucleus. The nature of these bodies I did not determine.

The sarcode of *Difflugia spiralis* is colorless, independently of the color given to the endosarc from the presence of food. In the more translucent specimens it can often be detected as a spheroidal mass of variable size occupying the body of the shell, with a narrow neck passing off from one side, in a retort-like manner, and extending through the aperture of the partition, and thence gradually widening to the mouth. The food usually gives to the endosarc a yellowish or pale brownish hue, which is sometimes mingled with green and other colors. The pseudopods in number, form, and changes, are of the same character as in other species of the genus.

The size of *Difflugia spiralis* ranges from the $\frac{1}{275}$th to the $\frac{1}{135}$th of an inch.

Difflugia spiralis may be regarded as the oldest known species, and, as previously intimated, was described and figured by Leclerc in 1815. He represents two varieties; one in which the shell is composed of quartz-sand, the other in which it appears to be composed of chitinoid membrane. He also represents two individuals united, mouth to mouth, in the condition usually indicated as that of conjugation.

Perty describes and figures the same species, but regards it as a monstrosity of *Difflugia pyriformis*, in which view he is sustained by Dr. Wallich. I can see no reason why *Difflugia spiralis* should be considered a monstrosity any more than any other recognized form of the genus.

Difflugia spiralis is a common species, but I have found it especially abundant in the ponds of sphagnous and cedar swamps in New Jersey, where it is also to be obtained, in the greatest variety of form, in association with *D. pyriformis*, *D. urceolata*, etc. The habits and food are the same as in other species generally.

I have occasionally observed two individuals of *Difflugia spiralis* applied together, mouth to mouth, in the manner first described and figured by Leclerc, and as represented in fig. 3, pl. XIX. This condition I have not been able to discover leading to any important result, and I may say the same of other species of Difflugia seen in conjugation.

In one instance I saw two small individuals applied to the mouth of a third and larger individual, and in another instance I saw three small individuals in like manner applied to a larger one.

In the instance represented in the figure, on focusing the conjugating pair so as to see the contents, they were observed to flow from one to the other and back again. After about half a dozen repetitions of the flow and ebb, the contents, apparently equally divided in the two shells, remained quiescent for a time, and then the two individuals separated and moved away in the usual manner. The construction of the shell prevented the determination of any change within, even if such had taken place.

HYALOSPHENIA.

Greek, *hualos*, crystal; *sphen*, a wedge.

Hyalosphenia: Stein, 1857. *Difflugia:* Tatem, 1870. *Catharia:* Leidy, 1874.

Shell compressed ovoid to pyriform, composed of transparent structureless chitinoid membrane; mouth terminal, inferior, transversely elliptical. Sarcode mass occupying the interior of the shell to a variable extent, attached to its inner surface by divergent threads and also connected to the border of the mouth; composed of pale granular protoplasm mingled with colorless or colored corpuscles, or both together. Nucleus large, and centrally situated in the fundus of the sarcode. Contractile vesicles several, occupying a position between the former and the periphery of the fundus. Pseudopods few, digitate.

HYALOSPHENIA CUNEATA.

PLATE XX, figs. 1–10.

Hyalosphenia cuneata. Stein: Sitzungsb. Böhm. Akad. Wissens. 1857.
Difflugia ligata. Tatem: Month. Micros. Jour. iv, 1870, 313, pl. lxviii, fig. 1.
Catharia ligata. Leidy: Proc. Ac. Nat. Sc. 1874, 79.
Hyalosphenia lata. Schulze: Archiv mikr. Anat. xi, 1875, 335, Taf. xviii, Fig. 15, 18.—Archer: Quart. Jour. Mic. Sc. 1877, 110.
Hyalosphenia ligata. Leidy: Pr. Ac. Nat. Sc. 1875, 415; 1876, 197.

Shell compressed ovoid, with the narrower part conical and truncate at the oral end, laterally and at the fundus convex; mouth terminal, oval. Shell composed of delicate, transparent, colorless, and structureless chitinoid membrane. Sarcode mass colorless, pyriform, and attached by threads of ectosarc to the interior of the shell; pseudopods digitate, usually not more than one or two.

Size.—Length 0.06 mm. to 0.076 mm.; breadth 0.044 mm. to 0.06 mm.; thickness 0.02 mm; breadth of mouth 0.016 mm. by 0.012 mm.

Locality.—Lansdowne station spring, on Westchester railway, five miles from Philadelphia.

Hyalosphenia cuneata, figs. 1–10, pl. XX, is compressed ovoid, and in the view of the broader side presents a transversely convex fundus and more or less tapering lateral borders, which may be plane, convex, or concave in their descent to the mouth. The narrower view of the shell is also obtusely rounded at the fundus and tapering at the sides. The mouth is terminal and oval, with obtusely rounded commissures.

The shell of *H. cuneata* consists of delicate, transparent, colorless chitinoid membrane without trace of definite structure. It is sometimes sufficiently delicate to be bent by the tension of the threads of ectosarc attached to it within. In one specimen, the broad sides of the fundus appeared to be bent inward by the tension of these threads, as seen in the lateral view, fig. 5. In another specimen, the tension of the threads appeared to indent every point of attachment, as seen along the border in fig. 1.

The size of the shell in several specimens ranged from $\frac{1}{400}$th to $\frac{1}{330}$th of an inch in length, by $\frac{1}{480}$th to $\frac{1}{416}$th of an inch in breadth, and about $\frac{1}{1250}$th of an inch in thickness. The mouth measured about the $\frac{1}{1500}$th of an inch wide.

The sarcode in the few specimens observed occupied about one half of the interior capacity of the shell. It was inverted vase-like in shape, attached at the border of the mouth, gradually contracting and then expanding again within the body. It was attached by long diverging threads of the ectosarc to the sides and fundus of the shell.

The sarcode is colorless, and its basis consists of a pale, finely granular protoplasm. Imbedded in the body, toward the fundus of the shell, it contains a large, faintly granular and globular nucleus, from $\frac{1}{2000}$th to $\frac{1}{5100}$th of an inch in diameter. At the periphery of the body, contiguous to the nucleus, two or three contractile vesicles may be visible at once.

Around, but especially below, the position of the nucleus, the endosarc contained a multitude of darkly outlined granules, and a variable number of larger, clear, well-defined globules, oil-like in appearance. A few pale vacuoles and small brown food masses were likewise visible.

Usually *H. cuneata* puts forth but a single digitate pseudopod, but occasionally two and less rarely three are emitted. They present the common form and the scarcely perceptible granular character observed in related animals.

H. cuneata, from its great transparency, would be admirably adapted for the study of the various life phenomena of its kind, but unfortunately the creature appears to be exceedingly rare. In four years I found only half a dozen individuals, and all these were obtained from the same locality, a spring, in which grew water-cress, near Lansdowne station, on the Westchester railway, a few miles from Philadelphia.

In one instance two individuals were found in conjugation, and when first observed they presented the appearance seen in fig. 6. The sarcode of both was continuous at the mouth of the shells; but in one of these it was less than a fourth of the quantity in the other. A moment after, the sarcode was observed to flow from the larger to the smaller portion until the two became equal in size, and assumed each a trilobate form, as seen in fig. 7. A fourth lobe was produced in one portion of the sarcode, and then the lobes became extended in both so as to form an attachment to the sides and fundus of the shell, as seen in fig. 8. Shortly after, one portion of the sarcode narrowed its connection with the other at the mouth of the shell, then detached itself and shrunk away, as represented in fig. 9. At this time the specimens were accidentally lost; but several hours later, one of the individuals was found again, and presented the appearance seen in fig. 10, with the sarcode contracted into the fundus of the shell.

From first to last a nucleus appeared to be absent in the sarcode. The endosarc contained fine granular matter, coarser, darkly defined granules, oil-like globules, clear vacuoles, and a few brown food particles.

Hyalosphenia cuneata, with this name, was first described by Stein. What appears to be the same was afterward described by Tatem, in England, under the name of *Difflugia ligata.* Schulze subsequently described what he regards as a distinct species from that of Stein under the name of *Hyalosphenia lata* I have not access to the description of the latter author; but from its quotation by Schulze I cannot detect sufficient difference to distinguish two species.

Stein remarks that in *H. cuneata* the animal can abruptly and quickly separate from the mouth of the shell and retract to the bottom. Schulze remarks that in *H. lata* he never observed such a sudden contraction as this. That this apparent difference of habit has no specific value is shown in the fact, that most lobose rhizopods, when disturbed, may retract their pseudopods, but retain the connection of the sarcode mass with the mouth of the shell, notwithstanding the rudest shaking, while at other times any of them may and will sever the connection and quickly retreat to the fundus of the shell.

The specific names of *cuneata*, *ligata*, and *lata* are expressive of characters common to any or all the examples described by Stein, Tatem, Schulze, and myself.

HYALOSPHENIA PAPILIO.

PLATE XXI.

Difflugia (Catharia) papilio. Leidy: Pr. Ac. Nat. Sc. 1874, 156.
Hyalosphenia papilio. Leidy: Pr. Ac. Nat. Sc. 1875, 415; 1876, 197.

Shell compressed oblong ovoid, or occasionally compressed pyriform; in the broader view, with the fundus transversely convex and the sides gradually tapering to the slightly convex oral end, or with a pyriform outline; in the narrower view, with the fundus angularly rounded and the oral end notched. Mouth transversely oval, with rounded commissures. Shell composed of transparent, yellowish chitinoid membrane. Sarcode with bright green endosarc from the presence of chlorophyl; the mass attached by divergent threads to the summit and sides of the shell; pseudopods colorless, digitate, up to half a dozen in number.

Size.—From 0.108 mm. to 0.14 mm. long, 0.068 mm. to 0.084 mm. broad, 0.032 mm. to 0.04 mm. thick; and the mouth end from 0.032 mm. to 0.04 mm. broad and 0.008 mm. in the opposite diameter.

Locality.—Abundant in the moist sphagnum of sphagnous swamps of Pennsylvania and New Jersey. Tobyhanna, Pokono Mountain, Monroe County; Broad Mountain, Schuylkill County, Swarthmore, Delaware County, Pennyslvania; Absecom, Atlantic County, Longacoming, Hammonton, Atco, Malaga, Vineland, etc., New Jersey.

Hyalosphenia papilio is common and at times exceedingly abundant in moist bog-moss or sphagnum, in sphagnous swamps, but is not found in ponds except accidentally. No other lobose rhizopod has more impressed me with its beauty than this one. From its delicacy and transparency, its bright colors and form, as it moves among the leaves of sphagnum, desmids, and diatoms, I have associated it with the idea of a butterfly hovering among flowers. From its comparative abundance, the readiness and certainty with which it may be obtained and preserved, and from its transparency, which allows its structure to be well seen, it is peculiarly well adapted for the study of the life-history of its order. I have collected it from early spring to late autumn, and have retained it alive in sphagnum, in a glass case, through the winter. During the Christmas holidays, I have repeatedly exhibited it, in the living condition, to the admiration of friends.*

* This interesting Rhizopod, found together with a profusion of other remarkable microscopic forms of both animal and vegetal life, of which many are novel and yet undescribed, recalls pleasing recollections of excursions into the sphagnous bogs, cedar swamps, and pine barrens in the southern region of New Jersey. These localities have special charms for the botanical student on account of the diversity of beautiful and interesting plants they produce. In proper season, in most places, they are redolent with the rich perfume of the *Magnolia glauca* and the fragrance of the *Clethra alnifolia*. In early spring, the ground is adorned with bright patches of the little Pyxie, *Pyxidanthera barbulata*, and Sand-Myrtle, *Leiophyllum buxifolium*. Later, the swamps display an abundance of *Helonias bullata*, and still later, many other liliaceous plants, as *Zygadenus limanthoides*, *Narthecium americanum*, besides more common ones. Rich are the woods and swamps in Orchids of the genera *Cypripedium*, *Goodyera*, *Spiranthes*, *Liparis*, *Habenaria*, *Calopogon*, *Pogonia*, and *Arethusa*. On dry banks, amidst a host of Vacciniums and other ericaceous plants, are conspicuously seen the spikes of white flowers of the grassy-looking *Xerophyllum asphodeloides;* while the bogs below are as conspicuously dotted with the curious green and purple Pitcher-plant, *Sarracenia purpurea*, nestling among sphagnum, and entangled among Cranberry and Sundews, *Drosera filiformis*, etc. In many places occurs the singular grass, with its underground fruit, the *Amphicarpum Purshii;* and in more restricted localities appears the rare little fern, the *Schizæa pusilla*.

Upward of thirty years ago, while examining the structure of sphagnum, my attention was distracted by the movements of a singular animal, whose character and affinities I did not then recognize. September 9th, 1873, the fiftieth anniversary of my birth, a friend, Clarence S. Bement, presented

The shell of *H. papilio*, pl. XXI, is usually compressed oblong ovoid, but occasionally is compressed pyriform. The compression is about equal to one half the greater diameter. The transverse section, figs. 14, 15, is elliptical, with rounded angular poles. Viewed on the broader surface, figs. 1, 3–5, 7, 11–13, the outline is broadly convex at the fundus, from which the sides slant in a straight or nearly straight line close to the mouth, where they are commonly slightly everted. The lower extremity or line of the mouth is transversely slightly convex. In a comparatively few specimens, in the view of the broad surface of the shell the outline is decidedly pyriform, as seen in fig. 10. In the view of the narrower side of the shell, the outline is flask-shaped, with the fundus rounded, obtusely angular, or slightly prolonged; and the oral end appears as a concave notch. See figs. 2, 6, 8, 9.

The mouth is inferior, terminal, and transversely elliptical, with rounded commissures, and is convex in the wider and concave in the narrower direction.

The shell is buff- or straw-colored, of lighter or darker shade, and rarely nearly colorless. Among thousands of specimens from different localities, I do not recollect meeting with one in which at least a trace of yellow could not be detected. As in other species of the genus, it is perfectly transparent and structureless, nor did I ever find a specimen with adherent extraneous bodies of any kind. The thickness of the shell is pretty uniform, but is slightly greater around the mouth.

In the view of the broader side of the shell, along the border of the fundus, there may be detected from two to half a dozen minute apertures, around which the shell is slightly thickened. These appear to serve for the ingress and egress of water accompanying the protrusion and retraction of the pseudopods. See figs. 1, 3–5, 7, 10–13.

The shell of *Hyalosphenia papilio* exhibits but little variation in size. It ranges from $\frac{1}{250}$th to $\frac{1}{200}$th of an inch in length by $\frac{1}{450}$th to $\frac{1}{250}$th of an inch in breadth, and $\frac{1}{780}$th to $\frac{1}{500}$th of an inch in thickness. The mouth ranges from $\frac{1}{780}$th to $\frac{1}{500}$th of an inch in breadth.

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me with a small Hartnack microscope, which, from its convenient size and form, I kept on my study table. From time to time I was led to make observations on Fresh-water Rhizopods detected in sediments collected in the vicinity of Philadelphia. A year later, in examining water squeezed from sphagnum obtained at Absecom, I observed many individuals of the same singular animal above indicated, but now, understanding its nature, I described it as *Difflugia papilio*. It was the rediscovery of this beautiful form which impelled me to pursue the investigations which constitute the material of the present work.

The sarcode of *Hyalosphenia papilio* I have never seen entirely filling the shell. Its proportionate size with the capacity of the latter varies very much, the difference apparently being more or less dependent upon the amount of nutriment taken by the animal. Thus I have observed, in the summer months, when apparently the conditions of life were most favorable to the animal, that the sarcode mass was largest, and most nearly filled the shell, as seen in fig. 1. Under less favorable circumstances the sarcode was smaller; and sometimes the animal would impress me with the idea of being starved, when the sarcode mass would occupy less than half the capacity of the shell, as seen in fig. 4.

In the view of the broad surface of *H. papilio*, the sarcode mass usually appears pouch-like in outline. The upper part is ovoid; the lower part is as wide as the shell contiguous to the mouth, and the intermediate part is contracted. In the view of the narrow side of the animal, the sarcode mass touches the shell laterally, and appears therefore to fill it more in the less than in the greater breadth.

Diverging processes of the ectosarc fix the sarcode mass to the sides and fundus of the shell. These processes, of course, vary in length in proportion as the sarcode mass diminishes or increases. They are conical extensions of the ectosarc, more or less tapering to filaments, and are usually simple, but sometimes furcate at their outer connection. They are of the nature of pseudopods, and may be detached from the shell and withdrawn into the sarcode mass, while new ones may be projected and extended to become attached to the shell.

The sarcode of *H. papilio* is remarkable for the quantity of chlorophyl which enters into its constitution. I have never met with a living specimen of the animal in which this material was absent. It is of a bright green color, like that of the green fresh-water polyp *Hydra viridis*, and occurs in spherical corpuscles ranging from $\frac{1}{12000}$th to the $\frac{1}{3000}$th of an inch in diameter. They are usually so numerous as to obscure all the other constituents of the sarcode; but almost invariably this is free from them in the vicinity of the mouth.

The basis of the sarcode is the usual faintly granular colorless protoplasm mingled with larger and more distinct granules. The ectosarc everywhere appears colorless and clear or faintly granular.

The interior of the sarcode mass near the upper part is occupied centrally by a large, spherical, clear or pale granular nucleus; in different specimens ranging from about $\frac{1}{1500}$th to $\frac{1}{1000}$th of an inch in diameter.

In the vicinity of the nucleus, at the periphery of the sarcode mass, there may be detected several contractile vesicles. From two to four are frequently seen at the same time together. They generally expand to about $\frac{1}{2000}$th of an inch in diameter before collapsing.

Below the position of the nucleus, between it and the clear sarcode contiguous to the mouth, the endosarc is occupied by variable quantities of brownish food-balls, vacuoles, and occasionally distinct algous forms, intermingled with the constituent elements.

Green algæ swallowed as food, unless of comparatively large size and more peculiar shape, are not usually distinguishable among the materials of the endosarc in consequence of their being obscured by the abundance of constituent chlorophyl corpuscles. Among them there may occasionally be seen a diatom, a desmid, or a fragment of an oscillaria. The endochrome of the algæ, as a result of digestion, appears to become shriveled and assumes a decidedly yellowish or reddish-brown hue.

The brownish food-balls vary in quantity and size. They are mostly granular, but sometimes have an oleaginous appearance, and lie free in the endosarc or are contained in vacuoles. They appear to be accumulations of food in the process of digestion, or the remains of food which have undergone digestion and are ready to be discharged.

The vacuoles vary in number and size, sometimes few, sometimes many, and ranging from $\frac{1}{3000}$th to $\frac{1}{1000}$th of an inch They appear as globules of clear colorless liquid, of pale colorless granular matter, or of colored food-balls surrounded by a stratum of either or both of the former.

At times one or more of the vacuoles may be seen slowly approaching the mouth of the shell, on reaching which their contents are discharged. Food-balls, in like manner, without being enclosed in vacuoles, may be seen pursuing the same course.

In the vicinity of the mouth not unfrequently vacuoles may be seen to appear, to gradually enlarge, and then collapse, in the manner of the contractile vesicles so constantly occupying a position at the upper part of the sarcode mass.

With the other materials of the endosarc there are numerous colorless well-defined granules which resemble starch, also many small pale globules resembling vacuoles, and in addition oil-like globules of various sizes, sometimes colorless and sometimes yellowish in hue. These latter materials especially are obscured by the chlorophyl corpuscles.

The pseudopods are digitiform and from two or three to half a dozen or more in number. They sometimes extend to a length of $\frac{1}{300}$th of an inch with a thickness of $\frac{1}{3000}$th of an inch. They are usually simple, but occasionally branch, and are blunt at the end. They are colorless, and with high powers can be seen to be finely but faintly granular throughout. The coarser granules of the endosarc do not enter them.

As the pseudopods protrude, the mass of the sarcode in the interior of the shell proportionately diminishes, and the threads of attachment are put to a greater stretch. When the animal is disturbed, the pseudopods are retracted, but the sarcode mass commonly retains its attachment to the mouth of the shell. Occasionally, however, when the animal is suddenly or rudely disturbed, the sarcode mass retreats far into the shell, as represented in fig. 5. In proportion as the sarcode retracts or extends, the attaching threads shorten or lengthen.

Not unfrequently, but especially in October and November, and also in the winter months, in sphagnum preserved in a moderate temperature, specimens of *H. papilio* are to be seen in which the sarcode mass forms a compressed spheroidal ball lying completely quiescent within the shell, as represented in figs. 7–11. The ball, in the narrower view of the latter, is seen to touch the sides, but in the broader view does not extend to the lateral borders. The ball ranges from $\frac{1}{500}$th of an inch to $\frac{1}{300}$th of an inch in breadth, and $\frac{1}{900}$th to $\frac{1}{600}$th of an inch in thickness. Generally it is a little greater in its longitudinal than in its broader transverse diameter. The constitution of the ball appears to be nearly the same as the sarcode mass in the active animal, but is devoid of the materials recognized as food, and also presents no vacuoles nor contractile vesicles. It is bright green from the presence of abundance of chlorophyl corpuscles, which exist in the same proportion as usually observed in the active condition of the animal. A central clearer spot would appear to indicate the retention of the nucleus. The exterior of the ball is composed of a layer, of variable thickness, of colorless, faintly granular ectosarc, not defined from the granular endosarc extending into the mass of chlorophyl corpuscles. Occasionally the green sarcode ball is invested by a more distinct and colorless membrane.

Not unfrequently specimens of the kind just described are seen with one or more globular masses of granular matter, colorless or colored yellowish or brownish, lying between the green sarcode ball and the mouth of the shell, as represented in fig. 10, which I have supposed to be excrementitious. In several instances I have seen an animal withdraw its pseudopods, retreat deeply into the shell, retract its threads of attachment, and assume the form of an oval or spheroidal ball. This would subsequently discharge several masses of excrementitious matter of the kind indicated, and become proportionately reduced in size.

In many specimens with the sarcode in the condition of a quiescent ball, the mouth of the shell appears to remain open; in others it is closed by a sort of gelatinoid operculum, as seen in fig. 11. In one instance observed, as seen in fig. 9, the lips at the mouth of the shell were in close apposition, and cemented together by the material of the operculum.

I have repeatedly met with specimens of *H. papilio*, as represented in fig. 12, in which the shell contained nothing excepting a quantity of scattered bright green chlorophyl corpuscles, in all respects like those ordinarily observed in the sarcode mass of the animal.

I have further repeatedly observed specimens in which the shell contained a variable number of globular, granular, colorless corpuscles, of nearly uniform size in the same specimen, but of different sizes in different ones, as represented in fig. 13. The nature of these bodies I have not determined, nor whether they actually pertain to the Hyalosphenia or belong to some parasite, but I have suspected them to be spores of the former.

H. papilio in comparison with many other rhizopods is of remarkable uniformity in size, shape, and constitution. Though I have seen thousands of specimens, from different localities, in mountainous regions, and nearly at the sea-level, I have observed but trifling variation. I never have seen anything like decided transitional forms, never any with the shell positively colorless, and not one in any condition, whether of activity or quiescence, in which the sarcode was devoid of the chlorophyl corpuscles.

As previously intimated, and for the reasons given, I have considered *Hyalosphenia papilio* peculiarly well adapted for study, and I have looked hopefully forward to it as a means of throwing light upon the modes of reproduction of the shell-covered rhizopods in general, but up to the present time I have been disappointed. Among the multitude of specimens I have seen I never observed a pair in the position which is commonly viewed as that of conjugation, and regarded as having some relation with reproduction.

HYALOSPHENIA TINCTA.

PLATE XX, figs. 11–18.

Shell compressed pyriform, variable in the relation of breadth to length; in transverse section compressed oval; composed of pale yellow, transparent, structureless, chitinoid membrane; mouth transversely oval. Sarcode colorless; pseudopods digitate, usually two, three, or more.

Size—Smallest specimen, 0.076 mm. long, 0.056 mm. broad, 0.028 mm. thick, with the mouth 0.02 mm. by 0.008 mm.; second specimen broader than long, 0.06 mm. long, 0.08 mm. broad, with the mouth as in the former; third specimen, 0.08 mm. long and broad, 0.036 mm. thick, and mouth same as in former; largest specimen, 0.092 mm. long, 0.064 broad, and mouth as in the others.

Locality.—Abundant in the sphagnous swamps of Tobyhanna, Pocono Mountain, Monroe County, Pennsylvania; found also in the sphagnum near Kirkwood station, on the Camden and Atlantic railway, New Jersey.

Hyalosphenia tincta, figs. 11–18, pl. XX, is closely related with *H. cuneata*, but from its more pyriform shape, pale tinted shell, and living in sphagnum instead of ponds, I have regarded it as distinct.

The shell is compressed pyriform, with a very short neck, usually with little difference between the length and breadth. It is composed of pale yellow or straw-colored transparent chitinoid membrane, without trace of definite structure. It is thicker than in *H. cuneata*, and is therefore less flexible. At the lateral borders, usually below the middle, it presents a pair of minute pores for the ingress and egress of water. Sometimes another pair of similar pores are found along the same border above the middle. See figs. 11, 12, 14, 16, 18.

In transverse section, the shell is laterally compressed oval, with obtusely rounded poles. The mouth has the same form, and is slightly directed upwardly toward the commissures.

The size of the shell differs but little, though there is considerable variety in the relation of the greater breadth to the length. Most frequently the specimens observed were quite or nearly equal in length and breadth. Specimens of usual size ranged from $\frac{1}{350}$th to $\frac{1}{300}$th of an inch in length and breadth, with rather less than half the thickness. The mouth is about $\frac{1}{1250}$th of an inch in breadth and $\frac{1}{3000}$th of an inch in the short diameter.

The sarcode is colorless and finely granular, and usually contains a multitude of large colorless globules, which are scarcely distinguishable as vacuoles, food-balls, or contractile vesicles. The latter were only to be recognized by looking for them in the usual position, along the border at the fundus of the sarcode mass. A nucleus is present, but is obscured by the surrounding granules and globules.

Viewed laterally, or from the extremities, the sarcode mass was observed to touch the broader sides of the shell; but more or less vacancy was left between it and the narrower sides. The lateral borders and fundus of the mass are attached in the ordinary manner to the inner surface of the shell by threads of the ectosarc.

The pseudopods are commonly two or three in number, thick, digitate and simple, but sometimes are more numerous and branching.

Some individuals of this species appeared to be particularly irritable, and tapping the glass upon which they were placed would not only cause them to retract their pseudopods, but also to separate from the mouth of the shell and retreat into its fundus. In the contraction of the sarcode mass it would assume a spheroidal form, but not withdraw the threads of attachment to the sides and fundus of the shell. After a few moments of rest, the sarcode would again descend and establish an attachment to the mouth of the shell, and once more protrude its pseudopods. In one individual, the sarcode mass actually protruded its pseudopods before the body was extended to the mouth of the shell, as represented in fig. 12.

Hyalosphenia tincta I found abundantly in moist sphagnum, of the large sphagnous swamps, at Tobyhanna, on the Pokono Mountain, Monroe County, Pennsylvania, in July, 1876. Later I found it, though rarely, in sphagnum, near Kirkwood station, on the Camden and Atlantic railroad, New Jersey.

I was at first disposed to view *Hyalosphenia tincta* as being the same as *H. cuneata*. They have nearly the same size and form; but the difference in color of the shell and the difference in the character of the locality they inhabit have led me to regard them as distinct.

Associated with *Hyalosphenia tincta*, I observed a number of specimens, of the same sizes, variations in form, and color, but in which the shell exhibited more or less evidence of areolation. In some, the appearance was exceedingly indistinct; in others, it was quite positive, and these latter had then all the characters of a species of another genus, which I have named *Nebela flabellulum.* Those with the indistinct appearance of areolation weie evidently transitional varieties toward the latter.

I have observed sufficient variation in specimens to suspect it probable that *Hyalosphenia tincta* merges into *H. cuneata*, and likewise into *H. elegans* and *H. papilio.*

HYALOSPHENIA ELEGANS.

PLATE XX, figs. 19–29.

Difflugia (Catharia) elegans. Leidy: Proc. Ac. Nat. Sc. 1874, 156; 1875, 415.

Shell compressed flask-shaped; in the view of the broader side, with an oval body and long cylindroid neck, slightly widened at the oral end, which is convex downward; in the view of the narrower side, long elliptical, and tapering to the oral end, which is deeply notched. Shell composed of pale brownish, transparent, structureless, chitinoid membrane, which is impressed with longitudinal rows of hemispherical pits. Sarcode colorless, attached by threads to the sides and fundus of the shell; pseudopods digitate, usually three or four in number.

Size.—Length from 0.088 mm. to 0.108 mm.; breadth of body 0.064 to 0.04 mm.; thickness of the same 0.02 to 0.028 mm.; breadth of neck and oral end 0.016 to 0.02 mm.; short diameter of oral end 0.008 mm.

Locality.—Abundant, in association with *Hyalosphenia papilio*, in sphagnum in the same localities.

Hyalosphenia elegans, figs. 19–29, pl. XX, a common and graceful form, living among sphagnum, appears to be quite distinct from the preceding species. The shell is compressed flask-shaped. Viewed on the broader side, the outline of the body is oval and more or less tapering into a rather long cylindroid neck. The fundus is convex, and the oral end is slightly expanded and convex downward. In the view of the narrower side, the shell presents a long elliptical outline, tapering to the oral end, which appears deeply notched from the turning upward laterally of the oral commissures.

The shell is composed of transparent chitinoid membrane, of a pale chocolate-brownish hue, without a trace of definite structure. It is of uniform thickness, except that it forms a thicker border to the mouth. The sides of the shell exhibit a more or less symmetrically corrugated appearance, due to series of hemispherical inflections, which are remarkably constant and persistent.

The mouth is oval, and is convex in its wider diameter.

The size and form of the shell vary but little. Commonly, specimens range from $\frac{1}{285}$th to $\frac{1}{260}$th of an inch in length, $\frac{1}{625}$th to $\frac{1}{520}$th of an inch in breadth, and $\frac{1}{1250}$th to $\frac{1}{780}$th of an inch thick, with the mouth $\frac{1}{1250}$th of an inch in the greater and $\frac{1}{3000}$th of an inch in the less diameter.

The sarcode of *H. elegans* is colorless, though sometimes the endosarc appears more or less yellowish from the quantity of food it contains. Usually, the endosarc contains many vacuoles and food-balls, mostly of a yellowish or brownish hue, besides which it contains the usual constituents found in allied forms.

The nucleus is usually more or less obscured or may be completely hidden from view by the surrounding materials. It is pale granular and globular, and measures from $\frac{1}{2000}$th to $\frac{1}{1500}$th of an inch in diameter.

From two to four contractile vesicles are frequently visible together in the vicinity of the nucleus at the periphery of the sarcode mass They measure about the $\frac{1}{3000}$th of an inch previous to their collapse.

The mass of sarcode occupies more or less of the interior space of the shell, according as the animal has been well or poorly supplied with nourishment. Sometimes it nearly fills the shell; at others, it barely occupies half its capacity. Extensible threads of ectosarc diverge from the sarcode mass to the sides and fundus of the shell, varying in length in proportion as the mass enlarges or diminishes

The pseudopods are digitate, usually three or four in number, mostly simple, sometimes forking or branching, and finely granular in constitution.

Specimens of *H. elegans* are frequently found with the sarcode in an encysted condition in the form of a compressed ovoid or spheroid ball, of variable size, as seen in figs. 27–29. These specimens also often exhibit a number of pale granular spheres, of variable size, occupying the neck of the shell, as represented in figs. 24, 29. They probably consist of excrementitious matters discharged from the sarcode ball as it assumed the resting condition. Sometimes specimens are met in which the position of the sarcode ball is occupied by a number of pale granular spheres, as represented in fig 25. They are of more uniform size and more definite granular structure than in the spheres of supposed excrementitious matter. Their nature I have not determined, but have suspected them to be spores or reproductive bodies, though they may be entirely foreign to the rhizopod. They measure about the $\frac{1}{2000}$th of an inch in diameter.

I have found no specimens referable to *H. elegans* which exhibited any clearly transitional disposition toward *H. papilio* or other forms.

The thing previously described which appears most to resemble *H. elegans* is the *Difflugia spirigera*, of Ehrenberg, from the Bavarian Alps.* If what I have described as series of hemispherical inflections of the shell correspond with his four internal longitudinal spiral lines, the animals are probably the same, though the size he gives is a third less than the smallest of those I have observed.

QUADRULA.

Latin, *quadrula*, a little square.

Difflugia: Wallich, 1863. *Assulina; Hologlypha:* Ehrenberg, 1871. *Quadrula:* Schulze, 1875.

Shell compressed pyriform, transparent, colorless, composed of thin square plates of chitinoid membrane, arranged in transverse or more or less oblique series, in consecutive or alternating order. Mouth inferior, terminal, oval. Sarcode colorless, having the characters of that of Difflugia, etc.

QUADRULA SYMMETRICA.

PLATE XXIV, figs. 20–25.

Difflugia proteiformis, var. *symmetrica*. Wallich: An. Mag. Nat. Hist. xii, 1863, 458, pl. x, fig. 16.
Difflugia pyriformis, var. *symmetrica*. Wallich: An. Mag. Nat. Hist. xii, 1863, 467; xiii, 1864, 232, pl. xvi, fig. 26.
Difflugia symmetrica. Wallich: Ibidem, 245.
Difflugia assulata. Ehrenberg: Abh. Ak. Wis. Berlin, 1871, 249, Taf. ii, Fig. 4, 5.
D. Assulina assulata. Ehrenberg: Ibidem, 246.
Difflugia carolinensis. Ehrenberg: Ibidem, 250, Taf. iii, Fig. 14.
D. Assulina carolinensis. Ehrenberg: Ibidem, 246, 274.
Difflugia Leptolepis. Ehrenberg: Ibidem, 254, Taf. iii, Fig. 15.
D. Assulina Leptolepis. Ehrenberg: Ibidem, 246, 274.
Quadrula symmetrica. Schulze: Arch. mik. Anat. 1875, 329, Taf. xviii, Fig. 1–6.—Leidy: Pr. Ac. Nat. Sc. 1875, 415.—Archer: Quart. Jour. Mic. Sc. 1877, 122.

* Monatsb. Berl. Ak. Wissens. 1853, 526; Abhand. 1871, Taf. iii, Fig. 4.

Shell compressed pyriform: viewed on the broader sides, with the fundus widely convex, and the sides sloping or more or less inflected toward the oral end, which is convex downward; viewed on the narrower side, ellipsoidal, with the fundus obtuse and the oral end roundly notched. Mouth transversely oval and convex downward. Shell colorless, transparent, composed of square plates arranged in transverse longitudinal or more or less oblique rows. Sarcode colorless; pseudopods digitate, from one to three or more.

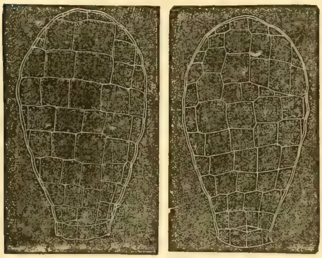
Size.—Length 0.08 mm. to 0.14 mm.; breadth 0.04 mm. to 0.96 mm.; thickness 0.028 mm. to 0.048 mm.; mouth from 0.02 mm. by 0.008 mm. to 0.032 mm. by 0.016 mm.

Locality.—Dripping rocks with *Fegatella*, in Fairmount Park; ditch at the side of the Norristown railroad above Manayunk, Philadelphia; sphagnum of the sphagnous swamps of Absecom, Vineland, and other places in New Jersey.

Quadrula symmetrica, figs. 20–25, pl. XXIV, the only representative of its genus, is remarkable for the peculiar construction of its shell, which is compressed pyriform. Viewed on the broader surfaces, the outline is pyriform, or ovoid, with the sides sloping or more or less inflected, so as to produce a neck of variable length. The oral end is transversely convex. Viewed on the narrower sides, the outline of the shell forms a long ellipse, tapering to the oral end, which appears notched. The mouth is transversely oval and entire.

The shell is perfectly colorless and transparent, and is composed of square, structureless, chitinoid plates. These are arranged, with some general degree of regularity, in transverse, more or less oblique, or longitudinal rows. Longitudinally for the most part they successively increase in size from the vicinity of the mouth toward the fundus. Frequently the row surrounding the mouth is larger than the next, and those on the summit of the fundus are smaller than the preceding ones. The general arrangement is like that of tiling with variable regularity. Mostly their order is consecutive, but sometimes somewhat alternating. They are not entirely disposed with the symmetry expressed by their name, for frequently smaller plates break the regular succession of larger ones, and sometimes one angle of a plate replaces that of a contiguous one.

Besides figs. 20–25, pl. XXIV, the accompanying figures, in the arrangement of the plates of the shell, represent the more important varieties which I have observed.



Quadrula symmetrica. Opposite sides of the same shell.

The size of the shell ranges from about the $\frac{1}{300}$th to the $\frac{1}{175}$th of an inch in length by $\frac{1}{625}$th to $\frac{1}{260}$th of an inch broad.

The sarcode is colorless, and in all its characters resembles that of Hyalosphenia. The food-vacuoles often appear yellowish. The nucleus when visible measures about the $\frac{1}{1560}$th of an inch or more. The pseudopods are digitate and usually two or three in number.

In several instances I have found specimens, late in the season, with the sarcode in a quiescent or encysted condition. Fig. 25 represents such a specimen obtained from sphagnum in November. It was of the largest size, about the $\frac{1}{175}$th of an inch in length. The plates were arranged obliquely across the shell, and were pretty uniform in size. The neck was occupied by a laminated diaphragm as thick as one third the length of the shell. The sarcode mass formed a compressed oval ball occupying a central position in the body of the latter The ball was nearly colorless or faintly yellowish, and granular, and contained several large oil-like globules. A central clearer space appeared to indicate the presence of a nucleus.

Dead shells are sometimes found containing in the interior a number of scattered plates, or the same in one or more little packets, like those composing the wall of the shell.

Quadrula symmetrica was first described by Dr. Wallich, under the name of *Difflugia symmetrica,* from specimens found in England. It was more recently described, and referred to a new genus, by Prof. Schulze, from specimens found near Dresden.

Ehrenberg described the same as pertaining to three different species, under the names of *Difflugia assulata, D. carolinensis,* and *D. leptolepis.* These, in 1871, with a number of other forms, he referred to a subdivision of Difflugia with the names of *Assulina* and *Hologlypha.* As, however, the latter would apply to the first members of the subdivision indicated, which appear to be only varieties or at most two species of Cyphoderia, neither of the names could be considered as properly taking precedence of Quadrula distinctly applied to *Assulina assulata*, the fourth member of Ehrenberg's list.*

NEBELA.

Greek, *nebel*, a bottle.

Difflugia: Ehrenberg, 1848. *Reticella; Allodictya; Odontodictya:* Ehrenberg, 1871. *Nebela:* Leidy, 1874.

Shell usually compressed pyriform, transparent, colorless, with or without appendages, composed of cancellated membrane or of peculiar intrinsic structural elements of variable form and size, mostly of circular or oval disks, of narrow rectangular plates or rods, or of thin, less regular, angular plates, often almost exclusively of one or the other, sometimes of two or more intermingled in variable proportions, sometimes of chitinoid membrane incorporated with more or less extrinsic elements, and sometimes of these entirely, as in Difflugia. Mouth inferior, terminal, oval. Sarcode colorless; in form, constitution, and arrangement as in Difflugia, Hyalosphenia, etc.

NEBELA COLLARIS.

PLATES XXII; XXIII, figs. 1–7; XXIV, figs. 11, 12.

Difflugia collaris. Ehrenberg: Monatsb. Ak. Wis. Berlin, 1848, 218; Microgeologie, 1854, 331; Abh. Ak. Wis. Berlin, 1871, 143, Taf. ii, Fig. 27; Taf. iii, Fig. 21.
Difflugia reticulata. Ehrenberg: Monatsb. Ak. Wis. 1848, 218; Microg. 1854, 331; Ab. Ak. Wis. 1871, 143, Taf. ii, Fig. 26.
Difflugia cancellata. Ehrenberg: Monatsb. Ak. Wis. 1848, 379; Microg. 1854, 331; Ab. Ak. Wis. 1871, 145, Taf. ii, Fig. 3.
Difflugia Carpio. Ehrenberg: Microg. 1854, 119.
D. Lagena β. Carpio. Ehrenberg: Microg. 1854, 331; Abh. Ak. Wis. 1871, 251, Taf. ii, Fig. 22, 27.
Difflugia binodis. Ehrenberg: Microg. 1854, 331; Abh. Ak. Wis. 250, Taf. ii, Fig. 22, 23.
Difflugia annulata. Ehrenberg: Microg. 1854, —; Ab. Ak. Wis. 1871, 249, Taf. iii, Fig. 19.
Difflugia laxa. Ehrenberg: Microg. 1854, —; Ab. Ak. Wis. 1871, 254, Taf. iii, Fig. 22.
Difflugia peltigeracea. Carter: An. Mag. Nat. Hist. xiii, 1864, pl. i, fig. 12.
Difflugia symmetrica. Wallich: An. Mag. Nat. Hist. xiii, 1864, pl. xvi, figs. 27–33.
D. Reticella collaris (Allodictya). Ehrenberg: Ab. Ak. Wis. 1871, 247.
D. Reticella reticulata (Odontodictya). Ehrenberg: Ibidem.
D. Reticella cancellata (Odontodictya). Ehrenberg: Ibidem.
D. Reticella Carpio (Allodictya). Ehrenberg: Ibidem.
D. Reticella binodis (Odontodictya). Ehrenberg: Ibidem.
D. Reticella annulata (Allodictya). Ehrenberg: Ibidem.
D. Reticella laxa (Allodictya). Ehrenberg: Ibidem.
Difflugia cellulifera. Ehrenberg: Deutsche Nordpolarfahrt, 1874, 460, 466, Taf. iii, Fig. 24.
Difflugia (Nebela) numata. Leidy: Proc. Ac. Nat. Sc. 1874, 157.
Nebela numata. Leidy: Proc. Ac. Nat. Sc. 1876, 116, figs. 1–5; 1877, 264.

*Abhand. Akad. Wissens. Berlin, 1871, 246.

Shell compressed pyriform, longer than broad; in the broader view, with the fundus widely convex, the sides sloping downward and generally slightly inflected toward the oral end, which is convex downward; in the narrow view, oblong, with the fundus obtuse, sometimes impressed on each side, gradually sloping, and usually slightly inflected toward the oral end, which is notched Mouth transversely oval, entire. Shell colorless, exceedingly variable in its structural elements, generally composed of oval or circular disks, sometimes nearly exclusively of one or the other, or intermingled in various proportions, more or less uniform or variable in size, sometimes mingled with rod-like or narrow rectangular plates, and sometimes almost wholly composed of these, rarely composed of thin, irregular, angular plates. Sarcode colorless, resembling in general constitution and arrangement that of Hyalosphenia, etc.; pseudopods digitate, usually from three to half a dozen.

Size.—In fifty specimens two thirds ranged between 0.1 mm. and 0.14 mm. in length. The smallest of the series was 0.064 mm. long, 0.036 mm. broad, 0.02 mm. thick, with the oral end 0.016 mm. broad and 0.008 mm. thick. The largest was 0 208 mm. long, 0.12 mm. broad, 0.06 mm. thick, with the oral end 0.048 mm. broad and 0.032 mm. thick. An average-sized specimen was 0.128 mm. long, 0.08 mm. broad, 0.048 mm. thick, with the mouth 0.032 mm broad and 0.024 mm. thick.

Locality.—Moist sphagnum, of the sphagnous swamps of New Jersey, Pennsylvania, Maine, Florida, Alabama; rarely in moss at the edge of a pond in the Uinta Mountains, Wyoming Territory.

Nebela collaris (pl. XXII; pl. XXIII, figs. 1–7), a remarkable and beautiful rhizopod, is common and abundant, living in the moist sphagnum of the sphagnous swamps of New Jersey and Pennsylvania. It is a constant associate of *Hyalosphenia papilio* and *H. elegans.* Sometimes the sphagnum in certain localities actually swarms with the animal, and a drop of water squeezed from the plant contains a multitude of them. At other times and in other localities, apparently under equally favorable circumstances, the sphagnum contains few or none of the animals, though it is rare not to find traces, such as a few dead shells, in the sphagnum of most localities.

The shell is compressed pyriform, longer than broad, though varying considerably in the proportion of the different measurements. Viewed on the broad surface, the outline is pyriform, with the oral end convex downward. The sides slope downward to the mouth, sometimes nearly in a straight line, sometimes with more or less inflection, giving rise to a neck of variable length, though generally short. In the view of the narrower surface, the outline is elliptical or more or less narrowly pyriform, with the oral end concavely notched, and with the fundus obtuse, and sometimes impressed at the sides.

The transverse section of the shell is oval and evenly rounded at the poles, but occasionally is narrowed gradually, or somewhat abruptly approaching the latter.

In some specimens, the section has a hexahedral outline, with concave sides and prominent rounded angles, as seen in fig. 6, pl. XXIII.

Sometimes the shell is impressed laterally and at the fundus, so as to produce obtusely angular borders and a somewhat carinated appearance, as seen in fig. 4, pl. XXII, representing a transverse section.

Sometimes the narrower forms present at the lower third, at each lateral border, a slight conical prominence, at the apex of which the shell appears to be perforated by a minute pore, as seen in figs. 1, 2, 4, 7, pl XXIII.

The mouth is transversely oval and entire, and has rounded commissures, as seen in fig. 4, pl. XXII.

In composition, the shell is of extraordinary character, from the variety in form and arrangement of its elements. Most frequently it is composed of oval or circular disks, as represented in figs. 1–12, 15–17. The disks usually hold no relationship in size with that of the shell: the smallest specimens may have the largest disks, and the largest ones may be composed of those of the smallest size. Sometimes the shell is almost entirely composed of circular disks, sometimes of oval disks, and frequently the two kinds are intermingled. Sometimes they are of pretty uniform size; at others, they are intermingled, of different sizes. Most frequently the larger disks occupy the fundus and body and the smaller ones the lower part or neck of the shell. Sometimes the larger disks are more or less scattered, with some approach to uniformity, and the intervals are occupied by smaller ones. Indeed, there exists almost any conceivable arrangement of the round and oval disks in the construction of the shell.

Another variety of the shell, not uncommon, though less frequent than the former, is composed of narrow rectangular plates, intermingled with a comparatively few round or oval disks, as seen in figs. 13, 18, pl. XXII. The narrow plates are usually placed parallel, in close juxtaposition, in small patches, which are arranged in different directions, while the round or oval plates occupy intervals here and there, singly or two or three together. The general appearance gives the impression of certain kinds of tessellated pavement.

Some shells are mainly composed of round and oval disks, of the variety first described, intermingled with a few narrow rectangular plates or rods, of various lengths, as represented in fig. 7.

Occasionally I have seen specimens with extraneous matters, such as quartz particles and diatoms, incorporated with the shell. A specimen represented in fig. 8 appears to have a few sponge spicules added to the ordinary intrinsic elements of composition.

Not unfrequently there are found, in association with the usual more characteristic varieties of *Nebela collaris*, individuals which have the same form of shell, but with its structure rather related with that of the ordinary forms of Difflugia. In some specimens the shell is composed of thin and irregularly angular silicious plates, as represented in fig. 12, pl. XXIV. The intervals of the plates appear as dark or clear outlines, according to the focus, and the margin of the mouth of the shell is uneven, as it is formed by the bordering plates. Mostly the intervals of the silicious plates are conspicuous, and appear to be occupied by a clear cementing substance, or the shell appears to be composed of clear chitinoid membrane paved with the silicious plates, as seen in fig. 11.

The specimens vary greatly in the forms of the component silicious plates, which consist of variable proportions of the kind just described, with others which are more regularly rectangular, or in the form of rods, and sometimes with diatoms, and round or oval plates like those which ordinarily compose the shell of *Nebela collaris*. Through such specimens the latter would appear by transition forms to merge into *Difflugia compressa*.

The sarcode of *Nebela collaris* is colorless, but frequently the endosarc appears more or less yellowish or brown, from the abundance of mingled food in balls and as diffused granular matter. It is a remarkable fact that rarely green food or food of any other color than those just mentioned is seen in this animal.

The general appearance, extent, arrangement, and constituents of the sarcode are the same as in Hyalosphenia. The nucleus is usually obscured from view by the accumulation of food and other matters. The contractile vesicles are seen, two or three in number, between the position of the nucleus and the periphery of the sarcode mass. Among the yellowish contents of the endosarc, the balls often have the appearance of oleaginous globules

The pseudopods are digitate, mostly simple, and usually from two or three to half a dozen in number. They extend to the $\frac{1}{300}$th of an inch in length or more, and commonly are about the $\frac{1}{3000}$th of an inch thick.

The range of size and the proportionate diameters of *Nebela collaris* vary considerably. Average-sized specimens are about $\frac{1}{200}$th of an inch long, $\frac{1}{300}$th broad, $\frac{1}{500}$th thick, with the mouth about $\frac{1}{900}$th broad and $\frac{1}{1200}$th in the short diameter. A common-sized specimen was the $\frac{1}{90}$th of an inch long, $\frac{1}{250}$th broad, $\frac{1}{520}$th thick, with the oral end $\frac{1}{890}$th by $\frac{1}{1250}$th of an inch. The smallest specimen, of a large number, was $\frac{1}{390}$th of an inch long, $\frac{1}{690}$th of an inch broad, $\frac{1}{1250}$th of an inch thick, with the mouth end $\frac{1}{1560}$th by $\frac{1}{3125}$th of an inch. The largest specimen, from moss, on the borders of a lake high up in the Uinta Mountains, Wyoming Territory, was $\frac{1}{120}$th of an inch long, $\frac{1}{208}$th of an inch broad, and $\frac{1}{416}$th of an inch thick, with the oral end $\frac{1}{520}$th by $\frac{1}{780}$th of an inch.

Nebela collaris may frequently be observed with the sarcode in the condition of a quiescent ball, or in an encysted state, occupying the central portion of the body of the shell, as represented in figs. 7, 8, 10, pl. XXII. The ball is compressed spherical, and varies in size in different individuals. At an early stage it contains a quantity of the yellowish food, but this is gradually discharged, and contributes to the formation of the epiphragm usually found occupying the mouth and neck of the shell. In its later condition, the sarcode ball is pale yellowish or nearly colorless, of granular constitution, mingled with coarser and more defined granules and oleaginous-looking globules, small and large.

The epiphragm (fig. 7) is laminated, and often contains globular bodies, apparently remains of the food discharged or purged from the sarcode ball.

Occasionally specimens occur in which the sarcode is substituted by a variable number of granular spheres, of nearly uniform size, which, as in other similar cases, I have suspected to be spores or reproductive germs; though they may not belong to the animal, and may be of parasitic nature.

Nebela collaris was originally described by me under the name of *Nebela numata;* but on studying the literature relating to the Fresh-water Rhizopods, I have been led to the conclusion that the same had been repeatedly described by Ehrenberg with different names, of which *Difflugia collaris* is one of the earliest.

All the forms described and figured by Ehrenberg with the names of *Difflugia collaris, D. reticulata, D. cancellata, D. Carpio, D. binodis, D. annulata, D. laxa*, and *D. cellulifera*, I suspect to pertain to the same animal, and this I suppose to be the same as that I first described as *Nebela numata.*

In a systematic arrangement of the Arcellinæ,* Ehrenberg has placed the above-named forms, except the last one, in a group he calls *Difflugia Reticella.* Of this he makes an edentate subgroup,—*Allodictya*, and a dentate group,—*Odontodictya.*

If the names of *Reticella, Allodictya*, and *Odontodictya* are to be regarded of generic or subgeneric value, they would apply to the first-named species of the group or subgroups.

D. Reticella asterophora is the first species of the first subgroup, and *D. Reticella binodis* that of the second subgroup. The character of the former is obscure; but, judging from the imperfect figure, it is not generically the same as *Nebela*, and therefore the names of *Reticella* and *Allodictya* would not supplant *Nebela.* Nor would *Odontodictya* correctly replace *Nebela;* for, although *Difflugia binodis* with little doubt refers to what I have considered a variety of *Nebela collaris*, the term is erroneous, for no species of Nebela is dentated.

I think it probable that several other forms described and named by Ehrenberg likewise pertain to *Nebela collaris*, but they are so doubtful that I think it unnecessary to mention them.

The series of specimens represented by Dr. Wallich in figs. 27 to 33, pl. XVI, of the thirteenth volume of the Annals and Magazine of Natural History for 1864, and described as transition forms of *Difflugia symmetrica*, appear to me to pertain to the same animal as *Nebela collaris.* Dr. Wallich remarks that the shell is sometimes compressed, but frequently is not so.

*Abhand. Akad. Wissens. Berlin, 1871, 244.

In all other respects, the forms agree with the varieties of *N. collaris*, but I have never met with specimens in which the shell was otherwise than compressed.

Mr. Carter, in the same work, described a form under the name of *Difflugia peltigeracea*, which probably also belongs to the same animal as *Nebela collaris*.

The nature of the singularly varied shell of *Nebela collaris* I have not been able to determine with any satisfaction. In the characteristic forms, the elements of structure, the disks and plates, appear to be intrinsic, and not of a foreign character. They appear to be cemented together or conjoined at the borders, and not implanted upon or incorporated with a distinct chitinoid membrane. In breaking the shell, the line of rupture follows the outlines or intervals of the disks and plates. The shell appears to be silicious, as it remains unchanged when exposed to the action of heated sulphuric and nitric acids.

Dr. Wallich, in referring to the structure of the shell of the transitional forms of *Difflugia symmetrica*, which, as previously intimated, I suspect to belong to *Nebela collaris*, calls the peculiar elements colloid disks and plates. He remarks of them that they are derived from the animal, and not directly from the medium in which it lives. He supposes, however, that they are formed through the coalescence of diatoms and other mineral elements with the chitinoid basal substance of the shell, which then undergo metamorphosis into all the colloid forms that occur.* Of this process I have been unable to satisfy myself; but the exceedingly varied specimens which have come under my notice, of shells composed of elements apparently intrinsic and of regular but widely different forms, of others apparently of extrinsic elements regular and irregular, with many others of a transitional character, would appear to justify the conclusion of Dr. Wallich.

Curved variety of *Nebela collaris*.

Since the foregoing went to press, in sphagnum from the cedar swamp of Malaga, Gloucester County, New Jersey, among multitudes of characteristic specimens of *Nebela collaris*, together

* Annals and Mag. of Nat. Hist. 1864, xviii, p. 234, pl. xvi, figs. 27–33.

with many other rhizopods, I observed a Nebela, agreeing with the former, except that it had a curved or retort-shaped shell, as represented in the adjoining woodcut. It was a living, active individual, and the only one of the kind detected. The shell was composed mainly of circular plates of variable size. Its length was 0.15 mm.; its greater breadth 0.072 mm., and its less breadth 0.036 mm.

NEBELA FLABELLULUM.

PLATE XXIII, figs. 8–19.

Difflugia (Nebela) flabellulum. Leidy: Proc. Ac. Nat. Sc. 1874, 157.
Nebela flabellulum. Leidy: Proc. Ac. Nat. Sc. 1876, 118, figs. 6, 7; 1877, 264.

Shell compressed pyriform or spheroid, usually broader than long, sometimes as long as or longer than the greater breadth; transverse section oval, with rounded angular poles; neck short or none; mouth transversely oval, slightly convex downward in the long diameter. Shell in color and structure like that of *Nebela collaris*. Sarcode and pseudopods like those of the latter.

Size.—Length 0.068 mm. to 0.096 mm.; breadth 0.072 mm. to 0.104 mm.; thickness 0.032 mm. to 0.048 mm.; mouth from 0.024 mm. by 0.012 mm. to 0.02 mm. by 0.012 mm.

Locality.—Sphagnous swamps of Pennsylvania and New Jersey. Tobyhanna, Pocono Mountain, Monroe County; Broad Mountain, Schuylkill County; Swarthmore, Delaware County, Pennsylvania; Absecom, Longacoming, Kirkwood, and other places in New Jersey.

Nebela flabellulum, represented in figs. 8–19, pl. XXIII, may be regarded as a variety of *N. collaris* in which the breadth in one direction is greater than the opposite one, and approaches nearly or exceeds the length. It is not so common as the characteristic varieties of the latter, but in some localities occurs abundantly. It is a beautiful object as ordinarily seen, and reminded me of a delicate lace-covered fan. Usually, as it lies in the field of the microscope, it presents a broad pyriform outline, with convex fundus, and the sides more or less inflected, so as to produce a neck of moderate length. Sometimes the sides slope in straight lines, so as to leave no distinction of body and neck. Occasionally, also, specimens occur in which there is no prolongation of the oral pole, so that the shell is slightly oblate spheroidal in outline, as seen in fig. 15.

The transverse section of the shell is broadly oval, with the poles angularly rounded, as seen in fig. 10.

In the narrower lateral view of the shell it is elliptical, with the oral pole tapering at the sides. The mouth is transversely oval. In the broader view of the shell it is slightly convex downward, but in the narrow view it appears as a concave notch.

The shell of *Nebela flabellulum* has the same constitution and variety of elements as in *N. collaris.* It is most frequently composed of oval or circular disks, as seen in figs. 8, 12, 17, or of the two together intermingled in different proportions. Sometimes the larger circular or oval disks are more or less regularly distributed, and the intervals filled in with small disks, as seen in fig. 16.

Sometimes narrow rectangular plates in different proportions are intermingled with the disks, and occasionally the former greatly predominate, as seen in fig. 14.

Occasionally I have found specimens in which quadrate plates, like those of *Quadrula symmetrica*, were mingled with the more usual structural elements, as seen in fig. 19.

The size and proportions of the shell of *Nebela flabellulum* vary but little, compared with *N. collaris.* Commonly the length is less than the breadth, and this is nearly twice in one direction what it is in the other. Often the length and breadth are about equal, or the former measurement is a little greater than the latter. Through varieties which are longer than broad, *N. flabellulum* merges into *N. collaris;* but the former is sufficiently distinct and prevalent in some localities to make it convenient to name it as a separate form.

Of the pyriform variety, or that with a more or less distinct neck, the size ranges from $\frac{1}{300}$th to $\frac{1}{260}$th of an inch in length, the $\frac{1}{295}$th to $\frac{1}{240}$th of an inch in breadth, $\frac{1}{690}$th to $\frac{1}{520}$th of an inch in thickness, with the mouth $\frac{1}{1250}$th by $\frac{1}{2080}$th to $\frac{1}{1080}$th by $\frac{1}{2080}$th of an inch.

The oblate spheroidal forms range from $\frac{1}{370}$th to $\frac{1}{350}$th of an inch long, $\frac{1}{350}$th to $\frac{1}{300}$th of an inch broad, $\frac{1}{780}$th to $\frac{1}{700}$th of an inch thick, with the mouth the same as in the former.

The sarcode has the same conformation, kind of attachments, and constitution as in *Nebela collaris.* The endosarc ordinarily contains a multitude of yellowish and brownish food-balls, many of which often have a highly oleaginous appearance.

In a specimen from the great sphagnous swamp of Longacoming, Camden County, New Jersey, represented in fig. 14, the sarcode mass was encysted, and the mouth of the shell closed with a laminated epiphragm. The shell was composed mainly of short, narrow, rectangular plates laid together in small patches, and arranged in diagonals, with intervals occupied by round and oval disks. The sarcode ball, about the $\frac{1}{480}$th of an inch in breadth, contained a large and uniformly granular sphere, occupying about three fourths of its capacity, and measuring the $\frac{1}{625}$th of an inch in diameter. The material of the ball exterior to the granular sphere appeared to consist of a portion of the original sarcode, retaining a numbei of the brownish food-balls.

Nebela flabellulum I have found most abundantly in the extensive sphagnous swamps of Tobyhanna, Pocono Mountain, Monroe County, Pennsylvania. Here especially I found the oblate spheroidal or neckless variety. The species was associated with *N. collaris*, *Hyalosphenia papilio*, *H. elegans*, etc. In the same swamp grew profusely, at the margin of ponds, the Water Arum, *Calla palustris*.

NEBELA CARINATA.

PLATE XXIV, figs. 1–10.

Difflugia carinata. Archer: Proc. Dub. Mic. Club, Dec. 1866, 122. Quart. Jour. Mic. Sc. vi, 1867, 178; ix, 1869, pl. xx, fig. 12; xii, 1872, 195.
Nebela carinata. Leidy: Proc. Ac. Nat. Sc. 1876, 118, figs. 10, 11.

Shell resembling in shape and structure that of *Nebela collaris*, but provided with a thin keel of chitinoid membrane, commencing above the neck and extending along the lateral borders of the body over the fundus. Sarcode also resembling that of *N. collaris* in color, arrangement, and constitution.

Size.—Length from 0.144 mm. to 0.24 mm.; breadth from 0.088 mm. to 0.168 mm.; thickness 0.04 mm. to 0.072 mm.; mouth 0.036 mm. by 0.02 mm. to 0.028 mm. by 0.028 mm.; carina from 0.004 mm. to 0.02 mm. deep.

Locality.—Moderately frequent in the sphagnous swamp of Absecom, Atlantic County, New Jersey; occasionally elsewhere in sphagnum.

Nebela carinata, represented in figs. 1–10, pl. XXIV, is a beautiful species, first discovered by Mr. Archer in Ireland. It is frequent in the moist sphagnum of the cedar swamp of Absecom, New Jersey, and I have obtained it from sphagnum bordering a spring in the vicinity of Swarthmore College, Delaware County, Pennsylvania, but have rarely found it elsewhere. It is usually larger than *Nebela collaris*, with which it is found associated, and which it closely resembles in shape and constitution.

The shell is transparent and colorless, and is compressed pyriform, usually being provided with a more or less distinct neck of variable length. From that of *Nebela collaris* it differs in the possession of a well-marked keel, extending from the lateral borders and fundus, and usually commencing about one third the length of the shell above the mouth. The keel is commonly of considerable depth, but is not proportioned in extent to the size of the shell. It is a thin membrane terminating by a sharp free edge, and by transmitted light is defined from the cavity of the shell by the double contour-line of the wall of the latter. It usually presents a more or less indistinctly granular aspect, but not the defined elements of structure of the shell, of which it is an expansion, excepting occasionally obscure traces of the same may be detected. In the transverse section of the shell, which is oval, the keel appears as acuminate points to the poles.

The mouth of the shell is transversely oval and convex downward, as in *N. collaris*.

The structure of the shell exhibits the same form, variety, and arrangement of elements—round and oval disks, narrow rectangular plates, and broader angular plates, as in *Nebela collaris*.

In a single instance, I observed a specimen, represented in fig. 4, in which some comparatively large quartz particles adhered to the shell, scattered on the fundus, and especially along the border from which emanated the carina.

As before mentioned, *Nebela carinata* is larger than *N. collaris*, and its range of size is not so great as in this. In twenty specimens measured at different times, six were $\frac{1}{130}$th of an inch long, five were longer, and nine shorter. The smallest specimen measured the $\frac{1}{175}$th of an inch long, $\frac{1}{285}$th of an inch broad, $\frac{1}{625}$th of an inch thick, with the oral end $\frac{1}{690}$th of an inch by $\frac{1}{1250}$th of an inch. The largest specimen was $\frac{1}{100}$th of an inch long, $\frac{1}{150}$th of an inch broad, $\frac{1}{350}$th of an inch thick, with the oral end $\frac{1}{570}$th by $\frac{1}{890}$th of an inch. The carina ranges from $\frac{1}{6250}$th of an inch to $\frac{1}{1250}$th of an inch deep.

The sarcode of *Nebela carinata* exhibits the same characters as that of

Nebela collaris. It is colorless, except that the endosarc is more or less brownish or yellowish, from the usual abundance of food-balls and diffused material of the same nature.

I have also observed *N. carinata* with the sarcode mass in an encysted condition and the shell closed with an epiphragm. A specimen of this kind is represented in fig. 5.

NEBELA HIPPOCREPIS.

PLATE XXV, figs. 9–14.

Difflugia (Nebela) equicalceus. Leidy: Proc. Ac. Nat. Sc. 1874, 156.
Nebela equicalceus. Leidy: Proc. Ac. Nat. Sc. 1876, 118, fig. 12.

Shell compressed pyriform, with a thick, blunt, solid carina extending around the body at the fundus and lateral borders, and ending in long digitate processes projecting downward into the interior of the cavity. Mouth transversely oval, convex downward. Shell transparent, colorless, composed of circular disks; the carina pale straw-colored, homogeneous, indistinctly granular. Sarcode, in color, structure, and arrangement, as in *N collaris* and *N. carinata.*

Size.—Length 0.252 mm. to 0.26 mm.; breadth, including carina, 0.14 mm. to 0.16 mm.; thickness 0.068 mm. to 0.072 mm., with the mouth 0.04 mm. by 0.028 mm., and the carina 0.016 mm. deep and 0.008 mm. thick.

Locality.—Wet sphagnum at the borders of Absecom pond, New Jersey.

Nebela hippocrepis, a remarkable species, represented in figs. 9–14, pl. XXV, is related to *Nebela carinata*, which it resembles in shape, but is larger. It is rare, as I have observed but six specimens in four years, and these were found only in the wet sphagnum at the edge of Absecom pond, New Jersey.

The shell is compressed pyriform and variable in the proportions of breadth to length, and a longer specimen may be of less breadth than a shorter one.

The top of the fundus and lateral borders of the body of the shell are occupied by a thick horseshoe-like keel, the ends of which project downward and inward into the cavity. The whole extent of this peculiar appendage to the shell occupies about two-thirds its length. Its projecting digit-like ends divide off from the general cavity of the shell a pair of elongated conical recesses extending upward and outward along the lateral border. At the fundus, the keel is about half the thickness of its depth, but becomes thinner to its termination. It is pale straw-color and indistinctly granular.

The structure of the shell, independent of the keel, is the same as in the other species of Nebela; but, in the few specimens observed, it was in all composed of circular disks of nearly uniform size

The sarcode has the same color, relations, kind of attachment, and structure as in *N. collaris.* A clearer space in the centre of the endosarc indicates the presence of the usual nucleus.

When *Nebela hippocrepis* was disturbed, ordinarily it would withdraw the pseudopods, but the sarcode mass would remain connected with the mouth of the shell. When obliged to leave the latter in receding, it would sometimes retain a connection with the ends of the horseshoe-like appendage of the shell, as seen in fig. 14.

The smallest specimen observed was $\frac{1}{99}$th of an inch long, $\frac{1}{156}$th of an inch broad, $\frac{1}{347}$th of an inch thick, and had the mouth $\frac{1}{570}$th by $\frac{1}{890}$th of an inch. The carina was $\frac{1}{178}$th of an inch deep at the fundus, and had the digit-like ends $\frac{1}{520}$th of an inch long.

The largest specimen was $\frac{1}{96}$th of an inch long, $\frac{1}{178}$th of an inch broad, $\frac{1}{367}$th of an inch thick, with the mouth $\frac{1}{625}$th by $\frac{1}{890}$th of an inch, and the carina was $\frac{1}{1560}$th of an inch deep and $\frac{1}{3125}$th of an inch thick.

In two instances I found specimens of empty shells of a Nebela, evidently related with that described, though they did not possess the horseshoe appendage. The shells had the same shape and structure as *N. hippocrepis,* but were smaller In one, represented in fig. 13, pl. XXIV, two long conical horn-like recesses, or hollow processes, extended from the lateral borders of the fundus downward into the cavity of the shell. In the other specimen, the horn-like recesses were interrupted in their course, so that the lower third was separated from the upper portion. If these horn-like recesses were solid and continuous by a horseshoe appendage in the interval around the fundus of the shell, we would have the condition ordinarily presented by *Nebela hippocrepis.*

NEBELA ANSATA.

PLATE XXV, figs. 1–8.

Difflugia (Nebela) ansata. Leidy: Pr. Ac. Nat. Sc. 1874, 156.
Nebela ansata. Leidy: Pr. Ac. Nat. Sc. 1876, 118, fig. 14.

Shell compressed pyriform, with a pair of lateral conical offsets divergent upwardly from the neck, but in other respects, in structure, color, and in the shape of the mouth, as in *Nebela collaris.* Sarcode likewise as in the latter.

Size.—Smallest, 0.216 mm. long, 0.132 mm. broad between the ends of the lateral horns, 0.104 mm. broad at the fundus, 0.06 mm. thick, with the mouth 0.04 mm. by 0.028 mm.; largest, 0.26 mm. long, 0.164 mm. broad at the ends of the lateral horns, 0.12 mm. broad at the fundus, 0.064 mm. thick, with the mouth 0.052 mm. by 0.028 mm.

Locality.—Moderately frequent in the sphagnum of the cedar swamp of Absecom, New Jersey.

Nebela ansata, represented in figs. 1–8, pl. XXV, another remarkable form, is distinguished by the spur-shaped appendages projecting from the sides of the neck. It gives the impression of *Nebela hippocrepis* devoid of the horseshoe-like body, which is the striking peculiarity of the latter. The general shape of the shell is like that of *N. hippocrepis*, and it is also about the same size. The lateral horns diverge upwardly at the conjunction of the neck and body of the shell. They are hollow, acute, conical offsets of the latter, and are usually more or less incurved, but are sometimes nearly straight or slightly recurved.

The structure of the shell is like that of the other species of Nebela, and, like that of *N. collaris*, presents great variety. Usually it is composed of circular disks nearly uniform or of more or less variability in size. Frequently the disks appear to overlap one another at the contiguous borders, a condition also observed in the other species, though comparatively rarely.

Occasionally specimens occur, as represented in fig. 1, in which a number of partially detached disks are seen projecting along the inner margin of the lateral horns and on the opposite border of the body of the shell.

The sarcode in all respects is like that in the previously described species of Nebela. Usually it presents the ordinary form, but sometimes individuals are observed in which processes of it extend into the lateral horns. These processes are, however, not persistent, and the animal may retract them entirely into the sarcodic mass, as it does the pseudopods, or the threads of attachment to the fundus of the shell.

Nebela ansata is a large species, and its shell measures from $\frac{1}{115}$th of an inch to $\frac{1}{96}$th of an inch in length, $\frac{1}{190}$th inch to $\frac{1}{150}$th inch in breadth at the points of the lateral horns, and $\frac{1}{250}$th inch to $\frac{1}{208}$th inch in breadth at the fundus, with the thickness $\frac{1}{400}$th inch. The mouth averages about $\frac{1}{550}$th of an inch by $\frac{1}{890}$th of an inch.

I have found *Nebela ansata* in the moist sphagnum of the cedar swamp of Absecom every year since my first notice of it in 1874. It is about as frequent as *Nebela carinata*, with which it is found in association, as well as with the other species described.

In September, 1874, I observed a specimen in which the mouth of the shell was closed by a doubly convex epiphragm, the sarcode was contracted into a mass nearly filling the body of the shell above the position of the lateral horns, and the interval was nearly filled with yellowish dirt, apparently the food remains discharged from the sarcode mass. The following morning the sarcode had extended itself so as to compress the dirt within a smaller space against the epiphragm. The third day the specimen was found, as seen in fig. 4, with the sarcode contracted into a compressed spheroidal ball, and with the dirt occupying a still smaller space than previously within the neck of the shell.

NEBELA BARBATA.

PLATE XXIV, figs. 14–17.

Difflugia (Nebela) barbata. Leidy: Proc. Ac. Nat. Sc. 1874, 157.
Nebela barbata. Leidy: Proc. Ac. Nat. Sc. 1876, 119, fig. 18.

Shell bottle-form, slightly compressed, with the neck cylindroid, and about as long as the ovoidal body; fundus obtuse, oral end slightly expanded, and in the longer diameter convex downward; mouth oval, entire. Shell transparent, colorless, composed of circular disks, and furnished with short stiff cilia.

Size.—Length 0.08 mm. to 0.12 mm.; breadth of body 0.044 mm. to

0.056 mm.; thickness of the same 0.036 mm. to 0.048 mm.; breadth of neck 0.014 mm. to 0.024 mm.; thickness of the same 0.012 mm. to 0.02 mm.; mouth 0.016 mm. to 0.024 mm. wide.

Locality.—Wet sphagnum of the cedar swamp of Absecom, and similar localities, New Jersey.

Nebela barbata, represented in figs. 14–17, pl. XXIV, has a slightly compressed bottle-shaped shell, with a cylindroid neck, which is about as long as the ovoidal body. In the view of the broader sides, the neck is more abruptly defined from the body, the fundus is broadly convex, and the oral end is slightly expanded and convex downward. In the narrower view, the neck is more gradually produced from the body, the fundus is more sloping from an obtusely angular summit, and the oral end is concave downward.

In composition, the shell accords with that of other species, being colorless and transparent, but I have observed it only composed of circular disks. The surface of the shell is furnished with short rigid cils, projecting straight outwardly, apparently from the intervals of the disks. The cils usually cease within a short distance of the mouth.

The sarcode and its habits in all respects are like those of *Nebela collaris* and other species.

Nebela barbata approximates in size average specimens of *N. collaris.* The shell measures from $\frac{1}{300}$th to $\frac{1}{250}$th of an inch in length, with the body $\frac{1}{570}$th to $\frac{1}{450}$th of an inch in breadth and $\frac{1}{690}$th to $\frac{1}{520}$th of an inch in thickness.

Nebela barbata is not of unfrequent occurrence in wet sphagnum of the cedar swamp of Absecom and similar places in New Jersey.

Rarely, I have found specimens of Nebela, in the same locality, which have the form and constitution of *N. barbata*, but are entirely devoid of the cils. They may be regarded as a transitional variety toward *Nebela collaris.*

NEBELA CAUDATA.

PLATE XXVI, figs. 21–24.

Nebela caudata. Leidy: Proc. Ac. Nat. Sc. 1876, 58.

Shell compressed ovoid, with from four to five narrow, blunt, conical or clavate processes projecting from the lateral borders and summit of the fundus. Mouth transversely oval. Shell transparent, colorless, with the structure resembling that of *Nebela collaris*, but usually less distinct. Sarcode colorless.

Size.—Length of the shell, exclusive of processes, 0.08 mm.; breadth 0.06 mm.; thickness 0.032 mm.; breadth of mouth 0.02 mm. by 0.016 mm. Length of processes 0.016 mm. to 0.024 mm.

Locality.—Rare, in sphagnum of the cedar swamps of Absecom and Malaga, New Jersey.

Nebela caudata, represented in figs. 21–24, pl. XXVI, is comparatively rare, as I have not seen more than half a dozen specimens, and none of these were in an active condition. It was found in association with the more common forms in the sphagnum of the cedar swamps of Absecom and Malaga, New Jersey.

The shell is compressed ovoid, but in the narrower view appears more pyriform. From the lateral borders and summit, as seen in the broad view of the shell, there projects an unsymmetrical row of four or five long caudate appendages. These are narrow conical or clavate, hollow prolongations of the shell, straight or curved and blunt. Gradually expanding at the base, they give a somewhat polyhedral outline to the shell. The mouth of the latter is transversely oval and convex downward.

The shell is colorless and transparent, and appears to have the same structure as in *Nebela collaris*, but usually less distinct.

In one of the specimens observed, of *N. caudata*, the shell was composed of comparatively large circular disks overlapping at their contiguous borders. Another specimen, an empty shell, was made up of circular and oval disks mingled with narrow rectangular plates. In a third specimen, the shell was composed of chitinoid membrane indistinctly granular and with no decided appearance of disks or rectangular plates. The caudate processes are chitinoid extensions of the shell.

In the specimens observed which were not dead, the sarcode was in an encysted condition, appearing as a compressed spherical ball, occupying the central part of the body of the shell, while the mouth of the latter was closed with a thick epiphragm. The sarcode ball was colorless, and filled with fine granules and clear globules.

Four specimens measured the same length, $\frac{1}{312}$th of an inch; two measured $\frac{1}{416}$th of an inch in the greater breadth, and two $\frac{1}{567}$th of an inch; the less breadth was $\frac{1}{789}$th of an inch. The mouth was $\frac{1}{1250}$th by $\frac{1}{1560}$th of an inch.

HELEOPERA.

Greek, *helos*, a bog; *pera*, a bag.

Shell compressed ovoid, composed of cancellated, chitinoid membrane presenting a reticulated appearance of mostly dotted or interrupted lines, often at the fundus incorporated with particles of sand. Mouth inferior, terminal, large, transversely elliptical. Sarcode and its constituents as usual in Hyalosphenia and Nebela. Pseudopods numerous, digitiform.

HELEOPERA PICTA.

PLATE XXVI, figs. 1–11.

Difflugia (Nebela) sphagni. Leidy: Proc. Ac. Nat. Sc. 1874, 157.
Nebela sphagni. Leidy: Proc. Ac. Nat. Sc. 1876, 119, figs. 16, 17.

Shell compressed ovoid, with the oral pole narrower; mouth terminal, forming a broad narrow ellipse with acute commissures, convex downward in the length, and appearing as an acute notch from the narrow sides. Shell composed of a yellowish, transparent chitinoid membrane with a reticular structure; the meshes of the net being polygonal and the lines of the net dotted. Sarcode with bright-green endosarc from the multitude of chlorophyl corpuscles entering into its constitution. Pseudopods numerous, long, digitate, simple, and branched.

Size—Length 0.092 mm. to 0.168 mm.; breadth 0.076 mm. to 0.136 mm.; thickness 0.044 mm. to 0.072 mm.; mouth 0.036 mm. by 0.016 mm. to 0.072 mm. by 0.032 mm.

Locality.—Frequent and abundant in the sphagnous swamps of Pennsylvania and New Jersey.

Heleopera picta, represented in figs. 1–11, pl. XXVI, I formerly included in the genus Nebela as *Nebela sphagni,* but now regard it as sufficiently peculiar to consider it as the type of another genus.

The animal is found abundantly in almost every extensive sphagnous swamp in association with various species of Hyalosphenia, Nebela, and other rhizopods. It has the same bright coloring as *Hyalosphenia papilio,* but has appeared to me of less graceful proportions and beauty.

The shell of *Heleopera picta* is compressed ovoid, and never presents the pyriform shape so common in Nebela. In the broad view of the shell, it has an egg-like outline, the narrow end forming the convex line of the mouth. In the narrower view of the shell, the outline is elliptical, and the mouth appears as a deep angular notch. The mouth is transversely elliptical, with angular commissures, as represented in fig. 11.

The shell is composed of chitinoid membrane, and is transparent and of a yellowish or pale raw sienna color. It presents a reticulated structure with polygonal meshes. Under higher powers, the lines of the reticulation appear to be composed of rows of granules, or they have a beaded arrangement. The surface of the shell is not perfectly even, but is slightly undulating, apparently from elevation of the reticulation above the level of the intervening meshes.

Occasionally irregular particles of hyaline quartz are incorporated with the shell at the summit of the fundus, as seen in figs. 6, 7, 10.

The sarcode of *Heleopera picta* has a bright green endosarc from the abundance of chlorophyl which enters into its composition. The chlorophyl corpuscles usually measure from $\frac{1}{6000}$th to $\frac{1}{3000}$th of an inch in diameter; but in different specimens and conditions of these, they range from $\frac{1}{12000}$th to $\frac{1}{2000}$th of an inch in diameter.

A large clear nucleus occupies the centre of the sarcode, but is usually more or less obscured from view by the surrounding chlorophyl corpuscles and other, uncolored, elements.

The sarcode occupies the greater part of the interior of the shell, usually leaving but a small interval at the sides and fundus, as seen in the view of the broad surfaces of the animal. It has the same means of attachment to the fundus by threads of ectosarc as in Nebela and other genera.

Contractile vesicles, three or four at the same time, occupy the ordinary position, at the periphery of the sarcode contiguous to the nucleus, as in Hyalosphenia, etc.

The pseudopods are large and numerous, and may be seen extending, and often writhing snake-like, in all directions, from the capacious mouth. They are commonly simple and cylindrical, with blunt ends, but they frequently branch, and at times present pointed ends. They not unfrequently extend the length of the shell, with a thickness of about $\frac{1}{3000}$th of an inch.

Commonly the size of *Heleopera picta* varies but little, a frequent size being about $\frac{1}{250}$th of an inch in length by $\frac{1}{325}$th of an inch in breadth; but individuals are met widely differing at different places and seasons. It ranges from $\frac{1}{270}$th to $\frac{1}{150}$th of an inch in length; $\frac{1}{330}$th to $\frac{1}{184}$th of an inch in the greater breadth, and $\frac{1}{570}$th to $\frac{1}{350}$th of an inch in the less breadth. The mouth varies from $\frac{1}{690}$th by $\frac{1}{1560}$th of an inch to $\frac{1}{350}$th by $\frac{1}{780}$th of an inch.

Heleopera picta is frequently found in the encysted condition, in which state the aperture of the shell is closed by a double convex laminated epiphragm of a yellowish or brown color, as seen in figs. 2, 4–7. The encysted sarcode is compressed spherical, occupying the centre of the shell, as seen in the view of the broader surfaces, and in contact with them, as seen in the view of the narrower surfaces. The encysted ball retains unchanged the profusion of chlorophyl corpuscles, which ordinarily obscure from view almost everything else. Commonly a clearer central spot of the ball betrays the presence of a nucleus

Generally the chlorophyl corpuscles, mingled with colorless granules, form a closely agglomerated mass enveloped with a stratum of colorless granular protoplasm of variable thickness. Most of the chlorophyl corpuscles appear of nearly uniform size, and in different specimens commonly range from $\frac{1}{6000}$th to $\frac{1}{3000}$th of an inch in diameter.

On the 9th of April, 1877, I observed an individual of *H. picta*, obtained from sphagnum preserved all winter in a glass case, with the appearance represented in fig. 2. The interior encysted ball was about $\frac{1}{250}$th of an inch in breadth, and contained the usual agglomeration of chlorophyl corpuscles, of comparatively uniform size, including a nucleus. The agglomeration was capped on one side by a large accumulation of fine molecules, which by reflected light appeared milk-white.

Individuals of *H. picta* are found, as represented in fig. 8, in which the mouth of the shell is closed by an epiphragm; but the usual sarcode mass is replaced by a multitude of more or less scattered chlorophyl corpuscles, like those which ordinarily occur within the sarcode. These are probably spores or germs derived from the breaking-up of the latter.

Sometimes, also, individuals are seen in which the shell, with the aperture open or closed, contains a multitude of yellowish bodies, as seen in fig. 10, which resemble the chlorophyl corpuscles deprived of their bright green hue.

In the encysted condition of *H. picta*, the compressed globular ball is more or less proportionate in size with that of the capacity of the shell; in different individuals it ordinarily ranges from $\frac{1}{400}$th to $\frac{1}{200}$th of an inch in breadth.

The mouth of the shell in the encysted condition of the animal is not only closed by an epiphragm, but is more or less narrowed by the approximation of the lips, and sometimes these appear closely glued together.

HELEOPERA PETRICOLA.

Plate XXVI, figs. 12–20.

Shell compressed oval; mouth terminal, broad, elliptical, convex downward, with acute commissures; fundus convex, loaded with quartz-sand. Structure of shell of chitinoid membrane, reticular, with polygonal or rounded meshes, transparent and colorless, but sometimes brownish. Sarcode colorless; pseudopods numerous.

Size.—Length from 0.096 mm. to 0.15 mm.; greater breadth 0.068 mm. to 0.09 mm.; less breadth 0.048 mm. to 0.06 mm.; breadth of mouth 0.052 mm. to 0.06 mm. by 0.015 mm.

Locality.—Sphagnous swamps of Pennsylvania and New Jersey. Absecom, Hammonton, and Longacoming, New Jersey; Broad Mountain, Schuylkill County, Pennsylvania.

Heleopera petricola, represented in figs. 12–20, pl. XXVI, is found in sphagnum in association with the former species, but is comparatively rare. A few individuals I have met with every year since 1874, in large swamps of New Jersey and Pennsylvania. In most cases I have observed the animal in the quiescent or encysted condition, and rarely have I seen it in an active state.

The shell is compressed oval, with a very wide terminal mouth, the line of which, in the broad view of the shell, is convex downward. The fundus is convex, and is invariably more or less loaded with large, hyaline, angular quartz-sand.

In structure the shell appears to be composed of chitinoid membrane, with a reticular arrangement, sometimes well marked, at others rather indistinct. It is usually colorless, but is sometimes of a pale ferruginous brown, probably due to the infiltration of iron oxyd, which is not unfrequent in sphagnous swamps.

The sarcode is colorless, except that the endosarc may be more or less colored by the presence of food, as seen in fig. 12. The form, arrangement, and mode of attachment of the sarcode mass are the same as in the species of Nebela, etc. The pseudopods are many, and variable like those of *H. picta.*

In the encysted state of *H. petricola*, the sarcode forms a compressed oval or spherical body, nearly colorless or pale yellowish, with a granular constitution, often mingled with globules of various sizes of an oleaginous appearance. The mouth of the shell is closed by a laminated epiphragm.

The shell of *Heleopera petricola* ranges from $\frac{1}{260}$th to $\frac{1}{166}$th of an inch in length, $\frac{1}{367}$th to $\frac{1}{277}$th of an inch in the greater breadth, and $\frac{1}{520}$th to $\frac{1}{416}$th of an inch in the less breadth. The mouth is from $\frac{1}{480}$th to $\frac{1}{416}$th of an inch broad by $\frac{1}{1666}$th of an inch in the opposite diameter.

ARCELLA.

Diminutive of the Latin, *arca*, an ark.

Shell composed of chitinoid membrane, with a minutely hexagonal cancellated structure, translucent and commonly of a brown color, variable in shape, but usually more or less campanulate, with a circular base concavely infundibuliform and convex at the border, and with the mouth central. Sarcode occupying the central portion of the shell, connected with the mouth by a cylindrical neck, and by means of threads of ectosarc with the dome of the shell. Pseudopods few, digitate, blunt, simple or branching. Commonly two nuclei, situated one on each side of the sarcode mass. Contractile vesicles several, occupying the periphery of the upper part of the latter.

The genus **Arcella** was discovered and first described by Ehrenberg in 1830. In its varied forms, it is among the commonest of the shell-bearing fresh-water rhizopods. Ehrenberg and others have described, figured, and named a number of varieties as so many different species, which, however, appear to graduate into one another by those of intermediate or transitional character. Claparède and Lachmann say they have proved that an Arcella, of the form described by Ehrenberg as *A. vulgaris*, sometimes constructs for itself a new shell of one of the forms to which Perty gives the names of *A. angulosa*, *A. dentata*, and *A. Okeni*. They add, that there can therefore be no doubt as to the specific identity of these different forms. Hertwig and Lesser further remark, that they were able to distinguish only a single species to the genus.

It has, nevertheless, appeared to me convenient to designate those which are widely different by separate names, as is done with other organic forms more positively regarded as distinct species. In this view I have described the more conspicuous forms, and have adopted the names applied to them, grouping with each those of intermediate characters which most nearly approximate them.

The shell of Arcella is usually more or less campanulate, and varies greatly in the proportion of height and breadth,—sometimes being so low as to appear shield-like, sometimes so high and expanded as to be balloon-like. Usually it is widest at the circular base, but often is widest near or at the middle. It has an even, convex dome, or this may be divided into facets defined by more or less prominent folds, or else it is impressed with rows of concave pits. The base is convex at the border, and forms an inverted concave funnel, with the circular mouth in the centre.

The shell is usually of some shade of brown: pale or darker raw sienna, to burnt sienna or deep brown, or even almost black. The younger the shell apparently the paler it is, and in the earliest condition is colorless and transparent.

The shell is composed of a more or less translucent or transparent chitinoid membrane, with a minutely hexagonal cancellated structure. It is intrinsic to the animal, and never has incorporated with it quartz-sand, diatom shells, or other extraneous matters.

The hexagonal cancelli are about $\frac{1}{12000}$th of an inch in diameter. According to Hertwig and Lesser they are hollow. This was proved by an ingenious experiment. The shell, after treatment with sodium carbonate, was treated with acetic acid, when the cancelli became filled with minute bubbles of gas.

The sarcode mass occupies the interior of the dome of the shell centrally, and is ordinarily attached to the mouth by a short neck. The periphery of the mass is attached by divergent threads of ectosarc to the interior of the dome and base of the shell.

The pseudopods are usually few, simple, cylindrical, and rounded at the end.

Auerbach* states that he has found in a single Arcella as many as forty nuclei. Claparède and Lachmann† remark that individuals are frequently found with a single nucleus; but it is not rare to see as many as twelve or fifteen. Hertwig and Lesser‡ confirm the statements of these observers, and state that under favorable circumstances they observed a very variable number of nuclei, mostly more than five. Carter§ says that there are but two nuclei, one on each side of the sarcode mass, and this accords with my own observations. Usually I have been able to detect two nuclei, occasionally one only, and rarely three. Perhaps, however, in some of the larger specimens, what I have casually assumed to be food-balls or contractile vesicles, may have been in part rather of the nature of nuclei.

In the usual views of Arcella from above or from beneath, two or three to half a dozen or more contractile vesicles are seen along the circular border of the sarcode mass, some slowly enlarging, one or more collapsing, and several reappearing. The Arcellas feed on various algæ and decaying vegetal matters, but I have not been able to determine whether they feed on infusoria. They are found in all standing waters, in the superficial sediment, and also on the surface of submerged plants. A favorite resort is the under surface of floating leaves of aquatic plants.

A singular condition not unfrequently occurring in Arcella is the production of one or more conspicuous air-bubbles within the sarcode mass. These I have observed gradually to enlarge, and then slowly to diminish and disappear without the evident escape of anything. In a single individual I have observed as many as six bubbles at once. They appear to be due to the development of gas, and their disappearance to its absorption. From experiments of Bütschli, he suspects the gas to be carbonic dioxide.||

Claparède and Lachmann declare that Arcella changes its shell several times during the course of its life. When the animal becomes too large for the shell, it constructs a new one. In this condition, the Arcella almost entirely passes out of its old shell, and at the aperture forms a large mass, which secretes upon its surface a new shell. In such a case, two shells are observed applied to one another, mouth to mouth, the one thick and dark, the other delicate, and at first perfectly colorless, but later pale

*Zeitschrift f. wissens. Zoologie, vii, 425.
†Études sur les Infusoires et les Rhizopodes, i, 444.
‡Archiv f. mik. Anatomie, x, Sup. 97.
§An. Mag. Nat. Hist. xviii, 1864, 221.
||Archiv f. mik. Anat. xi, 1875, 459.

yellowish. The former is the old shell; the latter, the new one. The Arcella passes alternately from one shell to the other, leaving always, however, a part of its body within the old shell. Finally, when the new shell has assumed due consistence, the Arcella passes entirely into it, and in the violent separation which occurs at the moment between the two shells, the old one is split.*

Individuals of Arcella are often met with in pairs applied base to base, and, in common with other rhizopods in a similar position, are generally supposed to be in conjugation, that is to say, in a condition akin to sexual intercourse. Sometimes the two individuals present the same appearance of form, size, and color, but frequently exhibit marked difference in color, while the size and shape are the same or very nearly so. Often the one shell is colorless or faintly yellowish, while the other exhibits a more or less decided yellow or brown color. Between these extremes, couples are met with exhibiting differences of color of every shade of those just mentioned. Frequently the sarcode of the conjoined Arcellas may be observed to form a single mass, rapidly streaming to and fro between the shells. Subsequently the mass separates into two portions, which retire into their respective shells. These finally separate, and the animals move away without showing anything conspicuously different from what is ordinarily observed in them.

Many of the instances of paired Arcellas I have looked upon as probable cases of conjugation; but others, especially those presenting wide differences in the color of the shells, I have suspected to be cases of reproduction, in which the individual with the colorless or nearly colorless shell was the offspring derived by division from the sarcode mass of the individual with the colored shell. This view accords with that of Hertwig and Lesser,† as I understand them, in relation to the same kind of cases. I have never observed the final result in the manner described by Claparède and Lachmann, that is to say, the occupation of the apparently new shell by all the sarcode mass of the old one, and the rupture of this. The new shell, instead of being larger than the parent shell, is often slightly smaller, but is more delicate and flexible, and perhaps, therefore, also more capable of expansion. It assumes color and becomes darker and stronger with age. At first, the cancellated structure is barely visible, but soon becomes more distinct.

* Études sur les Infusoires et les Rhizopodes, i, 445.

† Archiv f. mikroskopische Anatomie, x, 1874, Supplement, p. 97.

Bütschli,* after observing three individuals together, of *Arcella vulgaris*, in conjugation, saw them separate without evident change, but later noticed in one of them a number of cell-like bodies which occupied the space between the sarcode mass and the shell. The cell-like bodies afterward assumed the appearance and movements of Amœbas, and escaped from the mouth of the shell. He suspected them to be the young brood of the Arcella, but their subsequent fate he did not determine.

ARCELLA VULGARIS.

PLATES XXVII; XXVIII, figs. 1–7.

Arcella vulgaris. Ehrenberg: Abh. Ak. Wis. Berlin. 1830, 40, 53, 61, 69, 70, 75, Taf. i, Fig. vi; 1831, 90; 1871, 234. Infusionsthierchen, 1838, 133, Taf. ix, Fig. v.—Dujardin: Infusoires, 1841, 247, pl. ii, figs. 3–5.—Perty: Kennt. kleinst. Lebensformen. 1852, 183, 186, Taf. ix, Fig. 1–3.—Carter: An. Mag. Nat. Hist. xviii, 1856, 128, 221, pl. vii, fig. 79; xiii, 1864, 30, pl. ii, fig. 14.—Claparède and Lachmann: Études Infus. Rhizop. 1858, 9, i, 444.—Pritchard: Hist. Infusoria, 1861, 555, pl. xxi, figs. 7–9.—Wallich: An. Mag. Nat. Hist. xiii, 1864, pl. xvi, figs. 34–37.—Hertwig and Lesser: Arch. mik. Anat. 1874, 96.—Leidy: Pr. Ac. Nat. Sc. 1874, 14; 1876, 55.—Bütschli: Arch. mik. Anat. 1875, 459, Taf. xxv.

Arcella dentata. Ehrenberg: Ab. Ak. Wis. Berlin, 1830, 40; 1831, 90. Infusionsthierchen, 1838, 134, Taf. ix, Fig. 7, except *a.*—Perty: Kennt. kleinst. Lebensformen, 1852, 186.

Arcella hemispherica. Perty: Kennt. kleinst. Lebensformen, 1852, 186, pl. ix, fig. 5.

Arcella angulosa. Perty: Ibidem, 186.

Arcella viridis. Perty?: Ibidem.

Arcellina vulgaris. Carter: An. Mag. Nat. Hist. xviii, 1856, 247.

A. Sticholepis vulgaris. Ehrenberg: Abh. Ak. Wis. Berlin, 1871, 244.

A. Homœochlamys angulosa. Ehrenberg: Ibidem.

Shell hemispherical or campanulate; height about half the breadth and more or less, widest across the usually slightly expanded and circular base, which is inferior, convex at the border, and concavely inverted infundibuliform centrally to the mouth. Dome evenly convex or angularly faceted or concavely pitted at the summit and sides; the facets or pits variable in number, bounded by prominent folds and ranged in two or three circles. Mouth circular, mostly entire, rarely slightly crenulated at the border. Sarcode mass oblately spheroid, colorless independently of the color of the endosarc derived from the food, connected with the mouth by a short cylindroid neck, and attached by divergent threads of ectosarc to the inner surface of the dome. Pseudopods digitate. Color of the test passing from completely colorless in the earliest condition, through various shades of brown, to the deepest hue.

Size.—Breadth 0.048 mm. to 0.152 mm.; height 0.036 mm. to 0.072 mm.; breadth of mouth 0.012 mm. to 0.048 mm.; elevation of mouth 0.006 mm. to 0.016 mm.

*Archiv f. mik. Anat. xi, 1875, 459.

Locality.—Common in the ooze of almost all standing fresh waters, and on submerged portions of aquatic plants. Nova Scotia, Maine, New Jersey, Pennsylvania, Alabama, Florida, and in the Uinta Mountains and valley of Fort Bridger, Wyoming Territory.

Arcella vulgaris, represented in pl. XXVII, and figs. 1–7, pl. XXVIII, is one of the most common of the shell-bearing Fresh-water Rhizopods, and is found in almost every pond, ditch, or long-standing pool in boggy places, creeping in the soft ooze of the bottom or in the flocculent matter adherent to submerged plants.

As ordinarily seen (fig. 2, pl. XXVII) beneath the microscope, it appears as a brown circular disk, with a paler circular central spot corresponding with the mouth. In a side view (fig. 1), the outline is usually low bell-shaped or hemispherical, with the basal border rounded or slightly prominent and rounded. The height is about half the breadth of the shell, but is often more or less, and the greatest width is at or just above the base. The latter is mostly circular, convex downward at the periphery, and concave centrally, so as to appear like an inverted funnel. The mouth is central, circular, and situated at the top of the inverted funnel-like base. The border of the mouth is entire (fig. 2), but sometimes is more or less crenulated, as seen in fig. 9.

The dome of the shell may be evenly convex to the rounded or slightly prominent base. Often its summit and sides are depressed into a variable number of shallow concavities or more or less angular facets defined by folds of the shell. The depressions are ranged into two or three series, usually one on the dome and one or two at the sides, or there may be a single depression on the dome and one or two series at the sides.

Sometimes the shell appears like a truncated pyramid, or a tent supported by poles, as represented in figs. 8–13, pl. XXVIII. Such a form is indicated by Ehrenberg as one of the varieties described under the name of *Arcella dentata*, and referred to a particular species by Perty with the name of *A. angulosa.* Varieties occasionally occur with a transversely oval or quadrately oval outline, with depressed summit and sides, as seen in figs. 4–7 of the same plate.

The shell of *Arcella vulgaris* is usually of some shade of ochre-yellow or brown, but is found from a colorless transparent condition through every tint of raw and burnt sienna to dark umber brown, and so opaque as to obscure the contents from view.

The sarcode of *Arcella vulgaris* is colorless, independently of the color imparted to the endosarc by the presence of food. In the side view of the animal, it usually appears as an oblate spheroidal ball resting on the inverted funnel of the mouth, and attached by a variable number of divergent threads of ectosarc to the inside of the dome of the shell.

Generally I have been able to detect two nuclei, and only two, in the sarcode, one situated on each side. A number of contractile vesicles also are visible at the periphery of the sarcode mass. Among the food contents of the endosarc, yellowish-brown and green food-balls are to be detected, and sometimes with these small diatoms and desmids.

Sometimes individuals are seen with the sarcode detached from the mouth and retracted to the top or to one side of the fundus of the shell. Sometimes the sarcode mass assumes an irregular form, as represented in fig. 14, pl. XXVII. In this individual, the sarcode subsequently assumed the ordinary appearance, as seen in most of the accompanying figures. Its shell was so delicate and flexible, that the summit would become depressed with the protrusion of the pseudopods, and would again assume an even convex condition on their retraction.

Occasionally I have found *Arcella vulgaris* with the sarcode in an encysted condition, presenting the appearance of a spheroid ball, resting upon the position of the mouth, as seen in fig. 33. In this individual, the ball was surrounded with a flocculent granular matter, probably excrement discharged from the sarcode as it assumed the quiescent state. The ball was white and granular, and enclosed in a membrane.

Sometimes I have observed the encysted ball of sarcode so large that it produced a complete eversion of the base of the shell, as represented in fig. 3, pl. XXVIII.

Frequently I have observed pairs of individuals of *Arcella vulgaris* applied with their bases together, and with the shells alike in form, though often differing in color, and sometimes slightly in size. The couples have exhibited various degrees of difference in hue, and sometimes, while one shell is colored, the other is completely colorless, or presents only the faintest straw-yellow tint. See figs. 17, 24, pl. XXVII; fig. 1, pl. XXVIII.

The shell of *Arcella vulgaris* ranges from $\frac{1}{520}$th to $\frac{1}{165}$th of an inch in breadth, $\frac{1}{690}$th to $\frac{1}{350}$th of an inch in height, with the mouth $\frac{1}{2000}$th to $\frac{1}{520}$th of an inch in breadth, and elevated $\frac{1}{4100}$th to $\frac{1}{1500}$th of an inch.

ARCELLA DISCOIDES.

PLATE XXVIII, figs. 14–38.

Arcella discoides. Ehrenberg: Monatsb. Ak. Wis. Berlin, 1843, 139; Abh. Ak. Wis. Berlin, 1871, 259, Taf. iii, Fig. 1.—Leidy: Proc. Ac. Nat. Sc. 1876, 56.
A. Homœochlamys discoides. Ehrenberg: Ab. Ak. Wis. 1871, 244.
Arcella peristicta. Ehrenberg: Microgeologie, 1854, 331; Ab. Ak. Wis. 1871, 260, Taf. iii, Fig. 11, 12.
A. Heterocosmia peristicta. Ehrenberg: Ab. Ak. Wis. 1871, 245.

Shell mostly circular, shield-shaped, usually with the height from one fourth to one third of the breadth; dome low, evenly convex to the rounded or slightly expanded and rounded basal border; base and mouth, and likewise color of the shell, as in *Arcella vulgaris.* Sarcode as in the latter.

Size.—Breadth from 0.072 mm. to 0.264 mm.; height from 0.02 mm. to 0.08 mm.; width 0.02 mm. to 0.08 mm.; elevation of mouth 0.008 mm. to 0.02 mm.

Locality.—Everywhere in association with *Arcella vulgaris.* Pennsylvania, New Jersey, Florida, Alabama, and Fort Bridger and Uinta Mountains, Wyoming Territory.

Arcella discoides (pl. XXVIII, figs. 14–38) I view as the variety of *A. vulgaris* in which the shell presents a greater proportionate reduction in height compared with the breadth; but the one graduates into the other. Usually with the height from a little less than a fourth to little more than a third of the breadth, the shell appears shield-shaped, with an even convex surface, neither faceted nor pitted. The base has the same character as in *A. vulgaris.* The mouth varies greatly in its size in proportion to that of the shell, ranging from one fourth to one half the corresponding diameter of the latter.

From the comparative shallowness of depth of the shell, especially in the colorless condition, *Arcella discoides* is especially well adapted for the investigation of its contents.

The description and figure of *A. discoides* of Ehrenberg appear to apply to a large-mouthed colorless individual.

The sarcode mass usually forms a disk, convex above, with rounded or obtusely angular border, and impressed below, where it rests on the inverted funnel of the mouth. As many as a dozen contractile vesicles may sometimes be detected. Commonly I observed two nuclei, sometimes one, and sometimes three.

The size of the shell of *Arcella discoides* usually ranges from about $\frac{1}{350}$th to $\frac{1}{95}$th of an inch in breadth, $\frac{1}{1250}$th to $\frac{1}{300}$th of an inch in height, with the mouth $\frac{1}{1250}$th to $\frac{1}{300}$th of an inch wide, and elevated above the base from $\frac{1}{3125}$th to $\frac{1}{1200}$th of an inch.

Among some Utricularia from Jacksonville, Florida, I found a number of specimens, viewed as pertaining to *A. discoides*, in which the base of the shell was more widely and deeply concave than usual, as represented in figs. 33, 36. In some of the individuals, the shell was circular; but, in others, it was oval or quadrately oval. The mouth, also, was oval, but with the long diameter crossing that of the shell, as seen in fig. 35.

I have also occasionally met with *Arcella discoides* having an oval shell in Absecom pond, New Jersey, as represented in fig. 34. From the same locality I obtained several specimens, in which the shell had a somewhat trilobate outline, as seen in fig. 38.

In empty shells of *Arcella discoides* I have generally noticed a circle of bright dots surrounding the mouth, as seen in figs. 34–38. Whether these dots are pores or minute tubercles I have not ascertained. When present in living specimens, they are entirely obscured from view by the granular sarcode within the shell. Similar dots I have likewise noticed in some of the specimens attributed to *Arcella vulgaris*, as represented in figs. 4, 6.

Occasionally I have observed small discoid Arcellas, measuring about $\frac{1}{400}$th of an inch in diameter, such as are represented in figs. 30, 31, which I have supposed to be the young of *Arcella discoides.* The shell is transparent, has a pale yellowish tinge, and is so delicate that traction of the threads of attachment of the sarcode draws parts of the shell out of shape, or at times bends the two sides toward each other. The mouth is indistinctly seen; a cancellated structure, if existing, is not evident; and even the shell itself, at times, requires attention to perceive it.

The sarcode is colorless and granular, and usually exhibits two or three contractile vesicles at a time. Mostly I detected no nucleus; but in several specimens I observed what I supposed to be one, measuring $\frac{1}{3000}$th of an inch. The pseudopods are few and digitate. Specimens of the kind just described appear to me to resemble the *Pseudochlamys patella* of Claparède and Lachmann,* and I have suspected that they may be the same.

ARCELLA MITRATA.

PLATE XXIX.

Arcella mitrata. Leidy: Proc. Ac. Nat. Sci. 1876, 56.

Shell mitriform or baloon-shaped, obpyriform or polyhedral, higher than the breadth of the base, widest at or near the middle, more or less contracted or sloping inwardly toward the base; dome mostly inflated; summit and sides evenly rounded or depressed into broad angular facets, bounded by prominent folds; base rounded at the border, inverted concavely infundibuliform; mouth circular, crenulated, mostly everted into the inverted funnel. Sarcode mass spheroidal, usually connected with the mouth by a cylindrical neck, and attached by threads of ectosarc to the interior of the shell. Pseudopods up to half a dozen or more.

Size.—Height from 0.08 mm. to 0.18 mm.; breadth at base 0.072 mm. to 0.168 mm.; breadth at dome 0.084 mm. to 0.2 mm.; width of mouth 0.02 mm. to 0.08 mm.; elevation of mouth from base 0.02 mm. to 0.024 mm.

Locality.—Abundant in Absecom pond; also found in ponds at Atco, Malaga, and other places, New Jersey; Tobyhanna, Pocono Mountain, Pennsylvania; and ponds in the Uinta Mountains, Wyoming Territory.

Arcella mitrata, though by no means so common as the forms which have been viewed as characteristic of *A. vulgaris* and *A. discoides*, is rather frequent in the ponds of sphagnous and cedar swamps of New Jersey. I have found it especially abundant in Absecom pond, so rich in other rhizopods. I found it also in a pond in which grew a profusion of the Yellow Pond-lily, *Nuphar advena*, at an altitude of about 10,000 feet, in the Uinta Mountains, Wyoming.

Arcella mitrata, as represented in the figures of pl. XXIX, departs from the form of *A. vulgaris* in a direction opposite to that of *A. discoides*. Viewed from above or below (figs. 1, 3, 5, 7, 10), it is commonly circular, though often more or less modified by angular projections of the base or

*Études s. l. Infus. et Rhizopodes, 1858, 9, 443, pl. xxii, fig. 5. Hertwig and Lesser: Archiv f. mikr. Anat. 1874, 100, Taf. iii, Fig. 1.

prominent sides of the body of the shell. Viewed from the side (figs. 2, 4, 6, 8, 9, 11), it is variable in shape, though ordinarily it is more or less balloon-like or rounded mitriform, commonly of greater height than the breadth, and narrowed at or near the base.

The dome is mostly inflated, and is round and even, or both it and the sides may be depressed into a variable number of faces defined by folds. The base is circular, and sometimes irregularly and widely dentate in outline, and it is more or less deeply inverted in a funnel-like manner toward the mouth. The latter is circular, with a variably crenulated border, and is everted into the top of the inverted funnel-like base of the shell.

The color of the shell of *A. mitrata* presents all the shades of difference occurring in *A. vulgaris*.

The sarcode, as in the latter, is colorless. It usually forms an oblate spheroidal mass connected with the mouth by a cylindroid neck of variable length. Sometimes the sarcode mass is prolate spheroidal, and often demispheroidal or demioval, in which case the base mostly rests upon the position of the mouth of the shell. The body of the sarcode is ordinarily attached by a multitude of diverging threads of ectosarc to all parts of the interior of the shell.

Pseudopods appear commonly to be more numerous in *A. mitrata* than in the other forms, but in other respects do not differ.

Generally, the size of *A. mitrata* exceeds that of *Arcella vulgaris*. It ranges in height from about $\frac{1}{300}$th to $\frac{1}{140}$th of an inch; in breadth at base from $\frac{1}{350}$th to $\frac{1}{150}$th of an inch; in breadth near the middle from $\frac{1}{300}$th to $\frac{1}{125}$th of an inch. The mouth ranges in width from $\frac{1}{1200}$th to $\frac{1}{200}$th of an inch, and its elevation above the base, exclusive of the eversion, is from $\frac{1}{1200}$th to $\frac{1}{1000}$th of an inch.

I am uncertain whether a form like that of *Arcella mitrata* has been previously recognized. I had suspected that it might be the same as *Arcella costata* of Ehrenberg, but this is doubtful from the absence of ribs, and its being more than three times the size. Since first describing it, in looking up the literature of the rhizopods, I met with Mr. Archer's description of *Arcella globosa*, with which it appears best to agree, and perhaps it may be the same.

ARCELLA DENTATA.

PLATE XXX, figs. 10–19.

Arcella dentata. Ehrenberg: Ab. Ak. Wis. Berlin, 1830, 40; 1831, 90; 1871, 264. Infusionsthierchen, 1838, 134, Taf. ix, Fig. vii (the first figure only of the series).—Leidy: Proc. Ac. Nat. Sc. 1874, 14; 1876, 56.

Arcella stellaris. Perty: Mittheil. Naturf. Gesells. Bern, 1849, 126.

Arcella Okeni. Perty: Kennt. kleinst. Lebensformen, 1852, 182, 186, Taf, ix, Fig. 4.

Arcella stellata. Ehrenberg: Microgeologie, 1854, 192. Ab. Ak. Wis. 1871, 261, Taf. iii, Fig. 10.

A. Homœochlamys dentata. Ehrenberg: Ab. Ak. Wis. 1871, 244.

A. Heterocosmia stellata. Ehrenberg: Ibidem, 245.

A. Sticholepis stellaris. Ehrenberg: Ibidem, 244.

Shell, as seen from above or below, circular and more or less dentated; in the side view, crown-like; breadth more than twice the height; dome convex and even, or depressed at summit and broadly fluted at the sides; base centrally inverted, concavely infundibuliform, at the periphery more or less everted, and divided into points of variable length. Mouth circular, entire. Sarcode resembling that of *Arcella vulgaris.*

Size.—Breadth between points of base from 0.132 mm. to 0.184 mm.; breadth of base to position of eversion 0.104 mm. to 0.14 mm.; height from 0.44 mm. to 0.048 mm.; width of mouth from 0.04 mm. to 0.044 mm.; elevation of mouth above the base 0.01 mm. to 0.016 mm.

Locality.—Same as for *Arcella vulgaris*, but comparatively rare. The most characteristic found at Lake Hattacawanna, Morris County, New Jersey. Obtained also in Pennsylvania.

The dentated form (figs. 10–19, pl. XXX) only of the *Arcella dentata* of Ehrenberg I have regarded as characteristic, while the others I have viewed as subordinate forms of *Arcella vulgaris.* While the latter appear to me as comparatively slight modifications from the evenly convex form of *A. vulgaris*, perhaps produced by unequal traction of the threads of the sarcode mass on the shell, the former could only be produced from the same form of *A. vulgaris* by evolution or growth of the dentate processes.

Perty has figured and described the same form from Bern, Switzerland, under the name of *Arcella Okeni* and *A. stellaris.*

Arcella dentata, represented in figs. 10–19, pl. XXX, occurs in the same localities as *A. vulgaris*, but is comparatively rare. I have found it in the ditches below Philadelphia, and sparingly in a number of other places. The most extreme forms I found, in considerable numbers, in Lake Hattacawanna, Monroe County, New Jersey.

The shell, as in other named forms, occurs colorless, and of every shade of brown, from the palest to the deepest.

Viewed from above or beneath (figs. 10, 12, 14, 16), the shell resembles a wheel with pointed cogs. Viewed from the side (figs. 11, 13, 15, 17, 18), it resembles a crown, sometimes with evenly rounded top and turned-up rim edged with conical points, sometimes with the top depressed and a series of radiating ridges curving to the points of the rim. The latter is formed by an eversion of the border of the base prolonged into points of variable length. Sometimes these are quite short, sometimes so long that they even reach as high as the top of the shell. They vary in number, usually from nine to a dozen.

The base of the shell from a level forms an inverted concave funnel, at the top of which is situated the circular, entire mouth.

The sarcode of *Arcella dentata* is in all respects like that of *Arcella vulgaris*, except that it has a more depressed or more oblate spheroid form, due to the greater shallowness of the shell.

Usually the shell of *Arcella dentata* is more than three times the breadth of the height, and in this respect is more like *A. discoides* than *A. vulgaris*, as I have distinguished them.

The size of the shell of *A. dentata* presents but little variation. It usually ranges from $\frac{1}{190}$th to $\frac{1}{135}$th of an inch in breadth between the points of the rim, $\frac{1}{240}$th to $\frac{1}{180}$th of an inch at the level of the base, $\frac{1}{570}$th to $\frac{1}{520}$th of an inch in height, with the mouth $\frac{1}{625}$th to $\frac{1}{570}$th of an inch wide, and elevated from $\frac{1}{2500}$th to $\frac{1}{1560}$th of an inch.

ARCELLA ARTOCREA.

PLATE XXX, figs. 1–9.

Arcella artocrea. Leidy: Proc. Ac. Nat. Sc. 1876, 57.

Shell from a fourth to less than half the height of the breadth; dome convex and even, or mammillated or pitted; basal border everted and rising from a fourth to nearly half the height of the shell, obtusely angular and entire; central portion of the base inverted in the usual concavely infundibuliform manner; mouth circular, entire, surrounded with a circle of minute tubercles. Sarcode having the same general form and relationships as in other Arcellas, but rendered bright green from the presence of abundance of chlorophyl corpuscles in the endosarc. Pseudopods colorless, digitate

Size.—Breadth at lateral border 0.144 mm. to 0.176 mm.; breadth at base 0.112 mm. to 0.136 mm.; height 0.04 mm. to 0.06 mm.; width of mouth 0.02 mm. to 0.028 mm.; elevation of the same 0.012 mm. to 0.024 mm.

Locality.—Absecom pond, New Jersey.

Arcella artocrea (pl. XXX, figs. 1–9) is most nearly related to *A. discoides*, but the sarcode mass is of a bright-green color from the presence of an abundance of chlorophyl corpuscles entering into the composition of the endosarc. It is rare, as I have found it only in Absecom pond, and in the wet sphagnum skirting the same, and here seldom.

The shell is comparable in shape to an ordinary pie, a turban, or to a low and round-crowned hat, and is of a bright raw sienna-brown color of varied shades.

The shell is commonly between a fourth and a third of the height of the breadth, but also occurs of greater or less proportionate height. Viewed from above or below (figs 1, 3, 5, 7), the outline is mostly circular, but is sometimes oval, quadrately oval, or more or less constricted, so as to be biscuit-shaped. The lateral, prominent, more or less angular border is elevated from a fourth to nearly half the height of the shell. The dome is evenly convex, or it is mammillated or conversely pitted. The base is centrally inverted in a concave funnel-like manner. The mouth is circular, or sometimes oval, and is entire. It is elevated from a fourth to nearly half the height of the shell, and sometimes appears slightly everted into the funnel formed by the base of the shell. Around the mouth there is a circular row of bright points which appear to be minute tubercles.

The sarcode forms a lenticular mass of variable proportionate size, occupying the central portion of the shell (fig. 1). It is attached in the usual manner by threads of ectosarc, and the pseudopods are like those of other forms of Arcella. The endosarc is bright green, from the presence of chlorophyl corpuscles measuring about $\frac{1}{6000}$th of an inch in diameter.

Arcella artocrea is a comparatively large form, in this respect also related to *A. discoides*. It ranges in breadth from $\frac{1}{170}$th to $\frac{1}{140}$th of an inch, and in height from $\frac{1}{625}$th to $\frac{1}{400}$th of an inch.

CENTROPYXIS.

Greek, *kentron*, a prickle; *puxis*, a box.

Arcella: Ehrenberg. *Difflugia:* Perty. *Centropyxis:* Stein, 1857.
Echinopyxis: Claparède and Lachmann, 1859. *Homœochlamys:* Ehrenberg, 1871.

Shell discoid, circular, oval, or ovoid, deepest or thickest and most obtuse posteriorly, with the base on a level inferiorly and deeply inflected to the mouth, with the dome highest posteriorly, gently curving or sloping forward, more abruptly convex backward; mouth and fundus eccentric in opposite directions, the former anterior and inferior, the latter posterior and even, or furnished with a variable number of conical spines. Mouth circular or oval and entire, or with the border more or less deeply sinuous, and extending into appendages within the shell toward the dome. Shell usually of various shades of brown, but sometimes colorless, composed of chitinoid membrane mostly incorporated with variable proportions of quartz-sand, and often to such an extent as to assume the structure common in Difflugia. Sarcode colorless; pseudopods digitate.

Centropyxis, according to my experience, always appears distinctly separated from Arcella, while, on the other hand, it appears more closely related with Difflugia through *D. constricta.* The shell of Centropyxis, as in the latter, has the mouth and fundus eccentric in opposite directions, while in Arcella they are both central in the same longitudinal axis. The shell of Arcella is chitinoid, with a distinct hexagonal cancellated structure, and is always free from extraneous particles, whereas in Centropyxis the shell, though often membranous or chitinoid, does not exhibit a cancellous structure, and is mostly incorporated with more or less extraneous matters.

CENTROPYXIS ACULEATA.

PLATES XXX, figs. 20–34; XXXI; XXXII, figs. 29–37.

Arcella aculeata. Ehrenberg: Ab. Ak. Wis. Berlin, 1830, 40; 1841, 368, Taf. iii, Fig. 5. Infusionsthierchen, 1838, 133, Taf. ix, Fig. vi.
Arcella ecornis. Ehrenberg: Ab. Ak. Wis. Berlin, 1841, 368, Taf. i, Fig. 9; Taf. iii, Fig. 46. Microgeologie, 1854, Taf. xxxiv, ii, Fig. 1.
Difflugia aculeata. Perty: Kennt. kleinst. Lebensformen, 1852, 186.
Centropyxis aculeata. Stein: Sitz. Böhm. Gesells. Wis. ? 1857.
Echinopyxis aculeata. Claparède and Lachmann: Études Infus. 1859, 447.—Carter: An. Mag. Nat. Hist. xiii, 1864, 29, pl. i, fig. 8.—Barnard: Proc. Am. As. Adv. Sc. xxiv, 1875, 241. Am. Quart. Mic. Jour. 1879, 83, pl. viii, fig. 3.
A. Centropyxis aculeata. Ehrenberg: Ab. Ak. Wis. Berlin, 1871, 245.
A. Homœochlamys ecornis. Ehrenberg: Ibidem, 244.
A. Centropyxis Diadema. Ehrenberg: Ibidem, 245.
Arcella Diadema. Ehrenberg: Ibidem, 259, Taf. iii, Fig. 7, 8.
Centropyxis. Leidy: Pr. Ac. Nat. Sc. 1876, 57.
Centropyxis ecornis, variety. Leidy.

Centropyxis aculeata (pl. XXX, figs. 20–34; pl. XXXI; pl. XXXII, figs. 29–37) is one of the most common of the Lobose Protoplasts, and is found everywhere in the usual localities of *Arcella vulgaris* It is exceedingly variable in character, but I have not been able to distinguish more than the one species. This is to be sure not always aculeate, as expressed by the name; but the spineless form is evidently a mere variety.

The spinous forms may be regarded as the more characteristic, as represented in the figures of pl. XXXI, except the last two of the series, and as seen also in figs. 29–34 and 37 of pl. XXXII. The spineless forms, constituting the *Arcella ecornis* of Ehrenberg, represented in figs. 20–34, pl. XXX, figs. 33, 34, pl. XXXI, and figs. 35, 36, pl. XXXII, may be regarded as a variety with the name of *Centropyxis ecornis.*

Size.—Length of shell transversely from 0.088 mm. to 0.26 mm.; breadth 0.072 mm. to 0.22 mm.; height 0.036 mm. to 0.08 mm.; diameter of mouth 0.028 mm. to 0 1 mm ; length of spines 0.02 mm. to 0.06 mm.

Locality.—Everywhere in association with *Arcella vulgaris* and quite as common. Abundant in ditches and ponds in Pennsylvania, New Jersey, Rhode Island, Massachusetts, Florida, Louisiana, Colorado, Wyoming Territory, Utah, and Nova Scotia.

The shell of **Centropyxis aculeata** as commonly observed reminds one of an Arcella with the fundus pressed to one side, so as to render the mouth eccentric. As usually seen beneath the microscope, from above or below, it appears with a more or less broadly ovoid outline, with the mouth nearer the narrower pole and a variable number of spines diverging from the opposite pole and sides.

In the lateral view, the shell is cap-shaped, like the shell of *Difflugia constricta*, but commonly more depressed. The mouth and fundus being eccentric in opposite directions, the former is anterior and inferior, and the latter posterior and more elevated than the fore part of the shell. The greatest perpendicular depth of the shell is back of its middle, and its shallowest portion forms the anterior border, which often is somewhat depressed below the general curvature of the front of the dome. The base of the shell rests on a level at its anterior two-thirds, and is inverted funnel-like as in Arcella. The fundus of the shell is obtusely rounded, and is usually furnished with a variable number of divergent spines arranged in a single, somewhat regular row, along the summit posteriorly and at the sides. The spines range from one to nine, but, as previously indicated, may be altogether absent. They are straight or curved, awl-shaped, hollow processes of the shell. In one instance, as represented in fig. 35, pl. XXXI, a curved spine projected from the front of the shell.

The shell of *Centropyxis aculeata* is commonly composed of a yellowish or brown chitinoid membrane, incorporated with variable proportions of quartz-sand. Often finer particles of this material are scattered over the shell, while usually the largest grains accumulate in variable quantity along the position of the spines on the fundus. Rarely, the shell is entirely devoid of adherent or incorporated sand or other particles, as seen in the specimens of figs 29–33, pl. XXXII. Often the shell appears composed of sand particles, as is ordinarily the case in Difflugias, and as represented in figs. 17–30, pl. XXXI. Sometimes the sand is substituted by thin plates, probably diatom fragments, as seen in fig. 3, and sometimes by more distinctly marked diatoms, as seen in figs. 31–34, pl. XXXI, and fig. 34, pl. XXXII.

Especially in the *Centropyxis ecornis* is the shell composed of quartz-sand, as seen in the figures of that variety in pl. XXX.

The spines of *Centropyxis aculeata* are almost always composed of chitinoid membrane, even when the body of the shell consists of sand, but sometimes these processes have particles incorporated, and not unfrequently they are terminated by a sharp quartz flake.

Mostly the shell of Centropyxis is of some shade of brown or dull yellow, but may also be colorless. Not unfrequently the specimens composed of sand appear to have the cementing substance stained while the sand is colorless, or the former may be of a darker hue than the latter. Such specimens appear as if invested by a colored net with lighter meshes.

The construction of the mouth of *Centropyxis aculeata* appears to be of more complex character than in most other Lobose Protoplasts, and its condition seems to have escaped the notice of previous investigators. This has no doubt been due to the fact that the orifice of the mouth is so deeply inverted, and is commonly more or less obscured from view by the sand composing or incorporated with the walls of the shell.

In many specimens, the mouth, as seen through the shell, from beneath or above, appears large, and simply circular, as represented in figs. 21, 25, pl. XXX, figs. 17–33, pl. XXXI, and figs. 34, 37, pl. XXXII. Commonly, in the same view, the mouth is more or less sinuous, as represented in most of the remaining figures of Centropyxis in the same plates. The bordering sinuses of the mouth have seemed to me to be variable in number—ranging from two to eight.

When the shell is composed of chitinoid membrane, and is sufficiently translucent and clear of sand, in the lateral view, as represented in figs. 7, 10, pl. XXXI, figs. 29, 31, 32, 36, pl. XXXII, the mouth is seen to communicate with the cavity of the shell at the upper extremity of the inverted funnel-like base of the latter.

The borders of the orifice of the mouth appear to be extended in broad bands, corresponding in position with the sinuses of the mouth above indicated. From the difficulty of getting and maintaining the shell of Centropyxis in a favorable position for the purpose, I could not satisfactorily determine the exact arrangement of the ascending bands; but they seemed to me to expand at the upper extremity, in some cases to remain free, in others to come into contact with the interior of the roof of the shell. Mostly the upper ends of the bands appeared to be notched.

At times, in examining specimens, and causing them to roll about in the animalcula-cage, from the mouth beneath, a glimpse could be caught of one or two of the notched ends of the bands, as seen in fig. 5, pl. XXXI. Rarely, a specimen would occur in which a pair of the bands would be distinctly visible, through the mouth from below, as seen in fig. 30, pl. XXX, and fig. 35, pl. XXXIII.

While spineless specimens of Centropyxis, composed of chitinoid membrane, approximate Arcella in character, I never could satisfy myself that the shell of the former exhibited the cancellated structure of the latter. In some chitinoid shells of Centropyxis, as those represented in figs. 6, 14, pl. XXXI, I observed a punctated appearance of some uniformity, but it did not display the clear cancellated arrangement so characteristic of the shell of Arcella.

Centropyxis seems a decidedly more shy creature than Arcella, and is very much less disposed to put forth its pseudopods. The sarcode is colorless and transparent, and its constituents are usually much less evident than in other ordinary Lobose Protoplasts. Abundant as the animal is, I rarely have had the opportunity of observing it under favorable conditions, to see the sarcode so as to distinguish its different elements. Mostly, the structure of the shell was such as to obscure the interior soft structure, and generally it has so happened that in specimens in which the shell was transparent, it was almost invariably empty.

Centropyxis is frequently found among floating confervæ, or among the flocculent materials, with desmids, diatoms, and other algæ, adherent to aquatic plants. The spines of the shell would appear to enable it to maintain its position. According to Claparède and Lachmann, delicate pseudopods are transmitted by the spines; but this fact I have not observed. The ordinary pseudopods are protruded usually a few at a time, and they present the same appearance as in Difflugia and Arcella.

Smaller specimens of the variety *Centropyxis ecornis*, so far as the shell is concerned, become undistinguishable from the smaller, spineless kinds of *Difflugia constricta.*

Forms recently described by Professor Barnard, under the names of *Echinopyxis tentorium* and *E. hemispherica* (Am. Quart. Micros. Jour. 1879, 84, pl. viii, figs. 1, 2), found in association with *Centropyxis aculeata*, in creeks and ponds of New York, I have not observed. The figures of the former, *E. tentorium*, remind me of the single-spined variety of *Difflugia constricta*, as represented in fig. 51, pl. XVIII.

COCHLIOPODIUM.

Greek, *cochlis*, a shell; *pous*, a foot.

Amœba: Auerbach. *Amphizonella:* Archer. *Cochliopodium:* Hertwig and Lesser.

Animal minute, provided with a flexible, chitinoid shell thinning away to the broadly expansive mouth, and exhibiting a minutely cancellated structure. Sarcode intimately adherent to every part of the interior of the shell, pale granular, mingled with variable proportions of highly refractive corpuscles, often crystals and other elements, together with a large central nucleus and one or more contractile vesicles. Pseudopods delicate, hyaline, conical, pointed, and sometimes forking.

COCHLIOPODIUM BILIMBOSUM.

PLATE XXXII, figs. 1–25.

Amœba bilimbosa. Auerbach: Zeits. wis. Zool. vii, 1856, 374, Taf. xix, Fig. 1–13.
Amœba actinophora. Auerbach: Ibidem, 392, Taf. xx.
Amœba zonalis. Leidy: Proc. Acad. Nat. Sc. 1874, 87.
Cochliopodium pellucidum. Hertwig and Lesser: Arch. mikr. Anat. x, 1874, Suppl. 66, Taf. ii, Fig. 7.—Schulze: Ibidem, xi, 1875, 337, Taf. xix, Fig. 1–5.

Body when at rest spheroid or ovoid; by transmitted light, viewed from above, appearing as a usually translucent, granular, protoplasmic mass, with coarser, darkly outlined granules, closely invested by a transparent, colorless, doubly contoured, more or less distinctly punctate or cancellated membrane, like the young colorless shell of Arcella. When in movement, and viewed in the same direction, usually appearing more or less completely surrounded by a delicate transparent zone of variable width, and finely and regularly punctate. In the lateral view, usually appearing more or less widely bell-shaped in outline, with the fundus and sides defined by a doubly contoured dotted line, and at the mouth with a wide, more translucent, and more or less delicately punctate band defined by a scarcely perceptible dentated edge. Interior protoplasm with a large round nucleus toward the fundus, with variable proportions of highly refractive corpuscles, crystals, vacuoles, and usually one or more contractile vesicles. Pseudopods mostly few, hyaline, of variable proportions, conical, often irregular and sometimes furcate.

Size.—In the spheroidal condition from 0.024 mm. to 0.056 mm. in diameter.

Locality.—In springs, ponds, ditches, and other quiet bodies of clear fresh water, among algæ and in ooze. Pennsylvania, New Jersey, Florida, Fort Bridger, Wyoming Territory, and New Brunswick.

The genus Cochliopodium was first clearly characterized, and its often enigmatic appearances satisfactorily interpreted by those able investigators of the Rhizopods, Drs. Hertwig and Lesser. The species under consideration was named by them *C. pellucidum;* but, as the same appears to have been previously described by Auerbach under the name of *Amœba bilimbosa*, according to the rules of scientific nomenclature I have felt it obligatory to adopt the latter specific name.

Cochliopodium bilimbosum, represented in figs. 1–25, pl. XXXII, is common among algæ floating in the water of ditches and ponds, especially with Zygnema, Spirogyra, etc. From its minuteness it is easily overlooked; and in the younger condition, from the transparency and undeveloped structural character of the shell, it is apt to be mistaken for an Amœba.

At rest the animal may appear as a spheroidal or ovoidal, translucent, pale granular, colorless, or faintly yellowish ball, invested with a colorless membrane seen at the border as a distinctly double contour-line. When the creature begins to move, a clear, delicate, transparent zone is seen to extend from the body on one or another side or all around

An attentive study of Cochliopodium in its various movements indicates the animal to be bell-shaped, with a flexible shell, which it is capable of widely expanding at the mouth. At the fundus and sides, the membrane is comparatively thick, and is observed at the borders as a double contour-line. The lower part of the shell is exceedingly thin and delicate, and may be inflected or more or less widely reflected, the mouth contracting or enlarging proportionately with the inflection and reflection of the part of the shell surrounding it. The interior sarcode is continuous with its chitinoid membranous investment, and at no time appears to become separated so as to leave spaces filled with water, as in Hyalosphenia or Euglypha.

Cochliopodium in form may be compared with an Arcella, and the shell of this would be like that of the former, if its basal portion were very thin and capable of reflection beyond the border of the base.

The broad zone surrounding Cochliopodium, as seen in figs. 1, 16, 17, 21–23, in the upper or under view of specimens, or the broad crescentic band spreading more or less on one side in corresponding views, as seen in figs. 2–4, 12, 15, 19, are due to the reflection or turning outwardly of the thin basal band of the shell surrounding the mouth. In the lateral view of specimens, the same band may be likewise observed more or less reflected, as seen in figs. 5–9, 11, 18, 20. When the thin basal band is closed or completely inflected, specimens appear as in figs. 13, 14.

In the maturer specimens of Cochliopodium, the shell exhibits a punctate appearance, due to a minutely cancellated structure, probably like that of the shell of Arcella. The structure is especially to be detected in the double contour-line seen bordering the body, and in the basal band of the shell. In the intermediate position it is obscured by the granular structure of the sarcode. The punctated structure is sometimes exceedingly indistinct, and can be detected only under the best defining power of the microscope, together with the most favorable disposition of light. In young specimens, as in those represented in figs. 21–23, I could detect no evidence of the cancellated structure, and infer that it is developed only at a later period.

The sarcode of Cochliopodium is so closely adherent to the flexible and elastic investing shell that in all its changes of form, the shell accommodates itself to those changes. It consists of a pale, finely granular protoplasm, having scattered through the mass variable proportions of clear and darkly outlined round and oval corpuscles, which have an oleaginous or a starch-like appearance. Mingled with these there are commonly a few liquid globules or vacuoles, of which one or two may from time to time be recognized as contractile vesicles. Among the coarser elements of the sarcode, crystals are often present. The usual food contents consist of diatoms and one-celled algæ, together with some sand grains.

A large round nucleus with a large pale granular nucleolus occupies the sarcode toward the fundus of the shell.

The more conspicuously granular portion of the sarcode ordinarily remains confined within the thicker portion of the shell, while only a clearer portion spreads outwardly within the thin basal band of the shell.

The pseudopods of Cochliopodium are usually seen as hyaline awl-shaped extensions of the sarcode, of variable proportions, generally simple, but not unfrequently forking or moderately branching at the end. They often appear as delicate conical or more acuminate extensions from beneath the expanded border of the shell, and look as if they were actually processes of the latter. They also appear as more granular or darker extensions from the chief mass of the sarcode, seen through the basal band of the shell and projecting beyond it, as represented in figs. 5, 7, 15–17, 21–23.

Individuals are frequently observed in which the pseudopodal extensions seem to perforate the shell, as represented in figs. 10, 12. Auerbach, in describing the animal as *Amœba bilimbosa*, supposed that it actually had the power of forcing its pseudopods through the investing membrane; and this view appears to have been held by Greeff and Archer in Amphizonella. Hertwig and Lesser, and afterward Schulze, explained the true nature of this appearance, which seems to be due to the pseudopodal extensions protruding from between narrow folds of the bottom of the investing shell.

Cochliopodium bilimbosum is commonly observed gliding slowly over the surface of objects, as a round or oval granular body, included by a delicate zone or crescentic band of variable extent. The body is often so minute and transparent as readily to escape notice. The zone or band is of such extreme transparency and tenuity as scarcely to be visible without a favorable light. It is usually widest in the direction of movement of the animal, and often is seen only on the side of movement. It is incessantly changing, seems defined by a more or less irregularly dentated edge, and gives the impression of being a thin pseudopodal expansion of the sarcode. The true pseudopods, projecting from beneath the edge of the disk, are so little differentiated as to appear like pointed processes of the disk itself.

Cochliopodium seems to be a hungry animal, and is not unfrequently observed in the attempt to swallow diatoms or other algæ too large for its capacity, as represented in figs. 18, 19. The discharge of matters from the body occurs as in other rhizopods. In one instance, as represented in fig. 4, I observed a mass of matter discharged, looking like a portion of the sarcode itself, in which was contained a diatom.

COCHLIOPODIUM VESTITUM.

PLATE XXXII, figs. 26–28.

Amphizonella vestita. Archer: Quart. Jour. Mic. Sc. 1871, xi, 112, 135, pl. vi, figs. 1–6.
Cochliopodium pilosum. Hertwig and Lesser: Arch. mik. Anat. x, 1874, Suppl. 78.
Cochliopodium vestitum. Archer: Quart. Jour. Mic. Sc. 1877, 334. In part, including only the hirsute form, mostly with interior chlorophyl-like granules.

Body constructed as in the preceding species, but more or less covered with minute rigid cils or fine hair-like appendages. Sarcode containing variable proportions of chlorophyl granules, which, however, may be absent.

Size.—From 0.04 mm. to 0.06 mm. in diameter.

Locality—Absecom mill-pond, New Jersey; China Lake, Uinta Mountains, Wyoming Territory. Ireland, Mr. Archer.

Cochliopodium vestitum (figs. 26–28, pl. XXXII), discovered by Mr. Archer, was at first attributed to the genus *Amphizonella* of Professor Greeff; but subsequently, recognizing its difference, he accepted the position given to it in the former genus by Hertwig and Lesser. These authorities, without evident reason, substituted for it the name of *Cochliopodium pilosum.* Mr. Archer regards both this and the more common form described in the preceding article as varieties of the same species, and includes both under the name of *Cochliopodium vestitum.* While admitting that this view may be correct, and certainly it is so in the light that the so-called species of rhizopods merge into one another, yet, according to the plan adopted, I think it desirable to consider the two forms as distinct.

Cochliopodium vestitum is comparatively rare. Mr. Archer found it in pools, both in the green and colorless state, in two localities in Ireland; but Hertwig and Lesser, and Schulze, who describe the more common form, *C. pellucidum*, do not appear to have met with this one. I have found it only in two localities, and these very remote from each other:—in light ooze, in Absecom pond, New Jersey, September, 1874; and in the same kind of material, in China Lake, Uinta Mountains, Wyoming Territory, August, 1877.

Several specimens obtained at the former locality were of a bright-green color from the large quantity of chlorophyl diffused throughout the sarcode, as represented in fig. 26, pl. XXXII. Others, associated with the bright green ones, were much less colored from the less proportion of chlorophyl; and some had no color whatever, as represented in fig. 27. The investing shell or membrane was more or less thickly covered with short, delicate, rigid cils; but in all other respects, excepting the green color of the sarcode when present, these specimens were like those of *C. bilimbosum*.

The specimens from the Uinta Mountains, as seen in fig. 28, had the same character as the colorless ones of Absecom pond, but the shell had a yellowish tinge.

PROTOPLASTA FILOSA.

The **Filose Protoplasts,** or the Protoplasts with extremely delicate thread-like pseudopods, have the same general constitution and form as the shell-covered Lobose Protoplasts.

The sarcode or protoplasmic mass never exhibits so clear a differentiation of ectosarc and endosarc as that of the Lobose Protoplasts, but appears generally of more homogeneous character and exclusively like the endosarc of the latter. The pseudopods never occur as coarse lobate or digit-like extensions of the sarcode, but invariably as exceedingly delicate threads, acutely forking, and becoming finer and finer as they branch. They rarely or do not at all anastomose, and only at times become more or less confluent through the entanglement of portions of food. In composition, the pseudopods appear as filaments of the finely granular protoplasmic basis of the sarcode, and are commonly devoid of conspicuous granules or fine oil-like molecules.

Like in most shell-covered Lobose Protoplasts, the sarcode contains a large clear nucleus, which occupies a central position of the fundus. Mostly several contractile vesicles occupy a position peripherally in the intermediate part of the sarcode mass, just below the position of the nucleus.

The Filose Protoplasts are usually more sensitive or shy than the Lobose forms, and it is often difficult to induce the animals to project their delicate pseudopods. These are more numerous than in the Lobose Protoplasts, and are possessed of all the power and capabilities of movement and change of the digitate pseudopods.

Ordinarily the sarcode of the Filose Protoplasts occupies a greater proportion of the interior of the shell than in the Lobose forms; and when retracted from the interior surface they remain attached by much fewer threads, and oftener appear separated altogether.

The shell of the Filose Protoplasts exhibits similar varieties of construction and chemical composition as in the Lobose forms.

I have learned almost nothing in relation to the modes of reproduction of the Filose Protoplasts. I have many times seen pairs of individuals conjoined by the mouth in the so-called condition of conjugation, but ascertained nothing of the results. Besides observing certain genera and species in the encysted condition,—that is to say, the sarcode contracted into a ball within the shell and enclosed in one or a pair of additional egg-shaped shells,—I have from time to time seen individuals containing, instead of the ordinary mass of active sarcode, a variable number of globular spore-like bodies, which I have suspected to have resulted from the breaking-up of the sarcode mass.

PAMPHAGUS.

Greek, *pamphagos*, all-devouring.

Arcella: Ehrenberg, 1838. *Gromia:* Schlumberger, 1845. *Corycie:* Dujardin, 1852. *Pamphagus:* Bailey, 1853. *Difflugia:* Schneider, 1854. *Corycia* (Dujardin): Claparède and Lachmann, 1858. *Homœochlamys:* Ehrenberg, 1871. *Plagiophrys; Lecythium:* Hertwig and Lesser, 1874.

Animal colorless, transparent, invested with a hyaline, structureless membrane, which is flexible and elastic and concurs strictly with any changes of form of the body, but ordinarily restricts such changes, and is not voluntarily extensible. Sarcode always completely occupying the investing membrane, and appearing to be structurally continuous. A large, clear nucleus. Contractile vesicles not distinctly determined. Mouth small, terminal. Pseudopods filamentous, long, exceedingly delicate, branching dichotomously, not anastomosing.

PAMPHAGUS MUTABILIS.

PLATE XXXIII, figs. 1-9.

Corycie. Dujardin: An. Sc. Nat. 1852, xviii, 240.
Pamphagus mutabilis. Bailey: Am. Jour. Sci. Arts, 1853, xv, 341.—Archer: Quart. Jour. Mic. Sc. 1871, xi, 101; 1872, xii, 195, 423.—Leidy: Pr. Ac. Nat. Sc. 1878, 172.
Corycia (Dujardin). Claparède and Lachmann: Études Infus. et Rhiz. 1858-59, i, 453.—Pritchard: Hist. Infus. 1861, 550.—Leidy: Pr. Ac. Nat. Sc. 1874, 227.
Pamphagus (Bailey). Pritchard: Ibidem, 551.
Corycia Dujardini. Gagliardi: Quart. Jour. Mic. Sc. 1871, xi, 80.
Plagiophrys scutiformis. Hertwig and Lesser: Archiv mik. Anat. 1874, x, Suppl. 115, Taf. 3, Fig. 2.

Animal compressed ovoid, ovate, or sub-pyriform; lateral borders extending to the fundus, acute; fundus in the greater breadth obtusely rounded, more or less acute or even acuminate; mouth small, transversely oval, with a thickened border. Sarcode pale granular, colorless, or faintly yellowish, with diffused minute oil molecules, often with darkly defined oil-like globules in the upper region, and frequently water vacuoles in the lower region. Nucleus large, clear, compressed spherical. Food usually of various one-celled algæ. Animal in movement upright, with the mouth downward, and the pseudopods divergent and spreading horizontally; at rest, lying upon the broader sides.

Size.—Ranging from 0.04 mm. long by 0.028 mm. in the greater breadth to 0.1 mm. long by 0.068 mm. in the greater breadth.

Locality.—The ooze of springs and ponds, and pools in sphagnous swamps. Observed in Pennsylvania, New Jersey, and Fort Bridger, Wyoming Territory.

Dujardin described a rhizopod under the name of 'Corycie,' in 1852, from specimens found in rain-water, expressed from Jungermannia, collected in November and December. He observes that it is a very remarkable Amœba, on account of its membranous integument, which folds in various directions, according to the movements and contractions of the animal, and frequently presents the appearance of being twisted when it turns on itself. The membranous envelope is perfectly extensible and elastic. The size of the animal is from 0.08 mm. to 0.2 mm.

The following year, Professor Bailey described what seems to be the same animal under the name of *Pamphagus mutabilis.* It was found in great number in an aquarium which had been supplied with material from pools and streams in the vicinity of West Point, New York. Bailey adds: "I have thousands of these animals now living in midwinter." The description is accompanied with many woodcuts representing various changes of form and conditions of the animal.

Professor Bailey remarks: "If the reader will imagine a bag made of some soft extensible material so thin as to be transparent like glass, so soft as to yield readily by extension when subjected to internal pressure, and so small as to be microscopic; this bag filled with particles of sand, shells of diatoms, portions of algæ or desmids, and with fragments of variously colored cotton, woolen, and linen fibres, will give a picture of the animal; to complete which it is only necessary to add a few loose strings to the bag, to represent the variable radiant processes which it possesses around the mouth."

In the normal condition the animal appears to be compressed obcordate or pyriform, with the filamentous branching pseudopods projecting from the broader extremity. The animals observed by Professor Bailey were in a very active condition, and they are described and figured as gorged with a variety of food. Many are represented in different states of distortion due to the materials swallowed being so much longer than the usual length of the animal. A number of the figures further represent the creature either in the state of conjugation or of division, in which process from a pair to as many as five individuals are engaged together. Professor Bailey refers to the condition as probably being one of spontaneous fission, though he says he did not see it actually occur. Single undistorted individuals appear to have been about 0.1 mm. in length. One is represented extended on a swallowed fibre reaching the length of 0.25 mm. Another is represented in which a swallowed fibre, in the extension of the animal, has perforated the fundus.

Hertwig and Lesser, in their recent admirable researches, have described, as it seems to me, the same animal as the *Pamphagus mutabilis*, under the name of *Plagiophrys scutiformis*.

I have repeatedly, though rarely, observed specimens of what I have considered to be the *Pamphagus mutabilis* of Professor Bailey, but usually isolated, and never in anything like the number and variety described by the latter. Those I have met with presented some variety in size, proportions, and shape, but I have viewed them as pertaining to the same. I have adopted Professor Bailey's name of *Pamphagus mutabilis*, as this was preceded only by the vernacular one of 'Corycie,' and not until several years later was that of Corycia employed.

Pamphagus mutabilis is a remarkable creature, comparable to an Amœba in which the ectosarc had become coagulated, and retained its elasticity, but lost its voluntary power of extension. The investing membrane or shell is so thin, transparent, and elastic, and yet so intimately adherent or continuous with the interior fluent sarcode, that it appears scarcely more differentiated than the limiting ectosarc in *Amœba verrucosa.*

The animal is commonly of a compressed oval or ovate form (figs. 1, 3, 5, 7, 8, 9, pl. XXXIII), and in transverse section lenticular (figs. 2, 6). The fundus is mostly more or less acute, and sometimes acuminate, but is also in a variable degree obtusely rounded. The lateral borders are acute, extending to the fundus. The oral pole is usually the narrower; and the mouth is terminal, small, transversely oval, and bounded by a thickened border. At times this has appeared continuous; at others, interrupted on one side, as represented in fig. 3. Above the mouth, at a variable distance, the membrane often exhibits a circular line, apparently due to a temporary folding, as seen in figs. 7–9. The animal moves slowly in an upright position, with the mouth downward, and the delicate, long, filamentous pseudopods radiating in any and all directions, but mostly on a plane at right angles to the mouth. In movement the body of the animal is sometimes bent, curved, or twisted, and the investing membrane becomes variously inflected and wrinkled. The pseudopods usually diverge in straight lines, acutely branching, and often extend to a length even greater than that of the body. The angles of the forked branches often appear webbed from expansions of the protoplasm; and the terminal branches become more and more delicate. Occasionally the pseudopods assume a tortuous appearance, as seen in figs. 1, 2, and sometimes one or more are seen suddenly and abruptly to bend in a geniculate manner, as seen in figs. 5, 7. When the pseudopods are entirely withdrawn, the animal falls, and lies upon one of its broader sides, as usual with most of the shell-covered protoplasts of compressed form.

The interior sarcode of *Pamphagus mutabilis* always completely fills and is continuous with the delicate investing integument, never leaving any vacant space, such as is frequently observed in Euglypha and most shell-covered Protoplasts. The sarcode is formed of a basis of pale, granular, colorless protoplasm, not unfrequently presenting a feeble yellowish hue. Diffused through the protoplasm there are numerous fine oil-like molecules, and often an accumulation of these occupies an intermediate zone. The fundus of the sarcode mass is occupied centrally by a large, clear, homogeneous nucleus, as seen in figs. 1–6. Rarely, as in fig. 7, I have seen the nucleus occupy a lateral position.

Contiguous to the nucleus frequently the sarcode is mingled with variable proportions of scattered oil-like globules, as represented in figs. 5, 7, 9, but these are often absent or minute and inconspicuous, as seen in figs. 1–4, 8.

The lower region of the sarcode, intermediate to the nucleus and the mouth, is commonly occupied with more or less food materials, consisting of green one-celled algæ, diatoms, etc. The green algæ turn red, as a result of digestion. With the food there are often mingled colorless globules of various sizes. Some of these appear to consist of water; and occasionally I have seen one or more enlarge and collapse. In one instance I observed such a globule approach the mouth (fig. 3) and have its liquid contents expelled. Independently of these water globules, not always present, I detected no distinct contractile vesicle.

The pseudopods of *Pamphagus mutabilis* appear as filamentous extensions of the protoplasmic basis of the sarcode, finely and obscurely granular in constitution, and without oil molecules. I could never detect any appearance of circulation of granules in the pseudopods.

The investing membrane or shell of *Pamphagus mutabilis* is colorless, transparent, and structureless. It is highly elastic, so that it yields to the extension of rigid food, and returns to its normal condition when the extending force is removed.

PAMPHAGUS HYALINUS.

PLATE XXXIII, figs. 13–17.

Arcella ? hyalina. Ehrenberg: Infusionsthierchen, 1838, 134, Taf. ix, Fig. viii. Abh. Ak. Wis. Berlin, 1871, 235, 264.—Fresenius: Abh. Senck. Gesells. 1856–58, ii, 219, Taf. xii, Fig. 1–24.
Gromia hyalina. Schlumberger: An. Sc. Nat. 1845, iii, 255.
Difflugia Enchelys. Schneider: Müller's Archiv, 1854, 204, Taf. ix, Fig. 16–24.
A. Homœochlamys hyalina. Ehrenberg: Abh. Ak. Wis. Berlin, 1871, 244.
Lecythium hyalinum. Hertwig and Lesser: Arch. mik. Anat. 1874, x, Suppl. 177, Taf. iii, Fig. 8.—Archer: Quart. Jour. Mic. Sc. 1877, xvii, 197, pl. xiii, figs. 1, 2.

Animal spheroidal, and feebly produced at the lower pole into a short, broad neck, terminating in a circular mouth. Shell membranous, transparent, colorless, structureless, and elastic. Sarcode intimately adherent to the interior of the shell, finely granular, with variable proportions of oil-like molecules, usually more or less accumulated in a median zone, and with more or less vacuoles at the lower part. Nucleus large, and commonly with a large and distinct nucleolus. Pseudopods filamentous, delicate, and furcate.

Size.—From 0.032 mm. in diameter to 0.048 mm. in length and 0.044 mm. in breadth.

Locality.—In the superficial ooze of ponds, ditches, and lakes. Observed in Pennsylvania, New Jersey, and Wyoming Territory.

In his great work, the 'Infusionsthierchen,' Ehrenberg describes a small rhizopod under the name *Arcella hyalina*, almost spherical, and with a smooth hyaline membranous shell. It ranges from $\frac{1}{96}$th to $\frac{1}{48}$th of a line. It exhibited within many vesicles, and possessed many filamentous pseudopods. Later what appears to be the same animal was described by Schlumberger with the name of *Gromia hyalina*, and by Schneider with that of *Difflugia hyalina*. Recently Hertwig and Lesser have also described the creature, and have referred it to a new genus, with the name of *Lecythium hyalinum*. In what respect this genus differs from Pamphagus I am unable to see, and therefore have considered it as pertaining to the same.

Pamphagus hyalinus, as I take it to be, I have occasionally found, though I suspect it is not uncommon, but on account of its inconspicuous character is readily overlooked. It is a minute, spheroidal, translucent, colorless creature, represented in the magnified views of figs. 13–17, pl. XXXIII. The shape is nearly spherical, or it is slightly tapering at the oral pole, or feebly prolonged so as to be sub-pyriform. The mouth is inferior, terminal, comparatively large, circular, and dilatable, and its margin is entire and thin. The shell or membranous investment is structureless and elastic, but not voluntarily extensible or contractile.

The sarcode is like that of *Pamphagus mutabilis*, but usually contains a greater proportion of oil molecules collected in the intermediate zone, and a greater number of clear vacuoles in the lower portion. Sometimes the large nucleus is clear and homogeneous, as seen in fig. 14, but in others it has appeared of pale granular constitution, and contained a large distinct nucleolus, as represented in figs. 15–17.

Pamphagus hyalinus is a peculiarly delicate and sensitive creature, and readily undergoes decomposition. In repeated instances, I have observed the animal project from the mouth of the shell portions of the sarcode, which would gradually swell up and become more or less filled with different-sized vacuoles, as seen in figs. 15–17. The projected protoplasm would sometimes increase to more than half the bulk of the animal in its normal condition. Suspecting that this condition was a preparatory step to segmentation, I was led to watch patiently several individuals for some hours to learn the result, which however, in each case, proved to be decomposition or death.

PAMPHAGUS CURVUS.

PLATE XXXIII, figs. 11, 12.

Animal retort-shaped, or ovoid with the prolonged narrower pole curved, and with the body in transverse section circular. Mouth inferior, terminal, circular. Shell transparent, colorless or pale yellowish, structureless. Sarcode continuous with the interior of the shell, and having the nucleus as in *P. mutabilis.* Pseudopods likewise as in the latter.

Size.—From 0.044 mm. in length by 0.028 mm. in breadth to 0.06 mm. in length by 0.036 mm. in breadth.

Locality.—Vicinity of Philadelphia, in the superficial ooze of ponds.

In a few instances I have met with a small rhizopod resembling in structure and habit the *Pamphagus mutabilis,* but with a shape like that of Cyphoderia. The shell is structureless and closely adherent to every part of the surface of the interior sarcode, from which it appears to be as inseparable as in *Pamphagus mutabilis.* Figs. 11, 12, pl. XXXIII, represent two such specimens.

PAMPHAGUS AVIDUS.

PLATE XXXIII, fig. 10.

Body oval or ovoid, in transverse section circular, wider at the oral pole; mouth small, circular, expansile and contractile. Nucleus, etc., as in *P. mutabilis.*

Size.—From 0.148 mm. to 0.22 mm. in length by 0.12 mm in breadth.

Locality.—Cedar swamp of Atco, New Jersey.

In September, 1877, in some material collected in pools in the cedar and sphagnous swamp of Atco, New Jersey, I found several individuals of a species of Pamphagus, larger and apparently different from any of the preceding. Its size accords with that given for 'Corycie' by Dujardin, and perhaps the animal may be the same.

One of the individuals observed, represented in fig. 10, pl. XXXIII, was so replete with food as greatly to obscure from view the nucleus and other usual constituents of the sarcode. Among the food contents were two considerable portions of the alga Didymoprium, which were so long as to cause some distortion of the animal, making it project beyond the normal outline both in front and behind. Among the contents of the sarcode, besides the ordinary pale granular basis and fine oil-like molecules, there were noticed many clear globules or water vacuoles.

The pseudopods were like those of *P. mutabilis.* In the distorted condition of the animal, as represented in the figure, the creature measured 0.22 mm. in length by 0.12 mm. in breadth. The longest pseudopod measured 0.2 mm. in breadth. The following morning, after first seeing the specimen, it had discharged the two long portions of Didymoprium, and in this condition presented a cordiform outline, with the mouth depressed and puckered, and it measured 0.16 mm. in length by 0.112 mm. in breadth.

Another individual, of ovoid form, had the mouth in the centre of the broader pole. It was 0.148 mm. long by 0.12 mm. broad. It contained many clear globules or water vacuoles from 0.004 mm. to 0.008 mm., together with oil-like globules up to 0.01 mm. in diameter. The abundant food consisted of indistinct yellowish granular material and a number of round, one-celled, bright green algæ. A clear nucleus in the fundus of the sarcode measured 0 028 mm. in diameter.

This large form of Pamphagus may perhaps be the same animal as the *Plagiophrys cylindrica* of Claparède and Lachmann, which approximates it in size.

PSEUDODIFFLUGIA.

Greek, *pseudos*, false; Latin, *diffluo*, to flow.

Pseudodifflugia: Schlumberger, 1845. *Pleurophrys:* Claparède and Lachmann, 1859.

Animal provided with a thin chitinoid shell mostly incorporated with variable proportions of fine quartz-sand, or other extrinsic material, of indeterminate character, commonly distinguished as 'dirt.' Mouth terminal, inferior. Sarcode mostly colorless, with a large clear nucleus, but usually with other constituents of the former obscured by the nature of the shell. Pseudopods numerous, exceedingly delicate, filamentous, and forking at acute angles.

PSEUDODIFFLUGIA GRACILIS.

PLATE XXXIII, figs. 18–28.

Pseudodifflugia gracilis. Schlumberger: An. Sc. Nat. 1845, iii, 254.
Pleurophrys sphærica. Claparède and Lachmann: Études Infusoires et Rhizopodes, 1859, i, 455, pl. xxii, fig. 3.—Archer: Quart. Jour. Mic. Sc. 1869, pl. xx, fig. 1, 1870, 121.—Hertwig and Lesser: Arch. mik. Anat. 1874, x, Suppl. 135, Taf. iii, Fig. 4.—Schulze: Ibidem, 1875, xi, 122.
Pleurophrys? amphitremoides. Archer: Quart. Jour. Mic. Sc. 1870, 121, pl. xx, fig. 2.—Schulze: Arch. mik. Anat. 1875, xi, 123, Taf. vii, Fig. 1.
Pleurophrys? fulva. Archer: Ibidem, 1870, 122, pl. xx, fig. 3.—Schulze: Ibidem, 124, figs. 2, 3.
Pleurophrys compressa. Schulze: Arch. mik. Anat. 1875, xi, 125, Taf. vii, Fig. 4, 5.
Pleurophrys lageniformis. Schulze: Ibidem, Fig. 6–8.
Pleurophrys angulata. Mereschkowsky: Arch. mik. Anat. 1878, 192, Taf. x, Fig. 14.

Shell of variable form, mostly spheroidal, ovoidal, or oblong oval, and of uniform transverse diameters, but rarely somewhat compressed, usually straight, occasionally slightly curved. Mouth terminal, circular. Structure of the shell mostly obscurely granular, often with fine sand, and frequently almost or quite entirely composed of coarser sand; colorless or brownish.

Size.—Length from 0.04 mm. to 0.16 mm.; breadth 0.02 mm. to 0.1 mm.

Locality.—Frequent in the ooze of ponds, ditches, etc. Vicinity of Philadelphia and other places in Pennsylvania; New Jersey; Uinta Mountains, Wyoming Territory.

The genus Pseudodifflugia is one of those described by Schlumberger,* and not usually recognized by succeeding observers. It is characterized as having a membranous shell, ovoid or ovo-globular, smooth or rolled, with a wide round aperture, from which project very long fine filaments, simple and branched. The author remarks that the genus approaches nearly to Difflugia, but differs in the character of its pseudopods.

The species *Pseudodifflugia gracilis* is described as having an ovoid, bluish brown shell, of variable length, and encrusted as it were with minute grains of sand. The size is 0.035 mm. to 0.056 mm in length by 0.029 mm. to 0.035 mm. in breadth.

The characters assigned to Pleurophrys by Claparède and Lachmann lead me to suspect that it is not different from Pseudodifflugia. They observe that it is related with the Actinophryans as Difflugia is with the

* Annales des Sciences Naturelles, 1845, 254.

Amœbas. They further remark that the animal is covered with a shell composed of foreign substances cemented together, and having a single aperture. The species indicated by them under the name of *Pleurophrys sphærica** is described as possessing a spherical shell composed of silicious particles, and measuring 0.02 mm. The figure accompanying their description represents a nearly globular shell of coarse sand, with granular filamentous pseudopods extending like the rays of an Actinophrys.

I have many times met with inconspicuous rhizopods with a shell approximating in character that of the Difflugias, but with delicate filamentous pseudopods. I have suspected them to belong to the genus Pseudodifflugia of Schlumberger or of Pleurophrys of Claparède and Lachmann. They occur in the ooze of ponds, and are of such obscure character, that unless attention is directed to them, they are liable to be overlooked or mistaken for the excrement of worms or other masses of dirt. They present considerable variety in form, size, color, and exact composition of the shell, and such intermediate gradations that I have been disposed to view most of them as pertaining to the same species.

Pseudodifflugia gracilis, as I have supposed it to be, is of quite variable form, proportions, and size. Commonly it is ovoid, with the mouth at the narrower pole, but sometimes is ovate, oval, oblong, or sub-pyriform. See figs. 18–21, pl. XXXIII. The mouth is circular, and appears to be contractile or dilatable, so that it varies in size according to its condition. Sometimes it is oblique or sub-terminal, as seen in fig. 22, and occasionally I have found individuals with the shell somewhat curved and the mouth oblique, as represented in fig. 24. Usually the shell is of uniform transverse diameters, but sometimes is more or less compressed, as represented in the specimen of figs. 26, 27. The fundus of the shell is broad and mostly evenly convex, but sometimes rather flattened.

The color of the shell is variable, usually some shade of brown, but often colorless. In composition it often appears membranous, and incorporated with variable proportions of fine dirt and sand. Sometimes the distinctly visible sand grains are minute and scattered, and sometimes they are larger and closely cemented together, as is ordinarily the case in most species of Difflugia, and as seen in the figures last referred to.

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* Études Infusoires, 455, pl. xxii, fig. 3.

In several instances I found individuals which I viewed as pertaining to the same animal, in which the shell was mainly granular and translucent, but had large sand grains accumulated at the extremities, as seen in fig. 25.

In those specimens in which the shell is not too thoroughly incorporated with dirt or sand, the interior sarcode becomes more or less visible, and is seen to be of variable extent in relation to the capacity of the shell. A large clear spot in the fundus of the sarcode indicates the presence of a nucleus, and a darker intermediate zone the accumulation there of fine oil molecules. The lower region is likewise observed to contain vacuoles and portions of food.

The pseudopods of *Pseudodifflugia gracilis* are numerous, finely filamentous and branching. They are sometimes observed diverging from the mouth in profuse bunches ; at other times in a few filaments. See figs. 18–28. On one occasion I observed a number of pseudopods run together into a broad patch of protoplasm, which involved, within a vacuole, two green algous cells, as seen in fig. 22.

The movements of the animal are exceedingly slow, and it often requires long watching to observe it project the pseudopods.

Pseudodifflugia is more closely related with Pamphagus and Cyphoderia than with the Heliozoa. Subsequently to Claparède and Lachmann, other investigators have described Rhizopods which they refer to species of Pleurophrys, but which I suppose to pertain to Pseudodifflugia, and most of them to *P. gracilis.*

Mr. Archer* described a form which he refers to *Pleurophrys sphærica*, though of larger size and otherwise different from that of the former authors. Schulze considers the determination incorrect.† The shell is represented as spheroidal, brown, and composed of granular matter, with a size of $\frac{1}{150}$th of an inch.

Fig. 19 represents an individual of nearly the size and constitution of that just indicated, as described and figured by Mr. Archer. It is, however, of ovoid shape, and measures 0.16 mm. long by 0.1 mm. broad. Both forms I view as pertaining to *Pseudodifflugia gracilis.*

In the same memoir, Mr. Archer indicated two other forms as pertaining to Pleurophrys, with the names of *P. amphitremoides* and *P. fulva.*‡

* Quart. Jour. Micr. Sc. 1869, fig. 1, pl. xx ; 1870, 121.

† Archiv f. mikr. Anatomie, 1875, xi, 122.

‡ Quart. Jour. Micr. Sc. 1870, 121, 122.

Both have ovoid shells, in one incorporated with diatoms, in the other with sand and of a yellow color. Schulze admits these as species, and describes others he regards as the same,* but I would regard all as varieties of *Pseudodifflugia gracilis.*

The latter author has described two other forms with the names of *Pleurophrys compressa* and *P. lageniformis*, but these also I incline to believe belong to the *Pseudodifflugia gracilis* as mere varieties.

Hertwig and Lesser† have described a rhizopod which they regard as *Pleurophrys sphærica*, to which they also consider the large form pertains described by Mr. Archer. The specimens indicated by the former have an ovoid, brown, granular shell, ranging from 0.03 mm. to 0.05 mm. In structure, form, and size they sufficiently accord with Schlumberger's description to belong to *Pseudodifflugia gracilis.*

Quite recently, since the present work went to press, Mereschkowsky‡ has described a form under the name of *Pleurophrys angulata*, which appears to me not to differ from the former.

Fig. 28, pl. XXXIII, represents a remarkable variety obtained from ooze in a lake of the Uinta Mountains, Wyoming Territory, but the only specimen of the kind seen, though ordinary forms were common enough. The shell was amphora-shaped, with a nipple-like process to the fundus and a rim to the mouth, and was composed of comparatively coarse sand grains. Its length was 0.06 mm.; its breadth 0.036 mm. The pseudopods extended in a dense bundle. As a conspicuous variety, this might be appropriately distinguished as *Pseudodifflugia amphora.*

CYPHODERIA.

Greek, *kuphos*, curved; *deros*, the neck.

Difflugia: Ehrenberg, 1840. *Cyphoderia:* Schlumberger, 1845. *Euglypha:* Perty, 1852. *Lagynis:* Schultze, 1854. *Ampullaria; Hologlypha; Assulina:* Ehrenberg, 1871.

Animal provided with a retort-shaped shell, the mouth directed downward, and the long axis of the body inclined. Structure of the shell chitinoid, transparent, colored or colorless, composed of minute hexagonal elements of uniform size arranged in alternating series in parallel spiral rows. Mouth minutely beaded. Sarcode pale, granular, usually nearly

* Archiv mik. Anatomie, 1875, xi, 122.

† Archiv mik. Anatomie, 1874, 135, Taf. iii, Fig. 4.

‡ Ibidem, 192, Taf. x, Fig. 14.

filling the shell or slightly contracted from its sides; when shorter than the cavity of the shell, mostly adherent to the fundus by a pair of pseudopodal threads. Nucleus large, clear, and usually homogeneous. Contractile vesicles occupying an intermediate zone of the sarcode. Pseudopods numerous, forking, radiating in any direction from the mouth, but mostly on a horizontal plane, susceptible of a great variety of movement and change of form.

CYPHODERIA AMPULLA.

PLATE XXXIV, figs. 1–16.

Difflugia Ampulla. Ehrenberg: Bericht Preus. Ak. Wis. 1840, 199; Abh. Ak. Wis. 1871, Taf. iii, Fig. 11.
? *Difflugia Lagena.* Ehrenberg: Abh. Ak. Wis. 1841, 413, Taf. iv, Fig. 11; 1871, Taf. ii, Fig. 2.
Cyphoderia margaritacea. Schlumberger: An. Sc. Nat. 1845, iii, 255.—Fresenius: Abh. Senck. Naturf. Ges. 1856–58, ii, 225, Taf. xii, Fig. 28–36.—Stein: Sitzungsb. Böhm. Akad. 1857 (*fide* Schulze).—Carter: An. Mag. Nat. Hist. 1864, xiii, 33, pl. ii, fig. 18.—Hertwig and Lesser: Arch. mik. Anat. 1874, x, Sup. 132.—Leidy: Pr. Ac. Nat. Sc. 1874, 227; 1877, 294.—Schulze: Arch. mik. Anat. 1875, xi, 106, Taf. v, Fig. 12–20.
Euglypha curvata. Perty: Kennt. kleinst. Lebensformen, 1852, 187, pl. viii, fig. 21.
Lagynis baltica. Schultze: Organ. Polythalamien, 1854, 56, Taf. i, Fig. 7, 8.
Euglypha margaritacea. Wallich: An. Mag. Nat. Hist. 1864, xiii, 240, 244, 245, pl. xvi, fig. 48.
Difflugia margaritacea. Wallich: Ibidem, 245.
Euglypha baltica. Wallich: Ibidem.
Difflugia Seelandica. Ehrenberg: Abh. Ak. Wis. 1869, Taf. ii, Fig. 23.
Ampullaria (Werneck). Ehrenberg: Ibidem, 1871, 234.
Difflugia adunca. Ehrenberg: Ibidem, 1871, 248, Taf. iii, Fig. 8, 9.
? *Difflugia alabamensis.* Ehrenberg: Ibidem, Fig. 10.
Difflugia uncinata. Ehrenberg: Ibidem, Fig. 13.
Hologlypha, seu *D. Assulina adunca, D. A. alabamensis, D. A. Ampulla, D. A. margaritacea, D. A. uncinata.* Ehrenberg: Abh. 1871, 246.
Euglypha, seu *D. Assulina Seelandica.* Ehrenberg: Abh. 1871, 246.
Cyphoderia ampulla. Leidy: Pr. Ac. Nat. Sc. 1878, 173.

Shell retort-shaped, with a short cylindrical neck curving downward, and truncated by a circular mouth; body of the shell oblong oval, with the longitudinal axis, in the active or moving condition of the animal, more or less inclined, but nearly horizontal; fundus obtusely rounded, sometimes flattened, frequently more or less prolonged or narrowed at the summit into a nipple-like process. Color of the shell mostly yellowish, less frequently colorless.

Size.—Ranging from 0.112 mm. to 0.176 mm. long by 0.04 mm. to 0.08 mm. broad, with the mouth 0.016 mm. to 0.028 mm. wide.

Locality.—The superficial ooze of springs, ponds, lakes, and ditches. Pennsylvania, New Jersey, Rhode Island, Florida, Wyoming Territory, and Nova Scotia.

Cyphoderia ampulla has an oval oblong, retort shaped shell, with a short cylindroid neck curving downward to the mouth. See figs. 1–15, pl.

XXXIV. The long axis of the shell forms a line curving upwardly and backward from the mouth. In the ordinary position of movement of the animal, the mouth is directed downward on a horizontal plane, while the body of the shell is directed backward, with but slight inclination from the same plane.

The sides of the shell are commonly evenly convex, but occasionally somewhat flattened or slightly tapering toward both poles. The fundus is usually evenly convex, but sometimes flattened, and frequently more or less prolonged and narrowed at the summit into a nipple-shaped process, as seen in figs. 4–8.

The mouth of the shell is circular, and exhibits a beaded margin more or less distinct. Schulze describes it as possessing a delicate and structureless membranous expansion or zone;* but this, if it exists, escaped my attention, or was taken for an expansion of sarcode at the root of the pseudopods.

The shell is straw-colored or pale yellowish, and often entirely colorless. It is transparent, and apparently composed of chitinoid membrane, as in Arcella. It exhibits a structure of variable distinctness, consisting of exceedingly minute hexagonal elements, alternating with one another, and arranged in spiral rows. Ordinarily the shell has a more or less uniform punctate appearance; but when the structure is more than usually distinct, the arrangement of hexagons is very obvious. The outlines of the hexagons will appear single and dark, or double and clear, as seen in fig. 16, according to the focus in which they are viewed. In several instances it has seemed to me as if the hexagons were externally faceted in inclined triangular planes from common centres.

The soft contents of the shell of Cyphoderia occupies its capacity in varying extent, as in the case of Euglypha. Sometimes it entirely fills the shell, sometimes it is more or less contracted in an intermediate position from the sides, and it is not unfrequently more or less contracted from the fundus. In the last condition, the mass is usually attached to the dome of the shell by a pair or more of fine thread-like extensions of the sarcode, as is so conspicuously observed in Hyalosphenia, and as represented in figs. 13, 14.

A large clear nucleus occupies the fundus of the body, and generally

* Archiv f. mik. Anatomie, 1875, 111, Taf. v, 20.

below it there is an accumulation of oil-like molecules. Between the latter and the mouth of the shell, the sarcode contains variable proportions of food materials, water vacuoles, and commonly several contractile vesicles.

The pseudopods radiate from the mouth, often to a distance considerably more than the length of the shell. They are exceedingly delicate, and branch usually at very acute angles, but do not anastomose. Sometimes, in movement, they abruptly bend, and occasionally suddenly contract in a tortuous manner.

Ordinarily, the shell of Cyphoderia measures about 0.125 mm. in length by 0.05 mm. in breadth, but specimens range from about 0.11 mm. to 0.2 mm. in length.

Cyphoderia ampulla is common in the ooze of springs, ponds, and lakes, though I have never found it very abundantly at any one time. I have obtained it from springs and ponds in the vicinity of Philadelphia. The largest specimens I found at Lake Hattacawanna, New Jersey. I also found it in China Lake, in the Uinta Mountains, at an altitude of 10,000 feet, and likewise at the base of the mountains, at Fort Bridger, in Wyoming Territory. The Wyoming specimens were remarkable from their commonly having the shell with a nipple-shaped prolongation at the fundus.

The genus Cyphoderia was characterized by Schlumberger in 1845, and the species described under the name of *Cyphoderia margaritacea* from specimens obtained in the mud of brooks of the Vosges and Jura. The same was, however, described by Ehrenberg, five years earlier, in the 'Bericht' of the Academy of Sciences of Berlin, under the name of *Difflugia ampulla*.* This is confirmed by figures of the species published in the 'Abhandlungen' of the same society in 1871. Recent authorities adopt the specific name of Schlumberger; but there is no good reason for retaining it, and, according to the usual rule, I have employed the earlier name.

CAMPASCUS.

Greek, *kampe*, bent; *askos*, a bottle.

Animal provided with a shell having the form like that of Cyphoderia, but provided with a pair of lateral divergent processes to the fundus, and composed of homogeneous chitinoid membrane. The soft part together with pseudopods as in Cyphoderia.

* The original description is as follows: "Lorica oblonga clavata, punctorum seriebus obliquis eleganter notata, hyalina, ostiolo ovato. Mag. $\frac{1}{26}$'''."

CAMPASCUS CORNUTUS.

PLATE XXXIV, figs. 17–24.

Campascus cornutus. Leidy: Proc. Acad. Nat. Sci. 1877, 294.

Shell retort-form, with a short curved neck, and with the obtuse fundus directed backward and upward, and provided on each side with a divergent conical prolongation; composed of translucent, yellowish, homogeneous, chitinoid membrane, incorporated with scattered sand particles. Mouth circular, directed downward, bordered by a delicate, colorless, annular expansion. The interior soft part resembling that of Cyphoderia; a large nucleus at the fundus; pseudopods filamentous, furcate, exceedingly delicate.

Size.—Ranging from 0.112 mm. to 0.14 mm. long by 0.18 mm. broad, or between the lateral processes of the fundus from 0.08 mm. to 0.112 mm. broad; mouth 0.024 mm. to 0.028 mm. wide.

Locality.—The ooze of China Lake, Uinta Mountains, 10,000 feet altitude, Wyoming Territory.

Campascus cornutus is intermediate in character to *Centropyxis aculeata* and *Cyphoderia ampulla.* The shell has the structure and horn-like processes of the former; but the shape and the structure of the animal, with the pseudopods, have the character of the latter.

This animal I discovered in August, 1877, in ooze collected in China Lake, in the Uinta Mountains, about 25 miles from Fort Bridger, Wyoming Territory. I have not found it elsewhere. I at first took it for a new species of Cyphoderia; but I failed to detect the hexagonal structure characteristic of the shell of this genus.

In the side view of Campascus, as seen in fig. 21, pl. XXXIV, the shell has the exact form of that of *Cyphoderia ampulla,* the lateral processes being concealed. Either in the under or the upper view, as seen in figs. 17, 20, the lateral prolongations backward of the shell give it a triangular outline, in which the mouth forms the apex, the processes form the basal angles, and the intermediate portion of the base forms the rounded fundus. The lateral processes are conical and curved, and are on the ventral rather than on the dorsal aspect of the fundus. In some specimens, as seen in that of fig. 22, it is rudimental, and in this particular one also the summit of the fundus was somewhat pointed.

The mouth is circular, and surrounded with a delicate, structureless, membranous zone, as represented in figs. 20, 21.

The shell of Campascus is dull yellowish or straw-colored, and is composed of homogeneous chitinoid membrane incorporated with scattered sand particles. Even with high microscopic power I could detect no trace of hexagonal structure, such as exists in the shell of Cyphoderia and Arcella.

The soft part of the animal is like that of Cyphoderia or Euglypha. A large, clear nucleus occupies the fundus of the sarcode mass, and in contiguity with it, especially accumulated just beneath, there is a quantity of oil-like molecules. The adherent sand particles to the shell prevented me from detecting contractile vesicles, which no doubt exist in a corresponding position to that in Cyphoderia or Euglypha. The pseudopods are like those of the latter animals The shell of Campascus is commonly about 0.125 mm. in length.

EUGLYPHA.

Greek, *eu*, well; *gluphe*, sculptured.

Euglypha: Dujardin, 1841. *Difflugia:* Ehrenberg, 1841. *Assulina; Setigerella:* Ehrenberg, 1871.

Animal provided with a hyaline, ovoid shell, of uniform diameter, or compressed, composed of regular, oval or hexagonal plates of chitinoid membrane, arranged in alternating longitudinal series. Mouth terminal, circular or elliptical, with the marginal plates forming a series of minutely serrulate angular points. Shell mostly provided with spines or hairs, though sometimes absent. Sarcode colorless, with a large nucleus in the fundus, and usually several contractile vesicles occupying an intermediate position of the mass. Pseudopods filamentous, exceedingly delicate, dichotomously branching, not anastomosing, and with no evident circulation of granules. Animal when in motion with the shell erect or perpendicular, with the mouth downward, and with the pseudopods more or less horizontally divergent.

The genus Euglypha contains a number of distinct or well-marked forms which are conveniently considered to be so many species; but, through a multitude of intermediate conditions, the species appear to graduate into one another. They are the most elegant and complex in the structure of their shell of any of the Protoplasts provided with such a covering.

The shell of Euglypha is composed of plates, mostly of uniform size, and arranged with great regularity in longitudinal rows, alternating with one another in the different rows. Commonly the plates appear of longitudinally oval shape, and overlap at the contiguous borders so as to include hexagonal areas enclosed by circles of minute elliptical areas, or they appear of hexahedral shape, and are closely adapted together at the borders. Ehrenberg describes and figures in his various communications a number of forms in which the shell is represented as being composed of longitudinal rows of alternating rectangular plates.* Of this kind I have seen none, and incline to think, from my experience, that the shape of the plates as thus described is illusory. The shell of the ordinary forms of Euglypha, viewed with unfavorable light, or when the structure is not distinct, will appear to be composed in this way, when clearer definition will prove them to exhibit the structure as above described.

EUGLYPHA ALVEOLATA.

PLATE XXXV, figs. 1–18.

Euglypha alveolata. Dujardin: Infusoires, 1841, 252, pl. ii, figs. 9, 10.—Perty: Kennt. kleinst. Lebensformen, 1852. 187.—Pritchard: Hist. Infus. 1861, 556, pl. xxi, fig. 11.—Carter: An. Mag. Nat. Hist. 1856, xviii, 221, pl. v, figs. 25–36; 1864, xiii, 33, pl. ii, fig. 17.—Wallich: An. Mag. Nat. Hist. 1864, xiii, 240, pl. xvi, figs. 41–45.—Hertwig and Lesser: Arch. mik. Anat. Suppl. 1874, 124, Taf. iii, Fig. 5.—Schulze: Arch. mik. Anat. 1875, 97, Taf. v, Fig. 1, 2.—Micrographic Dictionary, pl. 23, fig. 54.—Leidy: Pr. Ac. Nat. Sc. 1874, 225; 1877, 262, 321; 1878, 171.

Euglypha tuberculata. Dujardin: Infusoires, 1841, 251, pl. ii, figs. 7, 8.—Perty: Kennt. kl. Lebensformen, 1852, 187.—Claparède and Lachmann: Études Infus. et Rhizopodes, 1858–9, i, 456.—Pritchard: Hist. Infus. 1861, 556.—Micrographic Dictionary, pl. 23, fig. 53.

Difflugia areolata. Ehrenberg: Abh. Ak. Wis. Berlin, 1841, 413, Taf. i, Fig. 8; Taf. ii, Fig. 4, 5; Taf. iv, Fig. 2; 1871, 264. Monatsb. Ak. Wis. 1845, 319; 1848, 215; 1849, 89, 98, 191, 228, 321; 1853, 182, 256, 322. Mikrogeologie, 1854, Taf. xxxii, Fig. 2; xxxviii, Fig. 2; xxxix, Fig. 25. Zweite deutsche Nordpolarfahrt, 1874, Taf. iii, Fig. 23.

Difflugia acanthophora. Ehrenberg: Ab. Ak. Wis. 1841, 413, Taf. iv, Fig. 36; 1871, 264.—Pritchard: Hist. Infus. 1861, 553, pl. xii, Fig. 64.

Difflugia lævigata. Ehrenberg: Ab. Ak. Wis. 1841, 413, Taf. ii, Fig. 43.

Difflugia striolata. Ehrenberg: Ibidem, Fig. 44. Monatsb. 1851, 321; 1853, 182. Mikrogeologie, 1854, Taf. xxxiii, Fig. 3.

Euglypha lævis. Perty: Kennt. kleinst. Lebensformen, 1852, 187, Taf. viii, Fig. 18.

Euglypha setigera. Perty: Ibidem, fig. 19.

Difflugia Floridæ. Ehrenberg: Monatsb. Ak, Wis. 1853, 366. Mikrogeologie, 1854, Taf. xxxiv, Fig. 3. Abh. Ak. Wis. 1871, 252.

Difflugia pilosa. Ehrenberg: Mikrogeologie, 1854, Taf. xxxiv, B. v, Fig. 6. Abh. Ak. Wis. 1871, 256.

Difflugia moluccensis. Ehrenberg: Abh. Ak. Wis. 1869, 48, Taf. ii, Fig. 12.

Difflugia amphora. Ehrenberg: Ibidem, 1871, 248, Taf. iii, Fig. 17.

Difflugia rectangularis. Ehrenberg: Ibidem, 256, Taf. iii, Fig. 16. Zweite deutsche Nordpolarfahrt, 1874, Taf. iii, Fig. 20.

Difflugia Roberti Müller. Ehrenberg: Abh. Ak. Wis. 1871, 256, Taf. ii, Fig. 16.

Difflugia seriata. Ehrenberg: Ibidem, 257, Taf. iii, Fig. 30.

Difflugia setigera. Ehrenberg: Ibidem, Taf. ii, Fig. 30.

Difflugia striata. Ehrenberg: Ibidem, 257.

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* Abhand. Akad. d. Wissenschaften, Berlin, 1871, Taf. iii, 16, 17.

Assulina alveolata, A. amphora, A. areolata, A. Floridæ, A. moluccensis, A. rectangularis, A. Roberti Müller, and *A. tuberculata.* Ehrenberg: Abh. Ak. Wis. 1871, 246.
Setigerella acantophora and *S. setigera.* Ehrenberg: Ibidem, 247.
Difflugia Shannoniana. Ehrenberg: Zweite deutsche Nordpolarfahrt, 1874, Taf. iii, Fig. 18.
Difflugia subacuta. Ehrenberg: Ibidem, fig. 19.

Shell transparent, colorless, mostly regularly ovoid, often oblong ovoid, sometimes flask-shaped; in transverse section circular, and rarely slightly compressed; fundus broad, obtusely rounded, rarely subacute; oral extremity narrowest, often more or less tapering. Mouth truncating the oral pole, circular, surrounded with from four to twelve? angular, denticulate points formed by the lowest circular series of the plates of the shell.* Plates of the shell generally oval or ovate or cordate?, arranged in longitudinal rows in alternating series, and overlapping at the contiguous borders, so as to produce hexagonal areas included in zones of minute elliptical areolæ. Fundus of the shell in the best developed forms mostly provided with from four to six spines, as appendages of certain of the plates, usually nearly equidistant and straight, of variable length and robustness, sometimes divergent, occasionally convergent, not unfrequently irregular; in the smaller and less well developed forms altogether absent.

Size.—Ranging from 0.03 mm. long by 0.018 mm. broad to 0.152 mm. long by 0.088 mm. broad.

Locality.—The largest and spinous forms in the ooze of ponds, ditches, etc.; the smallest spineless forms among algæ, mosses, and other plants in bogs, meadows, and other moist or damp situations. Pennsylvania, New Jersey, Maine, Florida, Nova Scotia, Wyoming Territory.

Euglypha alveolata, in what I have regarded to be its variations of form under different conditions, is perhaps the most common species. It varies considerably in size, proportions, exact shape, and other characters, and indeed the extreme variations have probably as much claim to be regarded as species as most of the forms of Euglypha I have viewed as such. See figs. 1–18, pl. XXXV.

Commonly the shell of *Euglypha alveolata* is regularly egg-shaped, with the narrow pole truncated by the mouth, as seen in figs. 1, 2, 4; frequently, however, the oral pole is more tapering and prolonged, and it is rarely somewhat flask-shaped, as represented in fig. 3. The fun-

* The number of points to the mouth of the shell of Euglypha is generally uncertain, from the difficulty of fixing the individual in such a position as to see them all distinctly. As the shell is usually viewed, the mouth can be seen only from one side, and it requires much time and patience to ascertain the exact number of points which surround it.

dus is almost always evenly dome-like, and only in some small forms have I observed it to be sub-acute. In transverse section, the shell is circular, and is rarely somewhat oval, indicating slight compression of the shell.

The mouth is circular, and is bordered with from four to a dozen angular, minutely serrulated points. The number of these points appears to hold no proportion with the size of the shell, for though usually the smallest kinds have fewest points, they sometimes have as many as the largest kinds. The points or denticles of the mouth are acute, and the minute serrulations on the sides have seemed to me usually three or four; but in the smaller forms of Euglypha I could not detect them.

In the larger and the largest forms of *Euglypha alveolata*, the shell is clearly seen to be composed of regular plates of nearly uniform size. In the smallest forms, the areolate structure of the shell is more or less obvious, but often obscurely defined. Where the definition of the plates and their arrangement is distinct, they have ordinarily appeared to me, as with some previous observers, Wallich, Carter, and Schulze, as of oval form, arranged alternately in longitudinal rows and overlapping at their contiguous borders. This arrangement produces the impression of hexahedral areas defined by zones of smaller elliptical areas.

In some large individuals of *Euglypha alveolata*, in which the structure of the shell was unusually well defined, as seen in figs. 2–4, 6, the plates appeared to be ovate, or somewhat cordate, and broader above, where they exhibited a minute median point. In some broken specimens of shells, this description of the plates seemed to be especially obvious.

From the sides of the fundus of the shell in the largest or best developed forms of *Euglypha alveolata*, there project from four to six thorn-like spines, as represented in figs. 1–10. The spines are of variable length, usually situated equidistant, and in the same individual about on the same level. In different specimens they may be on different levels, and are more or less divergent, though sometimes convergent, and rarely nearly straight, or in the same line as the long axis of the shell. Sometimes they are in greater number and irregularly placed, as seen in figs. 6–8. They are occasionally obsolete or altogether absent. In the smallest forms, and even in the largest, as they occur among algæ and the roots of mosses in damp situations, the shells are almost invariably destitute of spines. Figs. 11–14.

The conspicuous spines of the fundus of the shell of *Euglypha alveolata* are produced from certain of the plates, and seem to be a highly developed condition of the minute point at the upper median portion of the plates of the shell generally. The plates of the shell have considerable thickness, and appear to be lenticular or doubly convex. Those surrounding the mouth and forming its dentated border are usually conspicuously thicker than the rest.

In several instances, in some specimens, it has appeared to me that the second row of plates, above the oral series, was denticulated in a similar manner with these, as represented in fig. 18.

The sarcode of *Euglypha alveolata* and of other species does not differ essentially from that of the Difflugian forms. It usually occupies nearly the whole or the greater part of the interior of the shell. It almost invariably extends to the fundus, no matter what may be its reduction laterally or contraction from the sides of the shell. It is frequently more or less constricted in a somewhat hour-glass manner; but I never observed it adherent to the inner part of the shell by pseudopodal threads, as is so commonly the case in the Lobose Protoplasts.

Usually the sarcode is colorless, or is mainly so; though, from the admixture of food, it may appear to a variable extent yellowish or brownish, with darker colored spots, commonly green, from the presence of algæ. The basis of structure is a pale and finely granular protoplasm, and included in this are the usual elements found in most other Protoplasts. A large clear nucleus occupies the fundus of the sarcode mass, containing a pale granular central nucleolus, mostly obscurely or not at all visible without the action of acetic acid or other agent. Below the position of the nucleus, and partially enveloping it, a broad zone of the sarcode is mingled with an abundance of minute oil molecules, which give to this portion of the animal, when viewed by reflected light, a milk-white appearance, but by transmitted light a more or less black and punctated appearance.

Between the zone of oil molecules just indicated and the mouth of the shell, the sarcode often presents variable proportions of mingled food, sometimes as diffused and colored granular matter, and sometimes as colored granular balls included in drops of colorless liquid. Food materials of a more distinct character, as diatoms and other algæ, are also often seen in this position. Clear liquid globules in variable proportions and sizes are likewise frequently seen mingled with the foregoing. Contractile vesicles, two or three in number, are commonly to be detected in active individuals at the periphery of the intermediate zone of the sarcode body.

In movement, *Euglypha alveolata* assumes an erect position, as in the Difflugian Protoplasts, and its pseudopods diverge outwardly from the mouth of the shell. They are exceedingly delicate and filamentous, fork at acute angles, and commonly radiate in straight lines. Not unfrequently a branch may be noticed to bend abruptly in a geniculate manner, and occasionally the bent portion is seen slowly to vibrate. Sometimes a branch is seen rather suddenly to become tortuous and then retracted. Usually but a few pseudopods, two or three, are projected together, but sometimes a considerable number may be observed.

The size of *Euglypha alveolata* varies considerably as it occurs in the same and in different kinds of localities. It is usually largest, or best developed, and mostly provided with spines, when living in the sediment of springs, ponds, ditches, and lakes. The smaller and mostly spineless forms are found among algæ and mosses, in swamps, meadows, and similar moist positions; likewise among dripping rocks and about fountains.

The larger forms, provided with spines, range from 0.125 mm. to nearly 0.16 mm. in length and from 0.04 mm. to 0 083 mm. in breadth. The smaller spineless forms range from 0.03 mm. to 0.09 mm. in length by 0.012 mm. to 0.042 mm. in breadth The former appear to possess from six to a dozen or perhaps more teeth to the mouth; the later from four to eight teeth.

Euglypha alveolata, in its varied forms and conditions of development, is one of the commonest of Fresh-water Rhizopods. Its dead shells are found almost everywhere under conditions which may be or may have been favorable to the life of any species of the class. In the living state, of course, it is to be found only in water, or at least in positions which retain more or less moisture. The smaller, spineless forms occur in many places, especially about the roots of *Selaginella apus* and other mosses in wet meadows and half-dried marshes, on the borders of ditches and about the roots of trees in damp forests among algæ and mosses, on dripping rocks and at the mouths of caves, about fountain basins, and even among mosses in the crevices of brick pavements in shaded damp places in the city of Philadelphia. The larger forms, almost always provided with spines, are frequent in the superficial ooze of ponds, ditches, and lakes, and in such positions I have observed them in all parts of the country mentioned in other pages of this work.

Not unfrequently *Euglypha alveolata* is found with the sarcode contracted and in various stages of encystment, as represented in figs. 9, 10, 14, pl. XXXV. Usually in these the mouth of the shell is closed with an epiphragm, often more or less laminated in appearance, and composed of materials discharged from the sarcode mass as it was about to assume the encysted condition.

In one of the specimens observed, represented in fig. 9, the encysted sarcode mass formed an egg-like body covered with a shell having the same structure as that of the parent shell enclosing it. The sarcode itself was pale yellowish, of uniform granular constitution, mingled with fine oil molecules.

In other specimens, as seen in figs. 10, 14, the sarcode mass within the egg-shaped shell was contracted into a nearly spherical ball, and was invested with a distinct homogeneous membrane. The sarcode, in some such specimens, was finely granular, and in others was mingled with numerous oil-like globules.

Living active individuals of *Euglypha alveolata* are frequently to be met, containing in the sarcode, in a zone around the position of the nucleus, a multitude of rods, as seen in fig. 1. These rod-like bodies are likewise often seen occupying nearly the same position, but often irregularly scattered, in dead shells, and in these they are recognizable as detached plates, like those composing the shell of the Euglypha. What the meaning of this condition is I have been unable to determine. I have conjectured that it might be due to the hatching of an ovum-like body, such as those above described, and the retention of the plates of its broken-up shell within that of the parent.

On one occasion I observed a pair of specimens of *Euglypha alveolata* in a peculiarly interesting condition, which led me to believe that I had found the animal in the process of reproduction. As first seen, when the specimens attracted my attention, they exhibited the appearance represented in fig. 15. One of the individuals, which may, for convenience, be called the parent, had the usual form, and was $\frac{1}{7}$th mm. long. It had eight points to the mouth, and four long spines to the fundus, somewhat irregularly placed. The shell was replete with the contents, including the large nucleus occupying its ordinary position. The sarcode was mingled throughout with brownish particles of food, and also contained a single large navicula.

Closely adherent to the mouth of the parent Euglypha was the offspring, a smaller individual, little more than half the size of the former. Its fundus was somewhat contracted and acute, and was furnished with five spines. The peculiar structure of the shell was apparent, but appeared less extended or unfolded. The contents filled the shell, and consisted of finely granular colorless protoplasm, without any mixture of colored food particles, and without a nucleus.

Such was the appearance of the conjoined Euglyphas, parent and offspring, at the beginning of the observation, at 6¼ o'clock, in the morning of May 26, 1877.

Closely watching the pair, the young Euglypha was noticed very gradually to enlarge, and some of the brownish material of the parent sarcode gently flowed into and became slowly diffused in the previously clear, colorless sarcode of the offspring. The fundus of the latter expanded and became dome-like, as in the parent. The large clear nucleus of the latter disappeared, but the manner in which this took place escaped my notice. For some time afterward no further very perceptible change was detected in either individual.

An hour from the commencement of the observation, the young Euglypha had acquired nearly the size, shape, and appearance of the parent, as seen in fig. 16. Now commenced an active circulation, as indicated by arrows in the figure, a cyclosis, of the contents of the two shells, resulting in a thorough admixture. The sarcode flowed continuously from the parent on one side into the offspring and back again on the other side. Both individuals were replete with one continuous mass of brown, granular sarcode, without nucleus or contractile vesicles; the navicula alone retained its position within the parent. During the circulation of the sarcode, two spines with their basal plates became detached from the young Euglypha, but from what cause was not apparent.

The circulation ceased, and after a short period of quiescence, at 7½ o'clock, I observed the appearance of a contractile vesicle at the fundus of both individuals. The vesicle collapsed, and reappeared in two, three, or four, each again successively collapsing. With the appearance of the contractile vesicles the contiguous sarcode began to clear up, the brownish matter accumulating below the position of the usual position of the nucleus when present.

The sarcode of the parent now contracted at the middle, leaving a space between it and the sides of the shell, as seen in fig. 17. It afterward became clearer in the vicinity of the mouth, then separated from that of the offspring, and retracted a short distance. Simultaneously the same changes occurred in the offspring.

At five minutes to 8 o'clock, the two Euglyphas swayed slightly from side to side, protruded one or more delicate pseudopods, and two minutes afterward completely separated, and, with the mouth downward, slowly moved away from each other.

Half an hour after separation, a pale nucleus was visible in both individuals in the usual position, but the mode of its origin entirely escaped my observation. Two or more contractile vesicles disappeared, and reappeared around, but rather below, the position of the nucleus.

While the parent retained the original size, the young Euglypha remained slightly smaller.

The subject of this observation I have supposed might indicate one of the modes of reproduction of Euglypha, that is to say, the mode by division. As, however, Euglypha is often observed containing within the parent shell an ovum-like body, the process described may indicate the hatching of such a body, with segmentation of its sarcode, and the partition of this between the new and the old shell.

EUGLYPHA CILIATA.

PLATES XXXV, figs. 19, 20; XXXVI; XXXVII, figs. 30, 31, as *E. strigosa.*

*Difflugia ciliata.** Ehrenberg: Monatsb. Ak. Wis. Berlin, 1848, 379; Abh. Ak. Wis. Berlin, 1871, Taf. ii, Fig. 26.—Leidy: Pr. Ac. Nat. Sc. 1878, 172.

Euglypha compressa. Carter: An. Mag. Nat. Hist. 1864, xiii, 32, pl. i, fig. 13.—Leidy: Pr. Ac. Nat. Sc. 1874, 226.—Schulze: Archiv mik. Anat. 1875, xi, 101, Taf. v, Fig. 3, 4.

Setigerella ciliata. Ehrenberg: Abh. Ak. Wis. Berlin, 1871, 247.

Difflugia pilosa. Ehrenberg: Ibidem, 256, Taf. ii, Fig. 28.

Setigerella pilosa. Ehrenberg: Ibidem, 247.

Difflugia strigosa. Ehrenberg: Ibidem, 257, Taf. ii, 31.

D. Setigerella strigosa. Ehrenberg: Ibidem, 247.

Euglypha strigosa. Leidy: Pr. Ac. Nat. Sc. Phila. 1878, 172.

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* The original description is: "Lorica ovata, superficie areolata, areolis singulis posterioribus cirrhigeris, osteoli parte attenuata, aperturæ denticulis 10–16. Long.—$\frac{1}{36}$'''. D. areolatæ non cirrhigeræ admodum similis."

Shell compressed ovoid, with the oral pole usually more or less tapering and truncated by the transversely oval mouth; transverse section oval, with rounded or more or less sub-acute poles Fundus and lateral borders mostly fringed with spines or bristles, variable in number and degree of robustness, sometimes absent, and sometimes numerous, and extending to a variable extent over the shell and merging into the variety *E. strigosa.* Plates composing the shell mostly elongated hexahedral, closely fitting at the margins, and arranged in longitudinal rows in alternating series. Mouth bordered with from six to fourteen or more (?) blunt, angular, crenulated teeth composed of the lowest plates of the shell, which are usually decidedly thicker than elsewhere.

Size.—Ranging from 0.056 mm. in length by 0.024 mm. in the greater and 0.016 mm. in the less breadth to 0.1 mm. in length by 0.06 mm. in the greater and 0.032 mm. in the less breadth.

Locality.—Common in wet sphagnum of the sphagnous swamps of New Jersey and Pennsylvania. Collected in the sphagnous and cedar swamps of Atco, Hammonton, Absecom, Malaga, and Budd's Lake, New Jersey, and in the Pocono Mountains of Pennsylvania.

Euglypha ciliata is an abundant species in the wet sphagnum of sphagnous swamps, to the entire exclusion of *E. alveolata*, than which it is much more common in its own habitation. In general appearance it resembles *E. alveolata*, but is compressed, and is usually readily distinguished by its fringe of bristle-like spines extending around the fundus and along the greater part of the lateral borders.

The shell of *Euglypha ciliata*, like that of the preceding species, is variable in size, proportions, and form, and also in the number, strength, and extent of distribution of its bristles. It is compressed ovoid, or oblong ovoid, with the oral pole more or less tapering, and truncated by the mouth. Sometimes it is nearly round and somewhat prolonged at the oral pole. See figures of pl. XXXVI.

In transverse section, the shell is oval, with evenly rounded or more or less rounded angular poles, and the less breadth is commonly little more than half the greater breadth. See figs. 2, 10, 13, 15.

The spines or bristles commonly occupy the lateral or narrower borders of the shell, extending along the fundus and reaching below the middle of the sides. They sometimes form a single row in the median line of the lateral border, and at others a double row of variable regularity on each side of the lateral border. They are mostly single or isolated, but not unfrequently occur in pairs arising from the same point.

The form with the lateral fringe of spines or hairs, as represented in figs. 1–14, constitutes the species described by Carter and Schulze under the name of *Euglypha compressa*, and appears to be the same as that previously described by Ehrenberg as *Difflugia ciliata.*

With the more characteristic form, as indicated in the above description, in our sphagnous swamps, there occurs another in association with it, in which the shell is more or less invested with delicate spines or hairs, except in a zone of variable extent contiguous to the mouth. This hairy form has been indicated by Ehrenberg under the name of *Difflugia strigosa.* Specimens are represented in figs. 19, 20, pl. XXXV, figs. 16–20, pl. XXXVI, and figs. 30, 31, pl. XXXVII, and may be regarded as a variety with the name of *Euglypha strigosa.*

The spines or hairs of *Euglypha ciliata* vary not only in number, but also in length and strength, and sometimes they are altogether absent, as in the specimen of fig. 23, pl. XXXVI. Sometimes they are very short, as seen in fig. 8; sometimes of considerable length, as seen in fig. 19. In well-developed characteristic individuals, the spines are stout and subulate, and diverge outwardly with an inclination upward, as seen in figs. 1–5. When more numerous, and especially in the variety *E. strigosa,* they are more delicate, hair-like, or rather like rigid cils, as seen in figs. 7, 14, 16–20.

The shell of *Euglypha ciliata* ordinarily appears to be composed of somewhat elongated hexahedral plates of mostly uniform size, and closely fitting together in longitudinal rows and alternating series. The plates present a single intervening line; though in a different focus, they may be made to appear with a double outline, as represented in fig. 23. Though such seems to be the construction of the shell ordinarily, yet in a number of instances I have met with individuals, which I viewed as of the same species, having the shell composed of overlapping oval plates, as in *Euglypha alveolata,* and as represented in figs. 3, 4. I think the difference did not depend on an optical illusion, for in many empty cells of *E. ciliata* the octagonal plates were as distinctly marked as a pen-and-ink sketch, and by no alteration of the focus could I induce the appearance of overlapping plates with hexahedral areas enclosed in zones of minute elliptical areas.

The mouth of the shell of *Euglypha ciliata* is transversely oval, and bordered with a variable number of teeth, commonly ranging from four to twelve in number, though I have seen specimens in which I thought I could detect fourteen, sixteen, and eighteen teeth. The teeth are not acute, as in *E. alveolata*, but are obtuse, and are crenulate at the sides. They are formed by the lowest row of plates of the shell, which are decidedly thicker than elsewhere, and also appear to be carinated or ridged in the median line, as represented in figs. 4 and 23. Sometimes these plates appear to exhibit a number of ridges ending in the crenulations of the oral teeth, as represented in fig. 3.

The exact relation of the oral plates with those succeeding, and other points of their character, I failed satisfactorily to determine, so that my drawings, so far as they are concerned, are to be regarded as only approximately correct.

The sarcode of *Euglypha ciliata*, its pseudopods, and habits of the animal so far as observed, are identical with those of *E alveolata.* I have occasionally observed individuals of *Euglypha ciliata* with the sarcode retracted within the shell, and with the interval between it and the mouth of the latter occupied by a more or less thick epiphragm. The sarcode appeared entirely purged of remains of food, the accumulation of which on the outside apparently contributed to form the epiphragm, as represented in fig. 6. Individuals in this condition I have supposed to be ready to pass into an encysted state. In one instance I observed an individual, represented in fig. 3, in which the sarcode was retracted from the fundus and sides of the shell, and adhered to the latter only by two thick processes near the mouth. Outside the latter, clinging to the shell, was a discharged epiphragm of clear colorless substance. In this case I supposed that the sarcode had been contracted into a ball, but afterward had been stimulated to activity, and through pressure had ejected the epiphragm.

In my various observations on *Euglypha ciliata* and other species, it would appear that under certain conditions, among which are undue dryness or cold, the sarcode retreats to the fundus of the shell. It then gradually purges itself of all remains of food, which, together with successive films of discharged protoplasm, accumulate, and form a lid or epiphragm closing the mouth of the shell. If the sarcode contains little or no food, the epiphragm is composed only of discharged layers of protoplasm, and sometimes portions of discharged food are seen between the sarcode mass and the epiphragm. The sarcode then becomes contracted into an oval or spheroidal ball occupying the central portion of the shell. Under a change of circumstances, as a renewal of moisture and warmth, the sarcode may be stimulated to activity, when by pressure the epiphragm will be discharged from the shell, and the animal resumes its usual movements. Otherwise, the contracted ball of sarcode becomes invested with a membranous wall, and thus assumes the encysted condition. Under what circumstances the ovum-like form, with a shell composed of plates like those of the parent shell, is produced or developed, I did not learn.

Euglypha ciliata is commonly about 0.083 mm. in length by 0.055 mm. in its greater breadth, and one half this in its less breadth. Ordinarily it ranges from 0.055 mm. in length by 0.016 mm. in the greater breadth, to 0.1 mm. in length by 0.06 mm. in the greater breadth. The variety *Euglypha strigosa* I have observed ranging from 0.08 mm. in length by 0.06 mm. in greater and 0.032 mm. in less breadth, to 0.112 mm. in length by 0.08 mm. in greater and 0.04 mm. in less breadth.

Euglypha ciliata was first most clearly described by Mr. Carter under the name of *Euglypha compressa*, and subsequently under the same name by Dr. Schulze. Originally, however, it appears to have been indicated by Ehrenberg under the name of *Difflugia ciliata*.

Fig. 19, pl. XXXV, represents a somewhat peculiar specimen of Euglypha, in which the shell was oblong oval, and of uniform transverse diameters, as in *E. alveolata*, but furnished with hairs over a greater part of the surface, as in *E. strigosa*. The plates of the shell appeared distinctly hexagonal.

EUGLYPHA CRISTATA.

PLATE XXXVII, figs. 1–4.

Euglypha cristata. Leidy: Pr. Ac. Nat. Sc. Phila. 1874, 226; 1878, 172.

Shell tubular, flask-shaped, moderately inflated toward the fundus and tapering gradually to the mouth which is slightly contracted, circular in transverse section, hyaline, colorless, composed of oval plates in alternating longitudinal series, overlapping at the borders, and appearing as hexahedral areas limited by zones of minute elliptical areolæ, sometimes appearing to be composed of distinct hexagonal plates closely adapted by the edges. Mouth round, bordered by 4–6 angular, serrulated teeth. Fundus of the shell furnished with a central tuft of curved radiant spines.

Size.—Ranging from 0.04 mm. in length by 0.01 mm. in breadth to 0.072 mm. in length by 0.02 mm. in breadth.

Locality.—Frequent in wet sphagnum in the sphagnous and cedar swamps of New Jersey. Obtained at Absecom, Hammonton, Atco, and Malaga, New Jersey. Also found in sphagnum from Alabama.

Euglypha cristata is a well-marked form, readily distinguishable from the preceding, though I have met with forms of intermediate character which closely related it with *Euglypha alveolata*, pl. XXXVII. Usually it is flask-shaped, with evenly rounded fundus and more or less gradually tapering neck, as seen in figs. 1–3. Sometimes it is nearly tubular, especially in the smallest individuals, as represented in fig. 4.

The structure of the shell is the same as in *Euglypha alveolata*, as represented in figs. 1, 3; but in other instances it has appeared to be composed of distinct hexahedral plates, as commonly seen in *E. ciliata*, and as represented in figs. 2, 4.

The mouth is more or less contracted, and surrounded by four or six angular teeth, acute or blunt, and serrulated at the sides.

The summit of the fundus is provided with a tuft of curved, pointed spines diverging in a radiant manner.

Occasionally, in association with characteristic individuals of *Euglypha cristata*, I have seen one in all respects like them, but devoid of spines to the fundus.

The sarcode of *Euglypha cristata* is identical in character with that of the preceding forms.

The species is smaller than is usual with the others, ranging from 0.04 mm. to 0.071 mm. in length by 0.01 mm. to 0.022 mm. in breadth.

The species is frequent, in association with *E. ciliata*, etc., in the wet sphagnum of the sphagnous and cedar swamps of New Jersey.

EUGLYPHA MUCRONATA.

PLATE XXXVII, figs. 11–14.

Euglypha mucronata. Leidy: Pr. Ac. Nat. Sc. Phila. 1878, 172.

Shell like that of *Euglypha cristata*, but with a conical acute dome, prolonged into a long mucronate spine, sometimes two. Sarcode as in *E. alveolata.*

Size.—Ranging from 0.108 mm. in length by 0 032 mm. in breadth to 0.14 mm. in length by 0 044 mm. in breadth, independently of the mucro, which is from 0.02 mm. to 0.044 mm. long.

Locality.—Wet sphagnum of the cedar swamps of New Jersey.

Euglypha mucronata, like the preceding species, is a comparatively small and narrow form. See figs. 11–14, pl. XXXVII. The shell is commonly more tapering toward the mouth than in *E. cristata*, and it has a sharp conical fundus surmounted by a long, stout, pointed spine, sometimes straight, but usually more or less bent to one side, or it is somewhat curved. Frequently, two similar and smaller spines substitute the single stronger one, as seen in figs. 13, 14. Occasionally, the spine is quite short, and in two specimens observed, none existed.

The composition of the shell and of the sarcode is the same as in *E. cristata.*

In several specimens observed, the sarcode was in an encysted condition and contained in an egg-like case within the parent shell, the mouth of which was closed by an epiphragm, as seen in figs 13, 14.

Euglypha mucronata is not unfrequent in the wet sphagnum of sphagnous bogs.

EUGLYPHA BRACHIATA.

PLATE XXXVII, figs. 5–10.

Euglypha brachiata. Leidy: Pr. Ac. Nat. Sc. Phila. 1878, 172.

Shell like that of *Euglypha cristata,* but without the tuft of spines to the fundus, and with from two to four or six long spines, springing from the neck of the shell and diverging or curving upward and outward.

Size.—From 0.104 mm. long by 0.028 mm. broad to 0.128 mm. long by 0 04 mm. broad.

Locality.—Wet sphagnum of cedar swamps, and in the black ooze of Batsto River, New Jersey.

Euglypha brachiata is a near relative of the preceding two species. Its shell has the usual form and structure of that of *E cristata,* but the tuft of comparatively short spines of the fundus in this is substituted usually by two or four, or less frequently by six spines diverging from the sides of the neck at variable distances from the mouth. See figs. 5–10, pl. XXXVII. The spines are of variable length, usually long, curved and pointed. Rarely, I have seen them straight, with thickened ends and oar-like, as seen in fig. 7. Rarely, also, I have seen a specimen with two rows of spines, as in fig. 6.

Occasionally also, in this species, the spines are absent; at least, in one instance I observed a pair of individuals in conjugation, in one of which the shell had a pair of spines, and in the other there were none.

Euglypha brachiata is found in the same kind of localities as *E. cristata* and *E. mucronata*, but is comparatively rare. I once found it in considerable numbers in ooze from the headwaters of Batsto River, New Jersey.

Euglypha tegulifera, a Fresh-water Rhizopod, recently described under this name by Professor Barnard, in the American Quarterly Microscopical Journal, 1879, 85, pl. viii, fig. 4, I have not seen. It was found among algæ in New York. Its characters would refer it to a different genus from Euglypha.

PLACOCISTA.

Greek, *plax*, a plate; *kiste*, a box.

Euglypha: Carter.

Animal with a compressed oval, hyaline, colorless shell, with acute border and terminal elliptical mouth; the border of the latter entire, with acute commissures. Shell composed of longitudinal rows of alternating oval or roundish plates overlapping at their contiguous borders, so as to produce hexahedral areas limited by zones of minute ellipses. Lateral borders and fundus furnished with acuminate spines articulated with the shell. Sarcode and pseudopods as in Euglypha.

The genus is founded on what I take to be the *Euglypha spinosa* of Carter, the shell of which differs from that of the characteristic species of Euglypha, in having the mouth entire or destitute of dentate scales, and in the possession of articulated spines.

PLACOCISTA SPINOSA.

Plate XXXVIII.

Euglypha spinosa. Carter: An. Mag. Nat. Hist. 1865, xv, 290, pl. xii, fig. 13.—Archer: Quart. Jour. Mic. Sc. 1872, xii, 90; 1876, xvi, 237.—Leidy: Pr. Ac. Nat. Sc. 1874, 226; 1878, 172.

Shell transparent, colorless, compressed oval, with acute lateral borders, sometimes slightly tapering toward the oral pole; mouth large, transversely elliptical, with acute commissures and entire or edentulous border. Shell composed of oval, imbricating plates, in longitudinal alternating series, the overlapping borders producing hexahedral areas limited by zones of minute ellipses; oral row of plates like the others, and not forming angular teeth to the mouth as in Euglypha. The lateral acute border of the shell fringed with movable subulate spines articulated with the shell by a minute knob, usually in pairs, sometimes single and rarely triple. Soft structure as in Euglypha.

Size.—Ranging from 0.1 mm. to 0.136 mm. long and 0.08 mm. to 0.096 mm. in the greater and 0.036 mm. to 0.06 mm. in the less breadth; mouth 0.04 mm. to 0.06 mm. wide; spines 0.016 mm. to 0.04 mm. long.

Locality.—In the moist sphagnum of the cedar swamps of Absecom, Atco, and Malaga, New Jersey.

Placocista spinosa I suppose to be the same as the *Euglypha spinosa* discovered and described by Mr. Carter from specimens found in heath-bogwater, in South Devon, England. Mr. Carter states that he saw only two or three specimens, and those in the winter, when the animal was in a passive condition.* Since then the creature appears to have been observed only by Mr. Archer of Dublin. Schulze, who had not seen it, considers it to be only a variety, or resting condition, of *Euglypha compressa*,† which I view as the same as *E. ciliata*, described in the preceding pages.

Placocista spinosa usually exceeds in size any of the species of Euglypha, though I have occasionally found specimens of *E. alveolata* that were larger. It is completely colorless and hyaline, and is only rendered more or less opaque white about the middle zone of the body from the accumulation there, in the sarcode, of variable proportions of fine oil-like molecules By reflected light it exhibits a silvery white lustre.

The shell is compressed oval, sometimes with the oral pole feebly tapering, and in the broader view with the fundus broadly convex. The lateral borders meeting at the fundus are acute. The mouth is a wide, transverse, elliptical aperture, with acute commissures and an entire margin. Its broader line is more or less convex downward, but often also projects more downward at the commissures. See pl. XXXVIII.

The shell is composed of oval plates arranged in alternating longitudinal series, overlapping at the borders so as to produce hexahedral areolæ

* Annals and Magazine of Natural History, 1865, xv, 290.

† Archiv f. mikros. Anatomie, 1875, xi, 104.

limited by zones of minute ellipses, as seen in the figures of pl. XXXVIII. The plates bordering the mouth do not differ from those elsewhere, so that the margin of the latter is entirely destitute of the tooth-like processes, which form so conspicuous a feature in the species of Euglypha. Mostly, the margin of the mouth is quite even, but often the contiguous oval plates appear to give it a feeble wavy course.

The lateral borders of the shell extending to the fundus are fringed with awl-shaped spines, variable in number, length, and degree of robustness. The spines spring from the acute margin of the shell, or on each side of it, from between the contiguous plates. They are usually in pairs, but are often single, and occasionally a tuft of three may be seen with the others. The root of each spine possesses a minute rounded knob, by which it is movably attached to the shell, so that the spines may be turned in any direction, though usually they diverge outward and upward.

The sarcode and pseudopods of Placocista are identical in appearance with those of Euglypha. Although I have repeatedly found *Placocista spinosa* at different seasons and apparently under favorable conditions, I have rarely observed it in an active condition. The animal seems to be among the most shy of its kind. In most instances, the sarcode was retracted within the shell, was completely free from any recognizable food materials, and appeared to be ready to pass into an encysted condition. Though I have certainly seen some scores of living individuals, I do not remember to have observed more than four or five emit their pseudopods, and assume the erect position, as is customary with creatures of the kind.

The sarcode occupies the interior of the shell to a variable extent, sometimes completely filling it, and at others more or less partially, as represented in the figures of pl. XXXVIII. In reduction, the mass of sarcode undergoes contraction from the sides of the shell, but appears to retain a close connection with the fundus. Rarely have I seen it connected with the interior of the shell by pseudopodal processes, as exemplified in the active individual of fig. 4.

Most specimens of *Placocista spinosa* observed appeared to be perfectly free from food contents, presenting the mass of sarcode as a colorless, transparent, finely granular protoplasm mingled with variable proportions of darkly outlined oil-like molecules. The greater quantity of the latter, as usual in Euglypha, etc., are accumulated in an intermediate position of the body of sarcode, more or less including the lower part of the nucleus. In individuals which would appear to have been in an active state, the lower portion of the sarcode mass was mingled with variable proportions of globules or vacuoles of liquid of different sizes. In a similar position in active individuals, the colorless globules were mingled with distinct food globules of a brownish hue, and with them occasionally an alga of some kind, as seen in figs. 1, 4.

The nucleus is large and clear, and occupies the usual position in the fundus of the sarcode. Mostly, it could be seen to contain a central nucleolus, or a greater and variable number scattered throughout.

In the more active individuals, from one to three contractile vesicles would appear and disappear in the intermediate zone of the sarcode.

Many individuals exhibited the sarcode contracted into a mass occupying the upper part of the shell, as seen in figs. 7, 9. In these the mass was perfectly quiescent, and consisted of a uniform basis of finely granular protoplasm with diffused oil molecules and the large clear nucleus. Sometimes the mass appeared to be relieving itself of a portion of its granular contents by expulsion in layers, as represented in fig. 9. In some specimens the protoplasmic mass was enclosed in a thin homogeneous membrane, and the mouth of the shell was closed by compression, as seen in figs. 7, 8.

Among many empty shells of *Placocista spinosa*, exhibiting considerable variation in exact form, especially in the oral pole, I observed several, as seen in fig. 14, which contained the empty lenticular shell of an egg-like body evidently belonging to the animal.

The ordinary size of *Placocista spinosa* is about 0.125 mm. in length, 0.833 mm. in breadth, and about half that thickness. The mouth is 0.05 mm. wide, and the spines range from 0.02 mm. to 0.033 mm. in length. The nucleus of the sarcode measures about 0.0285 mm. in diameter.

ASSULINA.

Latin, *assula*, a little chip.

Difflugia; Euglypha; Assulina: Ehrenberg.

Shell compressed spherical or oval; neck almost obsolete, terminating in a transversely elliptical mouth with uneven or ragged edges, composed of minute oval or hexagonal plates in alternating rows. Sarcode and pseudopods as in Euglypha.

ASSULINA SEMINULUM.

PLATE XXXVII, figs. 15–27.

Difflugia Seminulum. Ehrenberg: Monatsb. Ak. Wis. 1848, 379.* Mikrogeologie, 1854, Taf. xxxv, B, A. ii, Fig. 1.—Pritchard: Hist. Infus. 1861, 553.
Euglypha s. Assulina Seminulum. Ehrenberg: Abh. Ak. Wis. 1871, 246.
Difflugia Semen. Ehrenberg: Abh. Ak. Wis. 1871, 257, 264.
Euglypha brunnea. Leidy: Pr. Ac. Nat. Sc. 1874, 226; 1876, 55; 1877, 321.
Euglypha tincta. Archer: Proc. Dublin Micr. Club, 1875, in Quart. Jour. Mic. Sc. 1876, 107; Ibidem, 1877, 103, 330; 1878, 105.
Euglypha seminulum. Leidy: Pr. Ac. Nat. Sc. 1878, 172.

Shell nearly as broad as long, compressed oval, brown in color; borders obtuse, spineless; plates hexagonal or oval; mouth transversely oval, with the margin lacerated or irregularly notched.

Size.—From 0.044 mm. long by 0.036 mm. broad and 0.016 mm. thick to 0.08 mm. long by 0.072 mm. broad and 0.032 mm. thick.

Locality.—Common in sphagnous swamps.

In **Assulina seminulum** the shell is compressed spheroidal or oval, with the breadth nearly equal to the length, and the thickness about half, or less than half the breadth. The dome and lateral borders are rounded or at most sub-acute. The mouth is transversely oval, and abruptly truncates the pole of the shell, or the latter may be slightly prolonged so as to form a short neck. The shell is chocolate-brown in color, of variable shade, sometimes quite light, and in very young individuals colorless, in old ones sometimes very dark. At the mouth it usually presents a lighter band of color. See figs. 15–27, pl. XXXVII.

The shell is composed of minute oval or hexagonal plates arranged in alternating longitudinal series or obliquely parallel spiral rows. The oral plates, lighter colored and thinner than the others, end in irregular processes, which give to the border of the mouth a lacerated appearance.

The soft part of *Assulina seminulum* has the same constitution as in the species of Euglypha. Usually, I have found it to occupy but little more than half the capacity of the shell, as seen in figs. 18, 19. The animal seems to be exceedingly shy or sensitive, and usually after disturbance remains quiescent for a very long time. The pseudopods are few and extremely delicate.

* The original description of *Difflugia Seminulum*, by Ehrenberg, in the 'Monatsberichte,' is as follows: "Lorica brevius ovata, fusca, superficie anguste et subtiliter areolata simplici, ostiolo lato, subtilissime denticulato aut integro. Long. $\frac{1}{96}$–$\frac{1}{48}'''$ "

The size of the shell ordinarily ranges from 0.05 mm. to 0.083 mm. long, 0.04 mm. to 0.071 mm. broad, and 0.0161 mm. to 0.033 mm. thick.

Assulina seminulum is common in sphagnum, and is often one of the most abundant forms. It is remarkable that among the specimens commonly observed comparatively few are living. The same observation has been made by Mr. Archer, who recently, as I, described the species as a new one of Euglypha.

TRINEMA.

Greek, *tri*, three; *nema*, thread.*

Animal provided with a hyaline, pouch-like shell, with its long axis inclined or oblique, and with the mouth subterminal. Dome obtusely rounded; mouth inverted, circular, minutely beaded at the border. Structure of the shell in the smallest forms mostly appearing homogeneous, but in the larger composed of circular plates arranged in alternating series, and often appearing with a beaded margin. Sarcode and pseudopods as in Euglypha.

Animal when in movement with the body inclined, the mouth being anterior and downward; the fundus directed upward and backward.

TRINEMA ENCHELYS.

Plate XXXIX.

Trinème. Dujardin: An. Sc. Nat. 1836, v, 198, 205, pl. ix, fig. *Aa–Ad*.

Difflugia Enchelys. Ehrenberg: Infusionsthierchen, 1838, 132, Taf. ix, Fig. iv.—Pritchard: Hist. Infusoria, 1861, 553, pl. xxi, fig. 19.

Trinema. Dujardin: An. Sc. Nat. 1838, x, 261, note to 263.†

Arcella hyalina. Ehrenberg: Abh. Ak. Wis. 1841, Taf. i, ii, Fig. 31, Taf. iii, vi, Fig. 6, Taf. iv, i, Fig. 34, *a*, *b*, v, Fig. 3; 1856, Tafel (p. 377), Fig. 2, 3. Monatsberichte, 1848, 215; 1849, 98.

Trinema acinus. Dujardin: Infusoires, 1841, 249, pl. iv, fig. 1.—Perty: Kennt. kleinst. Lebensformen, 1852, 187.—Fresenius: Abh. Senck. Naturf. Gesell. 1856–8, 223, Taf. xii, Fig. 25–27.—Claparède and Lachmann: Infus. et Rhizopodes, 1858–9, 455.—Leidy: Pr. Ac. Nat. Sc. 1874, 227; 1877, 321.—Schulze: Arch. mik. Anat. 1875, 104, Taf. v, Fig. 9–11.

Arcella constricta. Ehrenberg: Abh. Ak. Wis. 1841, 410, Taf. iv, i, Fig. 35. Mikrogeologie, 1854, Taf. xxxix, iii, Fig. 3.

Arcella Nidus Pendulus. Ehrenberg: Abh. Ak. Wis. 1841, 410, Taf. iii, i, Fig. 48.

Arcella Disphæra. Ehrenberg: Abh. Ak. Wis. 1841, 410, Taf. iv, ii, Fig. 12.

Arcella caudicicola Ehrenberg: Monatsb. 1848, 215, 218. Abh. Ak. Wis. 1871, Taf. ii, Fig. 31.

Arcella Enchelys. Ehrenberg: Mikrogeologie, 1854, Taf. xxxviii, Fig. 5, Taf. xxxix, iii, Fig. 4. Monatsb. 1845, 319; 1848, 215; 1849, 299; 1851, 228; 1853, 182, 266, 332; 1854, 710; 1856, 337, (Tafel) Fig. 2.

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* Named from the circumstance that commonly three pseudopodal threads are observed projected from the mouth of the shell.

† In 1836, Dujardin employed only the gallicized name of *Trinème* for the little rhizopod; and not until 1838, after the publication of Ehrenberg's 'Infusionsthierchen,' did he use the name *Trinema*. In the note indicated he speaks of Ehrenberg's *Difflugia Enchelys* as clearly being the same as his *Trinema*. Not until 1841, in his 'Histoire des Infusoires,' does he give to it the specific name of *T. acinus*.

Arcella Megastoma. Ehrenberg: Monatsb. Ak. Wis. 1853, 182; 1856, 337, (Tafel) Fig. 3. Mikrogeologie, 1854, Taf. xxxiv, viii, Fig. 1. Abh. Ak. Wis. 1871, 259.
Euglypha pleurostoma. Carter: An. Mag. Nat. Hist. 1857, xx, 35, pl. i, figs. 19 *a–i*.
Euglypha Enchelys. Wallich: An. Mag. Nat. Hist. 1864, xiii, 245, pl. xvi, figs. 46, 47.
Arcella rostrata. Ehrenberg: Abh. Ak. Wis. 1871, 272, Taf. iii, ii, Fig. 2.
Arcella reticulata. Ehrenberg: Ibidem, Fig. 5.
Arcella seriata. Ehrenberg: Ibidem, Fig. 6.
Arcella Pyrum. Ehrenberg: Ibidem, Fig. 15.
Homœochlamys constricta, H. Disphæra, H. Enchelys, H. hyalina, and *H. rostrata.* Ehrenberg: Abh. Ak. Wis. 1871, 244.
Sticholepis caudicicola, S. Nidus Pendulus, and *S. Megastoma.* Ehrenberg: Ibidem.
Heterocosmia Pyrum. Ehrenberg: Ibidem, 245.
Trinema enchelys. Leidy: Pr. Ac. Nat. Sc. 1878, 172.

The only species of the genus.

Size.—Ranging from 0.016 mm to 0.1 mm. long by 0.01 mm. to 0.06 mm. broad, and mouth from 0.005 mm. to 0.024 mm. in diameter.*

Locality.—Sphagnous swamps, wet forests about the roots of mosses, in marshes, and in the ooze of pools and ponds.

Trinema enchelys is one of the commonest and smallest of the shell-bearing rhizopods, and is found almost everywhere in moist places as well as in pools and ponds. It is especially abundant in sphagnous swamps, but is often found in the earth about the roots of mosses and other plants, even in such places as roadsides, on the bark of trees, old wooden or thatched roofs, and in the crevices of pavements of cities. It was originally described by Dujardin under the name of "Trinème," and it was not until after the publication of Ehrenberg's 'Infusionsthierchen,' in which it is described and figured as *Difflugia Enchelys*, that the former called it *Trinema acinus.* Though the latter name is employed by most subsequent writers, according to the rules of zoological nomenclature the one I have adopted at the head of this chapter is the proper one.

Trinema enchelys is very variable in form and size, and thus helped Ehrenberg to swell the long list of his Difflugias and Arcellas. See pl. XXXIX. The shell is colorless, transparent and pouch-like, with the oral end usually the smaller. The mouth opens downward beneath the oral extremity, and the inflated fundus of the shell is directed obliquely backward and upward.

In the full view of the shell, beneath, its outline is usually more or less

* The measurements are taken from the view of the shell beneath, giving the extreme length from the edge of the shell in advance of the mouth to the summit of the fundus, while the breadth indicated applies to the latter.

pyriform reversed, but it is sometimes oval, ovoid, oblong, or more or less constricted nearly on a line with the back part of the mouth. Sometimes the oral extremity appears broader than the fundus, which is obtusely rounded. The mouth is circular, and has a crenulate or beaded border.

In the side view of the shell, in the position in which it is maintained when the animal is in movement, the fundus is variably elevated. Sometimes the oral side of the shell is on the same plane as the mouth, and the fundus is directed backward. In other specimens, the longitudinal axis from the mouth to the fundus exhibits various degrees of inclination. The oral end of the shell beneath is concave, or the mouth appears inverted, forming the inner orifice of a shallow funnel.

In many specimens of *Trinema enchelys*, especially in small and perhaps young ones, the shell appears to be composed of clear homogeneous membrane. In many others, especially large individuals, the shell is composed of circular plates with beaded borders, conjoined by an intervening amorphous cement, as represented in figs. 1–4. In some specimens, as seen in figs. 28, 29, the circular plates appear to overlap in the same manner as in species of Euglypha.

In many specimens of Trinema, especially those of intermediate and of the larger size, in which the shell appears to be homogeneous, the outlines exhibit a more or less undulating character, apparently indicative of a constitution of disks, though these are not perceptible. The interior soft structure of Trinema is identical with that of Euglypha. Usually, two contractile vesicles are observable at the sides of the nucleus, even in the smallest individuals. The pseudopods are likewise of the same kind as those of Euglypha. Three are commonly seen, whence the name of the genus; but the number is by no means definitely restricted, and there may be one to half a dozen or more.

The size of Trinema presents a wide range The smallest one measured was 0.0161 mm. long by 0.01 mm. broad, with the mouth 0.005 mm. wide. The largest was 0.1 mm. long and 0.0625 mm. broad, with the mouth 0.0238 mm. wide. Between these extremes I have observed all gradations of size.

As mentioned at the beginning of the present chapter, Trinema is one of the most common of the Fresh-water Rhizopods, being found in almost all positions in which other forms exist. A small form appears to be a pretty constant associate of the common rotifer among mosses and other plants in damp, shaded places. I find it abundantly, all the year round, in the crevices of the brick pavement, in front of my house, about the roots of the little pearlwort, *Sagina apetala.* This small form appears to have a homogeneous shell, and is about 0.0238 mm. long by 0.02 mm. broad. In dry weather, like the rotifer, it becomes quiescent, but during and after rain it assumes the active condition.

SPHENODERIA.

Greek, *sphen*, a wedge; *dera*, the neck.*

Shell globular or oval, sometimes slightly compressed, hyaline, membranous, with a short, broad neck, and a wide elliptical, subterminal, or oblique (?) mouth. Body of the shell with circular, oval, or hexagonal cancelli or plates arranged in alternating series. Sarcode and pseudopods as in Euglypha.

SPHENODERIA LENTA.

PLATE XXXIV, figs. 25–41.

Sphenoderia lenta. Schlumberger: An. Sc. Nat. 1845, 256.—Ehrenberg: Abh. Ak. Wis. Berlin, 1871, 236.
Euglypha globosa. Carter: An. Mag. Nat. Hist. 1865, xv, 290, pl. xii, fig. 14.—Hertwig and Lesser: Arch. mik. Anat. 1874, x, Suppl. 129, Taf. iii, Fig. 7.—Schulze: Ibidem, 1875, 102, Taf. v, Fig. 5, 6.—Leidy: Pr. Ac. Nat. Sc. 1874, 226; 1878, 172.
Difflugia lenta. Ehrenberg: Abh. Ak. Wis. Berlin, 1871, 246.
Assulina lenta. Ehrenberg: Ibidem.

Animal comparatively small. Shell delicate, membranous, colorless, transparent, globular, oval or oblong, of uniform transverse diameter or sometimes slightly compressed, with a short, broad, compressed neck, widening toward the narrow elliptical mouth, which is oblique or subterminal (?). Border of the mouth thin, delicate, entire. Body of the shell composed of circular or oval plates overlapping at their contiguous borders and arranged in alternating series, and apparently not extending into the neck. Sarcode as in Euglypha and Trinema.

Size.—Globose forms from 0.032 mm. long by 0.028 mm. broad to 0.056 mm long by 0 052 mm. broad or to 0.056 mm. in diameter; oval forms from 0.028 mm. long by 0.02 mm broad to 0.056 mm. long by 0.044 mm. broad.

Locality.—Common in moist sphagnum in the cedar and other bogs of New Jersey, Pennsylvania, Alabama, and Florida; also in swampy localities at Fort Bridger, Wyoming Territory.

* Agassiz: Nomenclator Zoologicus, has *deros*, the skin; but this I infer to be a mistake.

Sphenoderia lenta is the subject of one of the descriptions of certain species and genera of Rhizopods, by Schlumberger, in the 'Annales des Sciences Naturelles' for 1845. The descriptions, being brief and unaccompanied by illustrations, have given rise to differences of opinion as to what particular forms they apply. The genus Sphenoderia is described as possessing "a diaphanous, globular shell, ornamented with polygonal impressions in regular oblique series, and having a broad, and short wedge-shaped neck, with the terminal aperture almost linear." The pseudopods are filiform, long and fine. The form of the neck and of the aperture separates the genus from Trinema and Euglypha, to which it is related in the structure of the shell.

Later, Mr. Carter described a rhizopod, under the name of *Euglypha globosa*, with a globular shell having a short, compressed, wedge-shaped neck, which has appeared to me to be the same thing. Schulze remarks that the *Euglypha globosa* is probably the same as Sphenoderia, but considers it uncertain for want of figures of the latter for comparison.*

Sphenoderia lenta, which I regard the same as *Euglypha globosa*, is common in the wet sphagnum of sphagnous swamps, and is also less frequently to be found about the roots of Selaginella, Hypnum, and other mosses and plants in bogs.

It is a comparatively minute creature, like Trinema, and is also a shy animal, little disposed to movement when disturbed.

The shell has the form of an oval or spherical sac, or less frequently is oblong oval, and is provided with a short neck. The body is usually of uniform transverse diameter, but is sometimes more or less compressed. The fundus is obtusely rounded and devoid of appendages. See figs. 25–41, pl. XXXIV.

Like other investigators, I have been puzzled to ascertain the exact characters of the neck and mouth of the shell. In the ordinary view, the neck has appeared to me to be short, wide, and saucer-shaped, with an elliptical mouth. In the opposite direction it appears as a conical point, whence no doubt the name of the genus Sphenoderia, signifying wedge-like neck. In viewing the shell in an intermediate position, by causing it to turn on its axis, the neck appears as a pair of conical points, with the border of the mouth festooned between them. I have supposed the mouth to be elliptical

*Archiv f. mikroskopische Anatomie, 1875, 104.

and oblique or subterminal, so that in the narrow angular view of the neck it is directed toward one of the wider sides. Hertwig and Lesser, in the same animal, under the name of *Euglypha globosa*, describe the neck as consisting of a pair of lateral points, between which the edges of the mouth are cut out concavely.*

The body of the shell of *Sphenoderia lenta* has appeared to me to be composed of circular or oval plates, arranged in alternating rows, and overlapping at the contiguous borders, so as to give the impression of hexahedral areas included within circles of minute elliptical areas, as represented in figs. 25, 26, 41, pl. XXXIV. Hertwig and Lesser describe the plates as hexagonal, with minute, intervening, transverse, elliptical, more prominent plates.† In some instances, the plates have appeared to me to be definitely hexahedral, and closely adapted to one another without accessory plates, as in the variety represented in fig. 34.

The neck of the shell, between its lateral angular points, is thinner than any other part, and consists of delicate homogeneous membrane, extending beyond the plates of the body to the border of the mouth. The latter is entire, but I have occasionally met with empty shells, in which the border was divided into several lobes, perhaps the result of laceration, as seen in fig. 34.

In repeated instances I have found individuals of Sphenoderia, with an oblong oval shell, having the border of the mouth divided into a number of minute points, as represented in fig. 40. Sometimes the points appear of an irregular character, as in *Assulina seminulum.* I have met with several individuals of Sphenoderia, in which the shell was ovoid, with the narrow pole terminated by the mouth, which had a minutely denticulated border. The body of the shell was composed of accurately adapted plates of hexagonal form and uniform size. In the specimens previously indicated, fig. 40, the plates of the shell were circular and overlapping

The interior soft structure of Sphenoderia, and its pseudopods, are identical in character with those of Trinema and Euglypha. Sphenoderia nearly related with Trinema, and the variety having a denticulated mouth is also nearly related with *Assulina seminulum.*

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* Archiv f. mikros. Anatomie, 1874, x, Suppl. 130. † Ibidem, 131.

Globular forms of *Sphenoderia lenta* range from 0.033 mm. to 0.055 mm. in diameter; oval forms from 0.0285 mm. to 0.0625 mm. long by 0.02 mm. to 0.0454 mm broad.

SPHENODERIA MACROLEPIS.

Shell pyriform, compressed, with a broad neck gradually extending from the body, and terminating in the oblique elliptical mouth, and with the broader surfaces composed mainly by a pair of large hexahedral plates, from which the neck is extended below.

Size.—From 0.02 mm. to 0.028 mm in length.

Locality.—Sphagnum of the cedar swamps of New Jersey.

Not until a comparatively recent date, and since the present work was going through the press, I have discovered what appears to be a second and quite distinct species of Sphenoderia. It was found in association with *S. lenta*, in sphagnum of several localities in New Jersey, but especially in that of the cedar swamp at Malaga, Gloucester County. It is probably not uncommon, but may be easily overlooked, for it differs little in size and form from *S. lenta*, and the peculiar structure of the shell in the living animal is obscured by the presence of the sarcode.

The shell is moderately compressed pyriform, and varies little in shape or size. It usually measures 0.024 mm. in length by 0.016 mm. in the greater and 0.012 mm. in the less breadth.

The neck tapers from the body of the shell, but in other respects appears to have the same characters as in *S. lenta*, and in the narrower side view of the shell it presents the wedge-like outline characteristic of the genus.

The delicate colorless shell when empty distinctly exhibits, on the broader sides of the body, a pair of large hexahedral plates, one above the other, as represented in the adjoining woodcut. Another less distinct plate occupies the fundus above the preceding, and a pair of smaller lozenge-like plates apparently occupy the intervals laterally of the two pairs of broad hexagonal plates. The neck is prolonged below the position of the body-plates, and appears to be devoid of distinct or separate plates.

Shell of *Sphenoderia macrolepis*.

The interior sarcode of *S. macrolepis* is identical in character with that of *S. lenta*.

HELIOZOA.

Greek, *helios*, the sun; *zoon*, animal.

While the Lobose and Filose Protoplasts are essentially creeping animals, and in all the shell-covered forms habitually move about with the mouth of the shell downward, and with the pseudopods spreading therefrom in contact with the surface on which they move, the Heliozoans or Sun-animalcules are swimmers. Their body is commonly of spherical form, and delicate pseudopodal filaments radiate from every part of its surface. While some are naked or entirely soft, others are provided with a sort of protective skeleton, consisting of radiant spines, of minute spicules imbedded in an exterior protoplasmic layer, or of a delicate latticed shell.

The soft spheroidal protoplasmic body, in general, exhibits the same essential constitution as in the Protoplasts, and commonly presents but little more distinction of ectosarc and endosarc than in the Filosa. A large proportion of clear globules or vacuoles form a common constituent, giving to the body a foamy appearance, not usual in any of the Protoplasts.

Generally, the body contains a single central nucleus; but, in a few forms, a number of nuclei occur scattered through the mass.

In some of the Heliozoans, one or more conspicuous contractile vesicles appear on the surface of the body, and exhibit the usual phenomena as indicated in the description of the Protoplasts. As the contractile vesicles enlarge, they rise prominently above the surface of the body, and appear like floating bubbles. In their abrupt collapse and discharge of the contents, they often give rise to a visible shock to the body of the animal. In other Heliozoans, if contractile vesicles occur, they have escaped detection.

Some Heliozoans appear bright green from the presence of chlorophyl in variable proportion, as one of the constituents of the body.

The pseudopodal rays are in the form of delicate threads of granular protoplasm, emanating from all parts of the body. They are commonly simple filaments, rising by a broad base, rapidly tapering to extreme fineness and variable length, often exceeding the diameter of the body. They rarely fork or branch at the ends, and even more rarely anastomose. In some forms, on the coarser rays, a slow circulation of granules may be detected, proceeding outwardly and inwardly. The pseudopodal rays are commonly very numerous, but are variable in number in the same as well as in different Heliozoans. They usually appear perfectly straight and rigid, but are highly flexible and contractile. The contact of a roving animalcule of some strength will cause them to bend like the hairs of a brush under similar pressure.

In one form of the Heliozoans, the Actinosphærium, the pseudopodal rays are sustained by a more consistent axial thread, springing from among the superficial layer of vacuolar corpuscles of the body.

The pseudopodal rays are the organs of locomotion and prehension of the Heliozoans. By their means the animals swim in a slow even manner through the water. Food particles, plant or animal, coming into contact with the rays, adhere, and are drawn by their contraction to the body. When the latter is reached, usually a quantity of clear protoplasm is projected or exudes and envelopes the food, which is then gradually drawn into the body of the animal through the contraction of the exuded protoplasm.

Heliozoans commonly multiply by division, as may be frequently seen with the common Sun-animalcule, *Actinophrys sol.*

The Heliozoans bear a close resemblance to the marine Radiolarians, and have hence been called Fresh-water Radiolarians; they are, however, of much simpler constitution, and are justly considered by most authorities as forming a distinct order of Rhizopods.

ACTINOPHRYS.

Greek, *aktin*, a ray; *ophrus*, the eyebrow.

Body soft, spherical, composed of a hyaline, colorless, pale, and finely granular protoplasm, with mingled coarser granules and minute oil-like molecules, and more or less crowded with large clear vesicles or vacuoles. Nucleus central, ordinarily obscured from view by the vesicular structure of the sarcode. A large contractile vesicle at the periphery. Pseudopods numerous, projecting as exceedingly delicate tapering rays, or filamentous, finely granular extensions of the protoplasm of the surface of the body, not branching.

ACTINOPHRYS SOL.

PLATE XL.

"Un poisson des plus extraordinaire que l'on en puisse voir." Joblot: Obs. Hist. Nat. i, 1754, 64, pl. 7, fig. 15.

Trichoda Sol. Müller: Verm. Terrest. Fluv. 1773, 76. Anim. Infus. 1786, 164, tab. xxiii, figs. 13–15.—Schrank: Fauna Boica, iii, 2, 1803, 93.

Peritricha Sol. Bory: Encycl. Méth., Vers. 1824.

Actinophrys Sol. Ehrenberg: Abh. Ak. Wis. Berlin, 1830, 42, 53, 61, 76, Taf. ii, Fig. 4; 1831, 102. Infusionsthierchen, 1838, 303, Taf. xxxi, Fig. vi.—Dujardin: Infusoires, 1841, 262, pl. iii, fig. 3.—Perty: Kennt. kleinst. Lebensformen, 1852, 159.—Stein: Infusionthiere, 1854, 151—Claparède and Lachmann: Études Infusoires, i, 1858–59, 450.—Pritchard: Hist. Infus. 1861, 559, pl. xxiii, figs. 28, 31, 32.—Wallich: An. Mag. Nat. Hist. 1863, xi, 446, pl. x, fig. 4.—Cienkowski: Arch. mik. Anat. i, 1865, 227.—Grenacher: Verh. phys.-med. Gesells. Würzb. i, 1868, 170, Taf. iii.—Hertwig and Lesser: Arch. mik. Anat. x, 1874, 164, Taf. v, Fig. 2.—Micrographic Dictionary, pl. 23, fig. 7 *b*.—Leidy: Pr. Ac. Nat. Sc. 1874, 23.

Actinophrys difformis. Ehrenberg: Abh. Ak. Wis. Berlin, 1831, 102. Infusionsthierchen, 1838, 304, Taf. xxxi, Fig. 8.

Actinophrys Eichhornii. Claparède: Müller's Archiv, 1854, 398, Taf. xv, Fig. 1–6.

? *Actinophrys oculata.* Stein: Die Infusionsthiere, 1854, 151, 157, Taf. v, Fig. 25. Organismus Infusionsthiere, ii, 1867, note to p. 5, "*A. oculata* nur eine marine Form von *A. sol.*"—Pritchard: Hist. Infus. 1861, 560, pl. xxiii, figs. 24, 25.

Animal spherical, translucent, vesicular or foamy, the vesicles usually numerous, more or less crowded and usually uniform. Contractile vesicle single, large, active. Nucleus commonly obscured from view. Rays numerous, straight, from one to three or four times the length of the diameter of the body.

Size.—Diameter of body from 0.04 mm. to 0.12 mm., with pseudopods commonly from 0.08 mm. to 0.16 mm. in length.

Locality.—In all quiet waters with aquatic plants. Observed in many parts of the United States, Nova Scotia, and Canada.

Actinophrys sol, the common Sun-animalcule, is one of the most familiar and striking forms of microscopic life of still fresh waters. When first seen, it would hardly be suspected to pertain to the animal kingdom, though Joblot, its earliest observer, spoke of it as "a fish the most extraordinary that one may see." Plate XL.

It may be found in almost every standing water-pool, pond, or lake, swimming among aquatic plants; its favorite haunts being duck-meat, hornwort, bladderwort, or the various filamentous algæ. It commonly appears as a globular, hyaline, foamy or vesicular body, bristling with delicate rays, and suspended almost stationary in the water.

The body of *Actinophrys sol* is soft and elastic, and though ordinarily spherical, occasionally, by feeble contraction, exhibits a slight change from the regular outline of form. Its surface is not even, but wavy or botryoidal, though sometimes this appearance is hardly evident. The body is composed of a basis of colorless, hyaline protoplasm with diffused, pale, granular matter and fine oil-like molecules. The protoplasm is crowded with clear globules or vacuoles, of comparatively uniform size, which give the body the appearance of being a foamy mass. Often these globules are so numerous, that the body of the Actinophrys appears to be made up of them, with barely sufficient protoplasm to hold them together and give to the whole a thin investment. When crowded, they become more or less polyhedral; and those at the periphery project slightly beyond the general outline, so as to give it the botryoidal appearance. Though usually of comparatively uniform size, they may vary considerably in different individuals and occasionally in the same individual. See figs. 1–5, 7–10.

Rarely have I seen what I have taken to be an individual of *Actinophrys sol* in which vacuoles, excepting the contractile vesicle, were altogether absent, as represented in fig. 6.

A large nucleus occupies a central position of the body, but is rarely even indistinctly visible, until brought into view by artificial means,—the action of acetic acid or other chemical reagent. When seen, it appears as a pale, faintly granular ball containing a darker nucleolus.

On one occasion I observed an individual, as represented in fig. 5, in which a nucleus was very distinctly visible. The animal appeared to be undergoing dissolution, and the figure represents it as first seen. The body consisted of a mass of granular protoplasm, with a single layer of large vacuoles occupying the periphery, and from it there projected only five pseudopodal rays. The animal was stationary and its vacuoles quiescent, but after a time several of these slowly expanded and became more prominent, then successively collapsed, and after an hour all had disappeared, leaving the body in a shriveled condition. The nucleus remained persistent, and was more distinct at last than at first. It was globular, and contained many granules of uniform size and a large central nucleolus.

Commonly, at some portion of the periphery of the body of *Actinophrys sol*, there appears a contractile vesicle. At one moment it may be undistinguishable from the contiguous vacuoles, but becomes evident from its slowly expanding and rising above the surface of the body, looking like an air-bubble floating on water. Reaching its full size as a sphere, half imbedded in the foamy-looking structure of the body, on a sudden it collapses, and a slight sinking occurs of that part of the body in which it was situated. The collapse of the contractile vesicle and the discharge of its contents impart a feeble tremor to the whole body, and this tremor may often be noticed, evidently from the same cause, even when the contractile vesicle is out of sight. The reappearance of the contractile vesicle commonly takes place in the same position that it previously occupied. Gradually expanding, it rises as a film of granular protoplasm, which, becoming thinner and thinner, finally bursts, and gives exit to the liquid contents.

The interior of the body of *Actinophrys sol* frequently exhibits, among its clear vacuoles, a variable number of colored and colorless granular balls, which are often included in liquid drops or vacuoles. These are food-balls, and may be situated at various depths from the surface. The colored balls are usually green, dependent on algæ or zoospores used as food, or they may appear brownish or reddish, due to changes produced by digestion.

The pseudopods of *Actinophrys sol* are ordinarily very numerous, though variable. They are delicate extensions or rays from the granular protoplasmic basis of the body, and are commonly so straight and fixed in position as to resemble fine acicular crystals. They are, however, quite flexible, so that when the animal is accidentally pressed against a resisting body they will bend like the hairs of an artist's pencil. They are retractile, though the animal ordinarily seems so little sensitive that they remain projected, notwithstanding any disturbance. They range in length equal to the diameter of the body, to two, three, or more times that extent.

Grenacher, and Hertwig and Lesser, describe the pseudopodal rays as being sustained by an axial thread of firmer consistence than the granular protoplasm occupying the exterior. I have been unable to confirm the statement of these authorities, and to me the pseudopodal rays seem to be nothing more than the most delicate filaments of viscid granular protoplasm.

Actinophrys sol ordinarily remains almost stationary in position suspended in water, but closely watched it is observed to glide slowly through its element without obvious cause, but probably as the result of some not easily detected action of the numerous rays.

The animal feeds on infusorians, rotifers, unicellular algæ, and zoospores. Active animalcules, in coming into contact with the rays of *Actinophrys sol*, in most instances appear to become more or less paralyzed. The smallest infusorians or algæ brought into contact with the rays glide slowly along them to their base. Larger and more active animalcules and zoospores, coming into contact with the rays, will cause several together to retract and draw the food to the body. When near or in contact with the latter, a portion of clear protoplasm is projected to involve the prey, in quantity according to the size and struggles of the latter.

Fig. 1, pl. XL, represents an individual, which, with others, was surrounded by a multitude of bright green, actively moving zoospores.* As one of these came into contact with the rays of the Actinophrys, it became instantly motionless. Gradually the zoospore was drawn inwardly by means of one or more retracting rays, and, when within a short distance of the body of the Actinophrys, a portion of clear protoplasm was projected to receive it. Becoming involved in the process of protoplasm, this, together with the zoospore, was slowly withdrawn into the interior of the Actinophrys, where, within a clear globule, it assumed the shape of a green ball. In the process of digestion, the green balls became brown, and occasionally in this condition one would gradually approach the surface of the Actinophrys and suddenly be expelled.

Fig. 2 represents an *Actinophrys sol*, which, while under examination, received upon its rays an active Euglenia. This, in its struggles, produced much disorder among the rays of its captor, but withal was drawn toward the body and received by a large flow of clear protoplasm. The Euglenia continued its struggles, which caused a greater effusion of the latter. At one moment it appeared as if the Euglenia would escape, but it became enveloped in an effused mass of protoplasm, which nearly extended around the semi-diameter of the body of the Actinophrys, and finally ceased all movements. The exuded protoplasm then gradually contracted into a hemispherical form, as seen in fig. 3, including centrally the Euglenia, now compressed into a ball. The pseudopodal protoplasm, continuing to contract, was slowly withdrawn, together with the Euglenia ball,

* I do not know whether these are really zoospores or infusoria. They are bright green, oval, with a central nucleus, and a colorless beak at one pole, but without flagellum. They measured 0.016 mm. by 0.012 mm.

into the body of the Actinophrys, when it presented the appearance seen in fig. 4.

Green food swallowed by *Actinophrys sol*, ordinarily, in the process of digestion, becomes brown, and the remains are discharged from the surface.

The common Sun-animalcule presents considerable range in size, the body measuring from one twenty-fifth to one eighth of a millimetre in diameter. Ordinarily it is from one twentieth to one twelfth of a millimetre, and the rays are from one to one and a half the length of the diameter of the body, but occasionally reach double that length or even more.

Not unfrequently *Actinophrys sol* is met with of a dumb-bell-like form, apparently consisting of a pair of individuals as ordinarily seen, united by an isthmus, of variable extent, as represented in fig. 10. The animal in this condition has been considered to be in conjugation, that is to say, to consist of two individuals, which have conjoined for some purpose of a sexual kind. I never happened to have the opportunity of seeing two individuals in the act of conjunction. In all those cases in which I have met with the animal in the duplex state, on closely watching, they turned out to be cases of multiplication by division. In these instances, the isthmus uniting a pair gradually becomes narrower and longer, and then breaks, leaving the original dumb-bell form as a pair of spherical individuals. During the process of division, the animal glides about less actively, and the rays diverge in the usual manner from each ball, but are absent from the isthmus. Each ball also has its own contractile vesicle, which exhibits the ordinary rhythmical movements. The remains of food may also be discharged, as seen in fig. 10, *a*, but I have not observed the animal feed during the condition of segmentation.

Though, as intimated, I have not had the opportunity of observing a pair of individuals of *Actinophrys sol* actually join and unite into one, I have occasionally met with a specimen of biscuit-shape outline, as in fig. 8, which, gradually contracting, assumed a spherical form, as in fig. 7. In the particular case represented, the specimen, when first noticed, contained four large clay-colored vacuoles, of which all but one subsequently, during the contraction of the animal, discharged their contents.

On one occasion, having observed an *Actinophrys sol* of peculiar and unusual appearance, I was led to watch it, and continued to do so at intervals from 3 o'clock in the afternoon until midnight. It turned out to be an instance of segmentation, as represented in figs. 11–22, but differing in the earlier steps from anything of the kind I had previously or since have seen.

At first, the Actinophrys appeared as a pair of ordinary individuals, retaining between them a third spherical ball nearly as large, as seen in fig. 11. The nature of this intervening ball I did not discover, but conjectured that it was a third individual of Actinophrys, altered from the usual condition. It was granular, without vacuoles and rays, darker on one side than the other, and with a central clearer spot, probably indicating the presence of a nucleus.

Three hours subsequently the pair of Actinophryes remained essentially unchanged, but were united by a cylindrical isthmus, which contained the third ball reduced to little more than half its original size, and with a less distinct outline,* as represented in fig. 12.

Two hours later the two Actinophryes remained unchanged, but the isthmus had become rather longer and narrower. The intervening ball had melted away, leaving in the isthmus, besides diffused granular matter, a large clear nucleus and a group of fat globules. See fig. 13.

Soon after, the two Actinophryes remaining unchanged, excepting a slight flattening at the opposite poles, the isthmus became narrowed on the left and retained the nucleus and oil globules on its right, as seen in fig. 14.

At the next step, the two Actinophryes increased in diameter in a direction opposite to that transverse with the isthmus, and became sunken at the opposite poles, as seen in fig. 15.

The isthmus continued to become narrower until it formed a mere cord, and the nucleus, together with the oil globules, were drawn into the Actinophrys on the right, as seen in fig. 16.

About 9 o'clock the isthmus parted, and the two Actinophryes appeared as represented in fig 17: the individual on the right being cordiform; that on the left reniform. Later, the reniform individual, or that on the left, assumed a dumb-bell form, fig. 18, its isthmus then gradually narrowed and elongated, fig. 19, and finally parted into two individuals. The cordiform Actinophrys, or the individual on the right (fig. 17), produced in the division of the original pair, contracted at the point, so that it became reniform, as seen in fig. 20. This now, still retaining the apparent nucleus and oil globules of the above described granular ball, also assumed a dumb-bell

* The outline has been made too dark in the lithograph ; in the original drawing there is none.

form, as seen in fig. 21. The isthmus of the latter then elongated, and containing within it the nucleus and oil globules, fig. 22, in this condition the Actinophrys nearly resembled the third stage, fig. 13, of the original specimen. It was now midnight, and I was obliged to retire from my observations. The next morning I could find nothing in the animalcula-cage but a half dozen individuals of Actinophrys having the ordinary appearance.

During the whole time the Actinophryes retained their usual characters, with numerous rays divergent everywhere except from the isthmus, and always a contractile vesicle exhibiting its ordinary rhythmical movements.

Another mode of reproduction of *Actinophrys sol*, as observed and described by Cienkowski,* I have not had the opportunity of seeing. According to this able investigator, the animal, preparatory to the reproductive process, withdraws its rays and becomes a closed cell by the formation of an exterior, sharply defined, investing membrane. The body loses its foamy character, and becomes finely granular and more condensed centrally. The more compact central portion after some hours divides into two masses, and the exterior membrane with the remaining peripheral matter, excepting a few granules, dissolves away. The pair of isolated balls then acquire each an investing membrane, and the granular contents become somewhat retracted from their wall, and are then provided with an additional investing membrane. Finally, from each cell thus formed, a young Actinophrys makes its escape.

ACTINOPHRYS PICTA.

PLATE XLVI, fig. 4.

Animal having the same constitution and habit as *Actinophrys sol*, but with the body of a bright green color, due to the presence of chlorophyl mingled with the colorless granular protoplasm.

Size.—From 0.056 mm to 0.105 mm. in diameter.

Locality.—Ponds in sphagnous swamps at Absecom, Vineland, and other localities in New Jersey.

Actinophrys picta, as represented in fig. 4, pl. XLVI, closely resembles the common Sun-animalcule, but possesses a bright green color. The globular body has the same foamy aspect, but the protoplasm occupying

* Archiv f. mik. Anatomie, 1865, 227.

the intervals of the nearly uniform, clear vacuoles, is mingled with bright green chlorophyl granules. A thin layer of protoplasm at the surface of the body is free from the latter, and gives off numerous simple rays, as in *Actinophrys sol.* A single contractile vesicle presents the usual phenomena, as in the latter.

Actinophrys picta is comparatively rare, and I have found it only in the ponds of cedar and sphagnous swamps in New Jersey. It may be the same as the *Actinophrys viridis* of Ehrenberg, though I believe the weight of evidence is in favor of the latter being the more common Heliozoan hereafter described as *Acanthocystis chætophora.*

The size of the green Sun-animalcule above described is about 0.1 mm., with the rays of the same length.

With the preceding I have observed bright green Heliozoans, as represented in figs. 5, 6, which may pertain to the same animal, though they possess some peculiarity. The body, instead of having a foamy appearance, as in *Actinophrys sol*, is composed of colorless granular protoplasm, with numerous but variable proportions of bright green chlorophyl corpuscles. These are much larger than the green granules of the animal above referred to *Actinophrys picta*, and are especially accumulated in an intermediate zone of the body. A clearer central spot indicates the presence of a nucleus. A contractile vesicle was observed in the usual position, as in *Actinophrys sol*, and as seen in fig. 5, but it was less active in its movements, and in some individuals was not detected or appeared not to exist.

The pseudopods have the same character as in *Actinophrys sol*, but commonly were fewer, and often coarser. Individuals range from 0.056 mm. to 0.1 mm. in diameter, with the rays about equal in length to the latter. The green chlorophyl corpuscles measure from 0.004 mm. to 0.006 mm.

HETEROPHRYS.

Greek, *heteros*, diverse; *ophrus*, an eyebrow.

Animal resembling Actinophrys in general form, constitution, and habit, but ordinarily with the body enveloped with a thick stratum of protoplasm defined by a granulated or thickly villous surface, and penetrated by the pseudopodal rays.

HETEROPHRYS MYRIAPODA.

Heterophrys myriapoda. Archer: Quart. Jour. Mic. Sc. 1869, 267, pl. xvii, fig. 4; Ibid. 1870, 110.—Greeff, Arch. mik. Anat. 1875, xi, 21, Taf. i, Fig. 8, 9 ?.
? *Heterophrys varians.* Schulze: Arch. mik. Anat. 1874, x, 386, Taf. xxvi, Fig. 2–5.
? *Heterophrys variabilis.* Greeff: Arch. mik. Anat. 1875, xi, 28, Taf. ii, Fig. 20–23.

Body composed of a soft, usually spherical, granular mass of protoplasm, colorless at the surface, and commonly bright green in the interior, due to the presence of variable proportions of chlorophyl corpuscles, or in some conditions with little or no color independently of that produced by food; also containing clear colorless corpuscles, vacuoles, nuclei, and one or more contractile vesicles. With or without an exterior envelope of clear, colorless protoplasm defined at the surface by granules or cil-like villi. Pseudopods as simple granular rays.

Size.—Diameter $\frac{1}{380}$th to $\frac{1}{300}$th of an inch (Archer).

Locality.—Ireland (Archer); Germany (Schulze, Greeff).

The genus Heterophrys, established by Mr. Archer, consists of Actinophrys-like animals, the body of which usually contains colored corpuscles, and is invested with a layer of protoplasm defined by a ciliated or granulated surface, and penetrated by the pseudopodal rays.

To the genus Mr. Archer refers a creature of gregarious habit, previously described by Focke (Zeitschrift für wissenschaftliche Zoologie, 1868, 353, Taf. xxv, Fig. 1), and gives it the name of *Heterophrys Fockii.* This I am disposed to view as pertaining to *Raphidiophrys elegans*, hereafter to be described.

Heterophrys myriapoda, as described by Mr. Archer, is a beautiful, bright green, Actinophrys-like animalcule, having the body enveloped in a thick layer of granular protoplasm defined by a villous surface and penetrated by numerous simple rays like those of the common Sun-animalcule.

Professor Schulze has described a colorless heliozoan, which he attributes to the same genus under the name of *Heterophrys varians.* He indicates two conditions of the animal: one in which the body is surrounded by a clear protoplasmic layer defined by a granular surface; the other in which this layer is absent. The interior contained from three to half a dozen nuclei and a variable number of contractile vesicles. The size of the body was about 0.06 mm.

Apparently the same animal has been described by Professor Greeff with the name of *Heterophrys variabilis.* It contained variable proportions of colored granules, green and red, together with colorless vacuoles and nuclei. The body possessed a transparent, colorless envelope, defined at the surface by minute linear particles. The size of the animal with its envelope was 0.06 mm.

It is probable that the forms described by Professor Schulze and Professor Greeff represent different conditions of the form described by Mr. Archer as *Heterophrys myriapoda.*

In many instances I have observed colored Actinophrys-like animalcules, of uncertain reference, resembling Heterophrys, but devoid of its cloak of protoplasm. I have suspected, however, that the latter belongs to one stage of the animal's existence, and in another stage may be absent. If this view is correct, it is probable that the forms referred to *Actinophrys picta*, and those allied to it, may belong to Heterophrys.

Animals of the same general character, probably referable to several different species, are represented in figs. 1–6, pl. XLV, and figs. 7–13, pl. XLVI.

Forms like those of figs. 7–9, pl. XLVI, are not unfrequent in the ponds of sphagnous swamps in New Jersey. The body of the Heliozoan is commonly spherical, but capable of changing its shape. It is composed of soft, homogeneous, granular protoplasm, with or without minute oil molecules, colorless at the surface, but variably green and yellowish or brownish in the interior. It usually exhibits neither vacuoles nor contractile vesicles, and commonly a central nucleus, if present, is obscured from view. The pseudopodal rays, generally fewer, are often longer and coarser than in *Actinophrys sol*, but have the same composition. They are quite changeable in form; usually tapering and simple, they sometimes fork at an acute angle. In the elongation of the body of the animal, the poles often appear more or less abruptly tapering into one or several of the coarser pseudopodal rays. Sometimes the rays become clavate or thickened as they proceed outwardly, and rarely I have seen one or more divide in a brush-like manner at the distal extremity. Commonly straight, they will sometimes become quickly tortuous, especially in the act of retraction, and sometimes they become beaded in appearance. Occasionally some of the finer ones will form a little ball at the end, so as to resemble the pin-like suctorial rays of Acineta.

Fig. 7 represents an individual from Absecom pond, obtained in September, exhibiting the different changes which occurred in the pseudopodal rays during the time the animal was observed.

Figs. 8, 9, represent two views of another individual, found with the former, exhibiting successive changes, both in the shape of the body and the pseudopodal rays. At first spherical, it became elliptical, and again assumed the former shape, when it measured 0.02 mm. in diameter.

An individual of the same kind, from a sphagnous swamp of Broad Mountain, Pennsylvania, is represented in fig. 12. As first noticed, the body was globular, with numerous simple rays projecting from one hemisphere, but later they emanated from all parts of the surface. The interior was composed of colorless granular protoplasm with fine oil-like molecules, greenish and yellowish granules, and a few bright-red ones. It also contained a large oval body, probably something swallowed as food, but the character of which was not ascertained. Neither nucleus nor contractile vesicle was seen.

Another individual, apparently of the same kind, represented in fig. 11, was obtained, in association with others, with the alga Lyngbya, from a roadside gutter in the suburbs of Philadelphia. The soft body of a diffused green hue, except at the surface, which was colorless, contained many red-colored objects, which appeared to be segments of the Lyngbya used as food and changed in color by digestion.

Similar Heliozoans, from bog-water obtained in the Uinta Mountains, Wyoming, are represented in figs. 1–3, pl. XLV, and fig. 13, pl. XLVI. In constitution and habit they resembled the former, but they were usually yellowish, with a few bright-red granules, though sometimes they were also partly greenish. In all, a pale central nucleus was more or less distinctly visible, and usually some clear globules or vacuoles.

The individual of fig. 13, pl. XLVI, contained a number of scattered corpuscles of different sizes and colors,—green, dull yellow, and red. These I supposed to be one-celled algæ in various stages of digestion. At first elliptical, the animal afterward became spherical, and measured 0.028 mm. in diameter.

The individual of fig. 1, pl. XLV, contained some diffused yellowish and greenish granular matter mingled with the otherwise colorless protoplasm. It also contained some oil molecules and clear vacuoles

The individual of fig. 2, obtained at the same time with the preceding, was composed of homogeneous, finely granular, and colorless protoplasm, with fine yellowish granules intermingled. As food, it contained a diatom and a few brown balls, of which two were afterward seen to be discharged. It also contained a number of clear globules, of which the largest one was observed to collapse, though it did not reappear in the manner of a contractile vesicle. Pseudopods projected mainly from one hemisphere, and the animal slowly moved in that direction at the rate of about one millimetre in nine minutes. The creature, on coming into contact with a Closterium, gradually changed from the globular to a three-sided shape, then became oval, and finally again spherical as it moved away from the alga.

The individual of fig. 3, also found with the preceding, appeared to have its opposite poles rather abruptly prolonged into several of the coarser pseudopodal rays. It contained some scattered colorless and red-colored corpuscles, together with a large vacuole, which remained unchanged.

A green Heliozoan, resembling those just described in the changeable form of its body, is represented in fig. 10, pl. XLVI. It was found, with several others of the kind, in Absecom pond, in the month of May. The body is composed of a basis of soft, colorless, granular protoplasm, with green granules diffused through it, but more abundant centrally, where they appear to obscure the nucleus from view. Several contractile vesicles were observed at the periphery. As first seen, the body was elliptical, with the opposite poles giving off the two strongest pseudopodal rays. A large vacuole, containing a food-ball, was in the act of being withdrawn. The creature afterward assumed a spherical form, and then measured one seventh of a millimetre in diameter.

Later, an active rotifer came into contact with the Heliozoan, and ceased movement as if paralyzed, but after a moment it recovered and attempted to move away. It was, however, restrained by a protruding hemisphere of clear ectosarc, and in the struggle the Heliozoan appeared to be extended toward its victim, and the rays of the same side converged to it. Finally, the rotifer succeeded in making its escape. The portion of clear protruded protoplasm projected several rays, and was then slowly withdrawn, and gradually the Heliozoan assumed once more a spheroidal shape.

A small colorless Heliozoan, represented in fig. 4, pl. XLV, probably pertains to Heterophrys, and resembles the *H. Fockii* described by Mr. Archer.* It also resembles a form described by Professor Greeff, and with doubt considered to be the young of *Acanthocystis viridis*.†

The individual was obtained in August, from a pond in a sphagnous swamp, at Vineland, New Jersey. It resembled the *Actinophrys sol*, but was of less uniform foamy aspect, being composed of a spherical mass of pale granular protoplasm, with a number of clear globules or vacuoles of various sizes scattered through it. The body was enveloped in a thick layer of clear protoplasm rising in wave-like points on the pseudopodal rays.

An enigmatic body of uncertain reference, of which two views of the same individual are given in figs. 5, 6, pl. XLV, may perhaps pertain to Heterophrys. It was obtained in July, from a ditch in which grew *Hippuris vulgaris*, at Fort Bridger, Wyoming. When first observed, it was nearly spherical, and resembled in general appearance an Actinophrys, but was of a red hue, and was enveloped with a thick layer of colorless protoplasm defined by a minutely dentate outline. The body measured 0.04 mm. in diameter, and consisted of a basis of colorless, faintly granular protoplasm mingled with red granules of varied depths of hue, diffused and partially collected in irregularly rounded masses. It also contained two large clear globules, probably nuclei, which remained unchanged during the time the creature was under examination. The rays were comparatively few, and appeared as abruptly tapering processes of the superficial colorless protoplasm of the body. They varied in length and degree of robustness, and were mainly straight and simple, though a few of the stronger ones were furcate.

The stratum of protoplasm enveloping the body was clear, and appeared to have a finely echinate or granular surface. Sometimes the granules appeared to be connected with fine perpendicular striæ, extending through the cloak of protoplasm, as seen on one side of fig. 6, so as to resemble the pin-like rays of Acineta; but the appearance was uncertain, and may have been deceptive.

As the animal moved in the same slow, gliding manner of an Actinophrys, it gradually underwent a variety of changes in shape. Becoming

* Quart. Jour. Mic. Sc. 1869, pl. xvi, fig. 3.

† Archiv f. mik. Anatomie, 1869, Taf. xxvii, Fig. 35.

elliptical and then elongated pyriform, a small portion, of elliptical shape, gradually extended itself from the main portion, and remained connected with it by a narrow isthmus of clear protoplasm, in which condition the animal presented the appearance seen in fig. 5. Watching the creature with the expectation of seeing the smaller portion separate and become a distinct individual, after some time it was observed to be gradually withdrawn into the main portion. Subsequently the animal became ovoidal, and then assumed an irregularly quadrate outline with festooned borders, as represented in fig. 6. Later it continued to undergo changes of the same general character so long as it was convenient to observe the animal.

This creature bears some resemblance to the subjects of Focke's figs. 2, pl. xxv, of the Zeitschrift für wissenschaftliche Zoologie for 1868.

RAPHIDIOPHRYS.

Greek, *raphis*, a needle; *ophrus*, an eyebrow.

Animal ordinarily associated in groups of variable number, closely aggregated or conjoined by isthmus-like bars. Individuals of Actinophryan form, consisting of a soft spheroidal body of granular protoplasm, with oil-like molecules and variable proportions of clear colorless or bright green corpuscles, and with a large central nucleus. Exterior of the body invested with a thick layer of delicate, colorless protoplasm, extending in tapering processes on the pseudopodal rays and densely pervaded with minute spicules tangentially arranged. Pseudopodal rays very long, numerous, straight, simple, and finely granular.

RAPHIDIOPHRYS VIRIDIS.

Raphidiophrys viridis. Archer: Quart. Jour. Mic. Sci. 1870, x, 103, pl. xvi, fig. 2.

Animal single, or more commonly in closely aggregated groups of variable number. Individuals more or less bright green from the presence of chlorophyl corpuscles (and probably at times colorless from the absence of these). Spicules of the exterior envelope thickly distributed and extending outwardly on the bases of the pseudopodal rays, comparatively coarse and slightly bent.

Size.—About $\frac{1}{300}$th of an inch (Archer).

Locality.—Ireland.

Raphidiophrys viridis, a remarkable Actinophrys-like animal, of gregarious habit, was discovered in Ireland by Mr. Archer. From the original description and figure, it consists of a close aggregation of a number of spherical individuals of a bright-green color, enveloped together in a pale yellowish layer of protoplasm pervaded with numerous slightly bent spicula, apparently silicious in character.

In several instances I have observed Heliozoans which I have suspected to be isolated individuals of the above species, but of this I cannot be positive.

A specimen, from Absecom pond, New Jersey, supposed to pertain to *Raphidiophrys viridis*, is represented in fig. 1, pl. XLVI The globular body was composed of a basis of pale, indistinctly granular protoplasm, with a number of bright-green chlorophyl corpuscles scattered through it, together with a smaller proportion of yellow and brown corpuscles. My first impression in regard to the character of these colored corpuscles was that they pertained to the food, and it may be that some portion of them did so. With them I observed a single diatom. A central nucleus was indicated by a clearer round spot, and on each side of the body there was an equally large vacuole, which remained unchanged during the examination of the animal.

Pseudopodal granular rays emanated from all parts of the body, as in *Actinophrys sol.* The exterior of the body was invested with a layer of faintly granular protoplasm containing a profusion of delicate linear spicules, slightly bent. The spicules were in general arranged tangentially to the surface of the body and extended outwardly a short distance upon the rays. The body measured 0.09 mm. in diameter, and the longest rays exceeded the latter in length.

Another Heliozoan, obtained with the preceding and represented in fig. 2, may probably belong to the same species, though exhibiting some peculiarity. The spherical body was composed of a finely granular, colorless protoplasm, containing a central nucleus, a number of vacuoles, and a few colored corpuscles, mostly yellowish and brown, together with a few green single-celled algæ. The surface of the body was invested with spicules arranged tangentially, with a somewhat tufted appearance. The spicules were comparatively coarse, nearly straight or feebly bent, and pointed at both ends. They resembled the simple spicules of the fresh-water sponges. The pseudopodal rays were numerous, simple, and long, like those of *Actinophrys sol.*

Another Heliozoan, related with the preceding, is represented in fig. 3, and was found in the material adherent to a stone, on which grew a Spongilla, from the Schuylkill River, at Philadelphia. The animal was entirely colorless. The spherical body, composed of pale granular protoplasm, contained a central nucleus, and numerous scattered, clear globules. Externally it was invested with a thick layer of protoplasm densely pervaded with delicate, curved spicules, arranged tangentially to the body, and rising in pointed processes upon the pseudopodal rays. This creature resembles the *Raphidiophrys pallida* of Schulze,* and probably pertains to the same species.

RAPHIDIOPHRYS ELEGANS.

PLATE XLII.

? *Actinophrys oculata* and *Actinophrys Sol.* Carter: An. Mag. Nat. Hist. xv, 1865, 277, pl. xii, figs. 1–3.
Raphidiophrys elegans. Hertwig and Lesser: Arch. mik. Anat. x, 1874, Suppl. 218, Taf. iv, Fig. 1.—Leidy: Pr. Ac. Nat. Sc. Phila. 1874, 167.—Archer: Quart. Jour. Mic. Sc. 1876, 374, pl. xxii, fig. 19.
Sphærastrum conglobatum. Greeff: Arch. mik. Anat. xi, 1875, 29, Taf. ii, Fig. 24–26.
? *Schalenlose Süsswasser-Radiolarien.* Focke: Zeitschr. f. wissens. Zoologie, 1868, 353, Taf. xxv, Fig. 1.

Animal single, or usually in groups up to two or three dozen or more, separated by more or less wide intervals, and united by narrow bands or isthmuses. Individuals with the body more or less bright green from the presence of chlorophyl corpuscles, or colorless when the latter are absent. Spicules of the exterior protoplasmic envelope delicate, in the form of semicircles, and tangentially arranged, with their convexity directed toward the body and pseudopodal rays

Size.—Diameter of the body 0.032 mm. to 0.04 mm.; length of pseudopodal rays to 0.24 mm.; length of the semicircular spicules 0.006 mm.

Locality.—In springs and ponds among aquatic plants. Pennsylvania and New Jersey.

Raphidiophrys elegans, represented in pl. XLII, occasionally solitary, is commonly observed in groups of from five to twenty or more, and on one occasion I found an assemblage of thirty-eight individuals This remarkable creature, as usually seen, roaming about in flocks, appears

* Archiv f. mik. Anatomie, x, 1874, 377, Taf. xxvi, Fig. 1.

like an entangled mass of Actinophrys-like animals. The groups vary in form, but are more or less irregular. The individuals composing them have the shape and general appearance of an Actinophrys, and in the groups are associated by means of bands or bridges of protoplasm passing between those which are contiguous. The distance separating the individuals in different groups is variable, but mostly is less than the diameter of the body of the individuals. In active movement they are commonly farthest apart, and when at rest they become more closely aggregated.

The individuals are usually spherical and of uniform size; but they are capable of changing their shape, so that they may be oval or of some other form. The body is composed of a basis of soft, colorless, granular protoplasm, with fine oil molecules disseminated It contains variable proportions of bright green and colorless corpuscles, which exhibit some uniformity of size. Sometimes the green chlorophyl corpuscles are numerous, sometimes comparatively few, and at times altogether absent. The colorless corpuscles mingled with the green ones are clear and homogeneous, and at times exist to the exclusion of the latter.

The bridge-like bands passing between contiguous individuals of the groups vary in length and thickness, and are more or less temporary conjunctions composed of the protoplasmic basis of the bodies. At times they may be seen to shorten or elongate, to contract and to part, and the divisions withdraw; and at other times projected processes may be observed, which unite with contiguous ones to form new bridges Frequently green and other corpuscles may be seen traversing the bridges from one individual to another.

The individuals contain a central nucleus, which, though usually obscured from view by the colored corpuscles and other constituents, sometimes is distinctly visible, as seen in fig. 3.

Though a distinct contractile vesicle, with rhythmical action like that of *Actinophrys sol*, appears not to exist in *Raphidiophrys elegans*, frequently a large vacuole is observed near the periphery of the body, which enlarges and collapses, to be replaced by a similar one in some other position.

Hertwig and Lesser remark that they observed no contractile vesicle in this species, and Mr. Archer likewise detected none in *Raphidiophrys viridis*.

The pseudopodal rays of *Raphidiophrys elegans* are numerous and often very long. In solitary individuals they emanate from all parts of the surface, as in Actinophrys; but in the groups they commonly project from the exterior of the whole only. They are simple, delicate extensions of the granular protoplasm of the surface of the body. From their perfect straightness they seem to be rigid; but they are highly flexible, and at times may be seen to bend in a bunch from the rude shock of a passing rotifer, like the hairs of a brush from the pressure of the fingers.

Each and every individual composing a group is enveloped with its own cloak of transparent homogeneous protoplasm, which is, however, extended upon the bridge-like bands, and also extends in more or less long tapering processes on the pseudopodal rays. The protoplasmic investment is loosely pervaded with a multitude of delicate semicircular lines or spicules, which are arranged with their convexity tangentially to the bodies of the animals, and to the rays upon which they extend. Upon the surface of the protoplasmic investment they give a wavy or delicately festooned outline.

Not unfrequently the interior of the body of some individuals contains brownish or reddish balls of variable size, sometimes large, as seen in fig. 4. These I have supposed to be food-balls, and of the same nature probably are some of the green globules viewed chiefly as pertaining to the structure of the animal

Occasionally I have observed a group of *Raphidiophrys elegans* retaining among them large colored balls, as represented in fig. 6, the character of which I did not ascertain, though I supposed them to consist of discharged excrementitious matter.

The individuals of *Raphidiophrys elegans* commonly range from 0.033 mm. to 0.04 mm. in diameter. The pseudopodal rays extend from 0.1 mm. to 0.2 mm. in length, but occasionally may reach 0.4 mm. The semicircular spicules, which envelope the animals, are about 0.0125 mm in length.

Raphidiophrys elegans is commonly more active in its movements than *Actinophrys sol.* The groups move in the same gliding manner, but more rapidly, and they continually change their shape. At first spheroidal, they may become oval or more or less quadrate, then elongate, and become conical, pyriform, or some other shape. The individuals of a group may approach or recede, break their bridge-like bands or establish others, or, as not unfrequently occurs, the large groups may break into two or more smaller ones. In the group of thirty-eight, above indicated, shortly after the observation it separated into three groups, of fifteen, thirteen, and ten.

Raphidiophrys feeds, and it also discharges the remains of the food, in the same manner as Actinophrys.

VAMPYRELLA.

Amœba: Fresenius, 1856. *Vampyrella:* Cienkowski, 1865.

Animal usually Actinophrys-like, with a soft spheroidal body, capable of amœboid variations of form, composed of pale, colorless, granular protoplasm, with abundance of coloring matter, oil-like molecules, and vacuoles. Pseudopods as Actinophrys-like rays, Acineta-like rays?, and digit-like, lobate, or wave-like expansions.

VAMPYRELLA LATERITIA.

PLATE XLV, figs. 10–16.

Amœba lateritia. Fresenius: Abh. Senck. Naturf. Gesells. ii, 1856–8, 218, Taf. x, Fig. 13–19.—Cienkowski: Jahrb. wis. Bot. iii, 1863, 428.
Vampyrella Spirogyræ. Cienkowski: Arch. mik. Anat. i, 1865, 218, Taf. xii, xiii, Fig. 44-56.—Haeckel: Biolog. Studien, 1870, 72.—Hertwig and Lesser: Arch. mik. Anat. x, 1874, Suppl. 61.—Archer: Quart. Jour. Mic. Sc. 1877, 347.

Body brick- or orange-red, with hyaline periphery, commonly spherical, but capable of much change of shape Pseudopods as Actinophrys-like rays, and lobate extensions, together with Acineta-like rays?

According to Hertwig and Lesser, *Vampyrella Spirogyræ*, originally described by Cienkowski, occurs mostly in an Actinophrys-like form, measuring 0.02 mm. to 0.075 mm. in diameter. The granular protoplasm of the body is pervaded with coloring matter of different shades of orange, reddish yellow, brownish yellow, and greenish. The coloring of the central portion is so intense as to obscure from view a nucleus, if one exists. The periphery of the body is hyaline, and contains several non-contractile vacuoles The pointed pseudopodal rays frequently start from a common basis, and may fork, but do not anastomose Besides these, from time to time, broad, blunt, lobate, hyaline processes of protoplasm rapidly appear and disappear In both kinds of pseudopodal extensions, peculiar movements of granules occur, in which they are quickly projected and withdrawn. Hertwig and Lesser observe, that so long as the Vampyrella retains its rounded form it so nearly resembles an Actinophrys, that an observer for the first time would be apt to take it for a colored species of the latter. Attention directed to it shows that it does not always retain the spherical form, but that, especially when it meets with algous filaments or similar objects, it withdraws part of its pseudopods, and adapts its shape to that of the object upon which it creeps. Its change is very striking when it becomes greatly elongated (to 0.24 mm.), and it creeps quickly across the field of view, reminding one of a caterpillar.

Neither Cienkowski, nor Hertwig and Lesser, detected a nucleus in Vampyrella, and from its absence in a marine species, *Vampyrella Gomphonematis*, described by Haeckel, this author has placed the genus in his proposed class of *Monera*.*

According to Cienkowski, the Vampyrella feeds only on the contents of the cells of Spirogyra. Applying itself to a filament of the alga, the animal perforates a cell, and slowly transfers the contents, including the chlorophyl band, to its own interior. In the same manner it may apply itself to another cell, and so continue until its appetite is satisfied.

Cienkowski remarks that the *Vampyrella Spirogyræ* appears to correspond with the *Amœba lateritia* of Fresenius; and so it has seemed to me, and in this view, according to the rules of zoological nomenclature, I have adopted the latter specific name.

I had repeatedly observed a bright orange-colored Heliozoan the relation of which for some time I did not recognize, even with the figures of Vampyrella by Cienkowski, and Hertwig and Lesser, before me, and it was only on reading the descriptions of the latter animal that I was led to regard the former as being the same.

Vampyrella lateritia, represented in figs. 10–16, pl. XLV, as I now suspect it to be, and as it has come under my notice, is a brick-red or orange-colored Actinophrys-like creature, from 0.02857 mm. to 0.083 mm. in diameter.

The body is a spherical, finely granular mass of protoplasm, with diffused oil-like molecules. For a variable depth at the periphery it is colorless, but the great portion centrally is brick- or orange-red, of variable intensity of hue, and is sometimes mingled with a few darker granules of the same color. The mass of protoplasm may be nearly homogeneous, as seen

* Studien über Moneren. Leipzig. 1870. Nachträge zur Monographie der Moneren, 163, Taf. vi, Fig. 1–4.

in figs. 10, 11, 13–15, or it may contain a few or numerous vacuoles, as in Actinophrys, and as represented in figs. 12, 16. A nucleus was not observed, and, if existing, is concealed from view by the surrounding material. Food, in the form of green algæ, was noticed among the contents in several individuals, as represented in fig. 15.

The pseudopodal rays of the creature under consideration, which I have taken for *Vampyrella lateritia*, have appeared to me to be of two kinds, one of the ordinary character, resembling those of Actinophrys, while the others have reminded me of the suctorial rays of Acineta.

The ordinary rays are delicate, straight, usually simple, and of very variable length; mostly shorter, sometimes longer than the diameter of the body. Not unfrequently several together start from the same base. They may project from a small portion or from the entire surface of the body; sometimes being confined to the semi-circumference or a smaller portion, and sometimes projecting everywhere, as in Actinophrys.

The Acineta-like rays are pin-like, or consist of a short stem ending in a minute round head, and measure from 0.004 mm. to 0.0125 mm. in length. Like the ordinary rays, they may project from any part or the whole of the surface of the body at once; and they may be mingled indiscriminately with the former, or the two kinds may appear separated and issuing alone from opposite poles of the body.

The pin-like rays are especially remarkable for the quickness with which they are successively projected and withdrawn. At times they are projected only in the slightest degree beyond the outline of the body, and rarely to a greater length than 0.0125 mm.

Sometimes an individual when first noticed exhibits only ordinary rays projecting from some portion or the whole surface of the body, and after a while the pin-like rays in variable number issue from some portion or the whole of the surface.

Vampyrella glides along in the manner of Actinophrys, but commonly with more speed. Frequently, while in motion, the pin-like rays issue only on the side opposite to the direction of movement of the body, while ordinary rays may project alone on the other side, as represented in fig. 14.

Commonly both kinds of rays are directed perpendicularly, but occasionally either may be seen projecting tangentially; and while the pin-like rays are incessantly and rapidly pushed forth and withdrawn, the ordinary rays, usually apparently motionless, now and then are seen slowly to vibrate.

In the account of Vampyrella, previous observers do not indicate the existence of the peculiar pin-like rays as I have apparently seen and described them, but they refer to certain remarkable and similar movements of granules, with which the pin-like rays seem to accord It was not until after I made observations on the creature I have supposed to be Vampyrella, that I read the descriptions of the latter, and it has occurred to me that the appearance of the pin-like rays as above indicated may have been illusory. Since this view has occurred to me, I have not had the opportunity of repeating my observations.

Besides the pseudopodal rays, Vampyrella frequently projects digit-like or lobular processes or broad wave-like expansions of clear or faintly granular protoplasm, as seen in figs. 10–13. These are quickly produced and as quickly disappear.

In motion, the body of Vampyrella was occasionally noticed to undergo slight change of shape from spheroidal to oval; but I was not so fortunate as to observe it undergo the remarkable changes indicated by others.

DIPLOPHRYS.

Greek, *diplous*, double; *ophrus*, eyebrow.

Diplophrys: Barker, 1868. *Acanthocystis:* Greeff, 1869. *Cystophrys:* Archer, 1869. *Elæorhanis:* Greeff, 1875.

Animal minute, spheroidal, provided with a delicate, homogeneous, membranous investment, with a pair of oral orifices slightly lateral to the opposite poles. The interior, transparent, slightly granular protoplasm with a central nucleus, several pulsating vesicles, and usually a single, bright, yellow or red, oil-like globule. Pseudopods delicate, filamentous, and radiant in a tuft from both oral orifices. The young associated in groups, often of many individuals

DIPLOPHRYS ARCHERI.

A minute rhizopodous form. Barker: Quart. Jour. Mic. Sc. vii, 1867, 232.

Diplophrys Archeri. Barker: Ibidem, viii, 1868, 123.—Archer: Ibidem, 123.—Hertwig and Lesser: Arch. mik. Anat. x, 1874, Suppl. 139, Taf. iii, Fig. 9.—Greeff: Arch. mik. Anat. xi, 1875, 15, pl. i, Fig. 11–13.—Schulze: Ibidem, 127, Taf. vii, Fig. 10–15.

Acanthocystis spinifera? Greeff: Arch. mik. Nat. v, 1869. 495, Taf. xxvii, Fig. 24–29.

Cystophrys oculea. Archer: Quart. Jour. Mic. Sc. ix, 1869, 265, 421, pl. xvii, fig. 3; x, 1870, 18, 22, 101; xi, 1871, 144.

A very minute or "Diplophrys-like" organism. Archer: Quart. Jour. Mic. Sc. ix, 1869, 323; x, 1870, 102; xi, 1871, 145, pl. vi, fig. 9, pl. vii, fig. 10.

Elæorhanis cincta. Greeff: Arch. mik. Anat. xi, 1875, 23, Taf. i, fig. 10.

Diplophrys archeri, in its mature individual condition, is described by Professor Schulze * as a minute globular body, 0.01 mm. to 0.02 mm., from opposite poles of which there radiates a tuft of fine and mostly unbranching pseudopods. The transparent, faintly granular protoplasm composing the body contains a bright refractive corpuscle of variable size, usually of an amber color, less frequently paler or even colorless, and sometimes light ruby red.

I have not observed Diplophrys in the isolated and mature condition; it having perhaps escaped my attention from its very diminutive size. On several occasions I have seen what I have supposed to be the young condition, in which numerous individuals were associated in a coherent mass, resembling similar groups described and figured by Professor Greeff and Mr. Archer.

Professor Greeff † has suggested the probability of such a group, represented in his fig. 29, pl. xxvii, and other forms, figs 25–28 of the same plate, more characteristic of *Diplophrys archeri*, having a genetic relation with *Acanthocystis spinifera*. A similar group Mr. Archer referred to another animal, distinct from Diplophrys, with the name of *Cystophrys oculea*.‡

Subsequently Professor Greeff § recognized the forms represented in his figs. 25–28, above indicated, as belonging to *Diplophrys archeri*, and further became convinced that the group represented in his fig. 29, previously described by him without name, together with the *Cystophrys oculea* of Archer, were colonies of *Diplophrys archeri*, probably resulting from segmentation.

The rhizopodal groups which I have observed, and regarded as pertaining to *Diplophrys archeri*, were obtained in sphagnous bog-water, on Broad Mountain, Schuylkill County, Pennsylvania, September, 1876, and at Atco, New Jersey, October, 1877.

The groups were composed of multitudes of minute globular individuals aggregated in masses, which in their movements slowly underwent change of shape. A group closely aggregated and nearly spherical measured about 0.04 mm. Gently gliding across the field of view, it

* Archiv f. mikros. Anatomie, xi, 1875, 127.
† Ibidem, v, 1869.
‡ Quart. Jour. Micros. Science, ix, 1869, pl. xvii, fig. 3.
§ Archiv f. mikros. Anatomie, xi, 1875, 15.

gradually assumed an oval and then an irregularly five-sided shape, as represented in fig. 8, pl. XLV. Continuing its slow changes, it elongated to more than double its former extent, becoming narrower and constricted toward the middle, as seen in fig. 7. In the latter condition, the group was more spread, thinner, paler, and more translucent, and the individuals more widely separated. Later the group rather suddenly shortened to an oval shape, then became irregularly quadrate, reniform, and so on

Another group, when first noticed, was biscuit-shaped, and as it slowly moved along, a break occurred near the centre, through which, by a slight change of focus, a deeper layer of individuals could be seen, apparently indicating the group to have formed a hollow mass.

The individuals composing the groups of Diplophrys have appeared to me to be associated by means of a transparent protoplasm; but the existence of this has been denied by Hertwig and Lesser, in opposition to similar views expressed by Archer, Greeff, and Schulze.

Hertwig and Lesser describe the larger groups or communities as being made up of smaller ones associated in fours; but such did not appear to be the case in the few examples which came under my observation.

The individuals composing the groups were of pretty uniform size, globular in shape, and measured 0.004 mm. to 0.005 mm. in diameter; therefore considerably smaller than those described by Hertwig and Lesser. They were transparent, and contained mostly a single, bright cherry-red corpuscle, oil-like and highly refractive. The presence of the large red corpuscles so far concealed everything else that I failed to detect a nucleus.

The pseudopodal rays were numerous, and diverged irregularly from all parts of the surface of the groups. They were exceedingly delicate, straight, simple, non-granular, and from 0.02 mm to 0.04 mm. long. I could not trace a connection between them and the individuals, and suspected that they emanated from a common enveloping protoplasm, according to a similar view of Professor Schulze.

ACTINOSPHÆRIUM.

Greek, *aktin*, a ray; *sphaira*, a sphere.

Body spherical or oval, composed of finely granular protoplasm enclosing a mass of delicate polyhedral vesicles or vacuoles occupied by a clearer hyaline protoplasm. The outer one or two layers of vacuoles more or less distinctly defined from the interior mass by greater size, translucency, and apparently the intervention of a thicker film of granular protoplasm. Nuclei numerous and imbedded in the latter beneath the peripheral vacuoles. Contractile vesicles two, commonly occupying opposite positions in the peripheral vacuole layer. Rays numerous, consisting of tapering extensions of the granular protoplasm, including an axis thread, which starts from the body beneath the peripheral vacuole layer.

ACTINOSPHÆRIUM EICHHORNII.

PLATE XLI.

Der Stern. Eichhorn: Beitr. Kennt. Wasserth. 1783, 15.
Actinophrys Eichhornii. Ehrenberg: Bericht Preus. Ak. Wis. 1840, 198.—Stein: Infusionsthiere, 1854, 148, 151.—Claparède and Lachmann: Études Infusoires, i, 1858, 9, 450.—Pritchard: Hist. Infusoria, 1861, 560.—Haeckel: Radiolarien, 1862, 165.—Wallich: An. Mag. Nat. Hist. xi, 1863, 444, pl. x, figs. 1-3.—Carter: Ibidem, 1864, xiii, 35, pl. ii, fig. 21; 1865, xv, 281, 283, pl. xii, fig. 6.—Cienkowski: Arch. mik. Anat. i, 1865, 227, 229.—Greeff: Arch. mik. Anat. iii, 1867, 396.—Micrographic Dictionary, pl. 23, fig. 7 *a*.—Schneider: Zeitsch. wis. Zool. xxi, 1871, 507.
Actinophrys sol. Kölliker: Zeitsch. wis. Zool. i, 1849, 198.
Actinosphærium Eichhornii. Stein: Sitzungsb. Böhm. Gesells. Wis. 1857, 41.—Greeff: Sitzungsb. niederrhein. Gesells. Bonn, 1871, 4.—Schulze: Arch mik. Anat. x, 1874, 328, Taf. xxii.—Hertwig and Lesser: Arch. mik. Anat. x, 1874, Suppl. 176, Taf. v, Fig. 1.—Leidy: Pr. Ac. Nat. Sc. 1874, 166.

Body transparent, colorless, usually with a single peripheral layer of the large vacuoles, which are deeper than broad; or, in the larger or older individuals, sometimes with two peripheral layers of vacuoles of more uniform diameters.

Size—Ranging from 0.088 mm. to 0.4 mm. in individuals of globular form, with rays to 0.22 mm. in length; in individuals of oval form, from 0.26 mm. by 0.24 mm. to 0.68 mm. by 0.65 mm., with rays as in the former.

Locality—In ponds, lakes, and ditches, among Ceratophyllum, Lemna, and other aquatic plants, in Pennsylvania, New Jersey, and the Uinta Mountains of Wyoming Territory.

Actinosphærium eichhornii commonly looks like a giant form of the common Sun-animalcule, but is usually readily distinguishable, even in the smallest individuals, by a more or less well-marked distinction of the peripheral layer of vesicles from the interior mass. It varies greatly in size, and, though less frequent than *Actinophrys sol*, is found in similar positions, and possesses nearly similar habits. See pl. XLI.

The body is mostly spherical, but often in the largest individuals is oval. It forms a colorless, hyaline, vesicular ball, with a clouded interior and a clearer peripheral layer. The latter, as seen in the various figures of pl. XLI, consists of a single stratum of large clear vesicles or vacuoles, forming mostly short six-sided columns, resting by their narrower end on an interior ball of smaller polyhedral vesicles, and with the opposite end free and convex, and contributing to the general surface of the body. The superficial vesicles are nearly uniform, but not unfrequently vary, and sometimes a pair of vesicles of more uniform diameters substitute the ordinary short columnar vesicle. The interior vesicles, besides being in general smaller than the exterior ones, are more regularly polyhedral and of greater uniformity in their several diameters.

The vesicles are composed of a thin, delicate, protoplasmic layer, containing apparently a more liquid and homogeneous protoplasm within. They appear to be held together and invested with a more granular protoplasm with diffused oil molecules. A thicker stratum of this material appears to define the peripheral layer of vesicles from the deeper mass, and a greater proportion also appears to extend between the vesicles of the latter. From this more granular protoplasm investing the body of the animal, that of the pseudopodal rays mainly has its origin.

In the peripheral layer of vesicles there are usually to be detected two contractile vesicles, situated at opposite poles of the body, as seen in figs. 1, 2, 3, *a*, *b*. At one moment they may exhibit no difference in appearance from the contiguous vesicles; but, from time to time, one or both may be seen slowly to enlarge, pressing on the surrounding vesicles, and rising as a clear hemispherical bubble above the surface of the body. See figs. 1–5, 7, *a*. On reaching the full degree of expansion, they rather abruptly collapse, and expel the liquid contents, causing a sinking of the wall of the vesicle, and producing a temporary concave depression on the surface of the body, as seen in figs. 1, 2, *b*. The collapse of the vesicles is sufficiently strong to give a visible shock to the body of the animal. Shortly after the collapse, the contractile vesicle reappears in the same place.

According to Stein, Carter, and other authorities, *Actinosphærium eichhornii* contains many nuclei, large individuals having a hundred or more. They occupy a position in the superficial part of the interior mass of vesicles, beneath the peripheral layer of larger ones, enveloped in the same kind of finely granular protoplasm. Ordinarily, they are invisible without the application of chemical reagents, or at most they are sometimes barely perceptible as pale, shaded spots in the interior of the body. Dilute acetic acid brings them into view as pale and faintly granular spheres, with a large central nucleolus, or several smaller nucleoli. The smallest individuals appear commonly to contain but a single nucleus, as in the common Sun-animalcule.

The pseudopodal rays project in all directions (figs. 1–3) as in the latter, and are equally numerous. They are long, tapering extensions of granular protoplasm, sustained by a delicate axial thread, but proportionately are commonly not so long as in *Actinophrys sol.*

The axial thread of the pseudopodal rays is a simple, comparatively rigid, and straight filament, which starts from the surface of the interior vesicular mass of the body, and passes through the peripheral layer of larger vesicles between them. The threads extend through the greater part of the length of the pseudopods, but do not reach their ends.

A portion of the granular protoplasm of the pseudopods appears to originate from the stratum immediately beneath the peripheral layer of vesicles, and extends upon the axial thread through the latter, when it is reinforced by an additional portion converging from the exterior investment of the same material, as seen in fig. 7.

The axial threads of the pseudopods are homogeneous, and appear to consist of more or less solidified protoplasm. They clearly contribute to sustain and strengthen the pseudopodal rays ; and, though they seem to be, they are not rigid spicules, for they may be seen to bend beneath the rude shock of active animalcules coming into contact with the rays. At times, also, they appear not to be persistent structures, as I have observed individuals in which they seemed to vanish with the retraction of the rays, and again reappear with the production of these.

Occasionally I have seen individuals of Actinosphærium with few or no rays.

The food of *Actinosphærium eichhornii* in general is of the same nature, and the mode of taking it the same, as in *Actinophrys sol.* With its usually greater size and strength than in the latter, the former will feed upon larger and more powerful animals, especially various rotifers. Though the animal is to all appearances exceedingly inactive and sluggish, remaining suspended in the water almost motionless or feebly gliding about, it is a gluttonous feeder and consumes a large amount of food. This commonly consists of ciliated and flagellated infusoria, rotifers, zoospores, diatoms, the smaller desmids, etc.

Large active animalcules rudely brush against the multitudinous rays of Actinosphærium, and turn them aside without apparent harm to either, and without the Actinosphærium displaying any evident mark of irritability, either in its rays or body. Weaker animalcules, coming within the influence of the rays, are often rendered more or less powerless, or their movements become enfeebled and finally cease. Being gradually drawn toward the body by the retraction of one or more of the rays, the prey becomes immersed in a mass of projected protoplasm, as seen in figs. 1, 2, *c*, which is then gradually withdrawn with the included food. It passes through the peripheral layer of large vesicles, and sinks among the mass of smaller vesicles within. In the interior of the latter, food of various kinds is often visible. Comparatively soft food, when swallowed quickly, assumes the form of a ball, and is commonly seen in this condition, included within a drop of clear liquid, in the interior of the body. More consistent food, such as diatoms or the hard parts of rotifers, retains the original form. The food is rapidly digested, undergoing changes, according to its nature, as in other Rhizopods, and as repeatedly indicated in the preceding pages.

Excrementitious matter, usually in the form of a ball, is discharged, by a somewhat quick projection of a portion of the interior protoplasm of the body containing the ball, through the peripheral vesicular layer, as represented in *d*, fig. 2.

As above indicated, *Actinosphærium eichhornii* may appear with few or no rays. Fig. 4 represents an individual, which, when first observed, possessed but a single long ray. After a brief interval, a second, and then a third, were projected, and after an hour had elapsed it presented many rays directed from all parts of the surface of the body.

I once met with a singular body, of vesicular constitution and rayless, as represented in fig. 6, which I supposed to be a rayless form of *Actinosphærium eichhornii*. It was irregularly oval, and about 0.4 mm. long. The peripheral vesicles were less uniform than in the characteristic forms of Actinosphærium, and had their greater diameter mostly in a reverse direction from the usual one. Though entirely rayless, the animal showed some activity, displayed in feeble changes in the outline of shape, and in the slow expansion and quick collapse of some of the larger vesicles of the exterior layer. It contained several articles of food, among which were conspicuously seen a diatom and a large rotifer. After twenty-four hours all the food was expelled except one green alga, and the animal had assumed a globular form, 0.28 mm. in diameter. No rays appeared, and later the animal died.

In several instances I have observed bodies, as represented in figs. 11, 12, which possessed the shape, size, and apparent vesicular constitution of *Actinosphærium eichhornii*, but they were lifeless, and the vesicles were composed of structureless membrane, without a trace of interior or exterior liquid protoplasm. Whether these bodies really have any relationship with Actinosphærium, or whether they pertain to some other animal, I have not been able to determine. Found in the same localities in which I had, at an earlier season of the year, observed many active individuals of Actinosphærium, I have suspected that they might be of the nature of an exuvium, discharged in some way by the latter.

Another enigmatic body occasionally met with, as represented in figs. 9, 10, I have suspected to be a fragment of an Actinosphærium. In this particular specimen, of which two views are given, the body consisted of a globule of granular protoplasm, containing at first two vesicles, and then, by union of these, a single larger vesicle, and a single pseudopodal ray sustained by an axial thread.

Another specimen, represented in fig. 8, consisted of a globule of granular protoplasm, proportionately more abundant than usual, together with a number of included vesicles of variable sizes. From the body there projected four long, delicate rays, upon each of which there was a large drop of protoplasm. I am uncertain whether the specimen had any relationship with Actinosphærium.

Actinosphærium eichhornii exhibits a considerable range of size. Ordinarily, spherical individuals are from 0.166 mm. to 0.33 mm. in diameter, with the rays usually of less length than the diameter of the body, and commonly from 0.1 mm. to 0.2 mm. long. Oval individuals reach 0.66 mm. in length.

Actinosphærium eichhornii is found in the same kind of localities as *Actinophrys sol*, and in association with it. Its favorite resort is quiet water among duckmeat, hornwort, etc. It commonly appears nearly stationary, or as if gently floated along by an imperceptible current of the water. It at times shows slight changes in the outline, while its contractile vesicles pursue their usual rhythmical movements, at each moment as one collapses giving the whole body a gentle quiver.

ACANTHOCYSTIS.

Greek, *akantha*, a thorn; *kustis*, a cyst.

Trichoda: Schrank, 1803. *Actinophrys:* Ehrenberg, 1833. *Acanthocystis:* Carter, 1864.

Animal Actinophrys-like in general appearance. Body spherical, soft, composed of finely granular protoplasm mingled with variable proportions of bright-green and colorless corpuscles, the former at times absent, also containing diffused oil molecules, a central nucleus, together with vacuoles, and a variety of food materials commonly in the form of balls. Exterior of the body invested with numerous delicate, silicious rays, implanted by minute basal disks, and ending in a simple, pointed or furcate extremity; also giving off numerous delicate, soft rays like those of Actinophrys; further enveloped by a layer of protoplasm, rising in pointed processes on the rays, and pervaded by a multitude of exceedingly minute, linear particles; the enveloping layer sometimes absent.

ACANTHOCYSTIS CHÆTOPHORA.

PLATE XLIII, figs. 1–6.

Trichoda chætophora. Schrank: Fauna Boica, iii, 2, 1803, 93.
Actinophrys viridis. Ehrenberg: Abh. Ak. Wis. Berlin, 1833, 228; Infusionsthierchen, 1838, 304, Taf. xxxi, Fig. vii.—Dujardin: Infusoires, 1841, 267.—Perty: Kennt. kleinst. Lebensformen, 1852, 159.—Pritchard: Hist. Infus. 1861, 560.—Micrographic Dictionary, pl. 23, fig. 6.
Acanthocystis turfacea. Carter: An. Mag. Nat. Hist. 1864, xiii, 36, pl. ii, fig. 25.—Archer: Quart. Jour. Mic. Sc. x, 1870, 27; xvi, 1876, 361.—Hertwig and Lesser: Arch. mik. Anat. x, 1874, Suppl. 204.—Greeff: Arch. mik. Anat. xi, 1875, 30, Taf. i, Fig. 1–4.
Acanthocystis viridis. Greeff: Arch. mik. Anat. v, 1869, 481, Taf. xxvi, Fig. 8–17.—Greenacher: Zeits. wis. Zool. xix, 1869, 289, Taf. xxiv, Fig. 1–3.—Schneider: Ibidem, xxi, 1871, 505.—Leidy: Proc. Ac. Nat. Sc. 1874, 166.
Acanthocystis pallida. Greeff: Arch. mik. Anat. v, 1869, 489, Taf. xxvii, Fig. 19.
Acanthocystis (viridis) turfacea. Greeff: Arch. mik. Anat. xi, 1875, 3, Taf. i, Fig. 1–4.

Body spherical, usually bright green from the presence of chlorophyl corpuscles, mingled in variable proportion together with colorless ones; sometimes colorless from the absence of the former. Nucleus central, commonly obscured from view by the surrounding constituents. Silicious or spinous rays of two kinds: the one long, comparatively strong and acutely furcate at the free end; the other short, very delicate, and widely furcate at the free end, and sometimes altogether absent. Soft rays simple, granular, as long as or longer than the spinous rays. Exterior envelope of the body appearing as an atmosphere of exceedingly minute bacterium-like particles, which are sometimes absent.

Size—Diameter of the body ranging from 0.048 mm. to 0.1 mm.; length of the larger furcate spines from 0.02 mm. to 0.06 mm.; length of the soft or pseudopodal rays about equal to the diameter of the body or longer.

Locality—In the same positions as *Actinophrys sol* and *Actinosphærium eichhornii*, in quiet waters, among various aquatic plants. Observed in the vicinity of Philadelphia and other places in Pennsylvania, in New Jersey, Rhode Island, Colorado, Wyoming Territory, and Nova Scotia. Found in ponds in the Uinta Mountains of Wyoming Territory, at an elevation of 10,000 feet.

Acanthocystis chætophora, as ordinarily observed under moderate powers of the microscope, resembles the common Sun-animalcule, but with the body of a bright-green color, hence its familiar name of the Green Sun-animalcule. Under high powers of the instrument it is seen to possess a more complex structure, as represented in fig 1, pl. XLIII

The body of *Acanthocystis chætophora* is spherical, and is composed of a basis of finely granular protoplasm, with scattered oil molecules, and variable proportions of globular corpuscles, mostly of nearly uniform size. A clearer central spot indicates the presence of a large nucleus, which may be brought into view by the action of reagents.

The corpuscles mentioned are commonly for the most part, if not entirely, of a bright-green color, and accord with the characters of chlorophyl. They are often very numerous, and appear especially to be confined to the more superficial portion of the protoplasmic mass of the body. Often mingled with them there are variable proportions of clear, colorless corpuscles, of about the same size, and occasionally individuals are to be found, as represented in fig. 4, in which these exist to the entire exclusion of green ones.

Among the green and colorless corpuscles, from time to time, other globular bodies exist, of variable sizes, some of which are distinguishable as food-balls and vacuoles. Distinct contractile vesicles I have never been able to detect.

A central nucleus brought into view in an individual, by the action of an ammoniacal solution of carmine, was finely granular, and about 0.0238 mm. in diameter.

The exterior of the body of *Acanthocystis chætophora* is profusely invested with exceedingly delicate spinous rays, which are straight and rigid, and remind one of minute acicular crystals emanating from a nuclear centre. In strong, reflected light, these rays appear glistening white, and they are silicious in composition. They are attached to the surface of the body by little disks, which give to it a minutely mammillated appearance, and are sufficiently numerous to form a complete scale-like armor to the animal.

The ray spines are of two kinds: a longer, stouter form, terminating in an acutely notched extremity (figs. 1, 2), and a shorter and more delicate form, with a wide, furcate extremity (fig. 3). The longer, stouter spines exhibit a dark axial line, apparently indicating a tubular condition. In some individuals, the shorter and more delicate spines are absent.

The pseudopodal rays of *Acanthocystis chætophora* are numerous, and of the same character as those of *Actinophrys sol.* Commonly, they are difficult to distinguish among the forest of spinous rays, excepting where they project beyond these.

Commonly, the body of *Acanthocystis chætophora* is invested with a thick layer of protoplasm, distinguished chiefly from its being densely pervaded by exceedingly minute, linear particles, which remind one of an atmosphere of bacteria enveloping the animal. Usually, this dust-like stratum includes completely the smaller furcate rays, and ascends in pointed processes upon the longer ones to a variable extent. Sometimes the exterior stratum, with its bacteria-like particles, is completely absent.

Commonly, the body of *Acanthocystis chætophora* is about 0.0833 mm. in diameter. The longer furcate spines measure about 0.1 mm. in length, and appear as fine as the micrometric lines themselves. The smaller spines are from a fifth to a third the length of the others, and much more delicate.

Acanthocystis chætophora occurs in the same localities as the ordinary Sun-animalcule, and, though frequent, is not so common as the latter. It likewise has nearly similar habits. At times it appears to remain quite stationary, but mostly exhibits a slow gliding motion, and apparently so passive that it seems to be induced by a feeble current of the medium in which it lives. The movement is, however, clearly active, as proved by the fact that equally light objects in the vicinity remain quiescent.

Acanthocystis chætophora feeds on the smaller algæ and animalcules, which are captured in the same manner as with *Actinophrys sol.* In the gradual approach of food, through the dense forest of rays investing the body, the armor formed by the basal disks of the spines rises in a conical eminence, and opens outwardly so as to allow of the entrance of the food. In the process, a portion of projected protoplasm receives the latter, and the whole together is withdrawn, when the body resumes its regular spheroidal form

In the act of discharging excrement, a similar process occurs, the armor at some point opening outwardly, so as to give passage to the expelled matter.

In the movements of the animal, at times slight changes in shape become obvious, from a spheroidal to a more ovoidal and polyhedral outline. The rays and spines, though ordinarily regularly divergent, may occasionally be seen, at some part of the body, to become more or less convergent, or to a greater degree divergent.

I think there can be little doubt that *Acanthocystis chætophora* is the same animal as the one described by Ehrenberg under the name of *Actinophrys viridis* This, however, appears to have been previously described by Schrank, with the name of *Trichoda chætophora*, and the original description applies so well to the creature in question, that, according to the rules of zoological nomenclature, I have adopted for it the earlier specific name.* Ehrenberg himself remarks, in reference to his description of *Actinophrys viridis*, that he had overlooked Schrank's form, which may probably be the same, and in which case his specific name should be preferred.†

I have commonly observed *Acanthocystis chætophora* of a bright-green color, dependent on variable proportions of chlorophyl corpuscles, as seen in fig. 1. Rarely, I have met with the same form in all respects alike, excepting in being devoid of the bright-green color, as represented in fig. 4. This colorless form has been described by Professor Greeff under the name

* The original description is as follows: "Kugelförmig, grün, nach allen Richtungen gestralt. Allenthalben ziemlich dicht mit crystallhellen Haaren besetzt. Bewegung langsam fortschreitend, ohne alle Bewegung der Haare."

† Infusionsthierchen, 304.

of *Acanthocystis pallida.* Mr. Archer* regards it as an accidental colorless form of *Acanthocystis turfacea* Probably it is one of the stages of life through which the ordinary green-colored animal may have to pass.

In one instance I observed a colorless individual of *A. chætophora,* 0.048 mm. in diameter, which contained, besides numerous colorless corpuscles, a single bright-green ball The animal was in active condition, and, while slowly gliding by, it lifted a portion of its armor, and discharged the green ball.

An individual of peculiar character, perhaps related with *Acanthocystis chætophora* as to form a stage in its history, is represented by fig. 5, pl. XLIII. It was obtained from Absecom pond, New Jersey, September, 1874, and was the only one of the kind observed. The body was elongated ovoid and transparent, and was filled with large, clear, irregularly polyhedral vesicles, together with a few small green corpuscles. The surface and rays were of the same character as in the ordinary condition of *A. chætophora,* and a granular layer likewise invested the body.

Occasionally I have found an empty sac of clear homogeneous membrane, and fragments of others, with attached furcate spines like those of *A. chætophora.* Fig. 6 represents a specimen of the kind, within which was an oval egg-like body with brownish granular contents and a few scattered green corpuscles. The empty membranes I have suspected to be the exterior covering of *A. chætophora,* left by the animal or its progeny of germs after passing through the encysted condition.

ACANTHOCYSTIS ——— ?

PLATE XLIII, figs. 7–13.

Body spherical, usually bright green from the presence of abundance of chlorophyl corpuscles; sometimes colorless from the absence of the latter; or of other colors. Spinous rays numerous, exceedingly delicate, emanating from minute lenticular disks at the surface of the body, and simply pointed at the distal end Enveloping layer of protoplasm finely granular; sometimes absent. Pseudopodal rays longer than the former.

Size.—From 0.036 mm. to 0.048 mm. in diameter.

Locality.—Among aquatic plants in ponds and ditches. Pennsylvania, New Jersey, Wyoming Territory.

* Quarterly Journal Microscopical Science, 1876, 362.

I have repeatedly observed a bright-green Heliozoan, which I at first regarded as *Acanthocystis chætophora*, but closer examination led to the detection of differences, which render it probable it may belong to another species. It is commonly smaller than the former, and appears of an intensely green color, due to the greater proportion of chlorophyl corpuscles it contains than is usually the case in *A. chætophora*, and as represented in figs. 7, 8, pl. XLIII. The surface of the body is mammillated, and this appears to be independent of the presence of the minute disks of the spinous rays. The latter are more numerous and more delicate than in *A. chætophora*, and they are not furcate at the free extremity. The exterior of the body is enveloped in a very finely granular stratum, as seen in fig. 7; but in other instances this is absent, as represented in fig. 8.

In association with the bright-green Heliozoans, as just described, or in similar positions others occur resembling them, but differing in being colorless, as represented in figs. 10, 11. In these the usual green corpuscles are replaced by colorless ones, or the latter may also be absent, when the body consists of a nearly homogeneous granular basis, containing a central nucleus and a few vacuoles. The size of the colorless specimens ranges from 0.028 mm. to 0.048 mm.

In size and structure, the Heliozoans above described nearly agree with the *Acanthocystis spinifera* of Professor Greeff.* In the latter, the body contains variable proportions of bright-yellow corpuscles; but as these are absent in some individuals, the color of the interior corpuscles would appear not to be an important distinctive character.

In one instance, in April, in water from a spring in which grew water-cress, I observed a bright-red Heliozoan, as represented in fig. 9. In general constitution it resembled the former, but contained numerous bright-red corpuscles, some colorless ones, and a few green ones. It also contained nearly at opposite poles two large granular spheres, one yellowish, the other pale green, which I supposed to be food-balls.

Late in autumn, on several occasions, I have observed Heliozoans, with sufficient resemblance to the former to lead me to suppose they were of the same kind in an encysted condition. An individual of this character, collected with Ceratophyllum, in the canal at Bristol, Pennsylvania, is represented in fig. 12.

*Archiv f. mikros. Anatomie, 1869, 493, Taf. xxvii, Fig. 20–23.

The supposed encysted forms consist of an outer sphere, bristling with delicate, simple, spinous rays, but without pseudopodal rays. The sphere is composed of a doubly contoured membrane, apparently cancellated, and filled with a clear liquid, including a second sphere. The latter is invested with a membrane like that of the outer sphere, but is devoid of spines, and is occupied with colorless granular protoplasm mingled with abundance of oil molecules, giving the contents a milky appearance.

With the foregoing I have occasionally met with empty membranous sacs, and fragments of others, as seen in fig. 13, which I have regarded as the remains of the capsule of encysted forms of the same species of Acanthocystis.

ACANTHOCYSTIS ———?

PLATE XLIII, figs. 14–16.

Body spherical, composed of a basis of colorless granular protoplasm, with a central nucleus, and with variable proportions of bright-green and colorless corpuscles or with colorless ones alone. Spinous rays numerous, short, pin-like in form.

Size.—From 0.039 mm. to 0.051 mm.

Locality.—In water among floating algæ. Pennsylvania.

A third kind of Acanthocystis, distinguishable from the two former by the shortness and pin-like character of its spinous rays, I have occasionally seen, but under circumstances unfavorable to making a full investigation of the animal.

In August, in water with Spirogyra, collected from the fountain at the entrance of Fairmount Park, Philadelphia, I observed a number of colorless individuals of Acanthocystis apparently passing into the encysted state. Seven specimens ranged from 0.039 mm. to 0.051 mm. in diameter. They were without pseudopodal rays, and mostly were completely inactive. The exterior of the body was mammillated and densely covered with short pin-like spines about 0.006 mm. long.

In one individual, represented in fig. 14, pl. XLIII, the body was a mass of granular protoplasm, mingled with fine oil molecules and a few larger ones, together with a nucleus and a clear vacuole nearly as large as the latter.

Another individual, represented in fig. 15, consisted of a membranous sac, resembling the exterior of the former specimens, but filled with a clear liquid and containing a large ball of granular protoplasm. This was nearly homogeneous, and presented several vacuoles at its periphery, which from time to time would successively collapse and again reappear. The mass exhibited feeble movement in a change of form, but finally it became quiet and all its vacuoles disappeared.

Another individual, fig. 16, was like the preceding; but the inner globular mass of protoplasm was more sharply defined, and exhibited a distinct nucleus. A fourth individual presented the same appearance, excepting that the inner ball contained a few scattered green corpuscles.

The specimens of Acanthocystis above described appear to me to be most nearly related to the *Acanthocystis Pertyana* of Mr. Archer.* They also approximate in character with the *Acanthocystis aculeata* of Hertwig and Lesser,† but in this the spines are much larger and coarser. I suspect also that the animal represents one of the stages of the form described by Perty as *Actinophrys brevicirrhis*.‡

HYALOLAMPE.

Greek, *hualos*, crystal; *lampe*, foam.

Hyalolampe: Greeff, 1869. *Pompholyxophrys:* Archer, 1869.

Animal spherical, composed of a finely granular protoplasmic mass mingled with variable proportions of colored granules and vacuoles, and containing a central nucleus. Body invested with a thick layer of loosely coherent, minute, clear, silicious globules. Pseudopods few, radiant, exceedingly delicate, filamentous, and non-granular.

HYALOLAMPE FENESTRATA.

PLATE XLV, fig. 9.

Hyalolampe fenestrata. Greeff: Arch. mik. Anat. v, 1869, 501, Taf. xxvi, Fig. 37; xi, 1875, 18, Taf. i, Fig. 6, 7.—Hertwig and Lesser: Ibidem, x, 1874, Suppl. 221.§
Pompholyxophrys punicea. Archer: Quart. Jour. Mic. Sc. ix, 1869, 386, pl. xvi, figs. 4, 5; x, 1870, 105, pl. xvi, fig. 4; xvi, 1876, 375.
Hyalolampe exigua. Hertwig and Lesser: Arch. mik. Anat. x, 1874, Suppl. 222, Taf. iv, Fig. 6.

Body usually more or less yellowish, brownish, or reddish. Investing silicious globules commonly in three layers.

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* Quart. Jour. Microscopical Science, 1869, 252, pl. xvi, fig. 1; 1870, 32.
† Archiv f. mikros. Anatomie, 1874, Suppl. 201, Taf. iv, Fig. 2.
‡ Kennt. kleinst. Lebensformen, 1852, 159, Taf. viii, i, Fig. 7.
§ The names of Hyalolampe and Pompholyxophrys are nearly cotemporary, and I have followed Hertwig and Lesser in the choice of the former as being the more euphonious.

Size.—From 0.04 mm. to 0.08 mm. in diameter; the central body from 0.048 mm. to 0.064 mm in diameter.

Locality.—Absecom pond, New Jersey.

Hyalolampe fenestrata is a remarkable Heliozoan, with spherical body composed of a granular basis of protoplasm, enclosed in a thick envelope consisting of minute transparent globules, which, according to Professor Greeff, are silicious in constitution. The globules are loosely coherent, and usually lie three layers deep, and would appear to correspond with the silicious latticed capsule of Clathrulina.

The protoplasmic body, according to Hertwig and Lesser, is colored yellowish green, orange, red, or reddish brown. A central nucleus is commonly obscured from view, and contractile vesicles are absent.

The pseudopodal rays are simple and straight, like those of Actinophrys, but commonly few in number.

I have rarely had an opportunity of observing *Hyalolampe fenestrata*, having seen but three individuals. These were obtained in Absecom pond, New Jersey, in June and October, 1877. The specimens were larger than the dimensions given by Archer, Greeff, and others, measuring from 0.064 mm. to 0.08 mm. in diameter. In none were pseudopodal rays to be detected, though the creatures were evidently alive, as indicated by their feeble gliding motion, and in one individual by a slight change in the shape of the outline. The protoplasmic body was of a pale yellowish color, and contained a variable number of large balls, either vacuoles or food or perhaps both, as seen in fig. 9, pl. XLV. One of the specimens contained several brown, biseptate fungus spores. The silicious globules of the exterior envelope measured about 0.004 mm.

CLATHRULINA.

Latin, *clathrus*, a lattice.

Clathrulina: Cienkowski, 1867. *Podosphæra:* Archer, 1868.

Animal provided with a spherical, latticed capsule composed of silex, attached by a long filiform stem to aquatic plants or other objects. Contents of the capsule consisting of a soft Actinophrys-like body, with the same kind of pseudopodal rays, which project through the openings of the capsule.

CLATHRULINA ELEGANS.

PLATE XLIV.

Clathrulina elegans. Cienkowski: Archiv mik. Anat. iii, 1867, 310, Taf. xviii.—Archer: Quart. Jour. Mic. Sc. viii, 1868, 71, 189; ix, 1869, pl. xvii, fig. 5; x, 1870, 117; xi, 1871, 322; xii, 1872, 195; xvii, 1877, 68, pl. xxii, figs. 23–25.—Greeff: Archiv mik. Anat. v, 1869, 467, Taf. xxvi, Fig. 1–7.—Hertwig and Lesser: Ibidem, x, 1874, Suppl. 227, Taf. v, Fig. 4.—Leidy: Proc. Ac. Nat. Sc. Phila. 1874, 145, 166.

Podosphæra Hæckeliana. Archer: Quart. Jour. Mic. Sc. viii, 1868, 67.

Capsule colorless when young, but becoming yellow or brown with the advance of age; openings more or less circular, or polygonal with rounded angles. The soft body occupying the capsule of variable proportion in relation with the latter, and, approaching maturity, more or less contracted from it, composed of a soft, colorless, granular protoplasm, with scattered oil-like molecules, and numerous vacuoles, as usual in Actinophrys, or nearly homogeneous, and with a central nucleus. Pseudopodal rays straight, mostly simple, or somewhat furcate, long and numerous. Pedicle of variable length, attached to objects by an expanded, somewhat lobate disk.

In the young condition, the capsule not obvious, and the pedicle of greatly thicker proportion; the soft body with numerous vacuoles, as in Actinophrys.

Size.—Diameter of the latticed capsule 0.03 mm. to 0.044 mm.; length of pedicle from 0.06 mm. to 0.26 mm.; thickness 0.002 mm. to 0.004 mm.

Locality.—In ponds and ditches, attached to aquatic plants; also in sphagnous swamps New Jersey and Pennsylvania.

Clathrulina elegans, represented in the figures of pl. XLIV, is well worthy of its specific name, and is a comparatively recent discovery of the Russian naturalist Cienkowski. It was first found by him on Nitella and Vaucheria, in a pond at St. Petersburg, and was afterward again found by him and others in Germany, and by Mr. Archer in Ireland and Wales. In general appearance it bears a likeness to *Trichoda fixa*, less characteristically described by Müller in 1786.*

I have repeatedly observed *Clathrulina elegans*, but mostly in detached and often dead specimens, collected in materials from ponds, especially in the sphagnous swamps of New Jersey. I have rarely been so fortunate as

* Animalcula Infusoria, 217, Tab. xxxi, Fig. 11, 12.

to find the animal in an active condition and at the same time in a fixed position. In one instance I found it attached to bladder-wort, *Utricularia vulgaris*, and in another instance to the under side of a leaf of the water-lily, *Nymphæa odorata;* both times in New Jersey. I have frequently noticed dead specimens, and occasionally living ones, in an encysted condition, among sphagnum collected in New Jersey and Pennsylvania.

Clathrulina elegans is essentially single or solitary, though individuals are often observed attached one or more to another in a candelabrum-like manner, a half a dozen or even more together, thus assuming the appearance of a compound animal, as exemplified by fig. 5.

The mature Clathrulina consists of a spherical latticed capsule, composed of silex, attached by a long thread-like stem of the same material to some relatively fixed object, and containing a soft body resembling the common Sun-animalcule, with its pseudopodal rays projecting through the apertures of the capsule.

The silicious capsule is a superb latticed globe, reminding one of the perforated ivory balls so well known as examples of Chinese skill and patience. In young animals, the capsule is colorless and transparent, and often continues in this condition at maturity; but usually, in the advance of life, it assumes a straw-color, and in old specimens is frequently observed of a dark yellow or even brown color. The apertures are large and commonly more or less polygonal, with rounded angles, but vary to circular and oval, and are of nearly uniform size. The bars separating the apertures are narrow and rounded, and, according to Professor Greeff, are grooved along the middle; but this feature escaped my attention.

In different individuals the capsule commonly ranges in size from 0.033 mm. to 0.04 mm. in diameter. The apertures are from 0.004 mm. to 0.006 mm.

The stem of attachment of Clathrulina is of variable length; sometimes comparatively short, and but little more than the diameter of the capsule, but more frequently double, and to upward of four times the length of the diameter of the capsule. It is highly flexible, and has the same color and composition as the capsule it sustains. It is fixed to bodies by an expansion or disk, usually somewhat lobate at the border.

Though Clathrulina is commonly attached to plants or other foreign objects, individuals often attach themselves to the capsules of others of their kind. Frequently one or two individuals may be seen attached by their stems to the capsule of usually an older individual, and sometimes a greater number are thus found attached to a single one. Not unfrequently also individuals of a third series may be found attached in the same manner to those of the second series, as represented in fig. 5, the whole together in the arrangement reminding one of a candelabrum. The individuals attached to others always appear successively younger, apparently as if they had originated by birth from those to which they adhere.

In the mature and active condition of Clathrulina, the soft protoplasmic body generally does not nearly fill its latticed capsule, and occupies a central position within it. In several instances observed, the soft protoplasm nearly filled the capsule, and in addition an obscurely granular layer enveloped the latter, as represented in fig. 2, *a*. In the mature, active individuals which have come under my notice, the interior protoplasmic body appeared homogeneous granular, with scattered oil-like molecules, and no distinctly visible vacuoles, as represented in figs. 1, 2, *a*.

Pseudopodal rays, like those of *Actinophrys sol*, emanate from all parts of the protoplasmic body, and project through the apertures of the latticed capsule. Mostly they are simple and straight, and rarely fork. Previous observers agree in the statement that the rays not only branch, but also anastomose, though both these points escaped my attention.

In none of the specimens observed by me could I detect a contractile vesicle; and in active individuals the nucleus was completely obscured from view.

In young individuals in which the latticed capsule is in process of being formed, but is not yet distinguishable, as represented in fig. 3, the protoplasmic body is filled with large vacuoles, as in *Actinophrys sol*, and is invested with a thick layer of clearer and faintly granular protoplasm. After the formation of the latticed capsule, the latter becomes less obvious, or apparently disappears, as represented in fig. 2, *b*.

In an animalcula-cage, in which I had placed some material from Hammonton pond, New Jersey, and in which I had observed several individuals of Clathrulina in an encysted condition, the following day I discovered a young active individual, as represented in fig. 4. It was fixed by a colorless pedicle, twice the usual thickness, to the glass cover of the animalcula-cage. The head or body was an Actinophrys-like mass, soft and changeable in shape, and without visible trace of the latticed capsule of the mature animal. The body was composed of granular protoplasm, with numerous oil molecules and vacuoles. From time to time a deeper one of the latter would slowly approach the surface and project above its level, but would remain a long time unchanged. Occasionally one of the superficial vacuoles would slowly and feebly contract and disappear, but none presented otherwise the aspect of the contractile vesicle of *Actinophrys sol*. A nucleus was indicated by a clearer central spot. The pseudopodal rays were like those of *Actinophrys sol*, but from time to time one or two would become thicker, and occasionally a considerable vacuole would form on one or more of them.

The thickened stem of this individual was attached by radiating threads, or perhaps these may have been delicate folds of an exceedingly delicate membranous disk.

Most frequently the individuals of Clathrulina I have seen happened to be such as were in an encysted condition, as represented in figs. 6–9. In these the latticed capsules, colored and colorless, contained one or two large spheres, which were colorless and granular, with scattered oil molecules and a central nucleus. They occasionally presented a few larger globules or vacuoles, as seen in fig. 6, and were always devoid of pseudopodal rays.

From the observations of Cienkowski, on the mode of reproduction of Clathrulina, it multiplies by division. According to him, the Actinophrys-like body within the latticed capsule undergoes constriction and divides into two. After a time the pair of animals withdraw their pseudopodal rays, and then appear as simple granular spheres. These pass out of the latticed capsule, and assume the appearance of the common Sun-animalcule, which subsequently develops a stem of attachment, and finally a latticed capsule enveloping the sarcode head. Sometimes the original Actinophrys-like body divides into four, and at times assumes the smooth spherical form without division.

The different examples of *Clathrulina elegans* represented in pl. XLIV would appear to exemplify nearly all the stages of development, including those of maturity.

FORAMINIFERA.

The **Foraminifera**, though constituting the most extensive and important order of the Rhizopods, are almost exclusively marine. A single well-known genus, Gromia, is represented by several species, inhabiting salt and fresh water.

GROMIA.

? Greek, *grumaia*, a small bag.

Animal spherical or oval, composed of granular protoplasm, with a large central nucleus, and invested with a homogeneous chitinoid membrane. Mouth situated at one pole of the body, and more or less copiously emitting streams of protoplasm, which flow around the body and extend into numerous pseudopodal rays, freely branching and anastomosing, so as to form an intricate net, which exhibits an incessant flow of granules along the filaments, both outward and inward.

GROMIA TERRICOLA.

PLATE XLVII, figs. 1–4.

Gromia terricola. Leidy: Proc. Ac. Nat. Sc. Phila. 1874, 88.

Body spherical or oval, pale yellowish or cream-colored, and more or less translucent. Investing membrane or shell chitinoid, homogeneous, thin, transparent, colorless, or pale yellowish, smooth, or with more or less adherent sand and dirt. Interior protoplasm white by reflected, pale yellow by transmitted light, composed of a pale granular basis with fine oil molecules, usually a few clear vacuoles of variable size, and a large, clear or pale granular nucleus. Mouth obscure, emitting an abundance of finely granular protoplasm, which ordinarily flows around the body, and then breaks up into a multitude of diverging streams or filamentous pseudopodal rays, that frequently form and anastomose so as to produce an intricate net. An incessant circulation of granules outward and inward along the course of the pseudopodal filaments.

Size.—From 0.112 mm. to 0.12 mm. in diameter; the oval variety 0.112 mm. long by 0.1 mm. broad.

Locality.—Among moist moss, in association with *Rotifer vulgaris*, *Trinema acinus*, *Difflugia constricta*, tardigrades, anguillulas, diatoms, and desmids, in the crevices of pavements, in shaded places, in the city of Philadelphia.

The genus Gromia was discovered and described by the French naturalist Dujardin, in 1835, from a species occurring among corallines and other marine algæ on the coast of France. A few years later the same acute observer described a second species, *Gromia fluviatilis*, discovered on hornwort, *Ceratophyllum*, in the river Seine.

The genus is of special interest, because it is a representative, in the simplest condition, of that great order of Rhizopods, the Foraminifera, which are exclusively marine, with the exception of the present one.

The animal I have named **Gromia terricola** I discovered in the summer of 1874, among moss growing in the crevices of the pavement, in the yard attached to my home, in the city of Philadelphia. It was associated with abundance of the common Wheel-animalcule, *Trinema enchelys*, *Difflugia cassis*, *Euglypha alveolata*, anguillulas, tardigrades, diatoms, desmids, etc.

On several occasions, having observed half a dozen individuals, I was led to believe it was common, but I have since failed to find it after frequent search in the same and similar localities. Nor have I been so fortunate to find any other Gromia, a circumstance I have greatly regretted, from the feeling that, with the experience gained in the investigation of rhizopods, after several years I would have been better able to resolve its characters.

Gromia terricola, represented in figs. 1–3, pl. XLVII, has a spherical or slightly oval, translucent body. By reflected light it is white or cream-colored; by transmitted light of a pale yellowish color. The investing membrane or shell is thin, transparent, homogeneous, and colorless or feebly yellowish. It is smooth, but usually has more or less adherent dirt consisting of fine granules and coarser particles of quartz-sand. See figs. 1, 2.

In the individuals observed, the mouth was obscure, and its exact character I neglected to determine.

The interior of the body was composed of a pale granular protoplasm, with scattered oil molecules, completely filling the shell. It contained a large, clear or pale granular nucleus situated centrally or eccentrically, and also variable proportions of vacuoles, usually few and of different sizes. A vacuole was at times observed to gradually disappear; and at times one or more were seen to make their appearance; but it was doubtful whether any of these exactly corresponded with the contractile vesicle of other rhizopods.

Professor Schulze intimates the absence of a contractile vesicle in Gromia;* but Dr. Wallich remarks that in one instance he detected this temporary organ in *Gromia oviformis*.†

The food contents observed in *Gromia terricola* consisted of minute diatoms, fragments of Lyngbya, and globular, green algæ, together with sand and other materials.

In the emission of the pseudopodal filaments of *Gromia terricola*, the protoplasm pours from the mouth of the shell in a slow manner, and gradually envelopes the body, as represented in figs. 1–3. From the protoplasmic envelope delicate streams extend outwardly, at first emanating from the front; they more or less rapidly multiply and radiate in all directions. Gradually extending, they fork into branches of the utmost tenuity. Contiguous branches freely join or anastomose with one another, and thus establish an intricate net, which in its full extent covers an area upward of four times the diameter of that of the body of the Gromia. The pseudopodal net incessantly changes,—putting forth new branches in any position, while others are withdrawn,—diminishing and disappearing in one spot, while it spreads and becomes more complex in another spot.

Gromia terricola, with its pseudopodal net fully spread, like its near relatives, reminds one of a spider occupying the centre of a circular web. If we imagine every thread of the latter to be a living extension of the animal under the same control as its limbs, the spider would be a nearer likeness to the Gromia Over each and every thread of the pseudopodal net Gromia has as complete control as if the threads were permanently differentiated limbs acted on by particular muscles, and directed in their movements by nervous agency. Threads dissolve their connection and are withdrawn; new ones are formed and establish other connections: they bend; they contract into a spiral; they occasionally move like the lashing of a whip, and indeed produce almost every conceivable variety of

*Archiv f. mikros. Anatomie, 1875, 116.

†Annals and Magazine of Natural History, 1863, 458.

motion. Not unfrequently spindle-like accumulations of protoplasm occur in the course of the pseudopodal threads. Sometimes, through the conjunction and spreading of several of the latter together, islet-like expansions occur, and become the centres of secondary nets.

The pseudopodal extensions of Gromia consist of pale granular protoplasm with coarser and more defined granules. The latter are observed to be in incessant motion along the course of the threads, flowing in opposite directions in all except those of the greatest delicacy. See fig. 4. In the larger threads, the granules are immersed and near together; in the smallest threads, they are in single rows, more or less widely separated, and thicker than the threads, so that these appear like strings of minute beads.

In the flow of the granules in the pseudopodal threads, they are sometimes seen to slacken their speed, or for a moment become stationary, and then reverse their course. Granules arriving at a dividing branch are sometimes retarded, and then take one or another direction; or, passing from one main branch to another through a by-path, they may take a reverse course from their former one.

The movements of the granules, though apparently independent, are rather due to the currents or flow of the protoplasm constituting the basis of the pseudopodal threads.

Besides the granules, minute vacuoles often make their appearance along the course of the pseudopods. Some of these seem to be of the character of contractile vesicles,—starting as mere points, slowly enlarging, and then collapsing. Other circular spots in the pseudopodal threads, or in patches formed by union and anastomosis of the latter, appear as mere circular spaces, due to spreading of the protoplasm in the meshes of the net.

Occasionally, minute diatoms and other objects which come within the territory of the pseudopodal net of *Gromia terricola* are seen to become immersed in the substance of the threads, and to move along in a manner reminding one of a boat carried along in the current of a river.

Gromia terricola, by means of its pseudopodal net, was observed to be strongly disposed to accumulate around it a quantity of dirt, and especially at the posterior part of the body, as seen in fig. 1. In one individual, after completely surrounding itself with sand and dirt, it entirely withdrew its pseudopodal rays, and nothing that was done could induce the animal again to protrude them.

Commonly, the specimens under observation remained nearly stationary in position, but occasionally the body appeared to be dragged along with extreme slowness through aid of the anterior pseudopodal extensions.

BIOMYXA.

Greek, *bios*, life; *muxa*, mucus.

Initial form spherical, but incessantly changing, consisting of a glairy, colorless, finely granular protoplasm, which has the power of expanding and extending itself in any direction, and of projecting pseudopodal filaments, which freely branch and anastomose; a circulation of minute granules in currents along the body and pseudopods; contractile vesicles numerous and minute, and occurring both in the body and pseudopods. A nucleus present or absent.

BIOMYXA VAGANS.

Plates XLVII, figs. 5–12; XLVIII.

Biomyxa vagans. Leidy: Proc. Ac. Nat. Sc. Phila. 1875, 124.

Body at rest, spheroidal, oval, or botuliform; in motion, of ever changing form,—centrally spheroidal, or elliptical, discoid, cylindroid, fusiform, triangular, quadrate, band-like, or dividing into several portions,—with pseudopodal prolongations, usually as filaments, mostly bipolar, of very variable form and length, branching and anastomosing so as to produce more or less intricate nets, often expanding into perforated patches. Composed of pale granular protoplasm with oil molecules, and numerous minute contractile vesicles appearing at the surface of the body and along the pseudopodal extensions. Nucleus when present large, distinct, clear or faintly granular. Vacuoles few or none.

Size.—Exceedingly variable.

Locality.—Sphagnous swamps, in bog-water. New Jersey and Pennsylvania.

In the Proceedings of the Academy of Natural Sciences of Philadelphia for April, 1875, I published a brief notice of a curious organism, under the name of *Biomyxa vagans.* I first discovered it in water with aquatic plants and sphagnum, from the border of Absecom pond, New Jersey, collected in the autumn and preserved in the house during the winter. The same thing I again found in sphagnum, obtained the following August, in the same locality, and in September, on Broad Mountain, Schuylkill County, Pennsylvania. Subsequently I observed specimens collected with sphagnum at Kirkwood station on the Camden and Atlantic railway.

Biomyxa vagans, as represented in figs. 5–12, pl. XLVII, and pl. XLVIII, is a colorless body of ever changing and most variable form, consisting of a glairy, colorless, finely granular protoplasm. From a usually more or less central mass or body it spreads itself into a sheet of irregular form, giving off pseudopodal extensions, which branch and anastomose with one another.

Biomyxa moves slowly, incessantly, and evenly, and never for a moment remains the same. The body mass of protoplasm composing it may spread more or less uniformly from the initial spheroidal form, or it may spread unequally, or divide and extend in any direction. Frequently it becomes narrowly extended at one or both poles, becoming more and more elongated into a cord, which may expand into a band, or may divide and extend into several divergent cords or bands. The whole or different portions may expand and become very thin, even to such a degree as to break into fissures and circular holes.

The pseudopods appear as long, tapering extensions of the body protoplasm, often forking, and with the terminal branches as exceedingly delicate filaments. Contiguous branches frequently anastomose and form nets, which here and there, by expansion, assume the aspect of thin patches with circular holes. The pseudopods are quickly produced, and as quickly modified or withdrawn.

A circulation of granules takes place along the course of the pseudopodal extensions of Biomyxa as in Gromia. It occurs both outwardly and inwardly at the same time in the trunks and larger branches, but in one direction only in the finest. In the flow, frequent fusiform accumulations of protoplasm are produced along the pseudopodal extensions, and these sometimes expand into patches or become secondary centres for the emanation of pseudopodal filaments.

In Biomyxa there is not the slightest distinction between endosarc and ectosarc, the whole structure being a homogeneous, pale and finely granular protoplasm, with variable proportions of minute oil molecules, with fewer, large, darkly defined granules, probably also oil-like in character. It contains numerous minute contractile vesicles, commonly ranging from 0.002 mm. to double that size, and rarely reaching quadruple the same. They are usually best seen and readily recognized by their characteristic movements—slow enlargement, sudden collapse, and reappearance—along the borders of the body and in the forks and nodal expansions of the pseudopods.

Rarely distinct vacuoles, independently of the contractile vesicles, and much larger, are to be seen within the body mass of Biomyxa The round holes which are often produced by the expansion and rupture of portions of the protoplasm or by the closure of meshes in pseudopodal nets are to be distinguished from the true vacuoles.

Biomyxa vagans occurs of very variable size, and sometimes appears so devoid of a definite centre, and without nucleus or other conspicuous element, that I have supposed it was perhaps nothing more than a detached fragment of Gromia.

It has also been a question with me whether to regard it as a true rhizopod or whether to view it as the plasmodium of a fungus.* In structure and habit, so far as observed, it seems to accord with the latter rather than with the former, though I have not detected a coalescence of individuals in Biomyxa

Cienkowski† has described several organisms, related with the latter, of which he regards one as a 'fresh-water plasmodium,' while the others are viewed as Rhizopods, under the names of *Vampyrella vorax* and *Arachnula impatiens.*

The character of Vampyrella has already been given; the diagnosis of Arachnula is as follows: body naked, colorless, without nuclei, with one or more contractile vacuoles; pseudopods but little branched, sometimes anastomosing, usually springing by thick cords from any part of the surface of the body.‡

In the same memoir, under the head of Naked Rhizopods, Cienkowski

* The researches of Bary, Cienkowski, and others show that the spores of the little fungi of the family Myxogastres emit flagellate cellules, which subsequently lose the flagellum and assume the appearance and movements of Amœbas. By continued growth and coalescence, a number of the amœboid cellules form together a branching and reticular layer of protoplasm, retaining its motory power, and named 'plasmodium' by Cienkowski. The plasmodium finally produces the spore-bearing fungus.

† Archiv f. mikros. Anatomie, 15, 1876.

‡ Ibidem, 27.

describes a form with the name of *Gymnophrys cometa*, * which resembles Biomyxa, as represented in fig. 12, pl. XLVII, and figs 7–9, 13, 14, pl. XLVIII. The former, however, differs in having no contractile vesicles. In this respect, likewise, Biomyxa differs from the nearly related Leptophrys of Hertwig and Lesser.†

As represented in fig. 6, pl. XLVIII, Biomyxa closely resembles the *Amœba porrecta* of Schultze, ‡ from the Adriatic

One of the earliest observed specimens of *Biomyxa vagans*, represented in fig. 1, pl. XLVIII, occupied, as first seen, a nearly semicircular space, about 0.6 mm. by 0.4 mm. The main protoplasmic mass extended from a common base in three bands, of which the intermediate one was longest and tapering as it was resolved into divergent pseudopodal branches; while the lateral bands expanded outwardly, and presented large circular holes previous to branching. The pseudopodal extensions freely anastomosed with one another. Small contractile vesicles appeared in many places, both in the principal bands and in the pseudopods. The median band and base contained numerous minute fusiform desmids, all of the same kind.

The protoplasm of the main bands exhibited a faintly striate appearance, perhaps due to an arrangement of granules occasioned by currents. Circulation was observed in different directions at the same time, as indicated by the arrows in the figure.

The organism gradually changed its shape, becoming a single band, then a central elliptical disk, etc. Large angular spaces included in the anastomosis of the pseudopodal extensions would slowly diminish, assume a circular form, and continue to decrease until they seemed to be vacuoles, or in their final closure as if they were contractile vesicles. The pseudopodal filaments were rather quickly projected, and sometimes as quickly contracted and entirely withdrawn. Occasionally they would appear tortuous, or would be seen with a slow, waving, or feeble, lashing movement.

Circulation, indicated by the motion of the granules, occurred along the course of the pseudopods, often in a reverse direction on the two sides

* Ibidem, 31. In an excellent compilation of "Recent Contributions to our Knowledge of Fresh-water Rhizopods," published in the Quarterly Journal of Microscopic Science, 1877, 349, Mr. Archer expresses an opinion in regard to Gymnophrys which accords with an early impression of my own in relation to Biomyxa. He remarks "that the figures of this Sarcodine remind one not a little of a *portion* of the mass of a Gromia become isolated and detached by some readily conceivable force, having wandered too far from the headquarters."

† Ibidem, 57, 1874.

‡ Ueber d. Organismus d. Polythalamien, 1854, 8, Taf. vii, Fig. 8.

of the same filament. Feeble movements, circulatory as well as contractile and expansile, were also seen in the body mass of the creature. Preserved until the following day, it presented no essential change, excepting that it had completely discharged all the desmids previously noticed.

In the same drop of water containing the individual just described there was a very much smaller one, which I supposed might be a fragment of the former. When detected, it presented an elliptical body prolonged into pseudopodal extensions at the opposite poles, as seen in fig. 2, and after a little the body appeared to run along one of the pseudopodal extensions to the end, like a drop of water flowing upon a string, when the creature assumed the shape seen in fig. 3. From the side of the body, in the latter condition, there projected a delicate pseudopod, which was noticed to vibrate slowly toward the main one.

The successive changes of shape of Biomyxa are sufficiently rapid often to render it difficult to delineate the exact forms. Figs. 5 and 6, pl. XLVII, represent two such changes in one individual, and figs. 7–9 three changes in another individual. Fig. 10 represents a third individual accompanying the preceding. The arrows indicate the general direction in the circulation of the granules. Figs. 4–6, pl. XLVIII, represent successive changes of another individual. As first seen, it was regarded as a minute worm casting; but after a moment its movements and extension of pseudopods indicated its true character.

The material containing the specimens above described, consisting mainly of sphagnum, was collected from the edge of Absecom pond, New Jersey, in September, 1874, and was preserved in a glass-covered case during the winter. The Biomyxas were noticed in association with a multitude of minute, bright-green, one-celled algæ, in a transparent jelly attached to the side of the glass case contiguous to the sphagnum covering the bottom of the latter.

At no time had I the opportunity of observing Biomyxa take food of any kind, and rarely have I noticed food within the animal. On one occasion I saw an individual which attracted my attention from its having entangled in its pseudopodal net two active, green Euglenias. These were watched with much interest, under the impression that they had been captured as food; but, after much wriggling, they both disengaged themselves, and escaped.

Fig. 12, pl. XLVII, and figs. 7–9, pl. XLVIII, represent four views of an individual, exhibiting the chief successive forms assumed in the course of an hour. The specimen was obtained, with others of the same character, in wet sphagnum, from the cedar swamp of Absecom, collected in August, 1876.

Organisms exactly of a like character to those above described I also obtained in sphagnum collected on Broad Mountain, Schuylkill County, Pennsylvania, in September, 1876. Figs. 10–14, pl. XLVIII, and fig. 11, pl. XLVII, represent six successive changes of an individual of the kind, as observed during one hour and twenty minutes.

None of the specimens above described or indicated contained any trace of a nucleus, and my impression of Biomyxa, as derived from the observation of these, was that it would form a member of the order of Monera, notwithstanding its possession of contractile vesicles, which are also considered as being absent in the latter.

In April, 1877, in material from a sphagnous swamp near Kirkwood station on the Camden and Atlantic railway, I found an organism agreeing with the former in all respects, except that it contained a distinct nucleus. This was globular and distinctly and uniformly granular. An individual of the kind, exhibiting three successive changes of form, is represented in figs. 18–20, pl. XLVIII.

With the nucleated specimens, others were detected without nuclei, mostly smaller, and looking as if they might be fragments of the former. Three successive views of an individual of this character are represented in figs. 15–17.

Nearly at the same date with the last observations, and under circumstances almost exactly similar to those in which I originally discovered *Biomyxa vagans*, I found an organism which I have supposed to be the nucleated form or condition of the latter. It was detected in a clear jelly, among numerous minute desmids, some of which were crescentoid and others straight and fusiform. The creature, of which a number of examples were noticed, appeared in general of a more compact or less translucent character than Biomyxa as commonly seen, and though of very changeable form appeared less disposed to produce those extreme changes observed in the latter. Fig. 21, pl. XLVIII, represents an individual of the kind, and figs 22–25 represent four successive changes of form of a second individual. The body was composed of colorless granular protoplasm, with numerous, scattered, darkly defined granules. The nucleus was large, globular, and clear, and contained a nucleolus. Mostly, it was central, though frequently displaced from this position in the successive changes of shape of the body. Several contractile vesicles occupied the borders of the latter, exhibiting the usual characteristic movements. None of the specimens contained distinct food, though occasionally colorless vacuoles, apparently different from the contractile vesicles, were observed among the contents. An individual, shortly after being noticed, was seen to discharge a large oval mass with granules, as represented in fig. 22.

LISTS OF FRESH-WATER RHIZOPODS, INDICATING THE MANY FORMS WHICH OCCUR TOGETHER IN CERTAIN LOCALITIES.

I. LIST OF RHIZOPODS OBSERVED IN THE SEDIMENT OF WATER SQUEEZED INTO A WATCH CRYSTAL FROM A SMALL BUNCH OF SPHAGNUM COLLECTED IN THE CEDAR SWAMP IN THE VICINITY OF MALAGA, GLOUCESTER COUNTY, NEW JERSEY, JUNE 6, 1879.

1. DIFFLUGIA PYRIFORMIS. Forms like those of figs. 14, 22–25, pl. x. Frequent.
2. D. ACUMINATA. Like those of figs. 23–26, pl. xiii. Frequent.
3. D. CONSTRICTA. Like those of figs. 5–7, 37–44, pl. xviii. Frequent.
4. D. GLOBULOSA. Small forms; numerous.
5. D. ARCULA. Figs. 34–37, pl. xv. Occasional.
6. D. SPIRALIS. Few.
7. NEBELA COLLARIS. Many varieties. Flask-like forms, with neck of variable length; length 0.06 mm. to 0.066 mm.; greater breadth 0.027 mm. to 0.036 mm. Broader pyriform kind, with less well defined neck: length 0.072 mm. to 0.132 mm.; greater breadth 0.042 mm. to 0.09 mm. Variety *N. binodis*, as in figs. 1–7, pl. xxii: length 0.12 mm.; greater breadth 0.054 mm. Varieties with the shell merging in structure into that of Difflugia, composed of irregularly angular and rod-like plates, or variable proportions of these with diatoms and fragments of the same, or with round or oval disks: sizes ranging from 0.09 mm. to 0.15 mm. in length by 0.084 mm. to 0.12 mm. in greater breadth. Variety *N. retorta*, a peculiar form for the first time observed; a single specimen as represented in the woodcut on page 151; shell retort-form, or resembling in shape that of *Cyphoderia ampulla*, but in structure characteristic of Nebela, being composed of circular disks of variable size: length 0.144 mm.; greater breadth 0.072 mm.; less breadth 0.036 mm.; greater breadth of mouth 0.027 mm.
8. N. FLABELLULUM. Length 0.09 mm.; greater breadth 0.096 mm. Comparatively few.
9. N. BARBATA. Occasional.
10. N. ANSATA. Shell composed of circular disks. Length 0.21 mm. to 0.24 mm.; greater breadth at fundus 0.102 mm. to 0.108 mm.; between ends of processes 0.132 mm. to 0.144 mm. Few.
11. N. CARINATA. Length 0.216 mm. to 0.228 mm.; greater breadth 0.156 mm.; depth of keel 0.018 mm. Rare.
12. N. CAUDATA. As in figs. 22–24, pl. xxvi. Rare.

13. ARCELLA VULGARIS. Varieties with both evenly convex and mammillated fundus. Occasional.
14. A. DISCOIDES. Frequent, and of varied sizes.
15. A. MITRATA. Rare.
16. HELEOPERA PICTA. Frequent.
17. H. PETRICOLA. Occasional, but more frequent than usually. In some the shell was incorporated with sand the greater part of its extent.
18. QUADRULA SYMMETRICA. Occasional.
19. CENTROPYXIS ACULEATA. Frequent and varied. Variety *C. ecornis* grading by intermediate ones into *Difflugia constricta*. Frequent.
20. HYALOSPHENIA PAPILIO. Frequent, but not so abundant as commonly observed in sphagnum from similar localities.
21. H. ELEGANS. Frequent.
22. EUGLYPHA CILIATA. Generally small, and very variable in size; larger ones occasionally devoid of cils. Large empty shells with twelve blunt, thickened denticles to the mouth; plates of the shell distinctly hexahedral and in close juxtaposition, with no signs of being oval and overlapping at the contiguous borders. Variety *E. strigosa*. Abundant.
23. E. CRISTATA. Frequent. A small individual with four conspicuously thickened denticles to the mouth of the shell was 0.054 mm. long, 0.018 mm. broad, and 0.009 mm. at the mouth.
24. E. BRACHIATA. Occasional. Two empty shells adhered at the mouth, as if when alive the animals had been in conjugation. The shells had each six acute denticles to the mouth, the plates of which were not perceptibly thicker than elsewhere. The plates generally were nearly round, and overlapped at the contiguous borders, so as to include hexahedral spaces. One shell was provided with a pair of lateral hair-like spines as usual, but the other shell was spineless. Size of the spinous shell 0.108 mm. long, 0.036 mm. broad, and 0.0135 mm. at the mouth; of the spineless shell 0.102 mm. long, 0.036 mm. broad, and 0.012 mm. at the mouth.
25. E. MUCRONATA. Occasional. Several without the mucro, but otherwise the same.
26. ASSULINA SEMINULUM. Frequent. Several large and uncolored observed besides the ordinary brown variety.
27. SPHENODERIA LENTA. Frequent. Observed several with the border of the mouth minutely but feebly denticulate.
28. S. MACROLEPIS. Frequent. A species for the first time observed, with characters as follows: small, compressed pyriform, with the neck gradually prolonged from the body. The latter with a pair of wide hexagonal plates across the intermediate portion of the broader sides of the shell. Length 0.036 mm.; breadth 0.024 mm.; width of mouth 0.012 mm. See woodcut, page 232.
29. CYPHODERIA AMPULLA. Few.
30. TRINEMA ENCHELYS. Numerous and of many varieties. Several bright brown shells, like those of Arcella, for the first time observed.
31. PLACOCISTA SPINOSA. Rare.
32. PSEUDODIFFLUGIA GRACILIS. Like fig. 21, pl. xxxiii. Length 0.045 mm.; breadth 0.03 mm., and at mouth 0.018 mm. Occasional.
33. CLATHRULINA ELEGANS. Dead shells, or individuals in the quiescent state. One observed in the latter condition containing five nucleated balls, 0.009 mm. in diameter. Occasional.

34. HYALOLAMPE FENESTRATA. All rayless individuals. Occasional.
35. ACANTHOCYSTIS? With delicate, simple, unforked spines. Occasional.
36. AMPHIZONELLA VIOLACEA? A single individual; for the first time observed. In the spheroidal form about 0.15 mm. diameter; endosarc of a deep violet hue; ectosarc colorless. Animal remained nearly stationary in position, with slight changes of form, and emitted from one to three digitate pseudopods, sometimes blunt, sometimes pointed, even or irregular, clear and colorless at the periphery and ends, but violet internally at the base.
37. AMŒBA RADIOSA. Occasional.
38. A. PROTEUS? Occasional.

With the Rhizopods there were associated a multitude of desmids—Micrasterias, Euastrum, Docidium, Closterium, etc., diatoms, etc., etc.

II. RHIZOPODS OBSERVED IN MATERIALS COLLECTED IN THE TRAP REGION OF ROCK HILL, BUCKS COUNTY, PENNSYLVANIA, JUNE 27, 1879.

a. From sediment of a ditch traversing a meadow in which grew Spatter-dock, *Nuphar advena.*

1. DIFFLUGIA GLOBULOSA. Ovoid variety, with the narrower pole truncated by the circular mouth, which sometimes has a short, straight, or a slightly everted rim. Shell composed of fine quartz-sand or of chitinoid membrane incorporated with thin angular plates of quartz. Endosarc colorless. Length 0.09 mm.; breadth 0.06 mm.; width of mouth 0.024 mm. Frequent.
2. D. PYRIFORMIS. Ordinary forms, mostly small. Shell of quartz-sand. Endosarc in some green, in others colorless. Frequent.
3. D. ACUMINATA. Shell of chitinoid membrane incorporated with variable proportions of thin angular plates of quartz-sand. Few.
4. D. LOBOSTOMA. Shell nearly spherical or oval, composed of angular quartz-sand; mouth trilobate, sometimes with a short and slightly reflected rim. Endosarc green. Frequent. Variety with smoky-colored shell, composed of fine angular sand, in shape spheroidal, oval or ovoid, and even, or mammillary, like *D. tuberculata*, Wallich; mouth six-lobed, with or without a narrow projecting rim. Length 0.132 mm.; breadth 0.12 mm.; width of mouth 0.036 mm. Frequent. Variety with shell of chitinoid membrane incorporated with variable proportions of thin angular plates of quartz; endosarc colorless. Few.
5. D. CONSTRICTA. Of varied sizes and proportions; yellow and colorless shells of quartz-sand. Frequent.
6. D. SPIRALIS. Characteristic specimens with shell of quartz-sand. Occasional.
7. CENTROPYXIS ACULEATA. Abundant, of considerable variety, large and small, mostly yellow or brown, and generally having the chitinoid shell incorporated with much sand. Variety *C. ecornis.* Frequent and merging into *Difflugia constricta.*
8. ARCELLA VULGARIS. Shell with even, convex, and with mammillated or cupped fundus. Frequent.

9. ARCELLA. One specimen observed with transversely oval shell 0.1 mm. long, 0.072 mm. broad, and 0.036 mm. high, with mouth 0.045 mm. in the long and 0.024 mm. in the short diameter. Even convex fundus and of bright burnt-sienna color. Animal active.
10. NEBELA COLLARIS. Narrow form with the cancellated structure of the shell obscurely developed. Rare.
11. TRINEMA ENCHELYS. Abundant, and of varied size and development.
12. CYPHODERIA AMPULLA. Well developed and active; shells yellowish and colorless. Frequent.
13. EUGLYPHA ALVEOLATA. Small spineless forms, of variable sizes and proportions, and with 4, 6, and 8 teeth to the mouth. Frequent.
14. EUGLYPHA CILIATA. With and without lateral hairs.
15. PSEUDODIFFLUGIA GRACILIS. Oval form. Occasional.

b. Contiguous to the ditch, from which the former were obtained, in the same meadow, there grew an unusual profusion of *Selaginella apus.* Portions of the plant, with earth adherent to the roots, on being moistened and squeezed, gave a sediment, which, besides many bright active diatoms, desmids, etc., yielded the following Rhizopods:

1. DIFFLUGIA GLOBULOSA. Shell oval or ovoid, even, colorless or yellowish, composed of chitinoid membrane incorporated with variable proportions of thin, irregular, angular plates of quartz, or composed of small sand particles. Mouth truncating the narrower pole, circular, sometimes with a short, straight, or slightly everted rim. Endosarc colorless. Length 0.072 mm. to 0.09 mm.; breadth 0.036 mm. to 0.048 mm.; width of mouth 0.018 mm. Frequent.
2. D. PYRIFORMIS. Small form; shell of quartz-sand. Length 0.108 mm. to 0.156 mm. Not unfrequent.
3. D. CONSTRICTA. Of varied proportions, colorless and yellowish, and merging into *Centropyxis ecornis.* Frequent.
4. QUADRULA SYMMETRICA. Occasional. Length 0.072 mm.; breadth 0.036 mm.
5. ARCELLA VULGARIS. Living and active. Shell with cupped fundus. Occasional.
6. TRINEMA ENCHELYS. Abundant and of varied sizes and proportions, and with varied degrees of obliquity. Ranging from 0.024 mm. to 0.096 mm. in length. A specimen constricted just above the position of the mouth was 0.96 mm. long, 0.042 mm. broad at the fundus, and 0.03 mm. wide opposite the mouth, which was 0.021 mm. wide.
7. EUGLYPHA ALVEOLATA. Small forms, spineless, with 4, 6, and 8 teeth to the mouth. From 0.03 mm. to 0.72 mm. long; 0.018 mm. to 0.036 mm. broad. Frequent.
8. E. CILIATA. Compressed forms, with lateral hairs, and 4- to 6-toothed. A specimen observed with divergent hairs to the summit of the fundus in addition to the lateral ones. Its length 0.06 mm.; breadth 0.03 mm.; mouth 0.012 mm.; nucleus 0.012 mm. Occasional.
9. CYPHODERIA AMPULLA. Several dead shells.
10. SPHENODERIA LENTA. Common form. Occasional. Also a variety *S. dentata*, with oval shell, composed of oval, overlapping plates; neck short or obsolete; mouth elliptical, oblique, with the border minutely denticulated. Length 0.054 mm.; breadth 0.03 mm.; width of mouth 0.012 mm.

III. RHIZOPODS OBSERVED IN SLIME WITH MOSS AND ALGÆ SCRAPED FROM THE VERTICAL FACE OF DRIPPING GNEISS ROCKS OF FAIRMOUNT RESERVOIR, PHILADELPHIA, JULY 6, 1879.

1. DIFFLUGIA CONSTRICTA. Occasional, and merging into forms which might be equally well viewed as the variety *Centropyxis ecornis;* 0.09 mm. long, 0.078 mm. broad, and with mouth 0.036 mm. wide. An unusually long specimen was 0.12 mm. long, 0.072 mm. in the greater and 0.054 mm. in the less breadth. When the mouth was on a level it stood 0.06 mm. high. All specimens of a yellowish hue.
2. CENTROPYXIS ACULEATA.' Small, of yellowish chitinoid membrane incorporated with sand, and usually with two or three spines. Length 0.072 mm.; breadth 0.06 mm.; width of mouth 0.03 mm.
3. EUGLYPHA ALVEOLATA. Small, spineless form; abundant. Shell ovoid; transverse diameters uniform, rarely slightly compressed; fundus obtuse, rarely in the smallest acute; mouth with 4, 6, or 8 teeth, the number not in accordance with size. More dead shells than living specimens; many with the sarcode apparently resolved into spores, which were shining, oil-like globules, from one or two to half a dozen or more in number, and of pretty uniform size, being about 0.012 mm. Specimens mostly 0.066 mm. to 0.072 mm. long, 0.036 mm. to 0.042 mm. broad, and 0.018 mm. wide at the mouth. Ranging from 0.033 mm. to 0.09 mm. in length, by 0.012 mm. to 0.042 mm. in breadth. Nucleus of the sarcode about 0.018 mm. Variety: several dead shells with the mouth oblique or subterminal; 0.06 mm. in length, 0.036 mm. in breadth, and 0.0135 mm. wide at the mouth. Variety: with a slight curvature approaching the mouth. A living specimen 0.06 mm. in length, 0.036 mm. in breadth, and 0.012 mm. wide at the mouth.
4. EUGLYPHA CILIATA. One living specimen observed. Shell ovoid, compressed, with three spines to one side, two to the other, and one to the fundus; mouth with four thickened teeth. Length 0.06 mm.; greater breadth 0.024 mm.; at mouth 0.009 mm. Resembled fig. 14, pl. xxxvi.
5. TRINEMA ENCHELYS. Mostly dead shells, small, and frequent. The cancellated structure not visible in the smaller but distinct in the larger ones. From 0.03 mm. to 0.078 mm. in length, 0.012 mm. to 0.042 mm. in breadth. Several with the sarcode encysted, and several with the latter resolved into spores. A pair of empty shells, observed adhering mouth to mouth, as in conjugation, and disposed in the same direction, and not in opposite directions as previously noticed. One of the shells 0.042 mm. long, the other 0.03 mm. long.
6. ACTINOPHRYS SOL. Occasional; in active condition. A pair observed either in conjugation or act of division.
7. AMŒBA RADIOSA. Few.
8. A. VERRUCOSA. Young condition as *A. quadrilineata.*
9. A. PROTEUS? Young. Occasional.

CONCLUDING REMARKS.

In closing my observations on the Fresh-water Rhizopods, the results of which are now presented to the world, I am impelled to say that they are neither so complete nor so accurate as it was my desire they should be. At one time I was disposed to lay both manuscript and drawings aside, and once more go over the ground before making my researches public. It was only after several years of experience that I felt qualified to investigate the subject in the manner it merits and as I should wish to introduce it to the reader. But, taking into consideration the uncertainty of events, and the probability that I might not be able to obtain and investigate the same or similar materials under equally favorable circumstances, or have an equally favorable opportunity for publication, I concluded to send forth the results of my labors, imperfect as they may be. The novel things of the work must compensate for any deficiencies, and the experiences related will prove of assistance to students who may follow in the same path of investigation. I may perhaps continue in the same field of research and give to the reader further results, but cannot promise to do so; for though the subject has proved to me an unceasing source of pleasure, I see before me so many wonderful things in other fields that a strong impulse disposes me to leap the hedges to examine them.

The objects of my work have appeared to me so beautiful, as represented in the accompanying illustrations, and so interesting, as indicated in their history, which forms the accompanying text, that I am led to hope the work may prove to be an incentive, especially to my young countrymen, to enter into similar pursuits. The study of natural history in the leisure of my life, since I was fourteen years of age, has been to me a constant source of happiness, and my experience of it is such that, independently of its higher merits, I warmly recommend it as a pastime, than which, I believe, no other can excel it. At the same time, in observing the modes of life of those around me, it has been a matter of unceasing regret that so few, so very few, people give attention to intellectual pursuits of any kind. In the incessant and necessary struggle for bread, we repeatedly hear the expression that "man shall not live by bread alone," and yet it remains unappreciated by the mass of even so-called enlightened humanity. In common with all other animals, the engrossing care of man is food for the stomach, while intellectúal food too often remains unknown, is disregarded or rejected.

"Going fishing?" How often the question has been asked by acquaintances as they have met me, with rod and basket, on an excursion after materials for microscopic study. Yes! has been the invariable answer, for it saved much detention and explanation, and now, behold, I offer them the results of that fishing. No fish for the stomach, but, as the old French microscopist Joblet observed, "some of the most remarkable fishes that have ever been seen"; and food fishes for the intellect.

To my pupils, both of the University of Pennsylvania and Swarthmore College, but especially the boys and girls of the latter, who have attended my lectures on natural history, the work will be of interest, as they will recognize in its illustrations many of the simplest forms of animal life with which they have been made familiar through my instruction. Indeed, in the course of preparation of the book I have always had my pupils in mind, and I shall be glad if it serve as an additional aid to their studies.

In conclusion, I embrace the opportunity of thanking those of my friends who have not only expressed a warm interest in my investigations, but who have aided me in my excursions, or who have collected materials in distant localities and sent them to me. Among them, especially, I take the liberty of mentioning Dr. Robert S. Kenderdine, Rev. Thomas C. Porter of Easton, Dr. Joseph K. Corson, U. S. A., Joseph Willcox, Dr. Isaac Lea, Clarence S. Bement, and Charles E. Smith.

CHIEF WORKS AND COMMUNICATIONS RELATING TO THE FRESH-WATER RHIZOPODS, WITH LISTS OF THE FORMS DESCRIBED, AND A PARTIAL AND PROBABLE REFERENCE OF THESE TO CORRESPONDING FORMS DESCRIBED IN THE BODY OF THE PRESENT WORK.

Archer, William.

Numerous Memoirs and Communications on Fresh-water Rhizopods, published in the Quarterly Journal of Microscopical Science, from vol. vi, 1866, to vol. xviii, 1878, inclusive. The titles of the principal ones are given below, followed by a list of the forms described in all.

On Some Fresh-water Rhizopoda, New or Little Known, 1869, ix, 250, 386, pl. xvi, xvii, xx; 1870, x, 17, 101; 1871, xi, 108, pl. vi, vii.

On *Chlamydomyxa labyrinthuloides*, a New Fresh-water Sarcodic Organism, 1875, xv, 107, pl. vi, vii

Résumé of Recent Contributions to Our Knowledge of "Fresh-water Rhizopoda," 1876, xvi, 283, 347, pl. xxi, xxii; 1877, xvii, 67, 107, 197, 330, pl. viii, xiii, xxi.

ACANTHOCYSTIS, x, 26.
A. Pertyana, ix, 199, 252; x, 32, pl. xvi, fig. 1; xii, 195. = A. CHÆTOPHORA?
A. spinifera, xi, 137, pl. vi, figs. 7, 8; xvi, 364, pl. xxii, fig. 8.
A. turfacea, xii, 195; xvi, 361. = ACANTHOCYSTIS CHÆTOPHORA.
A. aculeata, xvi, 365, pl. xxii, fig. 6.
A. flava, xvi, 366, pl. xxii, fig. 7.
ACTINOPHRYS, viii, 69; ix, 42.
A. SOL, xvi, 297, 306.
A. digitata, xv, 102.
ACTINOSPHÆRIUM EICHHORNII, xvi, 301.
Amœba—actinosphærium-like, xi, 101; xii, 94.
A. villosa, with linear appendages, vi, 19, 267; x, 305; xiii, 212; xvi, 337. = OURAMŒBA VORAX.
Amphitrema, vii, 174; x, 122.
A. Wrightianum, x, 20, 122, pl. xx, fig. 4, 5.
Amphizonella vestita, xi, 135, pl. vi, fig. 1–6; xii, 87, 195. = COCHLIOPODIUM VESTITUM
A. violacea, xi, 126, 134; xvii, 464.
A. digitata, xi, 129, 134.
A. flava, xi, 130, 134.
Arachnula impatiens, xvii, 347, pl. xxi, fig. 21.
Arcella globosa, viii, 69.
A. VULGARIS, xvii, 79.
Astrococcus rufus, xvi, 351, pl. xxi, fig. 2.
Astrodisculus, xiii, 320; xvi, 348. = POMPHOLYXOPHRYS?
A. minutus, x, 114. = POMPHOLYXOPHRYS?
A. ruber, x, 115. = POMPHOLYXOPHRYS?
A. flavescens, x, 115. = POMPHOLYXOPHRYS?

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A. flavocapsulatus, x, 115. =POMPHOLYXOPHRYS?
A. radians, x, 115. =POMPHOLYXOPHRYS?
Ciliophrys infusionum, xvi, 300, pl. xxi, fig. 1.
Chlamidophrys stercorea, xvii, 198, pl. xiii, fig. 3. =PAMPHAGUS HYALINUS?
Chlamydomyxa, xv, 107, pl. vi, viii.
Chondropus viridis, xvi, 358, pl. xxii, fig. 20.
CLATHRULINA ELEGANS, viii, 71, 189; x, 117, pl. xvii, fig. 5; xi, 322; xvii, 68, pl. xx, figs 23–25.
Cochliopodium pellucidum, xvii, 334, pl. xxi, fig. 8. =COCHLIOPODIUM BILIMBOSUM.
C. pilosum, xvii, 334. =COCHLIOPODIUM VESTITUM.
Cyphoderia truncata, xvii, 203, pl. xiii, fig. 6.
Cystophrys, x, 110. =PAMPHAGUS?
C. Hæckeliana, viii, 295, 296; ix, 259, pl. xvii, figs. 1, 2; x, 112. =PAMPHAGUS HYALINUS?
C. oculea, ix, 259, 421, pl. xvii, fig. 3; x, 112. =DIPLOPHRYS ARCHERI?
Dactylosphærium vitreum, xvii, 344, figs. 17, 18.
Diaphoropodon, ix, 321; x, 123.
D. mobile, ix, 394, pl. xx, fig. 6; x, 123; xii, 87, 194.
Difflugia acropodia, xvii, 114. =DIFFLUGIA GLOBULOSA?
D. carinata, vii, 178; x, 21, pl. xx, fig. 12; xii, 195. =NEBELA CARINATA.
D. CORONA, vi, 267.
D. triangulata, vii, 174; xii, 195.
D. vinosa, xviii, 212.
Diplophrys? xi, pl. vi, fig. 9, pl. vii, fig. 10.
Ditrema flavum, xvii, 103, 336, pl. xxi, fig. 9.
Euglypha ampullacea, xvii, 203, pl. xiii, fig. 7.
E. sacciformis, xvii, 196.
E. spinosa, xii, 90; xvi, 237. =PLACOCISTA SPINOSA.
E. tincta, xvi, 108; xvii, 103, 330; xviii, 105. =ASSULINA SEMINULUM.
GROMIA, xii, 310.
G. granulata, xvi, 343.
G. paludosa, xvii, 201, pl. xii, fig. 5.
G. socialis, ix, 322, 390; x, 124, pl. xx, fig. 7–11. =PAMPHAGUS HYALINUS?
Gymnophrys cometa, xvii, 348, fig. 22.
Hedriocystis, xvii, 67, pl. xx, fig. 21, 22.
HETEROPHRYS, x, 107; xvi, 351.
H. Fockii, ix, 267, 318, pl. xvi, fig. 3; x, 108; xii, 195; xiii, 214; xv, 331; xvii, 103. =RAPHIDIOPHRYS ELEGANS.
H. MYRIAPODA, ix, 267, 320; x, 110, pl. xvii, fig. 4.
H. marina, xvi, 354, pl. xxii, fig. 13; xv, 202.
H. spinifera, xvii, 67, pl. xx, fig. 21, 22.
HYALODISCUS RUBICUNDUS, xvii, 342, pl. xxi, fig. 16.
Hyalosphenia lata, xvii, 110, pl. viii, fig. 5. =HYALOSPHENIA CUNEATA.
H. ligata, xvii, 464. =HYALOSPHENIA CUNEATA.
Lecythium hyalinum, xvii, 197, pl. xiii, fig. 1, 2. =PAMPHAGUS HYALINUS.
Leptophrys cinerea, xvii, 345, pl. xxi, fig. 19.
L. elegans, xvii, 345, pl. xxi, fig. 20.
Mastigamœba aspera, xvii, 350, pl. xxi, fig. 24.
Microgromia socialis, xvii, 115, pl. viii, fig. 8.
M. mucicola, xvii, 121, 194, 465, pl. viii, fig. 9.
OURAMŒBA. On the proposed genus, xv, 202.
PAMPHAGUS MUTABILIS, xii, 194, 423.
Pelomyxa palustris, xvii, 337, pl. xx, fig. 10–15.
Pinaciophora fluviatilis, xvi, 367, pl. xxii, fig. 5.
Pinacocystis rubicunda, xvi, 367, pl. xxii, fig. 10.
Plagiophrys Hertwigiana, xvii, 124. =PAMPHAGUS.
P. sacciformis, xvii, 122, pl. viii, fig. 11. =PAMPHAGUS.

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P. scutiformis, xvii, 123, pl. viii, fig. 10. = PAMPHAGUS MUTABILIS.
P. sphærica, xi, 146, pl. vii, fig. 11–16. = PAMPHAGUS.
Plakopus ruber, xvii, 349, pl. xxi, fig. 23. = HYALODISCUS RUBICUNDUS.
Platoum parvum, xvii, 199, pl. xiii, fig. 1, 2.
Pleurophrys? amphitremoides, x, 17, 121, pl. xx, fig. 2. = PSEUDODIFFLUGIA.
P.? compressa, xvii, 204, pl. xiii, fig. 9. = PSEUDODIFFLUGIA.
P.? fulva, x, 17, 122, pl. xx, fig. 3; xiii, 437. = PSEUDODIFFLUGIA.
P. lageniformis, xvii, 204, pl. xiii, fig. 8. = PSEUDODIFFLUGIA.
P. sphærica, x, 17, 121, pl. xx, fig. 1; xvi, 343. = PSEUDODIFFLUGIA GRACILIS.
Podosphæra Hæckeliana, viii, 67. = CLATHRULINA ELEGANS.
POMPHOLYXOPHRYS, x, 105.
P. PUNICEA, Syn. *Hyalolampe fenestrata*, ix, 386; x, 105, pl. xvi, fig. 4, 5; xvi, 375.
Pseudochlamys patella, Syn. *Amphizonella flava*, xvii, 107, pl. viii, fig. 1–3. = Young of ARCELLA VULGARIS.
Pyxidicula operculata, Ehr., Syn. *Arcella patens*, Clap. et Lachm. xvii, 110. = Young of ARCELLA VULGARIS?
QUADRULA SYMMETRICA, xvii, 112, pl. viii, fig. 6.
Q. irregularis, xvi, 337; xvii, 103.
RAPHIDIOPHRYS, x, 103; xvi, 368.
R. ELEGANS, xvi, 374, pl. xxii, fig. 19; xvii, 103.
R. pallida, xvi, 370.
R. viridis, vii, 179; ix, 255; x, 103, pl. xvi, fig. 2; xii, 195; xv, 331.
Rhizopod, ix, 323; x, 303; xi, 94, 101; xiii, 102, 317; xvi, 105, 109, 340, 343.
Sphærastrum conglobatum, xvi, 356. = RAPHIDIOPHRYS ELEGANS.
Troglodytes zoster, xvi, 331, pl. xxi, figs. 1–7. = PAMPHAGUS HYALINUS.
Vampyrella Spirogyræ, xvii, 347. = VAMPYRELLA LATERITIA.

Auerbach, Leopold.

Ueber die Einzelligkeit der Amœben. Zeitschrift für wissenschaftliche Zoologie, 1856, vii, 365, Taf. xix–xxii.

Amœba bilimbosa, 374, Taf. xix. = COCHLIOPODIUM BILIMBOSUM.
Amœba actinophora, 392, Taf. x.
AMŒBA RADIOSA, Ehr., 400, Taf. xxi.
Amœba princeps, 407, Taf. xxii. = AMŒBA PROTEUS.
Amœba limax, probably the young of *Amœba princeps*, 430, Fig. 11–16.
Amœba guttula, 430, Fig. 17, 18.

Bailey, J. W.

Microscopic Observations made in South Carolina, Georgia, and Florida. Smithsonian Contributions. Washington, 1850, ii.

Observations on a newly discovered Animalcule. American Journal of Science and Arts. New Haven, 1853, xv, 341.

PAMPHAGUS MUTABILIS.

Notice of Microscopic Forms found in the soundings of the Sea of Kamschatka. Ibidem, 1856, xxii, 1, pl. i.

Cadium marinum, fig. 2. Marine form.
Difflugia? marina, fig. 7. A large marine form, 2¼ mm. long by 1¼ mm. wide, with structure of QUADRULA.

Barker, John.

Quarterly Journal of Microscopical Science.

AMŒBA VILLOSA, vi, 1866, 125.
DIPLOPHRYS ARCHERI, viii, 1868, 123.
Amœba quadrilineata, ix, 1869, 94. = Young of AMŒBA VERRUCOSA.
Heterophrys Fockii, 420. = RAPHIDIOPHRYS ELEGANS.

Barnard, William S.

Protozoan Studies. Proceedings of the American Association for the Advancement of Science, 1875, xxiv, 240 = (A).

New Rhizopods. The American Quarterly Microscopical Journal. New York, 1879, 83 = (B).

Echinopyxis aculeata, A, 241; B, 83, pl. viii, fig. 3. = CENTROPYXIS ACULEATA.
E. tentorium, A, 241; B, 84, fig. 1. = DIFFLUGIA CONSTRICTA?
E. hemispherica, A, 242; B, 84, fig. 2. = CENTROPYXIS ACULEATA?
Euglypha tegulifera, A, 242; B, 85, fig. 4.

Buck, Emil.

Einige Rhizopodenstudien. Zeitschrift für wissenschaftliche Zoologie. Leipzig, 1877, xxx, 1.

Beiträge zur Kenntniss der Entwickelungsgeschichte der *Arcella vulgaris*, 4.

ARCELLA VULGARIS, Taf. i, B, C, H—M.
Arcella Okeni var., Taf. i, A, D. = ARCELLA DENTATA.
Pseudochlamys Patella, Clap. et Lachm. As synonymous with ARCELLA VULGARIS.
Phonergates vorax, 20, Taf. i, Fig. 1–11, Taf. ii.

Bütschli, O.

Zur Kenntniss der Fortpflanzung bei *Arcella vulgaris*, Ehr. Archiv für mikroskopische Anatomie, 1875, xi, 459, Taf. xxv.

Beiträge zur Kenntniss der Flagellaten und einiger verwandten Organismen. Zeitschrift für wissenschaftliche Zoologie, 1878, xxx, 205.

Bemerkungen über die AMŒBA RADIOSA, Ehr., 271. *Podostoma filigerum*, Clap. et Lachm., as synonym.
Amœba Blattæ, 273, Taf. xv, Fig. 26 *a–d*. = ENDAMŒBA BLATTÆ.*

Carpenter, William B.

Introduction to the study of the Foraminifera. London, 1862. Of the Rhizopoda generally; their Organization and Physiological History, and their distribution into subordinate Groups, 12.

ACTINOPHRYS SOL, pl. i, figs. 1–4. After Claparède and Weston.
EUGLYPHA ALVEOLATA, fig. 5. After Dujardin, pl. iv, figs. 9–11. After Carter.
Plagiophrys cylindrica, fig. 6. After Claparède. = PAMPHAGUS.
AMŒBA RADIOSA, fig. 15. After Auerbach, pl. iv, figs. 6, 7. After Carter.
A. princeps, fig. 16. After Auerbach. = AMŒBA PROTEUS.
A. bilimbosa, fig. 17. After Auerbach. = COCHLIOPODIUM BILIMBOSUM.
A.? porrecta, fig. 18. After Schultze. Marine form.
ARCELLA VULGARIS, fig. 19. After Ehrenberg.
DIFFLUGIA GLOBULOSA, fig. 20. After Ehrenberg.
Lagynis baltica, fig. 21. After Schultze. = CYPHODERIA AMPULLA.
Lieberkühnia Wagneri, pl. ii. After Claparède.
AMŒBA VERRUCOSA, pl. iv, fig. 8. After Carter.

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* ENDAMŒBA. General character of Amœba; composed of homogeneous granular protoplasm, in the normal condition without distinction of ectosarc and endosarc; with a distinct nucleus, but ordinarily with neither contractile vesicle nor vacuoles. Intermediate to Protamœba and Amœba.

ENDAMŒBA BLATTÆ.

Eine Art Proteus. Siebold: Beiträge zur Naturgeschichte d. wirbellosen Thiere, 1839, *fide* Stein.

Amöbenform. Stein: Organismus d. Infusionsthiere, 1867, ii, 345.

Amœba Blattæ. Bütschli: Zeitschrift für wissenschaftliche Zoologie, 1878, xxx, 273, Taf. xv, Fig. 26.

Initial form globular, passing into spheroidal, oval, or variously lobate forms, mostly clavate and moving with the broader end in advance. Protoplasm more or less distinctly striate when in movement. Nucleus spherical, granular; with a large nucleolus. Size of globular forms 0.054 mm. to 0.075 mm. in diameter; elongated forms 0.075 mm. by 0.06 mm. to 0.15 mm. by 0.09 mm. Parasitic in company with *Nyctotherus ovalis*, *Lophomonas*, *Thelastomum gracile*, etc., in the large intestine of *Blatta orientalis*.

Carpenter, William B.

The Microscope and its Revelations. 5th edition. Philadelphia, 1875.

Carter, H. J.

Notes on the Fresh-water Infusoria of the Island of Bombay, No. 1. Organization. The Annals and Magazine of Natural History. London, 1856, xviii, 115, 221, pl. v–vii.

Amœba quadrilineata, 243, pl. v, fig. 3; pl. vii, fig. 81. = AMŒBA VERRUCOSA, young.
A. Roeselii? Duj., pl. v, figs. 4, 24.
A. Gleichenii? Duj., figs. 5–8.
A. radiosa? Duj., figs. 10–18. = COCHLIOPODIUM BILIMBOSUM.
EUGLYPHA ALVEOLATA, Duj., figs. 25–27.
Arcellina vulgaris, Ehr., 247, pl. vii, fig. 79. = ARCELLA VULGARIS.
Difflugia tricuspis, 247, fig. 80. = DIFFLUGIA LOBOSTOMA.
D. proteiformis, 128. = DIFFLUGIA LOBOSTOMA.

Additional Notes on Fresh-water Infusoria in the Island of Bombay. Ibidem, 1857, xx, 34, pl. i.

AMŒBA VERRUCOSA, 37, 40, pl. i, figs. 12, 13.
Euglypha pleurostoma, 35, 41, fig. 19. = TRINEMA ENCHELYS.

On Amœba princeps and its Reproductive Cells, etc. Ibidem, 1863, xii, 30, pl. iii.

Amœba princeps. = AMŒBA VILLOSA.

On the Value of the "Villi" on the surface of Amœba as a Specific Distinction. Ibidem, 198.

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Amœba princeps, 19. = AMŒBA PROTEUS and AMŒBA VILLOSA.
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Difflugia pyriformis (var. *symmetrica*), 458, 467, fig. 16. = QUADRULA SYMMETRICA.
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Classification of forms, page 240, as follows:
Species 1. *Difflugia proteiformis* (Ehr.).
Subspecies 1. *D. mitriformis* (Wal.).
Variety *a*. *D. acuminata* (Ehr.).
b. *D. spiralis* (Leclerc).
c. *D. pyriformis* (Perty).
d. *D. lageniformis* (Wal.).

Wallich, G. C.

Subspecies 2. *D. globularis* (Duj.).
Variety *a.* *D. tuberculata* (Wal.).
D. aculeata (Ehr.).
D. corona (Wal.).
Subspecies 3. *D. Arcella* (Ehr.).
4. *D. marsupiformis* (Wal.).
Variety *a.* *D. cassis* (Wal.).
Species 2. *Euglypha alveolata* (Duj.).
Subspecies *E. Enchelys* = *D. Enchelys* (Ehr.) = *Trinema acinus* (Duj.).
Species 3. *Euglypha margaritacea* = *Cyphoderia margaritacea* (Schlum.).
Variety ? *E. baltica* = *Lagynis baltica* (Schultze).

Difflugia globularis, figs. 1, 2, 17, 21. = DIFFLUGIA GLOBULOSA.
D. marsupiformis, figs. 3–5. = DIFFLUGIA CONSTRICTA.
D. cassis, fig. 6. = DIFFLUGIA CONSTRICTA.
D. mitriformis, figs. 7, 8. = DIFFLUGIA ACUMINATA ?
D. PYRIFORMIS, figs. 9, 10; also fig. 12, specimen of the mitriform series.
D. ACUMINATA, fig. 11; also figs. 12, 12*a*, 12*b*, specimens of the acuminate series.
Oblong variety, figs. 13, 14. = D. GLOBULOSA.
Difflugia lageniformis, figs. 15, 16. DIFFLUGIA URCEOLATA.
D. tuberculata, fig. 18. = D. GLOBULOSA ?
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D. aculeata, fig. 23. = CENTROPYXIS ACULEATA.
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Euglypha enchelys, figs. 46, 47. = TRINEMA ENCHELYS.
E. margaritacea, fig. 48. = CYPHODERIA AMPULLA.

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Names in small capitals refer to descriptions in the body of the work; those in italics to synonyms and forms incidentally mentioned.

REFERENCES TO THE PLATES.

The figures have all been drawn in their proper proportions upon a scale of measurements, which are given in diameters, or in fractions of the millemetre. It was intended to make the drawings generally upon the same scale of measurement, but subsequent comparison of the size of the figures with the actual measurements of the specimens indicated wide variation in the scale.

The lithographs fairly represent the characteristic features of the specimens, though not so well as the original drawings. The soft protoplasmic structure in general is too darkly and definitely outlined, and often too deeply shaded.

In regard to the contents of the animals when visible, so far as the more conspicuous objects are concerned, the relative proportions are preserved. In the case of the food, when consisting of definite forms such as diatoms, desmids, etc., while the shapes and proportions have been mostly represented, comparatively little attention was given to accuracy in delineating the details of their structure.

In those figures in which a pink ball is observed it is intended to represent the appearance of the contractile vesicle, but generally it is colored too deeply. The same is often represented without color. Arrows drawn with many of the figures mostly indicate the direction of movement in the animals.

When the size of the figures in diameters is not indicated, it is the same as in the preceding figure in which the measurement is given.

PLATE I.

FIGS. 1–7.—AMŒBA PROTEUS.

FIG. 1. An individual as often observed shortly after being transferred to the field of the microscope. At first simply globular or oval, it quickly projects numerous small pseudopods as represented. At the lower part of the figure the discoid nucleus *n* and the contractile or pulsating vesicle *p. v.* are seen. 200 diameters. From a ditch below Philadelphia.

FIG. 2. Another individual of the same kind, and found with the former, with globular body and fewer but larger pseudopods; a condition usually succeeding that of the previous specimen.

FIG. 3. An individual of ramose form; a condition usually succeeding that of the previous one. The nucleus obscured from view. Two contractile vesicles, of which the more constant and larger marked *p. v.* A posterior process of the body, *a*, which in contraction assumed a mulberry-like appearance. *b*, discharge of effete matter. From a large spring, in which grew cress, on Darby Creek, Delaware County, Pennsylvania, October, 1874.

FIG. 4. A ramose individual with the posterior part as a mulberry-like mass, *a*. *b*, discharge of excrement. *n*, two discoid nuclei. *p. v.*, contractile vesicle. The striated yellow bodies, of which one is discharged, are particles of sawdust. From ooze mingled with sawdust obtained in a ditch below Philadelphia.

FIG. 5. An individual found with the preceding, and observed in the act of capturing an active infusorian, *Urocentrum*, through the approach and conjunction (*c*) of a pair of pseudopods. Another recently-captured *Urocentrum* is seen within the body of the Amœba. Nucleus of unusual breadth. *a*, posterior portion of the body in a mammillated condition due to contraction. *b*, particle of sawdust.

FIG. 6. An example of the grotesque appearance often assumed by Amœba proteus, the individual being comparable to a caricatured human face. In the succeeding view the apparent pair of horns were withdrawn, and the face expended itself in the prolongation of the nose. Same locality.

FIG. 7. A large, palmate individual, represented as in movement from right to left. The posterior part of the body, with three mulberry-like lobes, of which the intermediate one contains the contractile vesicle. The nucleus, though present, was mostly obscured from view. The endosarc appeared to flow within thick walls of ectosarc, which often seemed to be longitudinally folded. 250 diameters. Woodstown Pond, New Jersey.

FIG. 8. Probably young of AMŒBA PROTEUS. Individual of small size; in the initial globular form 0.06 mm. in diameter. 500 diameters. Lake on Bridger Butte, Wyoming Territory, August, 1877.

FIGS. 9, 10. Probably young of AMŒBA VILLOSA. 636 diameters. From a pond on Darby Creek, Delaware County, Pennsylvania, March, 1877. Habitually of clavate shape, the posterior extremity (*a*) discoid and minutely villous. The interior containing a small nucleus, many crystals, several small contractile vesicles, and a few green algæ.

Jos. Leidy Del. Thos. Sinclair & Son Lith.

AMOEBA PROTEUS.

PLATE II.

FIGS. 1–13.—AMŒBA PROTEUS.

FIG. 1. Individual in a condition repeatedly observed immediately succeeding those represented in figs. 1, 2, of the preceding plate. Body ovoid with long divergent pseudopods. *n*, nucleus; *p. v.*, contractile vesicle. 200 diameters. Ditch below Philadelphia.

FIG. 2. An individual of stellate form, as frequently observed when swimming. The large contractile vesicle central, with the nucleus in advance to the left. Same locality.

FIG. 3. Small individual, similar to that of fig. 8 of the preceding plate and found with it. *p. v.*, contractile vesicle; *n*, nucleus. A large diatom extends across the posterior part of the body. 500 diameters.

FIG. 4. An active individual with a profusion of pseudopods, containing a large granular nucleus, together with vacuoles, brown food-balls, diatoms, minute crystals, etc. 250 diameters. In several similar individuals the nucleus ranged from 0.032 mm. to 0.036 mm. broad by 0.02 mm. thick, and the contractile vesicle enlarged to 0.036. With Bladder-wort, Jacksonville, Florida, February, 1875.

FIG. 5. Individual from China Lake, Mount Gilbert, Uinta Mountains, Wyoming Territory, August, 1877. The yellow septate alga seen in the figure was afterwards observed to be expelled. 200 diameters.

FIG. 6. Robust individual, containing two contractile vesicles and a discoid nucleus. Among the food contents of brown balls, grains of sawdust, etc., there may also be noticed an Arcella. 270 diameters. Absecom pond, New Jersey.

Another individual accompanying the former, at one time extended in a cylinder, with a single divergent pseudopod, and measured 1.2 mm. in length.

FIG. 7. A large and unusually pale, translucent, and seemingly starved individual, containing only colorless food-balls, together with clear vacuoles and contractile vesicles. No nucleus detected. 200 diameters. Sphagnous bog-water, Pokono Mountain, Monroe County, Pennsylvania, August, 1876.

FIG. 8. Small individual, found in company with that of fig. 3. 250 diameters.

FIG. 9. Appearance of the nucleus in a large individual like those of figs. 1, 2, from the same locality. 350 diameters.

FIG. 10. Appearance of the nucleus of another and similar individual after the action of acetic acid. 250 diameters.

FIG. 11. Extremity of a chief pseudopodal extension, intending to represent the mode of entrance of the granular endosarc into the advancing ectosarc. In the former many clear vacuoles and numerous crystals are seen. 500 diameters.

FIG. 12. Apparent forms of crystals as seemingly observed in the same individual from which the preceding figure was drawn. 2,500 diameters.

FIG. 13. Apparent forms of other crystals observed. 1,000 diameters.

FIGS. 14–16. Probably young of AMŒBA VILLOSA. 500 diameters. From water squeezed from wet moss from the crevices of pavements in Philadelphia.

FIG. 14. Individual containing a discoid nucleus, and as food several diatoms and a fragment of Lyngbya.

FIGS. 15, 16. Two views of the same individual, ending in a posterior minutely villous ball.

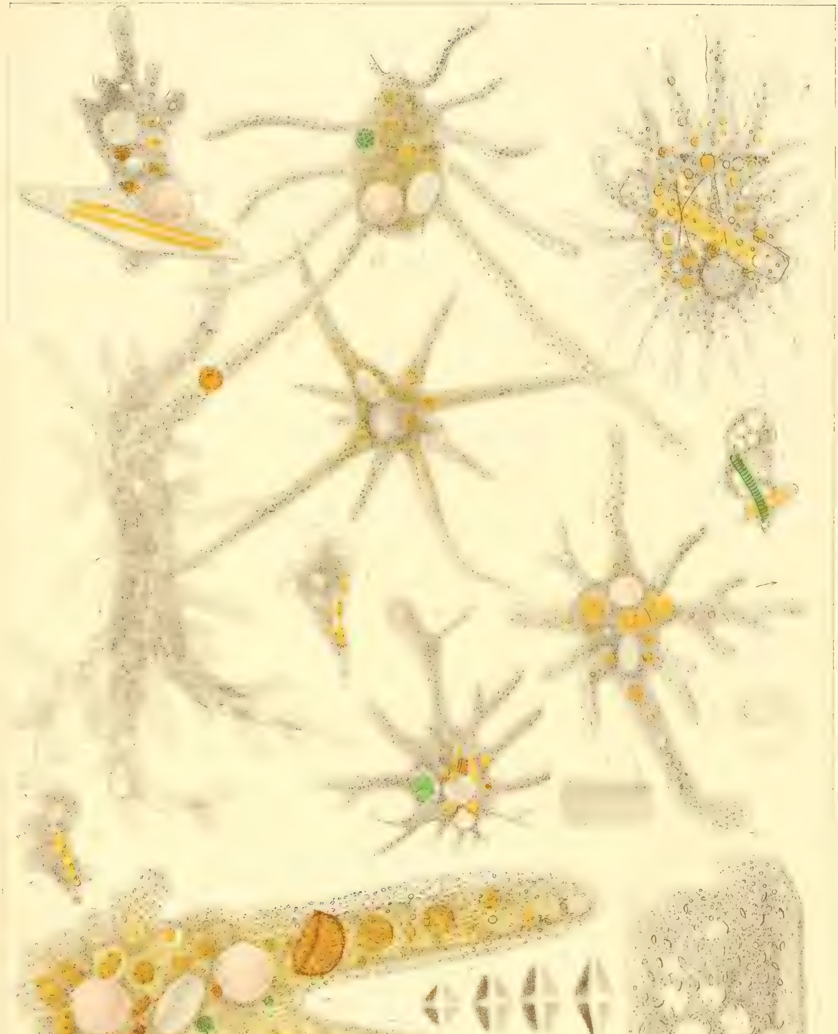


PLATE III.

AMŒBA VERRUCOSA.

FIGS. 1–4. Abundant form among Oscillaria, in a bog at the foot of the Zoological Garden on the Schuylkill River, Philadelphia, June, 1878. Mostly the animals contained an abundance of the alga Lyngbya, many of the segments of which were changed to brown as a result of digestion. 166 diameters.

FIG. 1. Individual with much wrinkled ectosarc ending in a posterior minutely papillose extremity. It exhibited three persistent longitudinal lines. The endosarc contains a discoid nucleus and two contractile vesicles. The latter united before collapse and three afterwards appeared in the same position.

FIG. 2. An individual nearly like the former, but exhibiting no longitudinal lines.

FIG. 3. An individual with four longitudinal lines, a small nucleus, and large contractile vesicle.

FIG. 4. An individual which when first observed looked nearly like the former, but which subsequently discharged the large pouch-like drop of yellowish liquid and brown-colored segments of Lyngbya. Many of the latter were at first green, and the surrounding liquid when within the body of the animal also imparted a greenish hue.

FIGS. 5–7. Forms, in water, squeezed from moss growing in the crevices of the brick pavement of my house in Philadelphia; found in association with the Wheel-animalcule, *Rotifer vulgaris*, June, 1874. 333 diameters.

FIG. 5. Individual comparatively quiescent, with nucleus and contractile vesicle.

FIG. 6. Individual with nucleus and food, but the contractile vesicle collapsed or absent.

FIG. 7. Individual with nucleus, two contractile vesicles, and food-balls.

FIG. 8. Small individual. It moved quickly with the broad end forward. Several contractile vesicles would appear, conjoin in a single one and then collapse. Frequent form in the bog at the foot of the Zoological Garden, Philadelphia, June, 1878.

FIG. 9. Small individual with active movement. It exhibits five contractile vesicles which all conjoined in one before collapse. 500 diameters. Frequent in bog-water, Broad Mountain, Schuylkill County, Pennsylvania.

FIG. 10. An individual widely spread and exceedingly sluggish in movement; with a nucleus and contractile vesicle. 666 diameters.

FIG. 11. The same individual, magnified half the extent of the former, as observed swimming. From the pavement at the fountain in front of the City Hall, on Market street, Philadelphia.

FIG. 12. Individual with three longitudinal lines. It contains a nucleus, two contractile vesicles, together with fragments of Lyngbya, and a diatom. 333 diameters. Fountain in Fairmount Park, September, 1876.

FIG. 13. An individual with four longitudinal lines. It shows two contractile vesicles, of which the larger is in the act of collapse. With the preceding. 333 diameters.

FIG. 14. An individual with five or six longitudinal lines. The contractile vesicle in the act of collapse. 500 diameters. With the preceding.

FIGS. 15, 16. Two views of an individual, with four longitudinal lines. A variable number of small contractile vesicles would appear as seen in fig. 15, conjoin as in fig. 16, then expand to a regular sphere and collapse. Fort Bridger, Wyoming Territory, August, 1877.

FIG. 17. Individual with two longitudinal lines. The contractile vesicle nearly collapsed. Same locality.

FIG. 18. Individual with four longitudinal lines. It contains a nucleus, many clear vacuoles (inadvertently colored by the lithographer), and at the posterior extremity a large contractile vesicle. Common in Swarthmore brick-pond.

FIGS. 19–27. Young forms, observed among green algous material, Lyngbya, etc., scraped from the brick pavements in damp shaded places in Philadelphia, and preserved a few days in a dish with water. Small actively moving individuals, exhibiting mostly two to four longitudinal lines or folds, containing a nucleus and a large posterior contractile vesicle. 500 diameters.

FIG. 28. Mature form, found with the preceding. 500 diameters.

FIG. 29. Mature form. Found in association with those of figs. 5–7. 333 diameters.

FIG. 30. Individual containing a nucleus, contractile vesicles, and food consisting of yellowish and colorless granular balls, a diatom, and grains of sand. 500 diameters. Marsh of the Uinta Mountains, Wyoming Territory, August, 1877.

FIG. 31. Individual, with nucleus, and large contractile vesicle (to left of the middle). The food-contents consist of abundance of the alga Lyngbya. The large posterior vacuole, with the greenish liquid and numerous isolated segments of Lyngbya, was observed to be expelled. 500 diameters. Among the algous slime at the base of the fountain, Eleventh street near Chestnut street, Philadelphia, September, 1876.

FIG. 32. Individual, from among Oscillaria and other algæ preserved during the winter, observed with others of same character, February, 1875.

FIG. 33. Individual of sluggish habit, with discoid nucleus, contractile vesicle, and food-balls. 200 diameters. Swarthmore brick-pond.

FIG. 34. Individual of exceedingly sluggish habit. With large discoid nucleus, contractile vesicle, and food-balls. 500 diameters. Sphagnous swamp of Vineland, New Jersey, September, 1876. The contractile vesicle from its first appearance to its greatest expansion required about ten minutes; its collapse, about six seconds.

FIG. 35. An almost motionless individual, without conspicuous contents except the contractile vesicle, which was observed to collapse and reappear. 500 diameters. Fort Bridger, Wyoming Territory, August, 1877.

FIG. 36. Individual, with oval nucleus, contractile vesicle (to the right), and food-balls (erroneously colored). 200 diameters. From ooze on the rocks below Fairmount, Philadelphia, October, 1875.

FIG. 37. Small active individual, found with the preceding.

FIG. 38. Large sluggish individual, found with that of fig. 34. Besides the oval nucleus, and large contractile vesicle, it contained a *Difflugia constricta* and a *Trinema enchelys*. 500 +.

PLATE IV.

FIGS. 1–18.—AMŒBA RADIOSA.

FIGS. 1–4. Four views of the same individual, exhibiting the successive changes of shape within a few minutes. From a pool at Fort Bridger, Wyoming, August, 1877. The pink globule within represents the contractile vesicle. Of the other globules two were food-balls and the remaining one probably the nucleus, though it was not very distinct. 500 diameters.

FIG. 5. Individual with globular body and long nearly linear rays, as seen floating. It contained a large clear globule and a smaller one. The contractile vesicle absent or collapsed. The animal subsequently assumed a more stellate appearance.

FIG. 6. Another individual accompanying the former. At first stellate it then assumed the tripod form, with central contractile vesicle as represented. In neither this nor the former specimen was a nucleus detected. From a spring on Darby Creek, April, 1875.

FIG. 7. Individual of globular form and long linear rays, with contractile vesicle, but no nucleus. From the gutter at the fountain on Market street, in front of the City Hall, Philadelphia, August, 1876. It subsequently assumed a more stellate appearance, with shorter, thicker, and more conical rays.

FIG. 8. Individual with globular body and comparatively short conical pseudopodal rays. It contains two contractile vesicles, which afterwards united in one. It also contains a diatom and a large globule, with apparently a central, darkly-defined corpuscle. The creature subsequently became more stellate and with longer arms. From a springy place on Darby Creek, Delaware County, Pennsylvania, May, 1875.

FIGS. 9–11. Three views of the same individual, from China Lake, Uinta Mountains, Wyoming, August, 1877. Figs. 9, 10, as seen floating. Fig. 11, as seen creeping, with numerous long digitate pseudopods diverging in advance. The nucleus is seen in front with a clear surrounding zone; the contractile vesicle central.

FIG. 12. An individual, resembling the former, as observed floating. From a ditch, among Duckmeat, below Philadelphia, September, 1874.

FIG. 13. An individual which, when first noticed, had a more stellate appearance, as in figure 4, but afterwards applying itself to the surface of the object-glass it retracted its pseudopods and slowly spread out so as to appear as in the present figure. At first it contained but few conspicuous globules, but a multitude were subsequently developed, and one among them becoming much enlarged finally collapsed. From the same locality as that of figure 8.

FIGS. 14–16. Three views of the same individual, exhibiting the successive changes of shape within a few minutes. From a dish of water with algæ and other aquatic plants, preserved during the winter. March, 1874. 333 diameters.

FIGS. 17, 18. Two individuals from mud collected at the mouth of Cooper's Creek, near Camden, New Jersey, May, 1874. 500 diameters. These in creeping on the object-glass extended a pair of broad, thin lateral expansions, from which radiated narrow pointed pseudopods. From time to time one or more of the latter would slowly vibrate from side to side. One of the specimens (fig. 18) dragged after it a large particle of quartz sand.

FIGS 19–21. SPONGILLA AMŒBOIDS. Obtained from the yellowish fresh-water sponge (*Spongilla fragilis*) attached to the under surface of rocks below Fairmount dam, in the Schuylkill River, Philadelphia. 500 diameters. Figs. 19, 20 are undistinguishable from *Amœba radiosa*; fig. 21 resembles *A. verrucosa*. Each contained a nucleus and from one to three contractile vesicles, together with colorless or yellowish granular balls, which in true Amœbas would be viewed as food-balls.

FIGS. 22–24. An Amœba of uncertain reference, but probably a variety of Amœba proteus.

FIG. 22. An individual, as seen creeping from left to right, projecting in advance broad, clear lobular pseudopods. From the sides and at the posterior extremity there projected a variable number of incessantly changing pointed conical pseudopods. The interior exhibits, from behind forward, a large contractile vesicle, a multitude of minute desmids, a nucleus, and a number of clear globules. 250 diameters. From the soft ooze in the Lehigh River, near Easton, Pennsylvania, June, 1874.

FIG. 23. An Amœba, with many conical pseudopods, mostly acute and divergent from the part of the body in advance, the posterior extremity ending in mammillary processes. 500 diameters.

FIG. 24. Another and larger individual of the same kind as the preceding, with many pointed conical pseudopods; the posterior extremity of the body ending in mammillary processes. The interior containing a multitude of pinkish globules, incessantly changing in number and size, together with a long doubled filament of Oscillaria and other algæ. From the posterior end of the body, as seen in the figure, a discharge of effete matters occurred.

The individuals of figs. 23 and 24, together with many similar ones of various sizes and intermediate forms, occurred in water from Absecom pond, New Jersey, collected in the autumn of 1875 and preserved during the winter until March, 1876.

FIG. 25. AMŒBA PROTEUS. An individual from Absecom pond, New Jersey, November, 1874. 250 diameters. Besides the usual granular protoplasm, the contents consisted of brownish-yellow and green food-balls, many crystals, several large clear globules, a uniformly granular nucleus (seen to the right of the centre), and a large contractile vesicle (seen to the left). Around the latter may be observed half a dozen darkly granular balls, the contents of which exhibited lively swarming movement.

FIG. 26. An amœboid animal, probably of the same character as those of figs. 23 and 24, and found with them. It moved slowly and contained a multitude of scattered chlorophyl grains of nearly uniform size. These were first supposed to be a constituent element of the structure, as in some of the *Difflugias* and in *Hyalosphenia papilio*. 500 diameters.

A similar specimen was observed occupying a space of 0.18 by 0.1 mm., with nucleus and contractile vesicle. Later, March, 1876, other specimens were observed, from the same locality, apparently merging into forms like those of figs. 23 and 24.

PLATE V.

PELOMYXA VILLÓSA, under the name of *Amœba villosa.*

The upper extremity of the figures corresponds with the forepart of the animal in movement. Magnified 250 diameters, except those specially indicated. Figs. 1, 11, 13, 14 viewed by reflected light; the others by transmitted light.

FIG. 1. Individual from China Lake, Mount Gilbert, Uinta Mountains, Wyoming, August, 1877. The broader part in advance, with projection of a cap of clear ectosarc, into which the granules of the endosarc are seen entering on the left. The posterior extremity with a circular patch of villous processes.

FIG. 2. Individual from a pond, Atco, N. J., September, 1877. The narrow part in advance, with a thick cap of clear ectosarc. The posterior extremity with a double villous patch, within one part of which three small contractile vesicles are visible.

FIG. 3. A smaller individual from the same locality. It presents four small conical pseudopods.

FIG. 4. Another individual from the same locality. It terminates in a villous ball.

FIG. 5. A more translucent individual, likewise from the same locality.

FIG. 6. Individual from China Lake, Uintas, exhibiting in the interior, mingled with the food, a multitude of sand grains.

FIG. 7. A small individual from Fort Bridger, Wyoming. The body ending in a villous ball.

FIGS. 8, 9. Two small individuals from the same locality. The former figure exhibits a granular nucleus near the centre, and both present posteriorly a large contractile vesicle.

FIG. 10. Individual from a ditch below Philadelphia, September, 1875.

FIG. 11. An individual of large size, at rest, from Absecom pond, New Jersey, June, 1874. Magnified 33 diameters. The specimen was remarkable for the abundance of quartz sand it contained.

FIG. 12. Individual from Hammonton pond, New Jersey, September, 1877. The posterior villous processes exhibit within a number of small contractile vesicles. Among the food-contents posteriorly a large diatom is observable.

FIG. 13. The same specimen as subsequently observed by reflected light.

FIG. 14. An individual from a pond on Dr. George Smith's farm, Upper Darby, Delaware County, June, 1874. 85 diameters. As seen by reflected light in movement. The posterior villous ball with a quantity of material adherent and dragged after the animal. Many similar specimens were obtained, varying from 0.25 to 0.75 mm. in length. They were remarkable for the abundance of sand they contained.

FIGS. 15–17. Three small individuals from the same locality. Magnified 350 diameters.

FIGS. 18, 19. Portion of the contents pressed from the specimen of fig. 11, consisting of granules, clear globules, granular corpuscles with nuclei, linear bodies, and quartz sand. Magnified 500 diameters.

AMOEBA [illegible]

PLATE VI.

DINAMŒBA MIRABILIS. Magnified 250 diameters.

FIGS. 1–3. Three views of the same individual. Fig. 1. As first seen, in the act of swallowing portion of a desmid (*Didymoprium grevillii*). Fig. 2. As observed shortly afterwards, with the unswallowed portion of the desmid detached and rejected. Nearly at the same moment the creature discharged from behind and to the left a portion of a cord of the same desmid, with its segments still conjoined, together with many isolated segments of the same and a few of another desmid (*Bambusina brebissonii*). In the discharged desmids the internal endochrome masses are shrunken and turned brownish-yellow. Fig. 3. The animal as it appeared in movement eight hours subsequently. Absecom mill-pond, New Jersey, October, 1876.

In fig. 2 the Dinamœba is represented with its transparent ciliated mantle or investment, but this is not represented in the others.

FIG. 4. An individual swallowing two portions of the desmid Didymoprium, which entered to the left of the posterior papillated extremity. Atco, N. J., September, 1877.

FIG. 5. An individual, in motion from right to left, from the same gathering. Viewed by partially reflected light.

FIG. 6. An individual closely embracing by its posterior widely expanded extremity a cord of Didymoprium. Found with the preceding.

FIG. 7. An individual, from the same gathering, as it appeared in the discharge of a multitude of isolated segments of Didymoprium from three different points simultaneously. The three points are indicated by protrusions of clear ectosarc and a single desmid segment.

PLATE V.

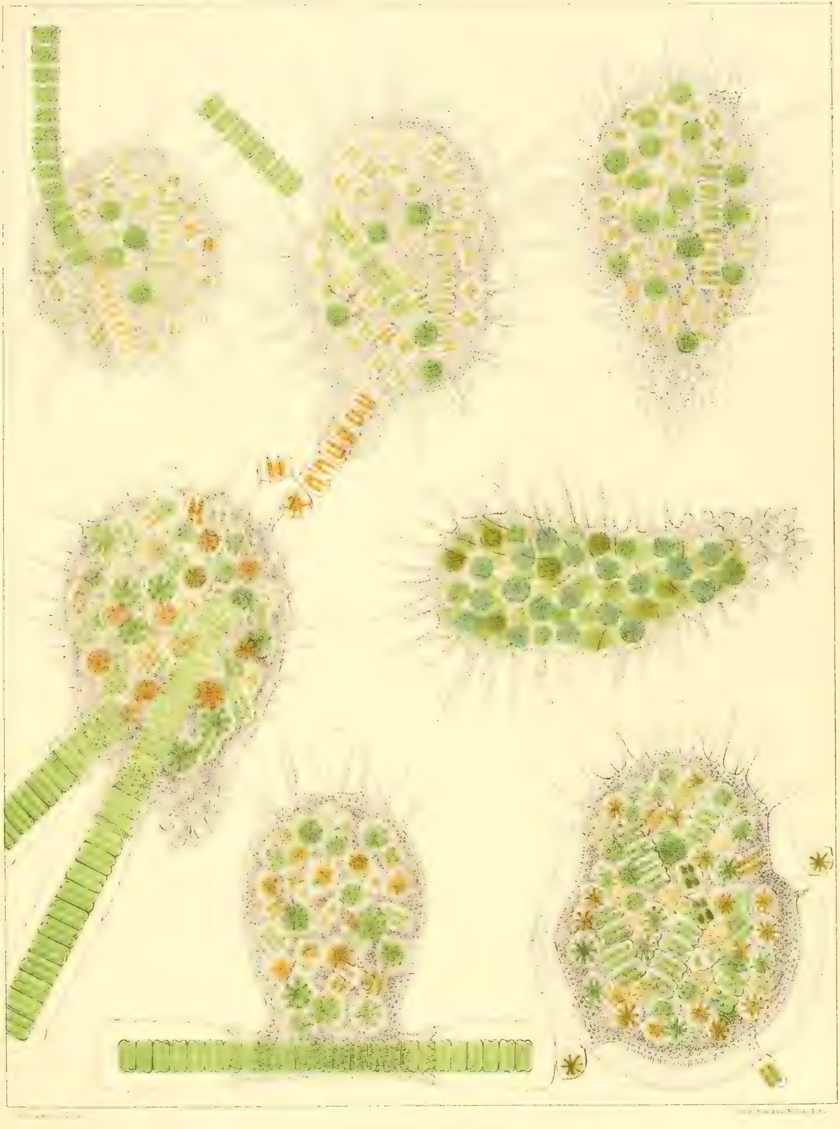


PLATE VII.

FIGS. 1–11.—DINAMŒBA MIRABILIS.

FIG. 1. Individual containing, besides a number of food-balls, a large Closterium which had been swallowed when one-half of the cell after division was yet in the soft condition and allowed of being doubled on the more consistent portion. The large conspicuous globule situated posteriorly remained for a long time unchanged but was finally discharged. From a cranberry-bog of Atco, N. J., September 21, 1877. 250 diameters.

FIG. 2. The same individual as seen the following morning, September 22. 333 diameters. The spicules or minute cils of the surface had everywhere disappeared. The Closterium had been discharged, and the interior was occupied with a multitude of clear globules. The pseudopods were long and pointed and were incessantly changing. The five pseudopods at the fore end, from the short knob to the two blunt ones on its right and the two longer pointed ones on its left, illustrate the mode of production and gradual extension of these temporary organs.

FIG. 3. An individual devoid of spicules, moving from right to left, the interior filled with numerous segments of Didymoprium enclosed in drops of liquid. From Absecom pond, New Jersey, June, 1876. 250 diameters.

FIG. 4. A small individual of the usual form and appearance. It contains a few segments of Didymoprium, the ordinary food; and at the posterior part a number of small contractile vesicles are seen. Atco, N. J., September, 1877. 250 diameters.

FIGS. 5–7. Three views of an individual, as it appeared at successive periods during 36 hours. The fore part of the body bristled with pointed pseudopods, while the posterior part was thickly papillate, but no part of the surface exhibited spicules. In fig. 6, the nucleus is concealed from view; in fig. 7, the green desmid of the former views has become brown. Absecom Pond, New Jersey, November 4th to 6th, 1874. 300+.

FIG. 8. Individual like the preceding, as observed swimming. From the same gathering. September, 1874. 530+.

FIG. 9. An individual which remained nearly motionless and without pseudopods. The interior occupied with abundance of food-balls and large clear globules, but no distinct contractile vesicle nor nucleus observed. The posterior semicircumference of the body finely ciliate, but the anterior smooth. Atco, N. J., September, 1877. 250+.

FIG. 10. Individual, from the same gathering, containing comparatively little food and exhibiting a distinct granular nucleus.

FIG. 11. Pseudopod of an individual, from the same gathering, observed October, 1877. The animal of the usual size, and well filled with food, had the surface of the body finely ciliate, but in addition it and the pseudopods appeared to be covered by minute adherent granules as represented in the figure. 500 diameters.

FIGS. 12–19 illustrate the series of changes observed in the swallowing and digestion of an *Amœba verrucosa* by an *A. proteus*. From Bristol marsh, Pennsylvania, August 27, 1876. 500 diameters.

FIG. 12. *Amœba verrucosa*, comparatively quiescent, with central contractile vesicle.

FIGS. 13–19. Successive changes in shape and relative position of *A. proteus* during the act of swallowing and digesting the former. Fig. 13. *A. proteus* approaching the *A. verrucosa*, with anterior short diverging pseudopods. Fig. 14. The *A. proteus* embracing closely the *A. verrucosa* by a pair of digitate pseudopods, the points of contact of which being marked by the left-hand arrow. Fig. 15. The *A. verrucosa* swallowed and forming a large sphere within the *A. proteus*. Fig. 16. The *A. verrucosa*, within the latter, has assumed an oval form, and is contained within a vacuole. The central contractile vesicle, which until now had remained persistent, has become less distinct. Fig. 17. The *A. verrucosa* has assumed a pyriform shape within a large elliptical vacuole, and its contractile vesicle has disappeared. Fig. 18. The *A. proteus* in the act of discharging a diatom, while the *A. verrucosa* has become doubled on itself. Fig. 19. The remains of the *A. verrucosa*, seen as five granular balls within the *A. proteus*. Later these balls disappeared, and their material appeared to be diffused among the granular contents of the *A. proteus*.

PLATE VIII.

FIGS. 1-16.—AMŒBA VILLOSA

FIGS. 1-3. Small individuals from water of a sphagnous swamp on Broad Mountain, Schuylkill County, Pennsylvania; collected September, 1876. 500 diameters. Figs. 1, 2, two views of the same individual. Fig. 3. Another individual in which the nucleus appears more distinctly discoidal.

FIGS. 4-16. Supposed young of *Amœba villosa*. In water from a brick-pond near Swarthmore College, Delaware County, Pennsylvania, kept during the winter, and examined February, 1875. Figs. 4-8, 500 diameters.

FIG. 4. An individual dragging after it a large spherical alga. Within, it exhibits the nucleus in advance of the position of the contractile vesicle.

FIG. 5. Another individual, with two contractile vesicles, and the nucleus posteriorly situated.

FIG. 6. An individual with the contractile vesicle in the act of collapse.

FIG. 7. Another individual with large contractile vesicle and in advance a small nucleus. Fig. 8 is an outline of the same individual as it first appeared.

The green balls within the animals consist of unicellular algæ or spores which covered the surface of the water containing the Amœba. The red balls appear to be the same kind of algæ changed in color by digestion. Among the contents numerous minute crystals are observed.

FIG. 9 *a–c*. Some of the crystals magnified 1,200 diameters.

FIG. 10. An individual, magnified 750 diameters, exhibiting a multitude of crystals among its contents. The nucleus occupies a position just posterior to the contractile vesicle.

FIG. 10 *a*. A crystal magnified 1,200 diameters.

FIG. 11. An individual which, after moving about for some time, with the form seen in the preceding figures, spread out in disk-like shape and became very thin. The nucleus to the left, with a reddened algous spore resting against it. 700 diameters.

FIG. 12. A resting individual containing a large nucleus with coarse uniform granules. 700 diameters.

FIGS. 13, 14. Two views of an individual containing two large and coarsely granular nuclei. Fig. 14 exhibits the mutual compressibility of the nuclei and contractile vesicle, as seen in the movements of the animal. 700 diameters.

FIG. 15. An individual as it appeared at the moment of collapse of the contractile vesicle and the bursting of one of the nuclei with the simultaneous escape of the granules or spores of the nucleus and the contents of the contractile vesicle. The red bodies are algous cells. 533 diameters.

FIG. 16. An individual containing six large granular nuclei, which, together with the equally large contractile vesicle, rolled about among one another in the movements of the animal. 500 diameters.

FIGS. 17-30.—Supposed young of AMŒBA PROTEUS.

FIGS. 17-20. Four individuals, from among a multitude contained in water with Nitella, furnished by Mr. Holman in one of his "life-slides," January 8, 1875. The nucleus of variable size. 1,000 diameters.

FIGS. 21, 22. Two views of an individual. Fig. 23. A second individual. Obtained, together with many others of the same kind, in water from a cow-track in a springy place on Darby Creek, Delaware County, Pennsylvania, March, 1876. 500 diameters.

FIGS. 24-26. Three individuals, observed with many others together with large characteristic specimens of *Amœba proteus*. From ditch-water, collected in the meadows below Philadelphia, April, 1874. 500 diameters.

FIGS. 27, 28. Two different individuals, observed in association with the preceding, containing a large tripartite nucleus. Others were observed with the nucleus simple and in various stages of tripartite division. 500 diameters.

FIG. 29. Individual found in association with those of figs. 21-23, together with others of intermediate size. Observed in the act of discharging two diatoms, while nothing else was seen to escape.

FIG. 30. An individual, observed in the act of division. Separation occurred in ten minutes after having noticed the animal as seen in the figure. Subsequently the lower individual escaped, while the upper one was watched and was seen to divide in the same manner as its parent, but in a direction at right angles to the former one. The offspring assumed a slug-like shape as in figs. 4, 10, 20, 29, and moved away. 500 diameters. The two largest globules to the left in each figure, inadvertently colored by the lithographer, were colorless and oil-like.

FIG. 31. PELOMYXA VILLOSA. An individual which was retained over night in abundance of clear water in an animalcula cage without pressure. It remained nearly motionless, but occasionally protruded a clear lobular portion of ectosarc together with a few pointed pseudopods and shifted its position. The posterior part of the body was minutely papillate. Slight pressure caused the sudden discharge through a rupture of the ectosarc of some of the contents, consisting of clear globules, granules, a few large nuclei, and numerous linear particles, together with food-materials. From Absecom pond, New Jersey, August, 1874. 100 diameters.

FIG. 32. One of the discharged nuclei, with coarse uniform granules superficially imbedded. 1,000 diameters.

FIG. 33. Granules and linear particles from the same. 1,000 diameters.

FIG. 34 *a–l*. Concretionary mineral elements observed in some Amœbas, of the kind represented in figs. 4-16, and found in association with them, February, 1875. 4,000 diameters.

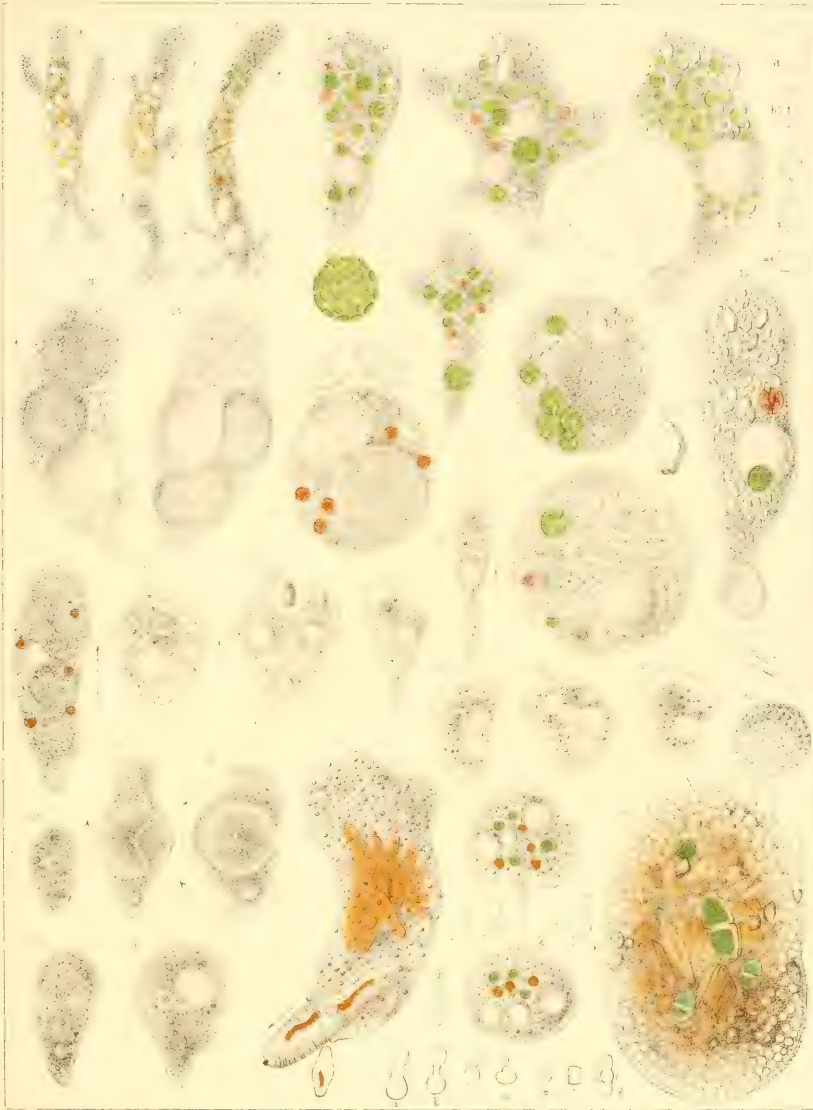


PLATE IX.

FIGS. 1–12.—OURAMŒBA VORAX.

FIG. 1. Individual as seen moving with the narrow end in advance, and with the tufts of appendages trailing behind in a widely expanded manner. The interior so completely gorged with food, consisting of algæ, as to completely obscure the nucleus and contractile vesicle. The first specimen observed. From a spring, in which grew water-cress, on Darby Creek, Delaware County, Pennsylvania, May, 1874. Magnified 200 diameters.

FIG. 2. Individual from same gathering as seen in movement. Five tufts of caudal filaments trailing behind. A discoid nucleus seen in advance of the middle; a contractile vesicle behind. The arrows indicate the direction of motion of the three principal pseudopods.

FIG. 3. The same specimen as observed in a contracted spheroidal form.

FIG. 4. Specimen from a pond on Darby Creek, Delaware County, June, 1874. Provided with only two tufts of short caudal filaments. The arrows indicate the direction of flow in the different pseudopods. The nucleus and contractile vesicle distinctly seen. 250 diameters.

FIG. 5. Specimen from same spring above mentioned, April, 1875. Body of palmate form, with distinct nucleus and contractile vesicle. The caudal filaments widely divergent, and presenting irregular constrictions. The large diatom occupying an extension of the body to the left posteriorly was subsequently withdrawn, and was finally seen to be expelled nearly in the same position it now occupies in the figure; *n.*, nucleus; *p. v.*, contractile vesicle. 250 diameters.

FIG. 6. Another specimen from same locality. Nucleus nearly central. 350 diameters.

FIGS. 7, 8. Two views of the same individual; a small specimen from the same gathering as that of fig. 5. With a single pair of long caudal filaments. Nucleus unobserved. 350 diameters.

FIG. 9. Another individual, with a pair of short caudal filaments projecting to the right of a mulberry-like process of the body. Nucleus just posterior to the middle. 350 diameters.

FIG. 10. Two tufts of caudal filaments showing the mode of branching near their origin.

FIG. 11. A single detached tuft apparently starting from a button of somewhat consistent protoplasm.

FIG. 12. Portions of two filaments from the specimen of fig. 1, exhibiting the structure. Magnified 400 diameters.

FIGS. 13–17. OURAMŒBA BOTULICAUDA.

All the specimens from the spring above indicated.

FIG. 13. Specimen obtained April, 1875. With three caudal appendages. A nucleus in advance and two contractile vesicles behind. The latter came into contact, united in one, and then collapsed. 500 diameters.

FIG. 14. Obtained January, 1878. Body somewhat palmate, containing a nucleus and two contractile vesicles, and with four caudal appendages. 730 diameters. Body elongated to 0.06 mm., contracted to 0.021 mm.

FIG. 15. Specimen with three appendages, obtained May, 1874. 500 diameters.

FIG. 16. Specimen with two tufts of appendages. From same gathering.

FIG. 17. Specimen obtained with that of fig. 13.

Five other specimens were observed at same time, all with three appendages except one, which had nine appendages. One of the specimens was swallowed by a little worm, Chætogaster, and could be distinctly seen within the stomach.

PLATE X.

DIFFLUGIA PYRIFORMIS.

The shells of most specimens represented, and the same may be said of the other species of Difflugia represented in the succeeding plates, are composed of irregular angular particles of quartz sand, which particles are mostly drawn only in outline. The transverse diameters of the specimens are uniform except in cases specially indicated.

FIG. 1. Individual with pseudopods protruded; the endosarc bright green. Swarthmore brick-pond, May, 1874. 200 diameters.

FIG. 2. Individual from the same gathering. The sarcode contracted into a ball, the endosarc of which was bright-green. 200 +.

FIG. 3. Individual with profuse extension of pseudopods; the sarcode colorless; the shell of coarse sand grains. Pond on Darby Creek, Delaware County, Pennsylvania, May, 1874. 100 diameters.

FIG. 4. Large individual with profusion of pseudopods; endosarc colored apparently only from the presence of food. Shell comparatively even. Absecom pond, New Jersey, June, 1874. 133 diameters. The same gathering contained many like it, ranging from 0.32 to 0.5 mm. in length.

FIGS. 5, 6. Two specimens; in the one with bright green endosarc; in the other with the endosarc colored brownish centrally. Ditches below Philadelphia, June, 1874. 200 diameters.

FIGS. 7–12. Individuals from Absecom pond, New Jersey, June, 1874. In all except the last one green coloring matter was absent in the endosarc. 200 diameters. Specimens collected in the same locality the following September and November presented the same appearances. Fig. 7. An unsymmetrical specimen. The shells presented various degrees of unevenness and proportionate size.

FIG. 13. Individual with remarkably uneven shell, composed of coarse sand and a large diatom case. Endosarc centrally brownish. Cranberry-swamp, at Atco, N. J., April 1877. 200 +.

FIG. 14. Specimen with shell of unusually coarse sand. An abundant variety from a sphagnous bog on Budd's Lake, Morris County, New Jersey, November, 1874. 250 diameters. The same kind observed in material from a sphagnous bog of Absecom, New Jersey, April, 1875.

FIG. 15. Large shell, slightly unsymmetrical, composed mainly of irregular angular quartz sand, but with a few rounded ones (which is very unusual), and a sponge spicule. Empty specimen. 200 diameters. Similar ones from 0.05 to 0.58 in length occasionally found.

FIG. 16. Large form, with shell of coarse sand, common in China Lake, Uinta Mountains, Wyoming Territory, August, 1877. 250 diameters. Specimens varying from 0.2 to 0.36 mm. in length, with shell of coarse sand, and endosarc centrally bright green.

FIG. 17. Empty shell, composed of comparatively thin angular flakes of quartz. A not unfrequent variety. Hammonton pond, New Jersey, July, 1877. 500 diameters.

FIG. 18. Empty shell, composed of narrow rectangular plates, diatom cases, and a comparatively few sand grains. From sphagnum bordering a spring at Swarthmore, Delaware County, Pennsylvania. 250 diameters.

FIG. 19. Specimen with shell composed of sand, diatoms, and spongilla spicules; the sarcode contracted into a ball, and colorless. Absecom pond, New Jersey, November, 1875. 133 diameters.

FIG. 20. A similar specimen from same gathering, with shell of sand and diatoms, and sarcode colorless. 100 diameters. Large specimens like this and the former, mostly with shell of variable proportions of sand and diatoms, and with colorless sarcode, are not unfrequent in the ponds of sphagnous bogs of New Jersey.

FIG. 21. Individual with shell of rectangular plates and a few coarse sand grains, and with sarcode contracted into a ball. Sphagnous bog of Absecom, New Jersey, November, 1875. 260 diameters.

FIG. 22. Small form, with shell composed of clear chitinoid membrane, incorporated with diatoms, sand, and dirt, and with yellowish endosarc. Pond near Egg Harbor, New Jersey, September, 1875. 500 diameters.

FIG. 23. Empty shell of chitinoid membrane incorporated with large diatoms and dirt. Found with the last. The same form, living, occasionally found in sphagnous bogs of New Jersey.

FIGS. 24, 25. Forms occasionally observed in water of the cedar swamp of Absecom, New Jersey. Shell of yellowish chitinoid membrane with incorporated diatoms, sand, and dirt. Sarcode colorless or with brown endosarc. In the individual of fig. 25 it formed an oval, brown encysted ball.

FIG. 26. Individual with shell of chitinoid membrane incorporated with thin siliceous plates, and with sarcode attached to the fundus of the shell by long pseudopodal threads. Absecom pond, New Jersey.

FIG. 27. Individual with shell of black dirt. Absecom pond, New Jersey, October, 1874. 200 diameters.

DIFFLUGIA PYRIFORMIS

PLATE XI.

DIFFLUGIA PYRIFORMIS.

The figures exhibit many variations in the also compressed variety, obtained, with multitudes of the same kind, from Swarthmore brick-pond, Delaware County, Pennsylvania. Shells of clear angular particles of quartz sand, with the bright-green endosarc visible through. The differences in the pseudopods represent the appearances as actually observed. Magnified from 100 to 110 diameters.

FIG. 1. Regular compressed pyriform individual. Length, 0.56 mm.; greater breadth, 0.28 mm.; less breadth, 0.18 mm.

FIGS. 2, 3. Two views of an individual; the broader, unsymmetrical.

FIG. 4. Broader lateral view of an individual in which the sarcode was contracted into a ball. Breadth, 0.24 mm. by 0.16 mm.

FIG. 5. Broader lateral view of an individual, with broad rounded fundus, of compressed pyriform shape. Breadth, 0.34 mm. by 0.18 mm.

FIG. 6. Individual with prominent fundus. Breadth, 0.31 mm. by 0.16 mm.

FIG. 7. Individual with conical fundus and nipple-like summit. The green endosarc appeared retracted to the fundus of the sarcode.

FIG. 8. Transverse section and oral view of the same.

FIG. 9. Broader lateral view of an individual with trilobed fundus. Breadth, 0.3 mm. by 0.16 mm.

FIG. 10. Broader lateral view of a comparatively long specimen with nipple-like summit. Breadth, 0.28 mm. by 0.16 mm.

FIG. 11. Individual with broad trilobed fundus. The peculiar fan-like spreading of the pseudopods was due to their extension beneath the inclined sides of the cell in "Holman's life-slide." A quantity of green corpuscles of the endosarc extended into the root of the pseudopods. Breadth of compressed shell, 0.32 mm. by 0.18 mm.

FIGS. 12, 13. Two views of the same individual, the latter reversed longitudinally, exhibiting the broader and narrower sides.

FIG. 14. Individual with flat fundus, and with the sarcode contracted into a ball. Breadth 0.28 mm. by 0.16 mm.

FIG. 15. Broader side view of a specimen with angular bilobed fundus. Breadth 0.26 mm. by 0.14 mm.

FIG. 16. Broader side view of a specimen with rounded bilobed fundus. To the shell a conspicuous crystal was attached. Breadth 0.32 mm. by 0.18 mm.

FIG. 17. Broader side view of an unsymmetrical individual. The narrower side view was symmetrical and like that of the succeeding specimen.

FIGS. 18, 19. Two views of the same individual, the latter reversed, and appearing in the former, with bilobed fundus.

FIG. 20. Broader side view of an individual with conical fundus and lateral angular projections. Breadth 0.28 mm. by 0.16 mm.

FIG. 21. Broader side view of an individual with three blunt lobes to the fundus. Breadth 0.28 mm. by 0.16 mm.

FIG. 22. Broader side view of an individual with quadrilobate fundus, unsymmetrical. A single long pseudopod extended outwardly as it appeared in a "Holman's life-slide." Breadth 0.32 by 0.16 mm.

FIG. 23. Appearance of clear colorless corpuscles of the endosarc measuring from 0.00266 to 0.00798 mm.

FIG. 24. Appearance of the green corpuscles having nearly the same range of size.

VAR. COMPRESSA

PLATE XII.

FIGS. 1–18.—DIFFLUGIA PYRIFORMIS.

FIG. 1. Individual with shell of uniform transverse diameters, but with less prolonged neck than usual. The contracted sarcode with bright green endosarc. Absecom pond, September, 1875. 100 diameters.

FIGS. 2–9. The variety *Difflugia vas* distinguished by a constriction in the neck of the shell.

FIG. 2. Individual from the same gathering as that of fig. 1. 100 +.

FIG. 3. Empty shell of coarse sand grains. Ft. Bridger, Wyoming.

FIGS. 4–6. Individuals with shell stained by ferruginous coloring. Sphagnous bog near Absecom, October, 1875. 100 diameters.

FIG. 7. Small, empty shell, somewhat unsymmetrical and of comparatively even surface. Swarthmore brick-pond, April, 1876. 350 diameters.

FIG. 8. Individual with comparatively even shell, and with endosarc mingled green and yellow. Found with the last. 350 +.

FIG. 9. Large individual with shell of coarse sand, and with sarcode contracted into a ball; the endosarc exteriorly green and centrally yellow. Budd's Lake, New Jersey, March, 1875. 100 diameters.

FIGS. 10–16. The variety *Difflugia compressa*, in which the shell is broader one way than in the other.

FIGS. 10, 11. Two views of the same individual in outline. The yellow spot indicates the appearance of the endosarc. Spring on Darby Creek, Delaware County, Pennsylvania. 100 diameters.

FIGS. 12, 13. Two views of an individual. The sarcode retracted but not encysted; the endosarc yellow. From material collected on South Mountain, Burke County, North Carolina. 200 diameters.

FIG. 14. Individual with shell composed of coarse sand, uneven surface and slightly-pointed summit. 200 diameters. Breadth 0.22 mm. by 0.112 mm.

FIGS. 15, 16. Two views of an individual, with shell of coarse sand and yellow endosarc. 200 diameters. This and the preceding from a pond on Darby Creek, Delaware County, Pennsylvania.

FIGS. 17, 18. The variety *Difflugia cornuta*. Both in outline; 250 diameters. From a bog near Atco, N. J., June, 1877. One with one, the other with two points, and both with colorless sarcode.

FIGS. 19–21.—DIFFLUGIA CRATERA.

FIGS. 19, 20. Two empty shells composed of chitinoid membrane with incorporated granules of sand. From Bristol Canal, Bucks County, August, 1876. 600 diameters.

FIG. 21. Empty shell. Lake Erie, Buffalo, N. Y., August, 1878. 800 diameters.

(Since describing these minute forms I have suspected that they belong to a ciliated infusorian of the genus Tintinnus.)

FIGS. 22, 23.—DIFFLUGIA URCEOLATA.

Common forms in China Lake, Uinta Mountains, Wyoming Territory, August, 1877. 125 diameters.

FIGS. 24–28.—DIFFLUGIA ACUMINATA.

Compressed variety with from one to three spines to the fundus of the shell.

FIGS. 24–27. Specimens from Swarthmore brick-pond, June, 1874. 350 diameters. Fig. 24. With a single spine; breadth 0.068 mm. by 0.052 mm. Fig. 25. With a pair of spines; breadth 0.072 mm. by 0.052 mm. Fig. 26. With two spines of unequal length; breadth 0.064 mm. by 0.048 mm. Fig. 27. With three spines; breadth 0.072 mm. by 0.056 mm.

FIGS. 28, 29. Two views of the same individual. Fig. 28. Broader view, with pseudopods protruded, and animal as observed in the act of swallowing a diatom. Fig. 29. Narrower view. From a ditch below Philadelphia, August, 1874. 200 diameters.

In this plate the lithographer has greatly exaggerated the yellow coloring. In figs. 4–6 the shells had a faint ferruginous tint; in figs. 8, 9, the color pertaining to the sarcode was browner and duller; in figs. 15, 16, and 22–28 the color was pale clay colored, and in figs. 19–21 the shell was nearly colorless.

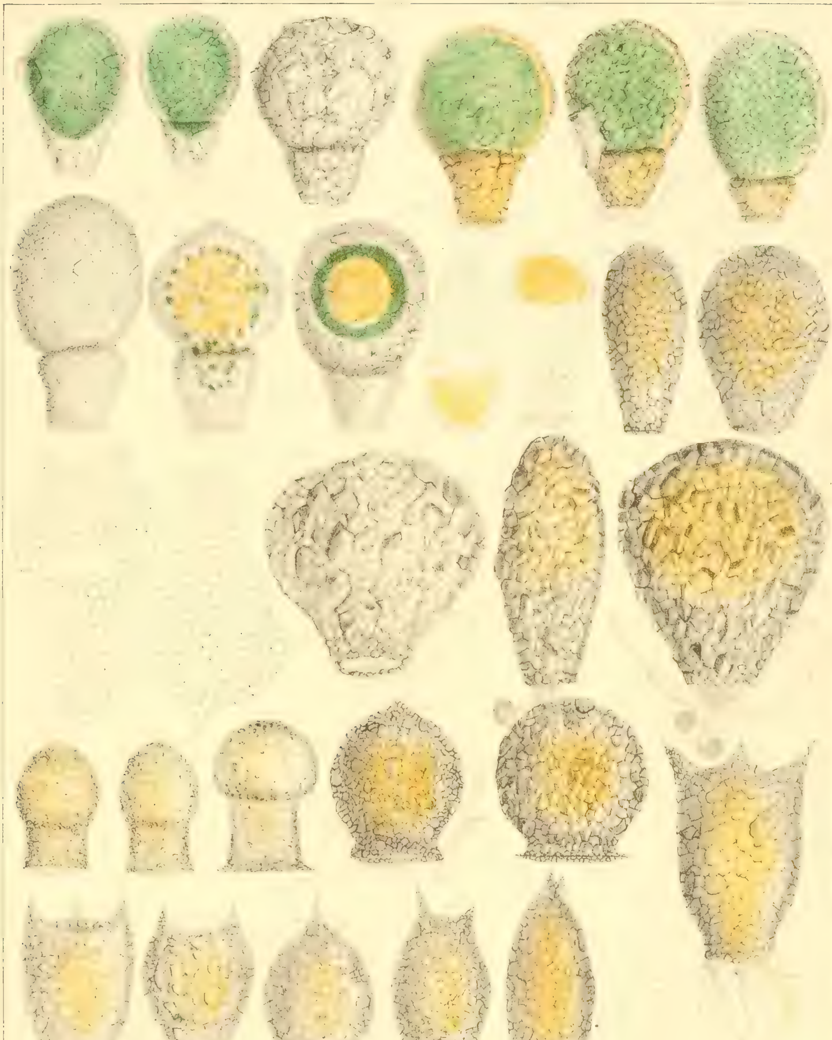


PLATE XIII.

DIFFLUGIA ACUMINATA.

The shell composed of angular particles of quartz sand, except in instances especially mentioned; the sarcode in nearly all colorless, or with a pale clay color to the endosarc.

FIGS. 1, 2. Examples of common forms in Swarthmore brick-pond, May, 1874. Sarcode colorless and commonly entirely obscured from view by the structure of the shell. 200 diameters.

FIGS. 3, 4. Shells of coarse angular quartz sand. China Lake, Uinta Mountains, Wyoming Territory, August, 1877. Common forms. 250 diameters.

FIG. 5. Two individuals in conjugation. The coarse structure of the shell prevented any movement of the sarcode from being visible; the yellowish stain produced by the endosarc. Swarthmore brick-pond, May, 1874. 200 diameters.

FIG. 6. Individual with pseudopods protruded. Pond on Mount Gilbert, Uinta Mountains, Wyoming, August, 1877. 250 diameters.

FIG. 7. Shell of coarse quartz sand. Absecom pond, New Jersey, August, 1876. 200 diameters.

FIG. 8. Individual with shell approximating the form of that of *Difflugia urceolata.* China Lake, Uintas. 250 diameters.

FIG. 9. Tubular form with acuminate summit, not uncommon. Pond on Darby Creek, Delaware County, Pennsylvania, October, 1874. 200 diameters.

FIG. 10. Small individual found with others of the same kind among Utricularia from Florida, October, 1874. 200 diameters.

FIG. 11. Shell of coarse sand, with a single pointed flake at the acuminate summit. Absecom pond, New Jersey, October, 1874. 500 diameters.

FIG. 12. Shell of unusual form, with well-defined neck and mouth surrounded with a distinct rim; also composed of comparatively coarse sand. Found in the same gathering as the last. 500 diameters.

FIGS. 13–15. From Swarthmorebrick-pond. 200 diameters. Fig. 13, an ordinary form of shell; sarcode with yellowish endosarc; fig. 14, individual with pseudopods protruded; fig. 15, individual with pseudopods protruded and with bright green endosarc. The brown spots on the shells of the two latter figures indicate grains of garnet entering into their construction, an unusual occurrence.

FIG. 16. Unsymmetrical shell, with unusually large stone adherent on one side. China Lake, Uintas, Wyoming T. 250 diameters.

FIGS. 17, 18. Shells of chitinoid membrane with incorporated sand. Pond at Atco, N. J., August, 1876. 250 diameters.

FIG. 19. Shell of chitinoid membrane, with incorporated sand and diatom fragments. Absecom pond, New Jersey, August, 1876. 250 diameters.

FIGS. 20–22. Drop tube-like forms. Absecom pond, New Jersey. 200 diameters. Fig. 20. Individual with unusually and remarkably rough shell, composed of sand; September, 1875. Fig. 21. Shell remarkably uneven, composed of chitinoid membrane with incorporated sand and diatoms; October, 1874. Fig. 22. Shell of chitinoid membrane with incorporated sand and diatoms; found in company with the last.

FIGS. 23–26. Shells of chitinoid membrane incorporated with diatoms; 23–25 empty, and the former with sand at the border of the mouth; 26, with the sarcode encysted. From sphagnum of Absecom cedar swamp, October, 1874. 500 diameters.

DIFFLUGIA ACUMINATA

PLATE XIV.

DIFFLUGIA URCEOLATA.

All the figures were taken from living specimens, represented in their usual position, and with the shells composed of angular particles of quartz sand.

FIG. 1. Variety approaching *Difflugia acuminata*. 200 diameters. Swarthmore brick-pond, Delaware County, Pennsylvania, October, 1875.

FIG. 2. Variety with less acuminate fundus to the shell. 250 diameters. Lake of Uinta Mountains, Wyoming, August, 1877.

FIG. 3. Variety *Difflugia amphora*. 100 diameters. Ditch below Philadelphia. Common form.

FIG. 4. Oral view of a similar specimen.

FIG. 5. Characteristic specimen of *Difflugia urceolata*. 200 diameters. Absecom pond, New Jersey, August, 1876. Common form.

FIG. 6. Narrower variety of the same kind occurring with it.

FIG. 7. Common form in ditches communicating with the Delaware River below Philadelphia.

FIG. 8. Common form: abundant in a pond of Bridger Butte, Fort Bridger, Wyoming, August, 1877. 250 diameters.

FIG. 9. Acuminate variety, with additional spines to the fundus. A not unfrequent form. Atco, N. J., September, 1877. 250 diameters.

FIG. 10. Common variety. Absecom pond, New Jersey. 250 diameters.

FIG. 11. Variety named *Difflugia olla*. Abundant in the ponds of sphagnous swamps. Budd's Lake, New Jersey, September, 1874. 250 diameters. The sarcode encysted.

FIG. 12. Unsymmetrical specimen. Absecom pond, New Jersey, September, 1875. 200 diameters.

FIG. 13. Many-spined specimen, found with the former. 200 diameters. Each spine ending in a single large sand grain.

FIG. 14. Single-spined specimen. Atco, N. J., September, 1877. 250 diameters. The spine ending in a single large sand grain.

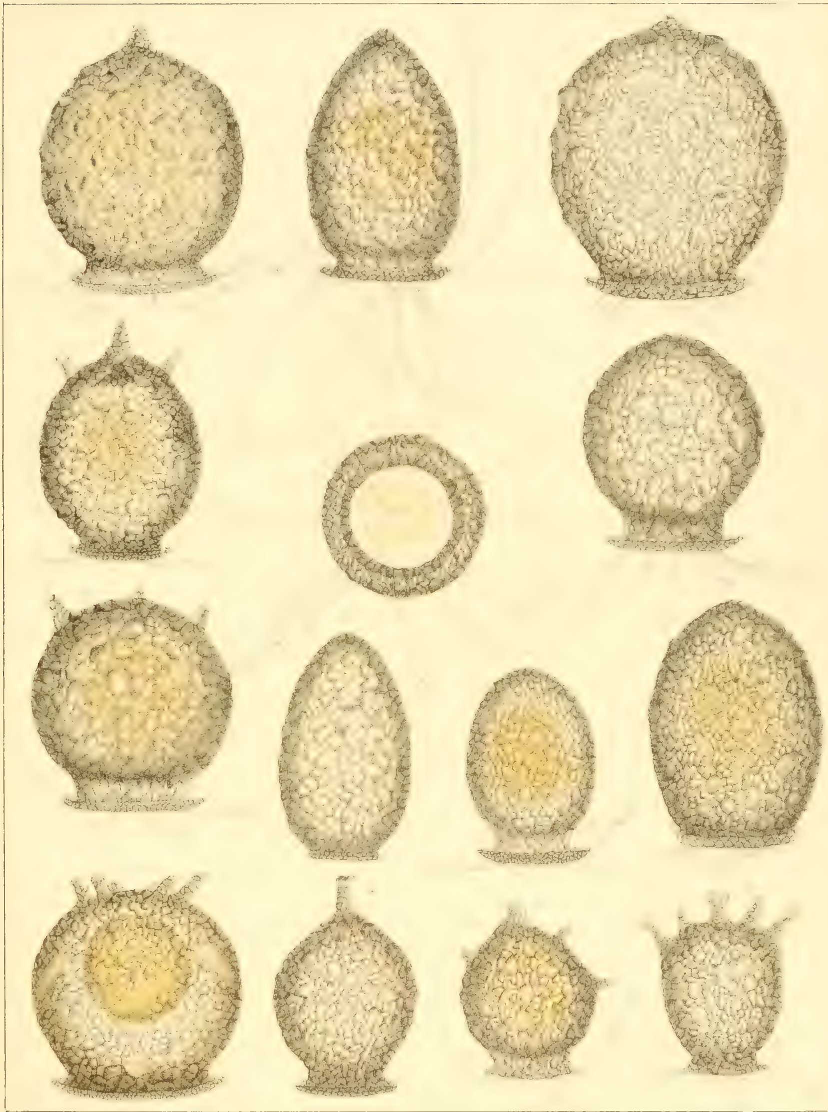


PLATE XV.

FIGS. 1–24.—DIFFLUGIA LOBOSTOMA.

FIGS. 1, 2. Two views of the same individual; the shell composed of coarse quartz sand; endosarc centrally bright green; the pseudopods protruded. Fig. 1, inferior view exhibiting the trilobed mouth; fig. 2, lateral view. Swarthmore brick-pond, June, 1874. 200 diameters.

FIGS. 3, 4. Similar views of another specimen found with the former.

FIGS. 5, 6. Similar views of an empty shell with quadrilobate mouth. Pond near Darby, Delaware County, Pennsylvania, October, 1874. 250 diameters.

FIG. 7. Lateral view of an individual, with trilobate mouth and projecting rim. Ditch below Philadelphia, May, 1875. 250 diameters.

FIG. 8. Inferior view of an individual with quadrilobate mouth and colorless sarcode. China Lake, Uinta Mountains, Wyoming Territory, August, 1877. Length, 0.18 mm.; breadth, 0.16 mm.

FIG. 9. Inferior view of an individual with quinquelobate mouth and colorless sarcode. Fort Bridger, Wyoming, August, 1877. 200 diameters. Length, 0.112 mm.; breadth, 0.1 mm.

FIG. 10. Inferior view of an individual with six-lobed mouth, the margin stained brown. Fig. 11. Side view of the same with remarkable pseudopodal extension. Ditch below Philadelphia.

FIG. 12. Inferior view of a similar individual. Fort Bridger, Wyoming Territory, July, 1877. Length, 0.14 mm.; breadth, 0.13 mm.

FIG. 13. Side view of an individual with a seven-lobed mouth. Appearance of the pseudopod, spread out beneath the edge of a Holman life-slide. Found with the preceding.

FIG. 14. Inferior view of an individual with seven-lobed mouth; the sand grains of the shell outlined with brown cement. Darby Creek, Delaware County. 250 diameters. Length, 0.14 mm.; breadth, 0.12 mm.

FIG. 15. Small individual with trilobed mouth, inferior view, with profuse extension of pseudopods. Ditch below Philadelphia, April, 1876. 200 diameters. Length, 0.055 mm.; breadth, 0.05 mm.

FIGS. 16, 17. Two views of an empty shell, composed of rectangular and oval plates with dotted intervals; fig. 16, inferior view exhibiting the quadrilobate mouth; fig. 17, lateral view showing projecting rim of the mouth. China Lake, Uinta Mountains, Wyoming Territory, August, 1877. 500 diameters.

FIGS. 18, 19. Two views of an empty shell, composed of rectangular plates and fragments of diatoms; fig. 18, inferior view, exhibiting an irregular multilobate (probably mutilated) mouth; fig. 19, lateral view. Hammonton pond, New Jersey, September, 1877. 250 diameters.

FIG. 20. Lateral view of a specimen with trilobed mouth, composed of thin angular plates and diatoms. Atco, N. J., June, 1877. 250 diameters.

FIGS. 21, 22. Inferior and lateral views of a mammillated specimen with six-lobed mouth bordered by a projecting rim. Woodstown pond, New Jersey, September, 1877. 250 diameters.

FIGS. 23, 24. Inferior and lateral (reversed) views of a small hemispheroidal specimen, with five-lobed mouth. Swarthmore brick-pond. 250 diameters.

FIGS. 25–31.—DIFFLUGIA GLOBULOSA. 250 diameters.

FIGS. 25, 26. Two views of the same individual, with colorless sarcode, except the color due to food in the endosarc; fig. 25, lateral view; fig. 26, inferior view exhibiting the circular mouth. Swarthmore brick-pond.

FIGS. 27, 28. Two views of the same individual, with colorless sarcode and extended pseudopods; fig. 27, lateral view showing a projecting rim to the mouth; fig. 28, inferior view showing the large circular mouth. Fort Bridger, Wyoming, August, 1877.

FIGS. 29, 30. Two similar views of a specimen. Ditch below Philadelphia, September, 1875.

FIG. 31. Lateral view of an individual, with the shell composed of chitinoid membrane, irregularly striated and incorporated with a few scattered sand grains. A single pseudopod enormously extended. Pond near Darby, Delaware County.

FIGS. 32, 33.—DIFFLUGIA PYRIFORMIS. 200 diameters.

Two individuals showing their approximation in shape to the subpyriform varieties of *Difflugia globulosa*. Swarthmore brick-pond.

FIGS. 34–37.—DIFFLUGIA ARCULA. 250 diameters.

FIGS. 34, 35. Two views of an empty shell, composed of clay-colored chitinoid membrane; fig. 34, lateral view, with sand grains incorporated at the fundus; fig. 35, inferior view showing the trilobate mouth. Sphagnous bog of Absecom, N. J., April, 1876.

FIGS. 36, 37. Two similar views of a specimen composed of chitinoid membrane with incorporated sand and dirt. Tobyhanna sphagnous swamp, Pokono Mountain, Pennsylvania, July, 1876.

PLATE XVI.

FIGS. 1–24.—DIFFLUGIA GLOBULOSA.

FIGS. 1, 2. Two views of an empty shell, composed of coarse quartz sand; fig. 1, inferior view showing the circular mouth; fig. 2, lateral view. Absecom mill-pond. 200 diameters.

FIGS. 3, 4. Two views of a large specimen, found with the preceding; magnified 100 diameters.

FIGS. 5, 6. Two views of a specimen with yellowish tint. Uinta Mountains, Wyoming. 200 diameters.

FIGS. 7, 8. Corresponding views of a living individual. Ditch below Philadelphia. 200 diameters.

FIGS. 9, 10. Similar views of a specimen, in which the shell is composed of chitinoid membrane incorporated with narrow rectangular plates, etc., and the sarcode contracted into an encysted ball. China Lake, Uintas, Wyoming, August, 1877. 200 +.

FIGS. 11, 12. Inferior and lateral views of a small shell, composed of sand. Sphagnous swamp, Absecom, N. J. 200 +.

FIGS. 13, 14. Same views of a small shell composed of chitinoid membrane incorporated with sand. A continuous circle of sand grains surrounds the mouth. Sphagnous swamp, Broad Mountain, Pennsylvania. 200 +.

FIGS. 15, 16, 17. Inferior, lateral, and superior views of a small shell composed of chitinoid membrane with scattered sand grains. Pond near Cape May, N. J. 250 +.

FIGS. 18, 19. Lateral and inferior views of a minute shell, composed of chitinoid membrane, striated and incorporated with scattered sand particles. An accumulation of the latter occupies the fundus. Pokono Mountain, Pennsylvania. 500 +.

FIG. 20. Inferior view of a living individual, with shell of sand, and with colorless sarcode. Fort Bridger, Wyoming Territory. 250 diameters. Shell of oval form 0.08 mm. long; 0.0[illegible]8 mm. broad.

FIG. 21. Inferior view of an empty shell, composed of chitinoid membrane incorporated with large diatoms, etc. Sphagnous swamp, Absecom, N. J. A not unfrequent kind. 500 +. Shell hemispheroidal, 0.036 mm. high; 0.0[illegible]8 mm. broad.

FIG. 22. Similar view of a specimen composed of rectangular plates, together with a few diatoms. Found with the preceding and likewise not an unfrequent kind. Height, 0.032 mm.; breadth, 0.0[illegible]4 mm.

FIG. 23. Inferior view of an individual in which the shell was composed of brown chitinoid membrane incorporated with sand and dirt. Boggy place near Swarthmore, Delaware County, Pennsylvania. 500 +. Shell 0.032 mm. high; 0.05 mm. broad.

FIG. 24. Inferior view of a specimen in which the shell was composed of sand with intervening brown cementing substance. Pseudopods numerous and more branching and pointed than usual. Same locality as the preceding. 500 +. Shell 0.33 mm. high; 0.05 mm. broad.

FIGS. 25–29.—DIFFLUGIA LOBOSTOMA.

FIGS. 25, 26. Two views of an individual in which the shell appeared to be composed of yellowish, cancellated chitinoid membrane as in the genus Nebela; fig. 25, lateral view, with sarcode seen attached by threads to the inside of the fundus of the shell. A large central nucleus and several contractile vesicles situated at the periphery are also visible. Fig. 26, inferior view exhibiting the trilobate mouth and protruding pseudopods. Among Duckmeat in a ditch below Philadelphia, June, 1874. 500 +.

FIGS. 27, 28. Inferior and lateral views of a living individual, in which the shell was composed of colorless chitinoid membrane with a few scattered sand particles. Swarthmore brick-pond, May, 1874. 333 diameters.

FIG. 29. Lateral view of a living specimen, in which the shell was composed of chitinoid membrane with incorporated flocculent dirt, and in which the mouth was trilobed. Boggy place on Darby Creek, Delaware County. 200 +.

FIGS. 30, 31.—DIFFLUGIA ARCULA.

Inferior view of two empty shells of hemispheroidal shape, composed of yellow chitinoid membrane incorporated with brownish dirt and a few scattered particles of sand. (The unsymmetrical outline of fig. 30 correct, though probably accidental.) Sphagnous swamp at Atco, N. J. 250 diameters. The shells shaped like that of an ordinary sea-urchin. Height of shell, 0.072 mm.; breadth, 0.136 mm. to 0.14 mm.

FIGS. 32–34.—DIFFLUGIA URCEOLATA.

FIG. 32. Variety *Difflugia olla*. Lateral view of a living individual with protruded pseudopods. Absecom pond, New Jersey, October, 1875. 100 +.

FIG. 33. Egg-shaped variety, with a narrow projecting rim to the mouth. Lateral view of a living specimen. A common form in a pond on Bridger Butte, near Fort Bridger, Wyoming Territory, August, 1877. 250 diameters.

FIG. 34. Variety *Difflugia amphora*. Lateral view with pseudopods extended. Common in the ditches below Philadelphia, October, 1875. 100 diameters.

FIG. 35.—DIFFLUGIA CRATERA.

Lateral view of an empty shell composed of chitinoid membrane incorporated with fine sand particles. Lake Erie, Buffalo, N. Y., October, 1878. 500 +.

FIG. 36.—DIFFLUGIA ——— ?

Lateral view of an empty pyriform shell possessing two long divergent appendages, and composed of colorless chitinoid membrane incorporated with irregular angular quartz particles. The only specimen of the kind observed. Sphagnous swamp, Atco, N. J. 250 +.

FIGS. 37, 38.—DIFFLUGIA PYRIFORMIS.

FIG. 37. Subpyriform variety approximating *Difflugia globulosa*. Lateral view of a living specimen, the shell of which composed of angular quartz sand with a comparatively large grain attached to the fundus. Ditch below Philadelphia, March, 1875. 100 +.

FIG. 38. Lateral view of an individual, from one side of the shell of which there projects unsymmetrically a comparatively large stone. Boggy place on Darby Creek, Delaware County, Pennsylvania. 100 diameters.

FIG. 39. Nucleus pressed from an individual of *Difflugia lobostoma*, October, 1874. 500 diameters.

FIGS. 40, 41. Isolated nucleus, and portion of crushed material from an individual of *Difflugia urceolata*. 500 diameters.

PLATE XVII.

DIFFLUGIA CORONA.

All the figures were from living specimens; the shell composed of angular quartz sand and the sarcode colorless. 200 diameters, except when specially indicated.

FIG. 1. Individual with extended pseudopods; the shell with seven spines to the fundus, of which five are visible in the lateral view. The mouth was furnished with twelve points or teeth and as many intervening sinuses. The somewhat palmate pseudopods were spread outwardly on the inclined border of a glass cell. A common form in Swarthmore brick-pond, Delaware County, and in ditches below Philadelphia.

FIGS. 2–4. Common forms, from Lake Hattacawanna, Morris County, New Jersey, October, 1874.

Fig. 2, lateral view of an individual with extended pseudopods; shell with seven spines to the fundus and fifteen teeth to the mouth.

FIG. 3. Inferior view of another individual, exhibiting the mouth and extended pseudopods. Shell with seven spines to the fundus and fourteen teeth to the mouth. A similar specimen, 0.248 mm. high and 0.24 mm. broad, had seven spines to the fundus and twelve teeth to the mouth.

FIG. 4. Upper view of a specimen with eleven spines to the fundus. Mouth 0.16 mm. in diameter with sixteen brown teeth.

As represented in the figures, while the body of the shell is colorless, the spines and border of the mouth are frequently stained of a ferruginous brown.

FIGS. 5, 6. Two views of the same individual; fig. 5, lateral view, with extended pseudopods, and four spines to the fundus; fig. 6, inferior view exhibiting the mouth with fifteen teeth. Ditch below Philadelphia, September, 1875.

FIG. 7. Lateral view of a specimen with an oblique mouth as in *Difflugia constricta*, but furnished with twelve teeth, and having a single spine to the fundus. The only specimen of the kind seen. Swarthmore brick-pond, March, 1875.

FIG. 8. Inferior view of a specimen exhibiting the mouth with six teeth. The fundus of the shell had seven comparatively short spines. Jacksonville, Fla., March, 1875.

FIG. 9. Lateral view of a slightly unsymmetrical specimen with a single spine to the fundus. The mouth had twelve teeth. Ditch below Philadelphia, September, 1875.

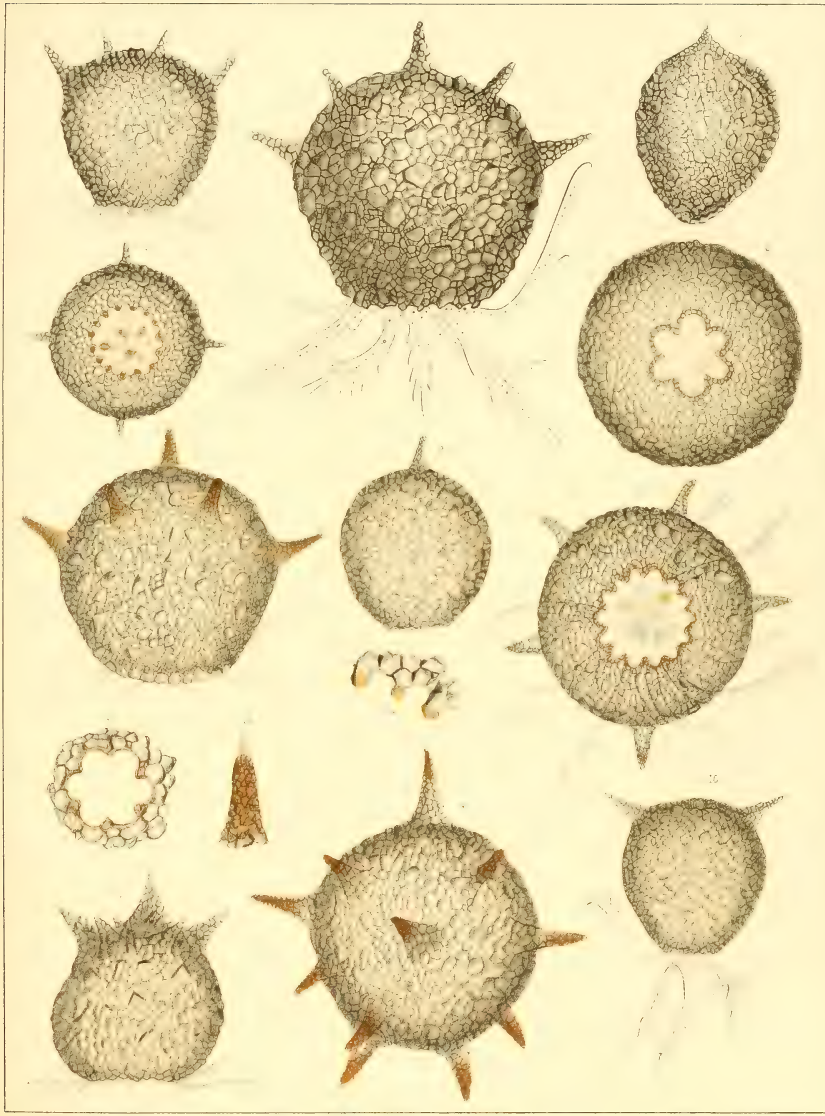
FIG. 10. Lateral view of an individual with a pair of widely divergent spines to the fundus, and with extended pseudopods. Mouth with twelve teeth. With the preceding.

FIG. 11. An unusually unsymmetrical specimen. Lateral view with extended pseudopods. Seven spines to the fundus and sixteen teeth to the mouth. Atco, N. J., September, 1877.

FIG. 12. Six-lobed mouth of a specimen which had seven spines to the fundus. The shell was 0.33 mm. in diameter. Lake Hattacawanna, New Jersey.

FIG. 13. One of the spines from the same specimen, showing a lance-head-like flake at the end. 375 diameters.

FIG. 14. Three teeth from a specimen like that of fig. 6, showing terminal colored sand grains.



DIFFLUGIA

PLATE XVIII.

DIFFLUGIA CONSTRICTA.

In the lateral views of the specimens, they occupy the natural position with the mouth downward and on a level; in the posterior views, they are tilted upward or appear as ordinarily seen, lying on the front beneath the microscope. Anterior views appear the same as the latter, as the mouth is visible through the front wall of the shell. The shell mostly composed exclusively of angular quartz sand, and the sarcode colorless.

FIG. 1. Lateral view of an individual with pseudopods protruded. Ditch below Philadelphia, June, 1877. 500 diameters.

FIGS. 2, 3. Two views of the same specimen; the former posterior, the latter lateral (inadvertently misplaced by the artist; the inclined line on the right should have been horizontal). From moss in the fork of an apple tree, Swarthmore, November, 1877. 250 diameters.

FIGS. 4, 5. Lateral and posterior views of the same specimen. Sphagnous swamp, Vineland, N. J., September, 1876. 250 +

FIGS. 6, 7. Lateral and posterior views of the same (the former misplaced by the artist; the inclined line on the left should be horizontal). Fort Bridger, Wyoming Territory, July, 1877. 250 +.

FIGS. 8, 9. Posterior and lateral views of a shell composed of yellowish chitinoid membrane, incorporated with scattered sand, and a continuous circle of grains around the mouth. Found with that of figs. 2, 3. 250 +.

FIG. 10. Posterior view of a shell composed of chitinoid membrane with sand and dirt. From among moss in the crevices of the pavements of Philadelphia, June, 1878. 333 +.

FIGS. 11, 12. Posterior and lateral views of an individual with extended pseudopods. Shell as in the preceding. From among moss of the pavement in the yard of my house, June, 1878. 333 +.

FIG. 13. Posterior view of the same specimen in the natural position, or not tilted forward.

FIG. 14. Lateral view of a specimen, with shell composed of sand and with projected pseudopods. A frequent form found with the preceding. 333 +.

FIGS. 15, 16. Posterior and lateral views of a shell of chitinoid membrane with sand grains. Perhaps pertaining to *Centropyxis ecornis*. Found with that of figs. 2, 3. 250 +.

FIGS. 17, 18. Lateral and posterior views of a shell, composed of sand, stained brown, with a darker cement. Fig. 19. Posterior view of another specimen. Mouth of a cave on Bushkill Creek, Easton, Pa., July, 1878. 333 +.

FIGS. 20, 21. Lateral and posterior views, with shell of chitinoid membrane incorporated with sand, diatoms, etc. China Lake, Uinta Mountains, August, 1877. 250 +.

FIGS. 22, 23. Posterior and lateral views. (Correct outlines; with no constriction nor abrupt projection of the fore-lip.) Egg Harbor, N. J., August, 1878. 333 +.

FIGS. 24, 25. Posterior and lateral views. With the preceding. 333 +.

FIGS. 26, 27. Posterior and lateral views of a specimen with shell of chitinoid membrane, incorporated at the fundus and around the mouth with sand grains. Sphagnous bog at Absecom, N. J., April, 1876. 250 +.

FIG. 28. Lateral view of shell, tilted up to a perpendicular line, composed of chitinoid membrane with large sand grains on the fundus. With the last. 500 +.

FIGS. 29, 30. Posterior and lateral views of a specimen with shell of yellow chitinoid membrane, incorporated with sand. A continuous circle of grains surrounds the mouth, and comparatively large grains occupy the fundus. Absecom pond, April, 1877. 250 +.

FIGS. 31, 32. Posterior and lateral views of a shell of chitinoid membrane with incorporated sand. Sphagnous bog of Broad Mountain, Pennsylvania, September, 1876. 250 +.

FIGS. 33, 34. Lateral and posterior views of a similar specimen. Vineland, N. J., September, 1877. 250 +.

FIGS. 35, 36. Lateral and posterior views of a large shell, composed of quartz sand. Vineland, N. J., September, 1877. 175 +.

FIGS. 37–44. Empty shells composed of yellow chitinoid membrane, incorporated with variable proportions of scattered sand grains and dirt. Sphagnum of Absecom cedar swamp, New Jersey. Figs. 37, 39, 42, lateral views; figs. 38, 40, 43, posterior, tilted up, views; figs. 41, 44, posterior views in the normal position. 250 +.

FIGS. 45, 46. Lateral and posterior views of a large individual with shell of quartz sand, acuminate at the fundus, and with extended pseudopods. Vineland, N. J., September, 1877. 175 +.

FIGS. 47, 48. Lateral and posterior views of a large two-spined shell. Absecom pond, New Jersey.

FIG. 49. Posterior view of a three-spined specimen. With the last. 175 +.

FIGS. 50, 51. Posterior and lateral views of a two-spined individual. Wind Gap, Northampton County, Pennsylvania. 175 +.

FIG. 52. Posterior view of an individual, with shell having a row of five spines to the fundus, and with a long, bifid pseudopod. Absecom, September, 1874. 175 +.

FIG. 53. Posterior view of an individual, with shell having six spines to the fundus, and exhibiting a single long pseudopod. Found with the preceding. 175 +.

FIG. 54. Posterior view of another specimen, with four spines. With the preceding. 175 +.

FIG. 55. Lateral view of fig. 53.

FIGS. 56, 57. Two spines, showing the lance-head-like flake at their termination. 500 +.

PLATE XIX.

FIGS. 1—23.—DIFFLUGIA SPIRALIS.

FIGS. 1, 2. Broader lateral, and anterior narrower views of the same individual, with shell of quartz sand and with extended pseudopods. Swarthmore brick-pond, September, 1874. 200 diameters.

FIG. 3. Broader lateral view of a pair of individuals in conjugation. Ditch below Philadelphia. September, 1875. 200 +.

FIG. 4. Broader lateral view of a shell composed of rectangular plates, with diatoms, and centrally with large angular particles of quartz sand. Hammonton pond, New Jersey, September, 1877. 250 +.

FIG. 5. Lateral view of an individual with extended pseudopods; the shell composed of quartz sand, except contiguous to the mouth where it is formed of vermicular pellets. From ditch of a cranberry-bog, Atco, N. J., October, 1877. 250 +.

FIG. 6. Broader lateral view of a small specimen, with shell of quartz sand. Pool at Manayunk, Philadelphia. 200 +.

FIG. 7. Broader lateral view of an individual, with extended pseudopods, and shell entirely composed of short vermicular pellets. A frequent kind in Absecom pond, October, 1874. 250 +.

FIG. 8. Similar view of an individual, with a profusion of pseudopods. The shell composed as in the last, but with the vermicular pellets separated by narrow intervals, occupied with cementing substance. Found with the former, but only a few of the kind observed.

FIGS. 9, 10. Posterior and lateral views of a specimen in which the shell is composed of vermicular pellets, as in fig. 7. Some of the pellets seen to project at the border. The interior contained an oval brownish ball, probably the much reduced and contracted sarcode. Sphagnous swamp, Absecom, N. J., March, 1875. 250 +.

FIG. 11. Broader lateral view of an empty shell composed of vermicular pellets and a few large particles of sand. Same locality, June, 1877. 250 +.

FIG. 12. Individual with shell apparently formed by a net with small angular meshes, and incorporated with a few large sand grains. Absecom pond, October, 1874. 250 diameters. The structure as represented I have suspected to be illusory, and to have been really as in fig. 8, but of this I am by no means positive. I have seen no more of the kind since the above date.

FIG. 13. Individual with shell of chitinoid membrane incorporated with scattered sand grains. The outline of the sarcode mass is seen within, ending below in the projecting pseudopods. Absecom pond. 225 +.

FIGS. 14, 15. Broader side view of two individuals, with the shell composed of narrow rectangular plates arranged in all directions and in close juxtaposition. The outline of the interior sarcode visible with its extension to the mouth of the shell. Same locality. 250 +.

FIG. 16. Small individual, with shell composed of chitinoid membrane incorporated with minute rods. It contains two balls: one oval and colorless, probably the sarcode; the other globular and colored, probably discharged remains of food. Same locality. 250 +.

FIGS. 17, 18. Posterior and lateral views of an empty shell composed of chitinoid membrane incorporated with scattered diatoms. Sphagnum of Absecom, October, 1874. 250 +.

FIG. 19. Broader lateral view of a shell composed of chitinoid membrane, incorporated with scattered rods, diatoms, and sand. Absecom pond. 250 +.

FIG. 20. Specimen with shell composed as in the preceding, and containing four balls, of which, the two colorless ones appeared to consist of the sarcode, while the colored ones were supposed to consist of discharged excrement. Found in company with the former. 250 +.

FIGS. 21, 22. Posterior and lateral views of an empty shell, with unusually long neck, and composed nearly as in the preceding specimens, with which it was obtained. 250 +.

FIG. 23. Broader lateral view of a shell composed of elements of undetermined character. Absecom pond, June, 1877. 250 +.

FIGS. 24–26.—DIFFLUGIA PYRIFORMIS.

The shell of coarse quartz sand, and with a slanting constriction at the root of the neck, so as to give it an appearance approximating that of *Difflugia spiralis*. Swarthmore brick-pond, September, 1874. 200 +. Others of a similar character found at the same time. Sarcode colorless, except a clay-colored hue to the endosarc. Most specimens also exhibited a black patch, probably due to some peculiar food.

FIGS. 27–29.—DIFFLUGIA URCEOLATA.

FIG. 27. Small individual, with shell of chitinoid membrane incorporated with diatoms and sand, and with an unusually irregular surface. China Lake, Uinta Mountains, Wyoming Territory, August, 1877. 250 +.

FIG. 28. Variety *Difflugia olla*. Lateral view, with shell composed of coarse sand, and with projected pseudopods. Absecom pond, New Jersey. 200 +.

FIG. 29. Variety *Difflugia olla*. Lateral view of an empty shell, composed of chitinoid membrane incorporated with diatoms, etc. Found in the same locality as the preceding. 200 +.

EULATA

PLATE XX.

FIGS. 1–10.—HYALOSPHENIA CUNEATA.

FIG. 1. Broader lateral view of an individual with a pair of projected pseudopods. The attachment of the interior pseudopodal threads produces indentations of the delicate shell. Spring at Lansdowne station, Delaware County, Pennsylvania, April, 1875. 500 diameters.

FIG. 2. Broader lateral view of another individual from the same locality, January, 1878. Fig. 3. Transverse section of the same. 666 diameters.

FIGS. 4, 5. Broader and narrower lateral views of an individual, from the same locality, June, 1874. 666 diameters.

FIGS. 6–10. Series of views of a pair of individuals in conjugation exhibiting successive changes in the sarcode. Same locality as the preceding, June, 1874. 500 diameters.

FIGS. 11–18.—HYALOSPHENIA TINCTA. 500 diameters.

FIG. 11. Empty shell, showing minute apertures at the margin, indicated by the arrows *a*. Sphagnum, Atco, N. J.

FIG. 12. View of the broader side of a living individual, showing the retraction of the sarcode from the mouth of the shell while pseudopods are yet projected. Fig. 13. Transverse view of the same. Sphagnous swamp, Tobyhanna, Pokono Mountain, July, 1876.

FIG. 14. Broader side view of an individual, with projected pseudopods. Fig. 15. Transverse section of the same, with the mouth.

FIGS. 16, 17. Broader and narrower lateral views of another individual, with pseudopods withdrawn. Same locality as the preceding.

FIG. 18. Small empty shell, showing minute apertures at the border. Same locality.

FIGS. 19–29.—HYALOSPHENIA ELEGANS. 500 diameters.

FIGS. 19–21.—From the same individual. Fig. 19. Broader lateral view, showing the interior sarcode attached by pseudopodal threads, and with projected pseudopods. Fig. 20. Narrower lateral view of the shell, showing the cup-like depressions. Fig. 21. Transverse view, with the mouth. Sphagnum, Absecom, N. J., October, 1874.

FIG. 22. Broader lateral view of an individual with ample sarcode and projected pseudopods. *p. v.* contractile vesicles. With the preceding.

FIG. 23. Broader lateral view of an individual with projected pseudopods. The sarcode exhibits at its periphery four contractile vesicles; and the nucleus is eccentric. Breadth of shell 0.064 mm. by 0.032 mm. Absecom, May, 1877. (The lithographer has erroneously colored the sarcode.)

FIG. 24. Broader lateral view, reversed, with the sarcode contracted into an ovoidal ball; and exhibiting in the neck a number of round balls, supposed to be excrementitious and discharged from the sarcode. Sphagnum, Swarthmore, Delaware County, April, 1877.

FIG. 25. Specimen containing isolated corpuscles, probably spores or germs, resulting from the segmentation of the original sarcode. Sphagnum, Absecom, October, 1874.

FIG. 26. Narrower lateral view of the shell of the same.

FIG. 27. Individual with the sarcode in an encysted condition. A frequent form and condition in sphagnum of Schooley's Mountain, New Jersey, October, 1874.

FIG. 28. Specimen with encysted sarcode. The arrow *a* points to one of the minute apertures of the shell. Absecom, N. J., April, 1876.

FIG. 29. Specimen with encysted sarcode. The mouth of the shell closed with a number of balls discharged from the sarcode. A frequent condition at Absecom, N. J., November, 187 .

PLATE XXI.

HYALOSPHENIA PAPILIO. 500 diameters.

FIG. 1. Broader lateral view of an individual in the normal position, with projected pseudopods, and in the act of discharging excrementitous matter. The sarcode nearly filling the shell; the large granular nucleus visible in the fundus, and contiguous to it four clear contractile vesicles. Abundant form in sphagnum of most localities in the United States. Specimen from cedar swamp, Absecom, N. J., May, 1877.

FIG. 2. Outline of the narrower lateral view of the following.

FIG. 3. Broader lateral view of an individual with protruded pseudopods. Found with that of fig. 1.

FIG. 4. Individual in which the sarcode is much reduced in extent, probably from deficiency of food. Three isolated green corpuscles are seen in the space between the sarcode and shell. Sphagnous swamp, Tobyhanna, Pokono Mountain, July, 1876.

FIGS. 5, 6. Two views of the same individual, with the sarcode retracted from the mouth of the shell. Sphagnum, New Jersey, May 1877.

FIGS. 7, 8. Two views of the same individual, with the sarcode contracted into a discoid ball. Absecom, October, 1874.

FIG. 9. Narrower lateral view of an individual with encysted sarcode, and with the mouth of the shell closed by contraction and by an operculum. With the preceding.

FIG. 10. Broad view of a similar specimen; the mouth of the shell not closed. The sarcode encysted. The two brown balls consist of discharged excrementitous matter. Absecom swamp, October, 1874.

FIG. 11. View of broader side of a specimen; the mouth of the shell closed by an operculum; the sarcode encysted. Sphagnum, Swarthmore, Delaware County, Pennsylvania, October, 1875.

FIG. 12. View of a specimen, containing numerous green corpuscles. From sphagnum of Absecom, preserved in a glass case during the winter. The specimen observed December, 1874. Many similar ones observed, with variable quantities of green corpuscles, which are suspected to be germs or spores derived from the breaking up of the encysted sarcode.

FIG. 13. Specimen of a kind repeatedly observed. Shell containing colorless granular corpuscles. These occur of varied size and in variable quantity. Undetermined whether to be the spores of the Hyalosphenia, or whether they are parasitic. Sphagnum, New Jersey, April, 1877.

FIGS. 14, 15. Transverse sections, exhibiting the form of the mouth, and the attachments of the sarcode mass to the interior of the shell.

HYALOSPHENIA PAPIL.

PLATE XXII.

NEBELA COLLARIS. 500 diameters.

From sphagnum of the sphagnous and cedar swamps of New Jersey.

FIG. 1. Broader lateral view of a living individual in the normal position, with pseudopods extended. Shell composed mostly of nearly uniform oval plates.

FIGS. 2–4. Three views of the same individual:—2. broader lateral view, with interior sarcode and extended pseudopods; 3, outline of narrower lateral view; 4, outline of transverse section with view of the mouth. Shell composed of regular circular disks.

FIGS. 5, 6. Two views of the same:—5, narrower side; 6, broader side, containing a number of unequally round and oval granular, clay-colored balls. Shell composed of larger oval plates, with intervening minute round and narrow rectangular plates.

FIG. 7. Individual with sarcode encysted, and throat of the shell closed by a thick laminar operculum, apparently composed of materials discharged from the sarcode. Shell composed chiefly of large oval plates, with smaller round ones and a few narrow rectangular ones.

FIG. 8. Individual with the yellowish sarcode contracted into a ball and about to pass into the encysted condition; with the food materials still retained. Shell composed of comparatively small round disks, largest in the neck, and mingled with a few spongilla spicules.

FIG. 9. Empty shell, reversed position, composed mostly of large oval plates.

FIG. 10. Individual with small sarcode forming a central ball. Shell composed of larger oval plates at the fundus, with scattered ones of the same kind in the throat, and the wide intervals occupied by small round plates.

FIGS. 11, 12. Two lateral views of small empty shells, accompanying the former specimen; in one with mostly oval plates; in the other with circular plates.

FIG. 13. Broader lateral view of an empty shell, composed of linear plates mingled with a few scattered round and oval ones.

FIG. 14. Broader lateral view of an empty shell, composed at the fundus mainly of large oval plates, and in the lower two-thirds of small round and oval plates, with scattered linear plates.

FIG. 15. Empty shell, in outline, composed mainly of oval plates, decreasing in size towards the mouth, and mingled with smaller circular and a few rectangular plates.

FIG. 16. Small shell, composed of comparatively very large oval plates, mingled with minute round ones.

FIG. 17. Empty shell, composed of circular plates, split at the fundus, showing that the fissure follows the intervals of the plates.

FIG. 18. Shell, of narrow rectangular and oval plates, from which a broad strip was broken away, showing that the fracture follows the intervals of the plates.

FIG. 19. Fragment of the same shell more highly magnified. 850 diameters.

FIG. 20. Similar fragment, in outline, from a different focus.

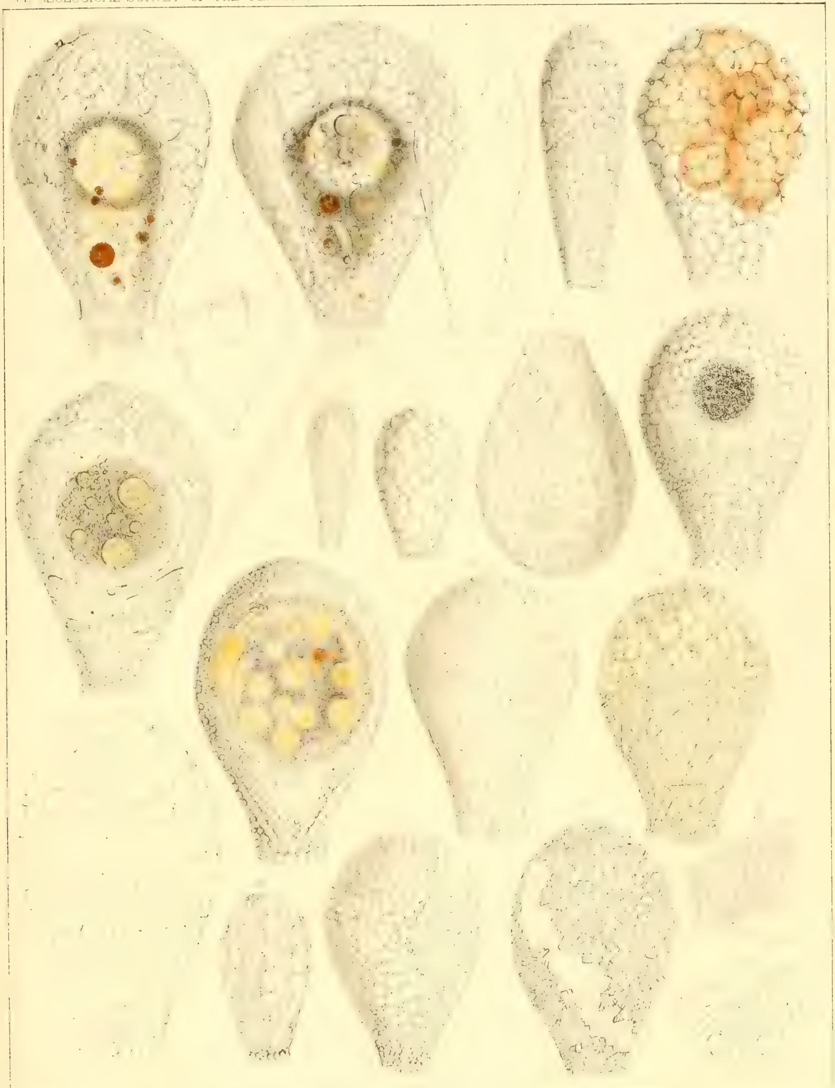


PLATE XXIII.

FIGS. 1–7.—NEBELA COLLARIS.

Narrower variety than the more common form, with a pair of minute apertures rendered prominent at the narrower border of the shell, marked *a* in fig. 4.

FIG. 1. Broader lateral view, with protruded pseudopods. The shell composed of large oval plates. Sphagnum of Absecom, N. J., September, 1874. 533 +.

FIG. 2. Broader lateral view of an individual with encysted sarcode, and shell closed with a thick laminar operculum, above which there is an accumulation of discharged excrementitious matters. Shell composed of intermingled linear and circular plates. Fig. 3. Outline of the narrower lateral view of the same. Sphagnum of Schooley's Mountain, New Jersey, October, 1874. 533 +.

FIGS. 4–6. Three views of the same individual:—fig. 4, broader lateral view; fig. 5, narrower lateral view; the sarcode visible in both and with protruded pseudopods. Shell composed of circular plates decreasing in size towards the mouth. Fig. 6. Outline of a transverse section. Sphagnum of Absecom N. J., May, 1876. 533 +.

FIG. 7. Broader lateral view of an individual with reticulated shell and encysted sarcode; the throat of the shell closed by a lenticular operculum. Absecom pond, New Jersey, October, 1875. 350 +.

FIGS. 8–19.—NEBELA FLABELLULUM.

FIG. 8. Broader lateral view of a living individual in the normal position, with protruded pseudopods, and with shell composed of nearly uniform, large oval plates. The large clearer central spot at the fundus of the sarcode indicates the nucleus; and four clear vesicles at the periphery contiguous to the latter indicate contractile vesicles. Breadth of shell, 0.097 mm. by 0.04 mm. Sphagnum of Absecom, N. J., September, 1875. 700 diameters.

FIG. 9. Broader lateral view of an individual, with protruded pseudopods. Shell composed of mostly circular plates of very variable size. Two contractile vesicles are seen, of which one occupies a prolongation of the sarcode at the fundus on the left. Fig. 10. Outline of a transverse section, with the mouth. Same locality. 500 diameters.

FIG. 11. Broader lateral view of a living individual. Shell composed of circular plates, of which the larger ones are scattered with an approximation to regularity, while the smaller ones occupy the intervals. Sphagnum, Swarthmore, Delaware County, June, 1877.

FIGS. 12, 13. Two views of the same individual, with the sarcode contracted into a central ball. Shell composed of circular plates. The narrower side viewed in a different focus from the broader side. Absecom, N. J., October, 1874.

FIG. 14. Broader lateral view of an individual, with the sarcode contracted into a ball, and containing a large and uniform granular nucleus. Shell composed of linear plates intermingled with round and oval plates; and the mouth closed by an operculum. Longacoming, N. J., October, 1875.

FIG. 15. Broader lateral view of an individual in which the shell is not prolonged into a neck. Common form in sphagnum of Tobyhanna, Pokono Mountain, Pennsylvania, July, 1876.

FIG. 16. Broader lateral view, reversed, of an empty shell composed of large mostly circular plates with the intervals occupied by small ones. Found in the same locality.

FIG. 17. Empty shell composed of oval plates. Absecom, N. J.

FIG. 18. Empty shell, of circular and oval plates of variable size, mingled with linear plates. With the preceding.

FIG. 19. Empty shell of circular, oval, square, and linear plates. Egg Harbor, N. J., May, 1877.

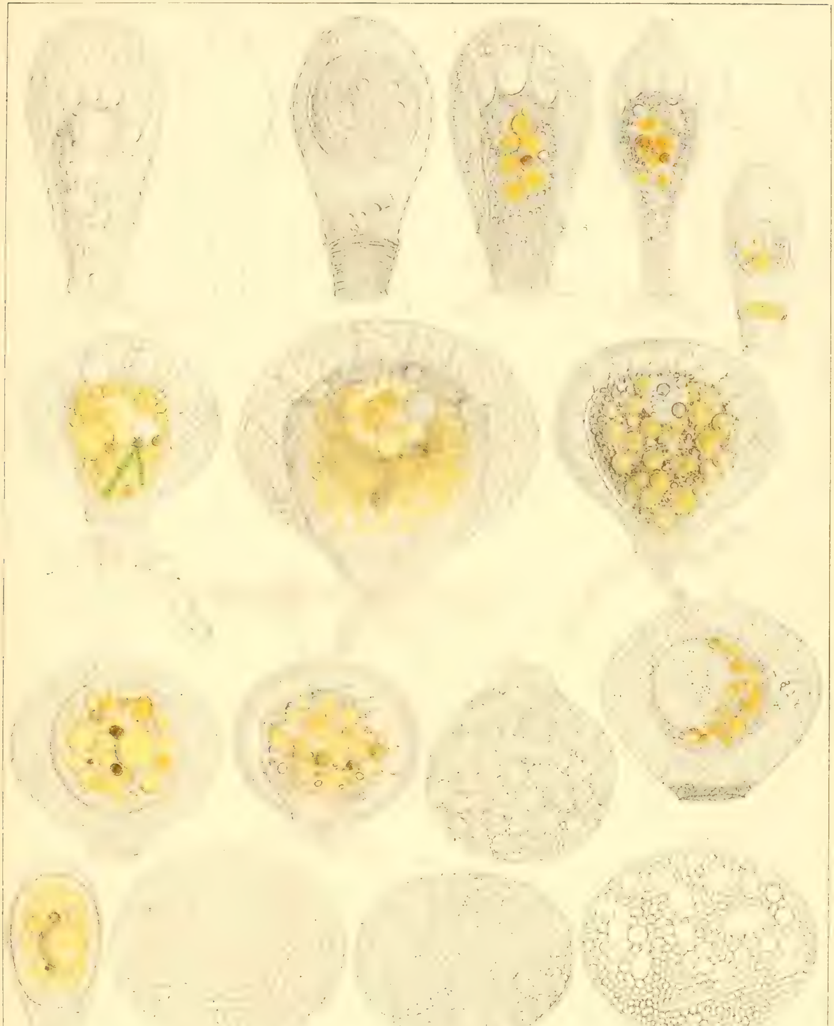


PLATE XXIV.

FIGS. 1–10.—NEBELA CARINATA.

FIG. 1. Broader lateral view of a living individual, with protruded pseudopods, and shell composed of thin plates of variable shapes. Fig. 2. Outline of the narrower side view. Fig. 3. Transverse section with outline of the mouth. Sphagnum of Absecom, N. J., June, 1877. 250 diameters.

FIG. 4. Broader lateral view of an individual in which the sarcode is of greater proportionate extent than in the preceding, and the shell composed of plates of varied shapes has also a few particles of sand attached—a rare occurrence in any species of Nebela. Absecom, October, 1874. 350 +.

FIG. 5. Individual with sarcode contracted into an oval ball, and throat of shell closed by a laminated operculum. The shell composed of thin angular plates. Sphagnum, Swarthmore, Delaware County, Pennsylvania, June, 1877. 250 +. Breadth of shell, 0.168 mm. by 0.04 mm.

FIG. 6. View of one-half of the broader side of an empty shell, composed of round and oval plates of very unequal sizes. Absecom, N. J. Shell, 0.088 mm. by 0.036 mm. 560 +.

FIG. 7. More highly magnified view of a portion of the same under a different focus.

FIG. 8. View of one-half of an empty shell with a comparatively narrow carina; the shell composed of large oval plates, with small and mostly circular ones in the intervals. Absecom, N. J. 350 +.

FIG. 9. View of one-half of the broader side of an empty shell with a wide or deep carina; the shell composed mostly of minute round plates, intermingled with linear plates and a few large oval ones. Absecom, N. J. 350 +.

FIG. 10. Empty shell, with broad keel, composed of chitinoid membrane incorporated with scattered particles of sand, etc. Absecom, N. J. 100 diameters.

FIGS. 11, 12. —NEBELA COLLARIS.

FIG. 11. Empty shell, composed of chitinoid membrane, incorporated with thin angular silicious plates, separated by narrow intervals. Sphagnum, Vineland, N. J., September, 1876. 250 diameters. A similar specimen found on Broad Mountain, Pennsylvania, with shell 0.1 mm. long, and 0.058 mm. by 0.02 mm. broad.

FIG. 12. Empty shell composed of thin, irregular, angular silicious plates in close juxtaposition. 500 diameters. Breadth of shell 0.064 mm. by 0.02 mm. This and the preceding form are transitional to the compressed variety of *Difflugia pyriformis.*

FIG. 13.—NEBELA HIPPOCREPIS.

An empty shell, with inflected hollow, spur-like processes; the shell composed of circular overlapping plates. Absecom pond, New Jersey, September, 1876. 250 diameters.

FIGS. 14–17.—NEBELA BARBATA. 500 diameters.

FIG. 14. Broader lateral view of an individual, the shell nearly replete with the sarcode and with projected pseudopods. The entire surface of the shell hirsute. Sphagnum water, Absecom, September, 1875.

FIGS. 15, 16. Two views of an individual, with the sarcode withdrawn into the body of the shell. Same locality.

FIG. 17. Individual with the sarcode contracted into a ball, and with the neck of the shell occupied with discharged excrementitious matter. Same locality.

FIGS. 18, 19.—NEBELA.

FIG. 18. An empty shell, the broader lateral view, reversed, composed of circular plates of unequal size. Intermediate in character to *Nebela barbata* and *Nebela collaris*, being shaped like the former, but without cils as in the latter. Absecom, N. J., April, 1875. 500 +.

FIG. 19. An empty shell nearly like the former. China Lake, Uinta Mountains, Wyoming Territory, August, 1877. 100 +.

FIGS. 20–25.—QUADRULA SYMMETRICA.

FIG. 20. Lateral view of a living individual. Around the base of the sarcode there were numerous detached plates like those of the shell. Pond at Vineland, N. J., September, 1876. 500 +.

FIGS. 21, 22. Two empty shells. Absecom pond, N. J. 500 +.

FIG. 23. Empty shell. Ditch on the Schuylkill, above Manayunk, Philadelphia, April, 1877.

FIG. 24. Plates of a similar shell highly magnified.

FIG. 25. Broader lateral view of an individual in which the sarcode is contracted into an oval discoid ball, and the mouth of the shell is closed with a thick laminated operculum. The plates of the shell arranged in a much more diagonal course than usual. Sphagnum, Absecom, N. J., October, 1874. 350 diameters.

PLATE XXV.

FIGS. 1–8.—NEBELA ANSATA. 250 diameters.

FIG. 1. Broader lateral view of a well fed, active individual, with sarcode nearly filling the shell, extending into the appendages, and with projected pseudopods. The abundance of food conceals the nucleus; a contractile vesicle seen on each side. The large vacuole within the neck was observed gradually to approach the mouth of the shell and discharge its contents. Sphagnum, Absecom, N. J., June, 1877.

FIG. 2. Individual with smaller sarcode attached to the fundus of the shell by tapering threads, and with projected pseudopods. Nucleus visible as a clearer spot; and a contractile vesicle on each side. Sarcode in the act of discharging excrementitious matter. Same locality, September, 1875.

FIG. 3. Individual in which the abundant sarcode is withdrawn from the mouth of the shell The yellow balls apparently food. With the preceding.

FIG. 4. Individual in which the sarcode is contracted into an oval discoid ball, ready to become encysted; the mouth of the shell closed by a laminated operculum composed of materials discharged from the sarcode. Fig. 5. Outline of the narrower lateral view of the same. Absecom, N. J., September, 1874.

FIGS. 6, 7, 8. Views from three specimens exhibiting the different forms of elements composing the shell. Same locality.

FIGS. 9–14.—NEBELA HIPPOCREPIS.

From sphagnum of Absecom, N. J. 250 diameters.

FIGS. 9–11, 13. Three views of the same individual:—fig. 9, broader lateral view, with sarcode extended and pseudopods projected; fig. 10, narrower lateral view of the same; fig. 11, broader lateral view, with the sarcode retracted from the mouth of the shell; fig. 13, superior view as the animal. presents itself beneath the microscope when in the normal position. August, 1874.

FIGS. 12, 14. Two views of an individual, with the sarcode very small, apparently exemplifying a starved condition. In fig. 12 the sarcode is greatly extended and attached to the fundus by long pseudopodal tapering threads. Pseudopods are protruded, and the sarcode is in the act of discharging excrement. In fig. 14 the sarcode is retracted and has formed an attachment to the ends of the horseshoe appendage. September, 1874.

PLATE XXVI.

FIGS. 1–11.—HELEOPERA PICTA.

From the sphagnum of sphagnous swamps of New Jersey. 500 diameters.

FIG. 1. Broader lateral view of an individual, with a profusion of pseudopods. April, 1875.

FIG. 2. Broader lateral view of an individual, with the sarcode forming an encysted ball, and with the shell closed by a lenticular, laminated operculum. April, 1877.

FIG. 3. Narrower lateral view of an empty shell.

FIG. 4. Individual with the sarcode encysted, and with the mouth of the shell closed by an operculum. April, 1877.

FIG. 5. Another specimen in the same condition as the preceding, June, 1877.

FIGS. 6, 7. Two views of the same individual, with encysted sarcode, and mouth of the shell closed. The fundus of the shell with an accumulation of incorporated grains of sand. October, 1874.

FIGS. 8, 9. Two views of the same specimen. In fig. 8 numerous isolated green corpuscles are seen, supposed to be germs derived from the breaking up of the sarcode. In fig. 9 the mouth is seen to be contracted. Collected in September, 1874, and observed December 30, of the same year.

FIG. 10. Specimen containing scattered green corpuscles or germs. Fundus of the shell with incorporated sand grains. November, 1874.

FIG. 11. Transverse view of an empty shell showing the mouth.

FIGS. 12–20.—HELEOPERA PETRICOLA.

FIG. 12. Broader lateral view of an active individual, with projected pseudopods; the fundus of the shell loaded with an accumulation of large grains of sand. Hammonton pond, New Jersey, September, 1877. 333 diameters.

FIG. 13. Broader lateral view of an individual with encysted sarcode, and with the mouth of the shell closed by an operculum. Fig. 14. Narrower lateral view of the same, in outline. Sphagnum, Longacoming, N. J., September, 1875. 500 diameters.

FIG. 15. Empty shell, with conical fundus; broader lateral view. Absecom, N. J., September, 1875. 250 +.

FIGS. 16, 17. Two views of an empty shell. Absecom pond, N. J. 200 +.

FIG. 18. Broader lateral view of an empty shell. Fig. 19. Transverse section of the same, with the mouth. Sphagnum, Absecom, N. J. 200 +.

FIG. 20. Empty shell thickly incorporated with fragments of diatoms and sand. Absecom pond, N. J. 250 +.

FIGS. 21–24.—NEBELA CAUDATA.

Sphagnum of Absecom, N. J. 500 diameters.

FIG. 21. Broader lateral view of an empty shell. June, 1877.

FIG. 22. Individual in which the shell appeared to be composed of chitinoid membrane, with circular disks. The sarcode encysted, and the mouth of the shell closed by a thick laminated operculum. September, 1874.

FIGS. 23, 24. Two views of the same individual, with encysted sarcode, and mouth of the shell closed. The shell was of chitinoid membrane of obscure structure. April, 1876.

PLATE XXVII.

ARCELLA VULGARIS.

In most of the figures of Arcella in this and the succeeding plates the cancellated or dotted appearance of the shell is omitted. The color is less varied than in the originals.

FIGS. 1, 2. Lateral and inferior views of the same individual, with extended pseudopods. Bog on the Schuylkill, West Philadelphia, June, 1877. 250 +.

FIG. 3. Lateral view of an empty shell. Ditch below Philadelphia. 250 +.

FIG. 4. Lateral view of a colorless, transparent individual, with projected pseudopods, and sarcode attached to the interior of the shell by tapering threads. Swarthmore brick-pond, Delaware County, Pa., September, 1874. 500 +.

FIG. 5. Individual with colored shell, the sarcode visible within. Same locality, and magnified same degree.

FIG. 6. Shell of a small individual. Original was living, and the shell of a brown color. Fort Bridger, Wyoming Territory, August, 1877. 250 +.

FIG. 7. Lateral view of an active individual, with sarcode visible, with protruded pseudopods, and with pale yellow shell. Absecom pond, N. J., April, 1876. 350 +.

FIG. 8. Upper view of a colorless individual. The sarcode attached by tapering threads to the interior of the shell; around its border five contractile vesicles visible, and more internally a pair of nuclei opposite each other. The dotted appearance of the shell represents the cancellated structure. *a*, one of the nuclei. Fairmount Park, Philadelphia, June, 1878. 250 +.

FIGS. 9, 10. Two views of the shell from a living specimen; inferior view showing a crenulated mouth, and lateral view showing the inflection of the base to the mouth. Absecom pond, New Jersey, August, 1876. 350 +.

FIGS. 11, 12. Lateral and upper views of an individual, with the sarcode visible, and with projected pseudopods. *a*, nuclei; *b*, contractile vesicle; *c*, amœboid corpuscles in the interval between the sarcode and the shell; *d*, large air-bubble. Fairmount Park, June, 1877. 250 +.

FIG. 13. Inferior view of a similar specimen. Ditch below Philadelphia, September, 1877. 250 +.

FIGS. 14, 15. Inferior and lateral views of the same individual. In the former view the sarcode appears of irregular form, and it exhibits a single nucleus and three contractile vesicles. Absecom pond, New Jersey, June, 1877. 250 +.

FIG. 16. Small shell (of a dark ochreous color) with pitted surface. Woodstown pond, New Jersey, September, 1877. 250 +.

FIG. 17. Side view of a pair of individuals in conjugation, both of the same size; the shell of one darker than the other. Swarthmore brick-pond, September, 1874. 250 +.

FIG. 18. Inferior view of a specimen, living and active, in which portions of the shell appear as if bitten out. Atco, N. J., June, 1877. 250 +.

FIGS. 19, 20. Inferior and lateral views of an individual, with constricted shell. Fairmount Park, Philadelphia, May, 1878. 250 +.

FIGS. 21, 22. Upper views of two minute specimens, probably young individuals, with the sarcode showing a single nucleus and several large contractile vesicles. Atco, N. J., October, 1877. 1,000 +.

FIG. 23. Lateral view of a living specimen, with pitted shell. China Lake, Uinta Mountains, Wyoming Territory, August, 1877. 500 +.

FIG. 24. Two similar individuals in conjugation, with the shells of different shades of color. With the preceding.

FIGS. 25, 26. Inferior and lateral views of an individual, with pitted shell. Swarthmore, Delaware County, Pa., April, 1874. 350 +.

FIGS. 27, 28. Superior and lateral views of an empty shell, with irregularly pitted surface. Same locality.

FIGS. 29, 30. Lateral and inferior views of an individual, with pitted shell. Ditch below Philadelphia, June, 1876. 350 +.

FIG. 31. Lateral view of a specimen. Fort Bridger, Wyoming Territory, August, 1877. 250 +.

FIGS. 32, 33. Lateral and inferior views of a specimen, with the sarcode encysted, and surrounded with flocculent matter, probably excrementitious. Atco, N. J., June, 1877. 500 +.

FIG. 34. Upper view of an empty colorless shell. Swarthmore brick-pond, September, 1874. 350 +

FIG. 35. Cancellated structure of the shell of Arcella highly magnified.

PLATE XXVIII.

FIGS. 1–7.—ARCELLA VULGARIS.

FIG. 1. Lateral view of a pair in conjugation, in one of which the shell is colorless. The mssaes of sarcode as observed were not in union. Egg Harbor, N. J., September, 1877. 500 diameters.

FIG. 2. Lateral view of an empty shell, with an even dome. Absecom, N. J. 500 diameters.

FIG. 3. Lateral view of a specimen, with the sarcode forming a large encysted ball, and causing the eversion of the usual funnel-like base of the shell. Same locality, March, 1876. 350 +.

FIGS. 4, 5. Inferior* and lateral views of an empty shell, with depressed fundus. Found with the preceding. 350 +.

FIGS. 6, 7. Superior and lateral views of a shell of quadrate outline, and depressed fundus. Pond on Pokono Mountain, Pennsylvania, July, 1876. 250 +.

FIGS. 8–13.—ARCELLA VULGARIS, var. *angulosa*.

FIGS. 8, 9. Superior and lateral views of the same specimen, the former represented without the sarcode. Woodstown pond, New Jersey, September, 1877. 250 +.

FIGS. 10, 11. Superior and lateral views of a similar specimen, found with the preceding. The sarcode not represented

FIGS. 12, 13. Superior and lateral views of another, and similar specimen found with the preceding.

FIGS. 14–38.—ARCELLA DISCOIDES.

FIGS. 14, 15. Inferior and lateral views of an individual. In the sarcode of the former a pair of opposite nuclei and several contractile vesicles visible. Swarthmore brick-pond, Delaware County, Pa., September, 1874. 350 +.

FIGS. 16, 17. Inferior and lateral views of another individual found with the former.

FIG. 18. Lateral view of a shell. China Lake, Uinta Mountains, Wyoming Territory. 250 +.

FIGS. 19–21. Lateral views of three shells from living specimens. Woodstown pond, New Jersey, September, 1877. Fig. 19 is inadvertently unsymmetrical, and should be the same on the right as on the left.

FIG. 22. Lateral view of a large individual, with extended pseudopods. As exemplified in this figure, while the mass of sarcode within the shell and the pseudopods exterior to the base are visible, the intermediate portions extending through the funnel, from their transparency, cannot be seen. Fort Bridger, Wyoming Territory, August, 1877. 250 +.

FIG. 23. Inferior view of a nearly colorless individual. The sarcode exhibits a pair of opposite nuclei and seven conspicuous contractile vesicles. Absecom pond, N. J., April, 1875. 350 +. The height of the shell was about one-third the breadth.

FIG. 24. Inferior view of an individual, with projected pseudopods. The sarcode exhibts a pair of nuclei, four contractile vesicles, and on the right upper border a large air-bubble. Fig. 25. Lateral view of the shell of the same. Bristol Canal, Pennsylvania, September, 1876. 500 +.

FIGS. 26, 27. Inferior and lateral views from the same individual. In the interior sarcode of the former the two opposite nuclei are seen, and at the border five contractile vesicles. Pond on Darby Creek, Delaware County, Pennsylvania, April, 1876. 500 +.

FIG. 28. Inferior view of a large individual (correct outline, though not quite regularly circular). Three nuclei visible in the sarcode; and a number of contractile vesicles at the border. On Utricularia. from Jacksonville, Florida, May, 1875. 266 +.

FIG. 29. Inferior view of a colorless individual, acted on by an ammoniacal solution of carmine; the nuclei as they appeared stained deep red. Absecom pond, New Jersey, June, 1874. 350 +.

FIGS. 30, 31. Two views of the same individual. The shell pale yellowish, very thin and flexible. China Lake, Uinta Mountains, Wyoming Territory, August, 1877. 500 +.

FIG. 32. Inferior view of an empty shell with quadrately rounded outline and oval mouth. Jacksonville, Fla. 250 +.

FIG. 33. Lateral view of a specimen, having the same shape as the former in the inferior view. Found with the preceding.

FIG. 34. Inferior view of a specimen with oval outline. With the preceding.

FIGS. 35, 36. Inferior and lateral views of a specimen; the former with oval outline, and oval mouth whose long diameter crosses that of the shell. (The lithographer has inadvertently colored the two figures differently.) Found with the preceding.

FIG. 37. Inferior view of a shell with oval outline and mouth. Absecom pond, New Jersey.

FIG. 38. Inferior view of shell, with trilobate outline and oval mouth. With the preceding.

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* In the empty shells, when transparent, the inferior and superior views appear the same.

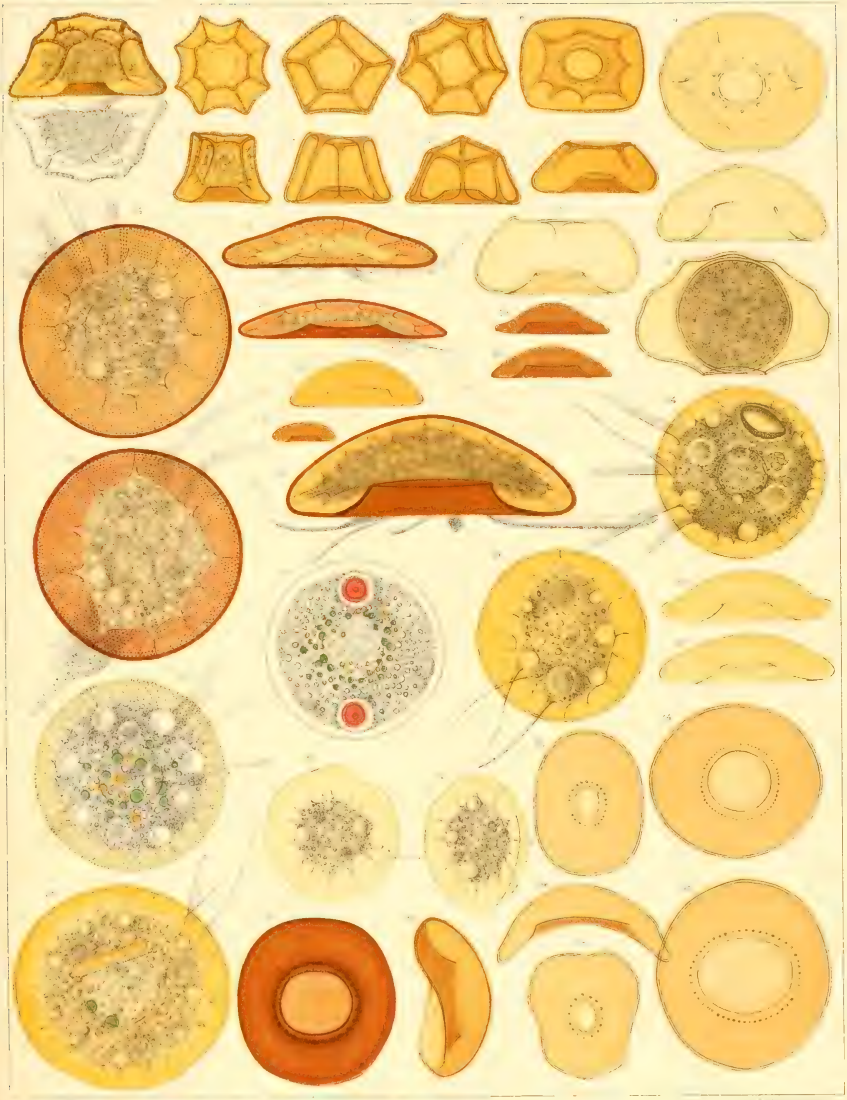

PLATE XXIX.

ARCELLA MITRATA.

FIGS. 1, 2. Inferior and lateral views from the same individual. In the former figure the central undulating circle is the mouth; and the second circle is produced by the border of the base of the shell. In the latter figure, the body of the sarcode is seen attached to the mouth of the shell by a long neck, and the periphery, by means of numerous threads, to the inside of the shell. China Lake, Uinta Mountains, Wyoming Territory, August, 1877. 250 diameters.

FIGS. 3, 4. Inferior and lateral views from an individual similar to the former. Atco, N. J., September, 1877. 250 +. An abundant form.

FIGS. 5, 6. Inferior and lateral views of an individual. Absecom pond, New Jersey, September, 1874. 350 +. The dotted appearance of the shell in fig. 6 represents the cancellated structure.

FIGS. 7, 8. Inferior and lateral views of an individual in which the sarcode is retracted into the fundus of the shell. The sarcode contained a single nucleus. Atco, N. J., September, 1877. 250 +.

FIGS. 9, 10. Lateral and inferior views of a specimen, in which the shell has a pyramidal summit, perpendicular sides, and a heptagonal base. Absecom pond, New Jersey, October, 1877. 250 +.

FIG. 11. Lateral view of a specimen, exhibiting the sarcode and its attachments, and projected pseudopods. Same locality, May, 1877. 500 +.

FIG. 12. Lateral view of an empty shell, with even, dome-like fundus. Absecom pond, N. J., September, 1875. 250 +.

FIG. 13. Lateral view of a colorless individual, exhibiting the sarcode and its connections. Atco, N. J., September, 1877. 250 +.

FIG. 14. Lateral view of an individual. Absecom, N. J., September, 1875. 250 +.

FIG. 15. Lateral view, with visible sarcode. Tobyhanna, Pokono Mountain, Pennsylvania, July, 1876. 250 +.

FIG. 16. Lateral view of a large individual, with shell having depressed sides and pyramidal dome. Atco, N. J., September, 1877. 250 +.

FIG. 17. Lateral view of an individual with perfectly colorless shell; with the sarcode and its attachments distinctly visible, and with protruded pseudopods. The dotted appearance on part of the shell represents the cancellated structure in focus. Absecom pond, N. J., August, 1874. 250 +.

FIG. 18. Lateral view of a specimen, with visible sarcode and protruded pseudopods. Absecom, N. J., September, 1874. 350 +.

FIGS. 19, 20. Inferior and lateral views from an individual. With the preceding. 350 +.

FIGS. 21, 22. Inferior and lateral views from an individual, in which the sarcode was contracted into a spherical ball lying on one side of the cavity of the shell. Found with the preceding.

FIG. 23. Lateral view of a pyriform specimen. With the preceding. 350 +.

FIG. 24. Lateral view from a specimen, in which the sarcode contained a multitude of chlorophyl grains. Absecom, N. J., July, 1876. 250 +.

PLATE XXX.

Figs. 1–9.—ARCELLA ARTOCREA. 250 diameters.

Figs. 1, 2. Inferior and lateral views; the former exhibiting the interior sarcode with its abundance of chlorophyl grains. Absecom pond, New Jersey, September, 1874.

Figs. 3, 4. Inferior and lateral views of a shell. Sphagnum of Absecom, N. J., April, 1876.

Figs. 5, 6. Inferior and lateral views of a shell; in the former with irregularly oval outline. Found with the preceding.

Figs. 7, 8. Inferior and lateral views of an individual, with the sarcode in an encysted condition. Shell with an irregularly oval outline as seen in the former view. The ball of sarcode produced an eversion of the base of the shell as seen in the lateral view. In the interval of the sarcode and shell a number of amœboid corpuscles were visible. With the preceding.

Fig. 9. Lateral view of a large empty shell. Absecom pond, N. J., September, 1874.

Figs. 10–19.—ARCELLA DENTATA. 250 diameters.

Figs. 10, 11. Inferior and lateral views of an empty shell. Ditch below Philadelphia.

Figs. 12, 13. Inferior and lateral views of a shell. Fairmount, Philadelphia.

Figs. 14, 15. Upper and lateral views of a shell. Budd's Lake, New Jersey, October, 1874.

Figs. 16, 17. Inferior and lateral views of a shell. Ditch below Philadelphia.

Fig. 18. Lateral view of a shell. Budd's Lake, New Jersey.

Fig. 19. Inferior view of a living individual. The sarcode exhibits a pair of opposite nuclei, several contractile vesicles, and a projected pseudopod. Found with the preceding. *a*, nucleus; *b*, contractile vesicle.

Figs. 20–34.—CENTROPYXIS ECORNIS = the spineless variety of CENTROPYXIS ACULEATA.

The shell in most examples composed of sand grains, cemented in close juxtaposition. 200 diameters.

Fig. 20. Inferior view of a living individual, with protruded pseudopods. The shell with large sinuous mouth; the height about one-third the breadth. Ditch below Philadelphia, September, 1875.

Figs. 21, 22.—Inferior and lateral views of an empty shell. Swarthmore brick-pond, Delaware County, Pa.

Figs. 23, 24. Inferior and lateral views of an empty shell, with a large circular mouth. Fairmount Park, Philadelphia.

Fig. 25. Inferior view of a shell, with a small circular mouth. Ditch below Philadelphia.

Fig. 26. Inferior view of a shell, with trilobed mouth. Pond on Darby Creek, Delaware County, Pennsylvania.

Fig. 27. Inferior view of a shell, with quadrilobed mouth. Same locality.

Figs. 28, 29. Inferior and lateral views of a shell, with quadrilobate mouth. China Lake, Uinta Mountains, Wyoming.

Figs. 30, 31. Inferior and lateral views of a living individual, with extended pseudopods. The brown shell, composed of sand grains, with the cement of a darker hue of the same color. Ditch below Philadelphia, June, 1874.

Fig. 32. Inferior view of a living individual, with extended pseudopods. The shell composed of chitinoid membrane incorporated with dirt and sand. Pond on Darby Creek, Delaware County, Pa., October, 1874.

Figs. 33, 34. Inferior and lateral views of an empty shell, composed of sand. Same locality as the preceding.

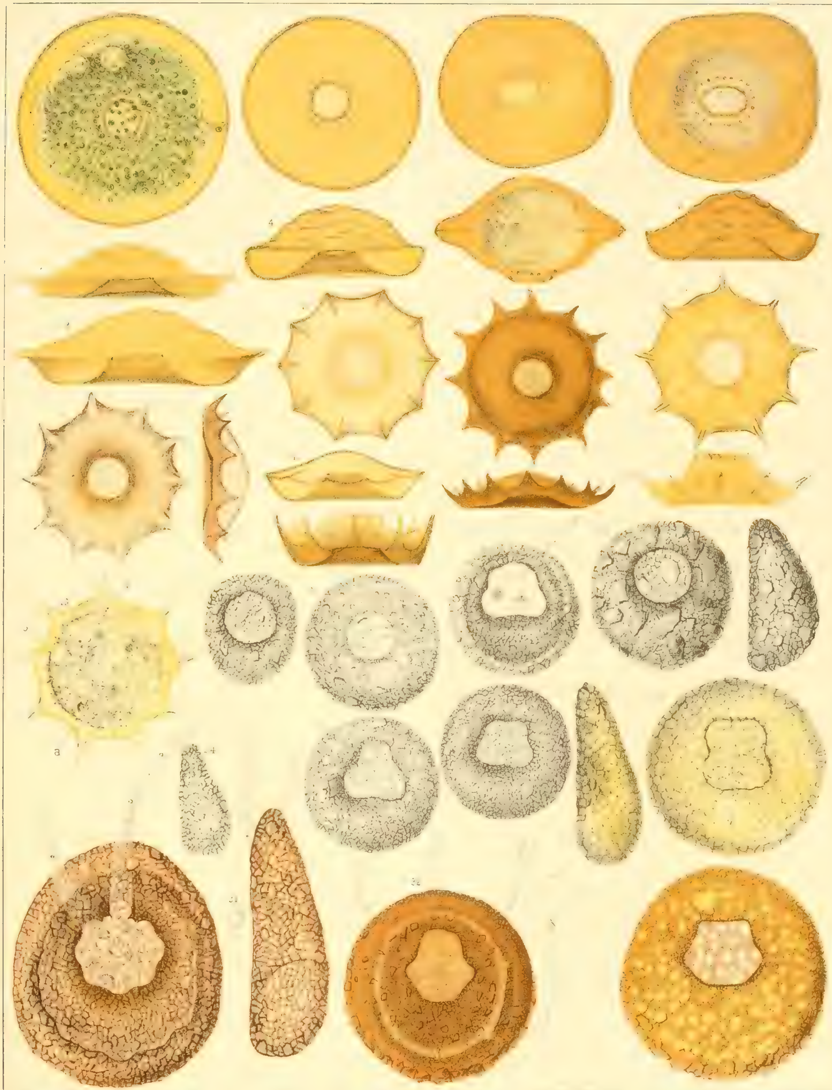

PLATE XXXI.

CENTROPYXIS ACULEATA.

FIG. 1. Inferior view of a living specimen, with pseudopods protruded; shell composed of chitinoid membrane, with scattered sand grains, and coarser ones loaded along the fundus. 200 diameters. Spencer pond, Maine, September, 1877.

FIG. 2. Inferior view of a living individual, with shell of chitinoid membrane and incorporated grains of sand. 200 diameters. Among Chara, in pond on Bushkill Creek, Easton, Pa., June, 1876.

FIG. 3. Inferior view of a shell composed of brown chitinoid membrane, with incorporated rods and irregular angular plates. 200 diameters. Ditch below Philadelphia.

FIGS. 4, 5. Inferior and inferior oblique views of the same specimen. Shell of chitinoid membrane with scattered sand grains. 200 diameters. Found with the preceding.

FIGS. 6, 7. Inferior and lateral views of a specimen. Shell of brown chitinoid membrane, finely punctate, and with scattered sand and diatoms. On Utricularia, from Jacksonville, Fla.

FIG. 8. Inferior view of a shell of brown chitinoid membrane, with incorporated sand along the posterior border. 250 diameters. Sphagnum of Absecom, N. J.

FIGS. 9, 10. Inferior and lateral views of a shell of chitinoid membrane, with a few incorporated diatoms and sand grains. 250 diameters. Absecom pond, New Jersey.

FIG. 11. Lateral outline of the shell of a living specimen, composed of chitinoid membrane with sand grains, and with a single spine to the fundus. 250 diameters. Pond on Darby Creek, Pennsylvania.

FIGS. 12, 13. Inferior and lateral views. Shell composed of chitinoid membrane, with scattered grains of sand. 200 +. Sphagnum of Absecom, N. J.

FIG. 14. Inferior view of an empty shell of brown chitinoid membrane, entirely devoid of foreign matter, and finely and regularly punctate; but the punctæ not resolvable into cancelli as in the shell of Arcella. Ditch below Philadelphia, with Lemna and Wolffia.

FIGS. 15, 16. Inferior and lateral views. 250 +. Absecom, N. J.

FIG. 17. Inferior view of a shell, composed of sand. 200 +. Ditches below Philadelphia.

FIGS. 18, 19. Inferior views of two similar specimens. Pond on the Delaware River above Easton, Pa.

FIGS. 20, 21. Inferior and lateral views of a specimen, composed of sand united by brown cement. Fort Bridger, Wyoming Territory.

FIG. 22. Inferior view of a specimen composed of sand. Same locality.

FIGS. 23, 24. Inferior and lateral views of a specimen composed of sand. Partridge Island, Nova Scotia.

FIGS. 25, 26. Inferior and lateral views of a small specimen. 500 +. Dripping rocks of Fairmount Reservoir, Philadelphia.

FIGS. 27, 28. Inferior and lateral views of a shell, composed of chitinoid membrane with sand and dirt. 200 +. Atco, N. J.

FIGS. 29, 30. Inferior and lateral views. 350 +. Pond on Darby Creek, Pennsylvania.

FIG. 31. Inferior view of a shell, except the spines composed of diatoms. 350 +. Pokono Mountain, Pennsylvania.

FIG. 32. Inferior view of a shell, composed of diatoms and sand. 500 +. Lake Hattacawanna, New Jersey.

FIGS. 33, 34. Inferior and lateral views of a shell of similar composition, pertaining to the variety *Centropyxis ecornis*. 500 +. Abundant form with the preceding.

FIG. 35. Lateral view of a shell, with spines fore and aft. 200 +. Ditch below Philadelphia.

PLATE XXXII.

FIGS. 1–25.—COCHLIOPODIUM BILIMBOSUM.

The dotted appearance in the broad band or zone, and in the double contour line, in most of the figures, is intended to represent the finely cancellated structure of the investing membrane or shell, but is represented more distinct than natural.

FIG. 1. Upper view of an individual, the broad dotted zone representing the expanded base or mouth of the shell. The nucleus seen centrally. 1,000 diameters. China Lake, Uinta Mountains, August, 1877.

FIG. 2. Individual with the basal border of the shell expanded on one side—in the direction of movement of the animal. With the preceding. 1,000 +.

FIG. 3. Upper view of an individual, with the basal border extended nearly all around. Among algæ, in ditches below Philadelphia, May, 1875. 1,000 +.

FIG. 4. Individual with pseudopodal extensions opposite the extension of the basal border of the shell, and in the act of discharging excrementitious matter. 500 +. Among water-cress, in a spring on Darby Creek, Delaware County, Pennsylvania, April, 1875.

FIG. 5. Lateral view of an individual, with pseudopods extending from beneath the expanded basal band of the shell. 1,000 +. Ditch below Philadelphia, April, 1876.

FIG. 6. Lateral view of an individual, with extended pseudopods, but with the basal band of the shell contracted. 500 +. Found with fig. 4.

FIG. 7. Lateral view of an individual with extended pseudopods, and extension of the basal band of the shell. With the preceding. 500 +.

FIG. 8. Lateral view, with pseudopods, and with the basal band of the shell contracted. 500 +. Fort Bridger, Wyoming, August, 1877.

FIGS. 9, 10. Lateral and upper views of an individual. 500 +. Spring on Darby Creek, Delaware County, Pennsylvania, April, 1875.

FIG. 11. Lateral view, with the basal band of the shell drawn into folds. Same locality.

FIG. 12. Upper view, with extension of the basal band on one side and a pseudopodal extension on the opposite side. With the preceding.

FIG. 13. Upper view, with inflection of the basal band, and projection of pseudopods. With the preceding.

FIGS. 14–17. Four successive views of the same individual seen from above. Fig. 14, with inflected basal band; fig. 15, the band extended on one side; figs. 16, 17, the band widely expanded all round. In all, pseudopodal extensions are seen, but their appearance across the basal band is drawn too darkly. Same locality as the preceding.

FIGS. 18, 19. Two views of an individual; in the former as it appeared either spread upon or attempting to swallow a large diatom; in the latter, as it disengaged itself from the diatom, moving off in the direction of the expanded basal band. With the preceding.

FIG. 20. Lateral view of a small individual, with inflected basal border, and with projected pseudopods. Among algæ at foot of fountain in front of City Hall, Market street, Philadelphia, August, 1878.

FIGS. 21, 22. Two views of an individual, with broad basal band, in which the punctated appearance could not be detected. With the preceding.

FIG. 23. Small individual, seen from above, with widely expanded basal band, in which no trace of the cancellated structure could be detected. Swarthmore, Delaware County, Pennsylvania, May, 1875.

FIG. 24. Lateral view of a specimen acted on by ammoniacal solution of carmine; the nucleus deeply stained.

FIG. 25. Lateral view of a specimen acted on by a feeble solution of iodine in potassium iodide.

FIGS. 26–28.—COCHLIOPODIUM VESTITUM. 500 +.

FIG. 26. Lateral view of an individual, with the basal band of the shell thrown into angular folds, and with the interior sarcode containing a large quantity of chlorophyl granules. Absecom pond, New Jersey, May, 1865.

FIG. 27. Lateral view of a colorless specimen. Same locality, September, 1874.

FIG. 28. Lateral view of an individual, with yellowish shell, and with extended pseudopods. Uinta Mountains, Wyoming, August, 1877.

FIGS. 29–37.—CENTROPYXIS ACULEATA.

FIGS. 29, 30. Lateral and inferior views of an empty shell, composed of chitinoid membrane. 500 +. Tobyhanna, Pokono Mountain, Pennsylvania.

FIG. 31. Lateral view of an empty shell of chitinoid membrane. 500 +. Sphagnum, Absecom, N. J.

FIGS. 32, 33. Oblique lateral and inferior views of an empty shell. 250 +. Same locality as preceding.

FIG. 34. Inferior view of a shell composed of chitinoid membrane, with incorporated diatoms. Empty and deeply stained brown. 250 +. Ditch below Philadelphia.

FIGS. 35, 36. Inferior and lateral views of a spineless shell, pertaining to the variety *Centropyxis ecornis*. The shell composed of chitinoid membrane incorporated with large sand grains. 250 +. Sphagnum, Absecom, N. J.

FIG. 37. Inferior view of a shell, composed of chitinoid membrane with sand. 250 +. Swarthmore brick-pond, Delaware County, Pennsylvania.


23.
25.
33.
37.

[illegible]

PLATE XXXIII.

FIGS. 1–9.—PAMPHAGUS MUTABILIS. Transverse diameters unequal.

FIG. 1. Animal viewed in the upright position partially twisted on itself. 500 diameters. Spring on Darby Creek, Delaware County, Pennsylvania, August, 1874.

FIG. 2. The same individual seen from above.

FIG. 3. Broad side view of an individual. Same locality as the former.

FIG. 4. Narrower side view of the same, bent so as to be concave on the right.

FIG. 5. Broader side view of an individual. Fig. 6. Inferior view of same. 500 diameters. Same locality, April, 1875.

FIG. 7. Broader side view of an individual. Kirkwood mill-pond, New Jersey, September, 1874. 1,000 diameters.

FIG. 8. Broader side view of an individual. 500 diameters. Darby spring, Pennsylvania, August, 1874.

FIG. 9. Broader side view of an individual. 500 diameters. Sphagnum, Atco, N. J., May, 1877.

FIG. 10.—PAMPHAGUS AVIDUS. Transverse diameters equal.

Upright view ; the mouth to the right inferiorly, and emitting pseudopods. The animal stretched in length out of its normal condition, by portions of the alga Didymoprium. 250 diameters. Atco, N. J., September, 1877.

FIGS. 11, 12.—PAMPHAGUS CURVUS. Transverse diameters uniform.

FIG. 11. Lateral view of an individual. Spring on Darby Creek, Delaware County, Pennsylvania, August, 1874. 500 diameters.

FIG. 12. Lateral view of an individual. Swarthmore brick-pond, Delaware County, Pennsylvania, September, 1874.

FIGS. 13–17.—PAMPHAGUS HYALINUS. Spheroidal.

FIGS. 13, 14.—Upper and lateral views of the same individual, with protruded pseudopods. 500 diameters. Spring, Darby, Delaware County, Pennsylvania, April, 1875.

FIG. 15. Lateral view of an individual, with pseudopodal extensions. 750 diameters. Fort Bridger, Wyoming, July, 1877.

FIGS. 16, 17. Lateral views of specimens with extensive protrusion of the sarcode. These were suspected to be individuals in the process of multiplication by division, but they died under observation in the condition as represented. Found with the preceding.

FIGS. 18–28.—PSEUDODIFFLUGIA GRACILIS.

FIG. 18. Lateral view of an ovoidal form, with shell apparently of chitinoid membrane and fine granular dirt. 250 diameters. Egg Harbor, N. J., April, 1878.

FIG. 19. Large specimen of the same character. From the same gathering. 250 diameters.

FIG. 20. Individual of same character as preceding, with a profusion of pseudopodal extensions. 500 diameters. Swarthmore brick-pond, Delaware County, Pennsylvania, June, 1874.

FIG. 21. Individual with a brown shell of chitinoid membrane and fine sand. Found with the preceding.

FIG. 22. Individual with an oblique mouth. With the preceding.

FIGS. 23, 24. Two views of the same individual, with a retort-like shell. Also with the preceding.

FIG. 25. Individual, in which the chitinoid shell at both extremities is heavily loaded with sand. 700 diameters. Spring on Darby Creek, Delaware County, Pennsylvania.

FIGS. 26, 27. Lateral and superior views of a compressed ovoidal specimen, with shell of sand. 166 diameters. Egg Harbor, N. J., August, 1878.

FIG. 28. Lateral view of a specimen, with shell composed of sand. 500 diameters. Swarthmore, Delaware County, Pennsylvania.

PLATE XXXIV.

FIGS. 1–16.—CYPHODERIA AMPULLA.

FIG. 1. Lateral view of an individual in its natural position, with pseudopods extended. 360 diameters. Spring on Darby Creek, Delaware County, Pennsylvania.

FIG. 2. Lateral view of an individual, with pseudopods extended. 360 diameters. Lake Hatacawanna, New Jersey, March, 1875.

FIG. 3. Inferior or anterior view of an empty shell. From the same collection.

FIG. 4. Lateral view of a large specimen, with spur-like process to the fundus. Same collection.

FIG. 5. Lateral view of an individual in the natural position. 350 diameters. Fort Bridger, Wyoming, July, 1877.

FIG. 6. Inferior view (corresponding with the lower part of fig. 5) of another specimen, from the same locality.

FIG. 7. Outline of lateral view of a third specimen.

FIG. 8. Lateral view of a living specimen. 360 diameters. Lake Hattacawanna, New Jersey, March, 1875.

FIG. 9. Lateral view. Spring on Darby Creek, Delaware County, Pennsylvania, April, 1874.

FIG. 10. Inferior or anterior view of an individual, from same collection.

FIG. 11. Lateral view of another individual, from the same.

FIG. 12. Lateral view of another individual.

FIGS. 13, 14. Inferior and lateral views of the same individual. Same locality.

FIG. 15. Lateral view of another specimen. Same locality.

FIG. 16. Appearance of the cancellated structure of the shell under high magnifying power.

FIGS. 17–24.—CAMPASCUS CORNUTUS. 250 diameters.

China Lake, Uinta Mountains, Wyoming, August, 1877.

FIG. 17. Inferior view, the specimen tilted forward, with interior sarcode visible, and pseudopods extended. Fig. 18. Transverse section with the mouth. Fig. 19. Outline of lateral view turned so as to see one of the processes of the shell.

FIG. 20. Inferior view of a shell, tilted forward and upright.

FIG. 21. Lateral view of the same specimen in its natural position.

FIGS. 22–24. Outlines of a specimen in the transverse, inferior and lateral views.

FIGS. 25–41.—SPHENODERIA LENTA.

FIGS. 25, 26. Two views of the same specimen; the shell of globular shape. 500 diameters. Sphagnum of Absecom, N. J., March, 1875.

FIGS. 27, 28. Two views of the same specimen. 250 diameters. Same locality.

FIGS. 29, 30. Lateral views of two living specimens. 500 diameters. Absecom pond, New Jersey.

FIGS. 31, 32. Lateral views of the same specimen. Sphagnum of Absecom, September, 1874.

FIGS. 33, 34. Lateral views of two empty shells, as seen under different foci. Found with the preceding.

FIGS. 35–37. Three views of the same specimen. Same locality.

FIGS. 38, 39. Two views of the same specimen. 500 diameters. Sphagnum of Absecom, N. J.

FIG. 40. Lateral view of a large oval shell. 500 diameters. With the former.

FIG. 41. Lateral view of a large specimen. In sphagnum from Mount Vernon, Alabama.

FIG. 42. Opposite view of the neck of the same shell.

41 SPHENODEI

PLATE XXXV.

FIGS. 1–18.—EUGLYPHA ALVEOLATA. Transverse diameters of the shell uniform.

FIG. 1. Lateral view of a living specimen. Sarcode exhibiting a nucleus at the fundus, and a contractile vesicle on each side; pseudopods protruded. Shell with six spines to the fundus. 500 diameters. Absecom pond, New Jersey.

FIG. 2. Lateral view of an unusually large empty shell. 500 diameters. Sphagnous swamp of Tobyhanna, Pokono Mountain, Pennsylvania. Shell with four spines.

FIG. 3. Lateral view of an empty shell. 700 diameters. Absecom pond, New Jersey. Shell with four spines, and double row of serrated plates to the mouth.

FIG. 4. Lateral view of shell, with six short spines to the fundus. 500 diameters. China Lake, Uinta Mountains, Wyoming.

FIG. 5. Lateral view of a living specimen. 500 diameters. Ditches below Philadelphia. Shell with two spines. Sarcode with large nucleus in the fundus; four large vacuoles below; and a contractile vesicle on each side.

FIG. 6. Shell with numerous spines all around the fundus. Absecom pond, New Jersey.

FIG. 7. Shell with six divergent spines to the fundus. Sphagnum of Absecom, N. J.

FIG. 8. Lateral view of a living specimen. Darby pond, Delaware County, Pennsylvania.

FIG. 9. Lateral view of an individual, with the sarcode encysted, and the mouth of the shell closed with an operculum. Same locality as the preceding.

FIG. 10. Individual in which the sarcode is encysted, and contained within two distinct envelopes. Found with the preceding.

FIG. 11. Small living individual; the sarcode exhibiting the nucleus, a pair of contractile vesicles, and pseudopods extended. The shell spineless. 1,000 diameters. With Rotifers, &c., among moss in the crevices of the brick pavements of the city of Philadelphia, August, 1878.

FIG. 12. Another specimen, from a similar position in the yard attached to my house. 666 diameters.

FIG. 13. A pair in conjugation; the sarcode mass contracted to the fundus of each shell. 1,000 diameters. In company with the preceding.

FIG. 14. An individual in which the sarcode is encysted and enclosed in a double envelope; and the shell closed with an operculum. 500 diameters. Fort Bridger, Wyoming, July, 1877.

FIGS. 15, 16, 17. Three successive views of the same pair in conjugation. 250 diameters. Absecom pond, New Jersey, May, 1877.

FIG. 18. Highly magnified view of the plates at the mouth of the shell.

FIGS. 19, 20.—EUGLYPHA CILIATA, variety *E. strigosa*.

FIG. 19. Empty shell; of uniform transverse diameter. 1,000 diameters. Sphagnum of Mount Vernon, Alabama.

FIG. 20. Empty shell. 700 diameters. Sphagnum of Absecom, N. J. Breadth of the shell, nearly double in one direction what it is in the opposite.

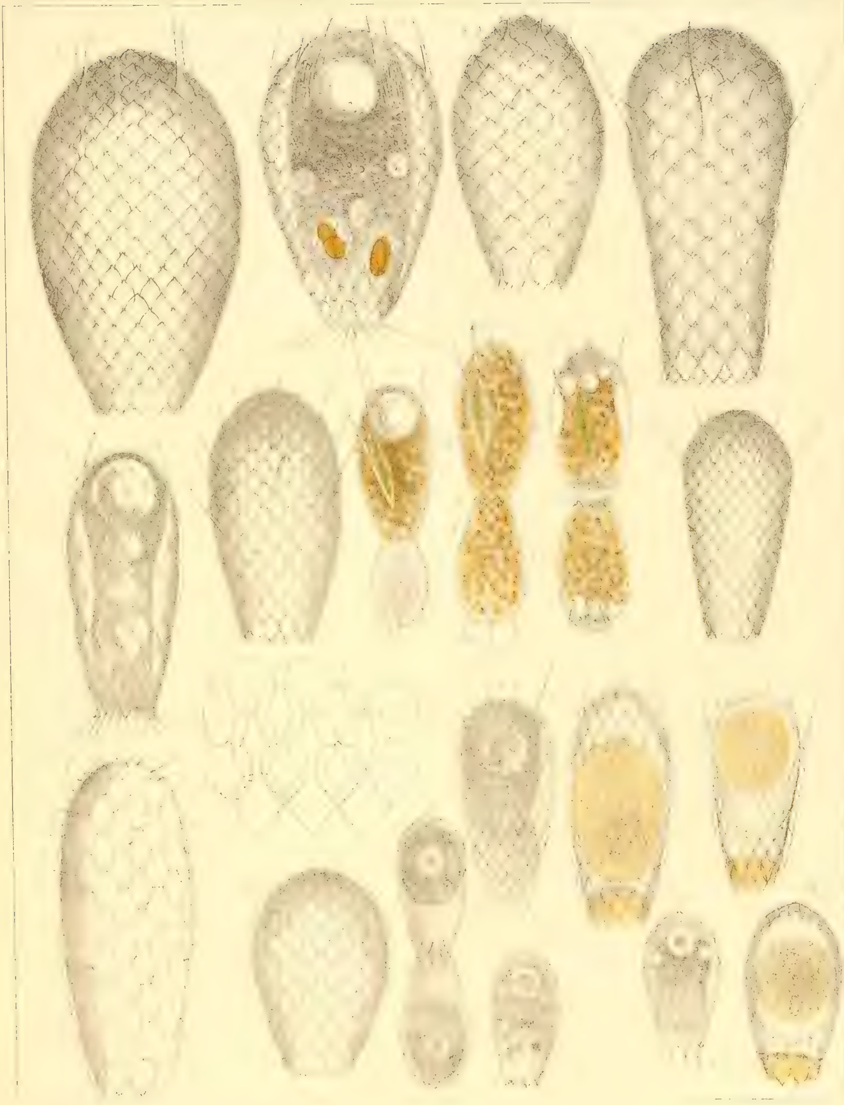

PLATE XXXVI.

EUGLYPHA CILIATA.

FIG. 1. Broader lateral view of an individual. The sarcode partially occupying the shell, with pseudopods projected, presenting a nucleus in the fundus, several contractile vesicles just below, and a quantity of food yet lower. Fig. 2. Transverse section of the shell of the same. 700 diameters. Sphagnum, Absecom, May, 1875.

FIG. 3. An individual observed in the act of discharging an operculum which had closed the mouth of the shell. Some dirt still occupies the neck of the latter. Found with the preceding.

FIG. 4. An individual also found with the former. The sarcode fills the shell, and contains side by side the nucleus and a large vacuole.

FIG. 5. An individual, in which the sarcode, together with a thick laminated operculum, fills the shell. Fig. 6. Section of the shell. 350 diameters. Sphagnum, Absecom, October, 1874.

FIG. 7. Small individual, in which the sarcode is retracted from the mouth and nearly fills the shell. Surrounding the position of the nucleus it exhibited a multitude of detached plates like those composing the shell. 500 diameters. Sphagnum, Vineland, N. J., September, 1876.

FIG. 8. Individual with sarcode filling the shell, which is closed by an operculum. Sphagnum, Vineland, N. J., April, 1877. 500 diameters.

FIG. 9. Individual, with sarcode nearly filling the shell. Scales at mouth of latter much thickened. Fig. 10. Transverse section of the same shell with the mouth. Sphagnum, Swarthmore, Delaware County, Pennsylvania, October, 1874.

FIGS. 11–13. Three views of an empty shell. Found with the former.

FIG. 14. Small individual, from spring on Darby Creek, Delaware County, March, 1876.

FIG. 15. Transverse or inferior view of a shell, with the mouth. 1,000 diameters.

FIG. 16. Hirsute variety of the shell. 500 diameters. Sphagnum of Absecom, N. J., October, 1874.

FIG. 17. Another specimen of the same kind. Same locality.

FIG. 18. A third specimen; hirsute at the fundus. Same gathering as the preceding two.

FIG. 19. Shell hirsute on the narrower sides. 700 diameters. Breadth of shell 0.052 mm. by 0.026 mm. Sphagnum, Absecom, N. J., October, 1874.

FIG. 20. Hirsute shell. Fig. 21. Outline of the narrower side. 500 diameters. Sphagnum of Absecom, September, 1874.

FIG. 22. Fundus of an individual, in which the nucleus appeared to be enclosed in a membranous cyst. 500 diameters. Sphagnum, Absecom, October, 1874.

FIG. 23. A shell, entirely devoid of spines or hairs. 750 diameters. Absecom, October, 1874. Breadth of the shell nearly double in one direction of the other.

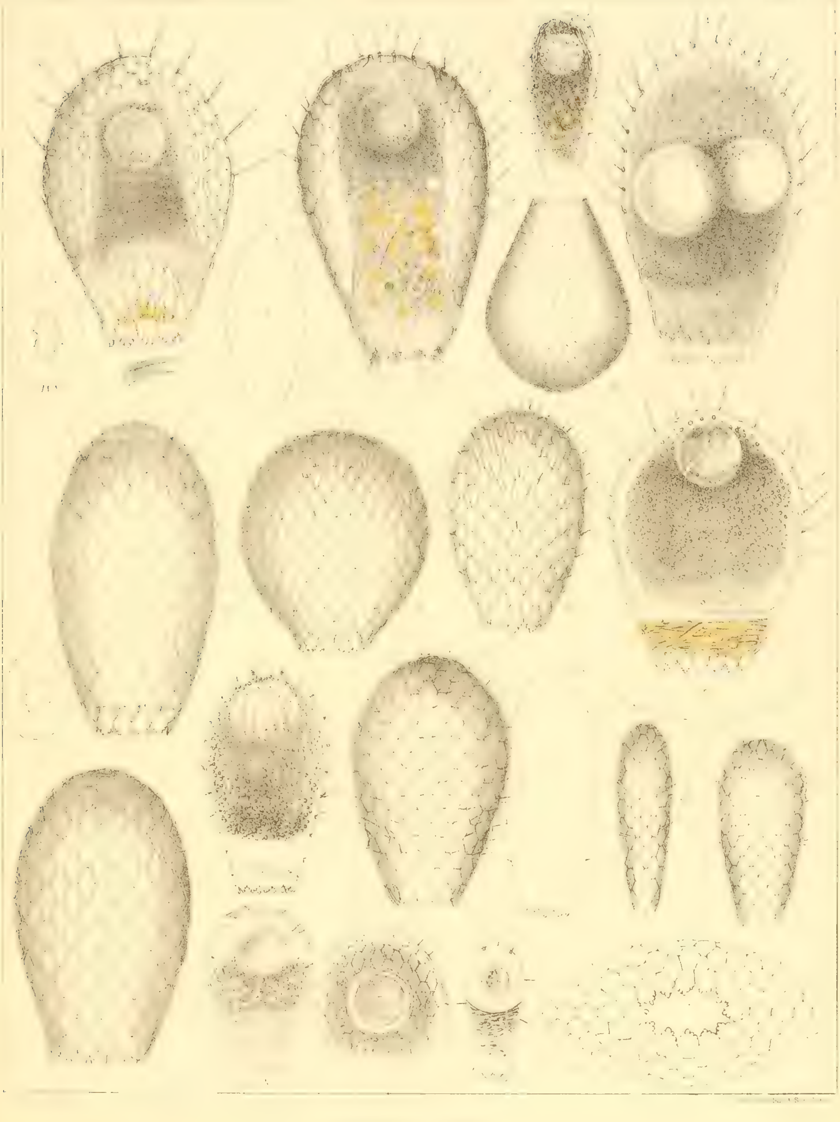

PLATE XXXVII.

FIGS. 1–4.—EUGLYPHA CRISTATA. 1,000 diameters.

FIG. 1. Lateral view of an empty shell. Absecom pond, New Jersey, March, 1876.
FIG. 2. Lateral view of a specimen from sphagnum, Mount Vernon, Ala., February, 1875.
FIG. 3. Individual, with retracted sarcode. Absecom, N. J., October, 1874.
FIG. 4. Specimen, with retracted sarcode. With preceding.

FIGS. 5–10.—EUGLYPHA BRACHIATA.

FIG. 5. Outline of a shell (from a living specimen). Ooze of Batsto River, Atco, N. J. 500 diameters. May, 1878.

FIG. 6. Lateral view of an empty shell. Atco, N. J., April, 1877. 500 diameters.

FIG. 7. Individual with sarcode, in the act of forming an operculum. At the fundus there is seen, on each side of the nucleus, an accumulation of plates like those of the shell. Sphagnum of Absecom, N. J., October, 1877. 666 diameters.

FIG. 8. Outline of a shell. Batsto River, Atco, N. J., May, 1878. 500 diameters.

FIG. 9. Lateral view of a shell. Atco, N. J. 500 diameters.

FIG. 10. Individual, with retracted sarcode. With the last.

FIGS. 11–14.—EUGLYPHA MUCRONATA.

FIG. 11. Lateral view of a shell. Sphagnum of Atco, N. J. 500 diameters.

FIG. 12. Lateral view of a shell. Absecom pond, September, 1875. Two others observed attached mouth to mouth, but empty. Also three similar ones from sphagnum of Absecom Creek, N. J.

FIG. 13. Individual with two spines to the fundus of the shell. The sarcode encysted, and enclosed in an egg-like case; and the mouth of the shell closed by a thick operculum. 360 diameters. Sphagnum of Absecom, N. J., June, 1876.

FIG. 14. A similar specimen, but with the encysted sarcode enclosed in a double envelope. 500 diameters. Sphagnum of Atco swamp, on borders of Batsto River, May, 1878.

FIGS. 15–27.—ASSULINA SEMINULUM. From Sphagnum of Absecom, N. J.

FIG. 15. Broader side view of an empty shell. Fig. 16. Outline of the narrower side view. Fig. 17. Transverse section with the mouth. 500 diameters.

FIG. 18. Broader side view of a living specimen; the sarcode with protruding pseudopods. September, 1875.

FIGS. 19, 20. Two lateral views of a living individual. October, 1874.

FIGS. 21–23. Three views of the same individual.

FIG. 24. Broader side view of an empty shell.

FIG. 25. Broader side view of a living specimen. September, 1875.

FIG. 26. Small colorless individual. The shell filled with sarcode. The plates of the shell were evident but indistinct. August, 1876.

FIG. 27. Outline view of a shell, magnified 666 diameters.

FIGS. 28, 29.—EUGLYPHA CILIATA.

FIG. 28. An empty shell, broader side view. 500 diameters. Sphagnum of Absecom, N. J.

FIG. 29. Broader side view, from a living specimen. The sarcode contained, in the vicinity of the nucleus, an inverted zone of denticulate plates like those of the mouth of the shell. 500 diameters. Sphagnum of Absecom, N. J., June, 1877.

FIGS. 30, 31.—EUGLYPHA STRIGOSA.

Two empty shells, compressed forms. 500 diameters. Sphagnum of Absecom, N. J., October, 1875.

PLATE XXXVIII.

PLACOCISTA SPINOSA.

Specimens mostly from the sphagnum of Absecom, N. J. 500 diameters.

FIGS. 1–5, 7, 9, 10, 13, 14. Broader side views. Figs. 8, 11, 12. Narrower side views.

FIG. 1. Individual with the sarcode contracted at the sides and retracted from the mouth of the shell. October, 1875.

FIG. 2. Individual in which the sarcode fills the shell and emits pseudopods. Sphagnum of Atco, N. J., April, 1877.

FIG. 3. Individual obtained with the preceding. The sarcode constricted and exhibiting no contractile vesicle.

FIG. 4. Individual with protruded pseudopods; the sarcode occupying a comparatively small proportion of the cavity of the shell. October, 1875.

FIG. 5. Individual with sarcode nearly filling the shell. October, 1874.

FIG. 6. Upper view of an individual, with pseudopods protruded. Atco, N. J., May, 1877.

FIG. 7. Individual, with the sarcode contracted and supposed to be ready to pass into the encysted condition.

FIG. 8. Outline of the narrower side of the same specimen, showing the closed condition of the shell below the position of the sarcode. October, 1874.

FIG. 9. Individual in which the sarcode appears to be shedding or discharging matter previous to its assuming the encysted state. Found with the preceding, October, 1874.

FIG. 10. Individual with pseudopods projected. Fig. 11. Outline of the narrower lateral view of the shell of the same. October, 1874.

FIG. 12. Outline of the narrower lateral view of an empty shell.

FIG. 13. View of the broader side of the same specimen.

FIG. 14. Outline of the broader side of a shell, which contained an empty lenticular shell, apparently from an individual in the encysted condition. *a*, a spine attached to the shell in an unusual position.

FIG. 15. A detached spine highly magnified.

FIG. 16. Another spine more highly magnified, apparently exhibiting a waving condition.

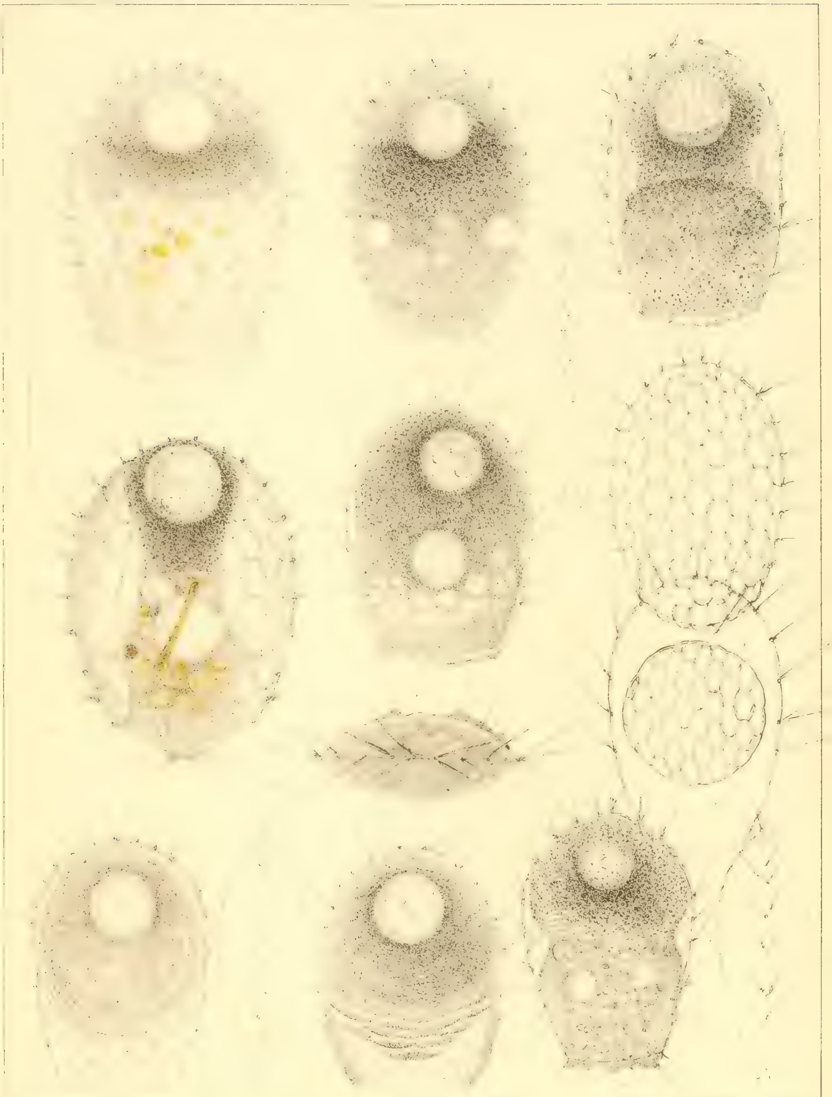

PLATE XXXIX.

TRINEMA ACINUS. 500 diameters, except where specially indicated.

FIGS. 1–5. Large individuals, from sphagnum of Absecom, N. J.

FIG. 1. Inferior view* of an empty shell, exhibiting the mouth at lower part of the figure, and the circular plates with beaded margins. Fig. 2. Lateral view of the same specimen.

FIG. 3. Inferior view of a second specimen.

FIG. 4. Inferior lateral view of another specimen.

FIG. 5. Inferior view of a living specimen. The pseudopods are extended; and the sarcode exhibits the nucleus, several contractile vesicles, together with a quantity of yellowish food material. April, 1875.

FIGS. 6, 7. Two views, inferior, of the same individual, showing successive changes in extension of the sarcode. Fairmount, Philadelphia.

FIG. 8. Inferior view of a living specimen; the sarcode exhibiting the nucleus, three contractile vesicles, and a single forked pseudopod. Pokono Mountain, Pennsylvania, July, 1876.

FIG. 9. Inferior view of a living specimen. Sphagnum, Broad Mountain, Pennsylvania, September, 1876.

FIGS. 10, 11, Inferior and lateral views of an empty shell. With moss in crevices of the pavements of Philadelphia.

FIGS. 12, 13. Inferior and lateral views of a living specimen. From moss and lichens in the crotch of an apple-tree. Swarthmore, Delaware County, Pennsylvania, December, 1877. 666 diameters.

FIGS. 14, 15. Inferior and lateral views of an empty shell. Sphagnum, Broad Mountain, Pennsylvania.

FIGS. 16, 17. Inferior and lateral views of a living specimen. Swamp near Bristol, Pa., September, 1876.

FIG. 18. Inferior view of a living individual. Uinta Mountains, Wyoming, July, 1876.

FIGS. 19, 20. Lateral and inferior views of an empty shell. Sphagnum of Egg Harbor, N. J. 666 diameters.

FIG. 21. Inferior view of a living specimen. Uinta Mountains, Wyoming, July, 1876.

FIGS. 22, 23. Lateral and inferior views of a living individual. Found together with Euglypha and Rotifers, among moss, in the yard of my house, Philadelphia, August, 1878. 1,000 diameters.

FIG. 24. Inferior view of a minute living individual. Sphagnum of Mount Vernon, Ala., October, 1875.

FIG. 25. Apparent production or birth of an individual from its parent. The upper is the parent; the lower the offspring. Sphagnum of Pokono Mountain, Pennsylvania, July, 1876.

FIG. 26. Lateral view of a specimen, in which the sarcode is encysted. Yard of my house, Philadelphia, June, 1874.

FIG. 27. Lateral view of a similar specimen, from sphagnum of Absecom, N. J., October, 1875.

FIGS. 28, 29. Inferior and lateral views of a shell. Ditches below Philadelphia.

FIG. 30. Inferior view of an empty shell. Broad Mountain, Pennsylvania.

FIG. 31. Inferior view. Darby pond, Pennsylvania.

FIGS. 32, 33. Inferior and lateral views. Mount Vernon, Ala.

FIGS. 34, 35. Inferior and lateral views. Fort Bridger, Wyoming Territory.

FIGS. 36, 37. Lateral views of two specimens. Fort Bridger, Wyoming.

FIG. 38. Minute specimen, inferior view. Mount Vernon, Ala.

FIG. 39. Inferior view. Uinta Mountains, Wyoming.

FIGS. 40–42. Inferior views of three shells. Mount Vernon, Ala.

FIG. 43. Lateral view of a minute shell. Uinta Mountains, Wyoming.

FIG. 44. Inferior view of a living specimen. Sphagnum, Swarthmore, Delaware County, Pennsylvania, September, 1874.

FIG. 45. Inferior view of a shell. Spring near Darby, Delaware County, Pennsylvania.

FIG. 46. Inferior view of a shell. Mount Vernon, Ala.

FIGS. 47, 48. Inferior and lateral views. Jacksonville, Fla.

FIGS. 49, 50. Inferior and lateral views. Sphagnum, Mount Vernon, Ala.

FIGS. 51, 52. Inferior and lateral views. Sphagnum, Mount Vernon, Ala.

FIGS. 53, 54. Inferior and lateral views. Jacksonville, Fla.

FIGS. 55, 56. Inferior views of two specimens. Fort Bridger, Wyoming.

FIGS. 57, 58. Inferior and lateral views. Mouth of a cave on Bushkill Creek, near Easton, Pa.

FIG. 59. Inferior view. Mount Vernon, Ala.

FIG. 60. Lateral view. Uinta Mountains, Wyoming.

FIGS. 61, 62. Inferior and lateral views. Jacksonville, Fla.

FIG. 63. Inferior view. Mount Vernon, Ala.

FIG. 64. Infero-lateral view, with sarcode resolved into spores. Sphagnum, Absecom, N. J., October, 1875.

FIG. 65. Inferior view. Mouth of cave, Bushkill Creek, Easton, Pa.

FIG. 66. Lateral view. Swarthmore, Pa.

FIGS. 67, 68. Inferior and lateral views. Jacksonville, Fla.

* The inferior views as they usually appear, tilted forward, or lying in the field of the microscope on their anterior face. From the transparency of the specimens they appear the same when viewed from behind or in front.

PLATE XL

ACTINOPHRYS SOL.

FIG. 1. An individual feeding on green zoospores of an alga. Ditches below Philadelphia, among Lemna, Wolffia, etc. May, 1874. 500 diameters.

FIGS. 2–4. Three views of the same individual, exhibiting the successive steps in the capture and swallowing of a Euglenia. In fig. 3 the rays are left out, and in fig. 4 only partially given. Fairmount Park, June, 1874. 500 diameters.

FIG. 5. Heliozoon, supposed to be an *A. sol.* The nucleus distinctly visible; large vacuoles at the periphery; and only about half a dozen rays. Fort Bridger, Wyoming, July, 1877.

FIG. 6. Individual of uniform granular constitution, without vacuoles, and exhibiting a contractile vesicle at the boundary. Found with the preceding.

FIG. 7. An individual, with even periphery, exhibiting a central nucleus, numerous vacuoles, and a large colored food-ball. Besides the ordinary filamentous rays, it projected digitate pseudopodal processes of protoplasm.

FIG. 8. Another individual apparently ready to undergo division. It contains a number of colored food-balls. With the preceding. Fort Bridger, Wyoming, August, 1877. 500 diameters.

FIG. 9. Large individual, of finely granular constitution, with visible central nucleus, and large peripheral vacuoles (the latter inadvertently left unshaded). Bristol Canal, Pennsylvania, with Ceratophyllum. August, 1876. 500 diameters.

FIG. 10. A pair in conjugation. The contractile vesicles seen above. *a*, discharge of an effete ball. Swarthmore brick-pond, Delaware County, Pennsylvania, May, 1875. 500 diameters.

FIGS. 11–22. A pair of individuals, exhibiting the successive changes in division. Some of the figures are given merely in outline, and in a number the rays are not drawn. 350 diameters.

FIG. 11. The pair as first noticed, with a large granular ball between them; fig. 12, as seen three hours subsequently; fig. 13, two hours later; figs. 14–16, successive changes during the next hour, when separation occurred as in fig. 17. Figs. 18, 19, successive changes of the left-hand individual leading to separation into a pair. Figs. 20–22, successive changes of the right-hand individual leading to separation.

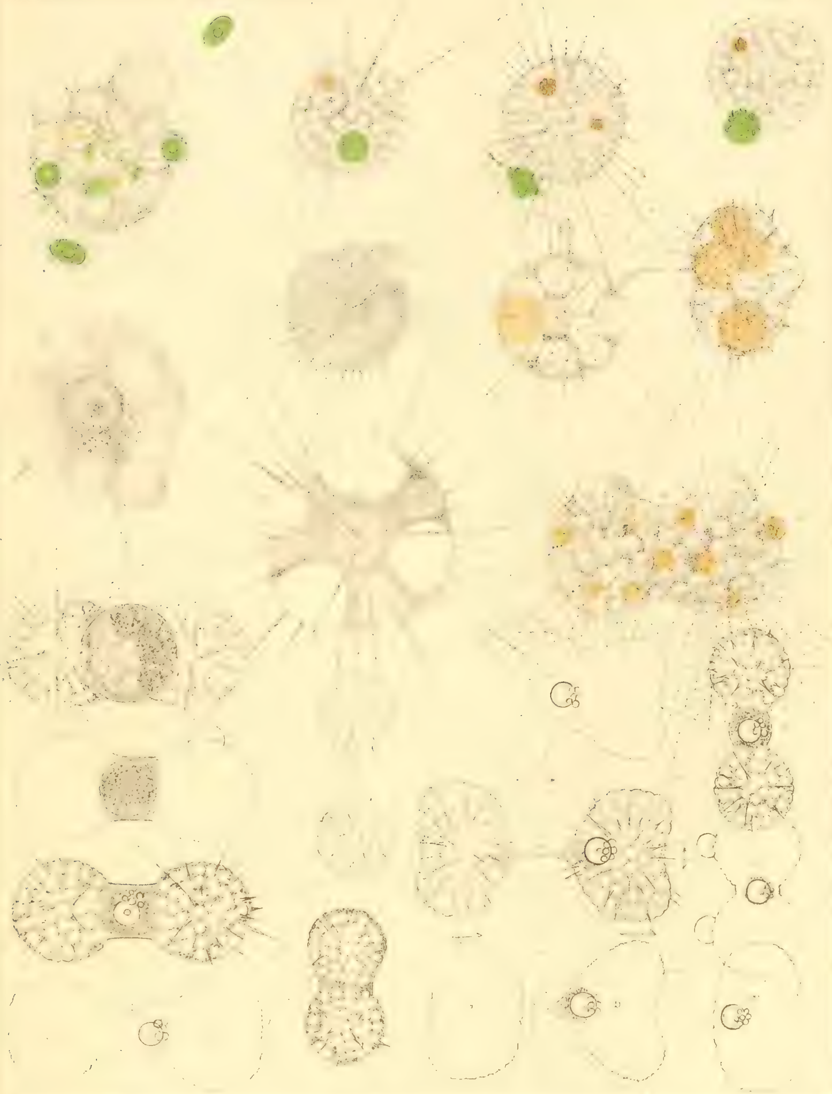

PLATE XLI.

ACTINOSPHÆRIUM EICHHORNII.

FIG. 1. An individual, exhibiting a contractile vesicle at *a*, and the position, *b*, at which another has just collapsed. The large sphere *c* at the lower part of the figure is a vacuole containing a Rotifer which has just been swallowed. In the interior, diatoms and other food materials may be seen. 250 diameters. China Lake, Uinta Mountains, Wyoming, August, 1877. Abundant at the locality.

FIG. 2. Individual with comparatively few and short rays. *a*, contractile vesicle; *b*, position at which one has just collapsed; *c*, large vacuole containing a Rotifer in the act of being swallowed; *d*, act of discharging effete matter. 250 diameters. Ditches below Philadelphia, with Lemna, Wolffia, etc., frequent, April, 1877.

FIG. 3. A small individual with long rays. 250 diameters. Lake Hattacawanna, Morris County, New Jersey, March, 1875. *a*, contractile vesicles.

FIG. 4. Individual with only five rays. Shortly after being noticed other rays were produced, and in an hour subsequently numerous rays extended in all directions. *a*, contractile vesicle; *c*, food in the act of being swallowed. 200 diameters. Pond in Fairmount, Philadelphia, September, 1875.

FIG. 5. Small individual with few rays. *a*, large contractile vesicle. 250 diameters. Ditches below Philadelphia, September, 1875.

FIG. 6. A remarkable rayless individual, containing a Rotifer and other food materials, which were subsequently discharged, when the animal assumed a more regular spherical form. 200 diameters. Found with the preceding.

FIG. 7. Portion of an individual magnified 1,000 diameters. *a*, contractile vesicle; *b*, nucleus.

FIG. 8. An unknown Heliozoan, suspected to pertain to Actinosphærium. 500 diameters. Marsh at Bristol, Pa., August, 1876.

FIGS. 9, 10. Anomalous body, suspected to be a detached portion of an Actinosphærium. 500 diameters. Ditches below Philadelphia, April, 1876.

FIG. 11. Areolated body, suspected to be a moult of an Actinosphærium. 100 diameters, Absecom pond, New Jersey, March, 1876. Similar bodies occasionally found and suspected to be related with Actinosphærium. Perhaps it is entirely foreign to the latter and may be a vegetable product. Fig. 12. A portion of the same magnified 200 diameters.

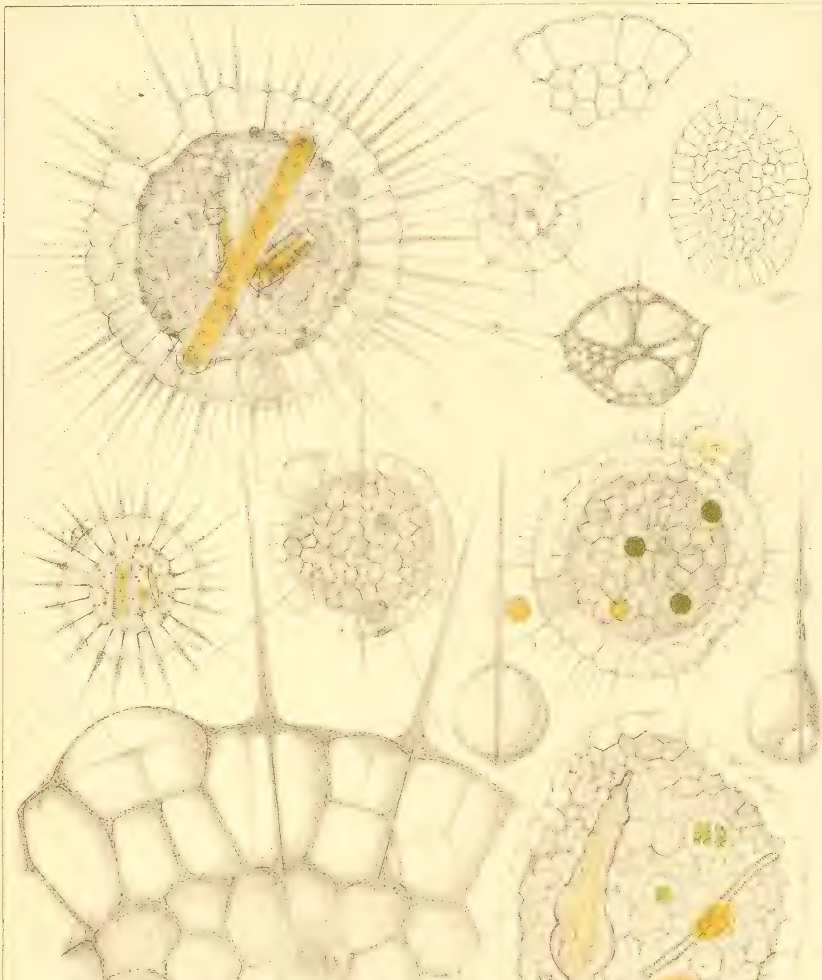

PLATE XLII.

RAPHIDIOPHRYS ELEGANS.

FIG. 1. A group of twenty individuals, associated by narrow isthmus-like bands. From a spring in which grew water-cress, near Darby, Delaware County, Pennsylvania, May, 1874. 250 diameters.

FIG. 2. A more compact group, in which the isthmus-like connections were comparatively few. Same locality. 200 diameters.

FIG. 3. A group of three individuals, part of the group of fig. 1. 500 diameters.

FIG. 4. Part of a group, which consisted of thirty-eight individuals. 500 diameters.

FIG. 5. An isolated individual in the act of taking a zoospore of an alga. 1,000 diameters. Collected with the preceding.

FIG. 6. A group of nine colorless individuals. Absecom pond, New Jersey, September, 1874. A similar group of fifteen was observed. 500 diameters.

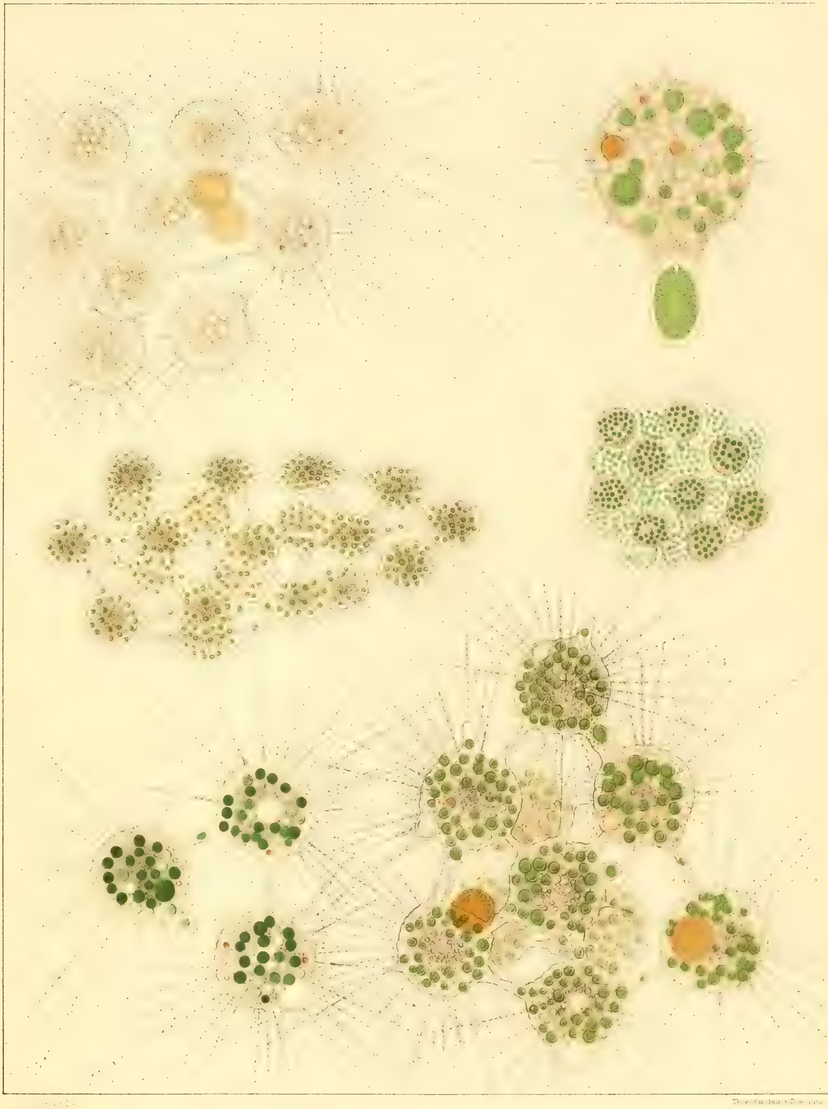

PLATE XLIII.

FIGS. 1–6.—ACANTHOCYSTIS CHÆTOPHORA.

FIG. 1. A green individual. Common form, in the vicinity of Philadelphia, among various aquatic plants. Ditches below Philadelphia, September, 1874. 750 diameters.

FIG. 2. One of the longer furcate spines more highly magnified.

FIG. 3. One of the smaller furcate spines more highly magnified.

FIG. 4. A colorless individual. Less common than the former variety. Swarthmore brick-pond, Delaware County, Pennsylvania, May, 1874. 1,000 diameters.

FIG. 5. An elliptical form, supposed to pertain to the same. Absecom pond, New Jersey, September, 1874. 275 diameters.

FIG. 6. Supposed shed capsule, containing a few green grains and a brownish ovum-like body. Fort Bridger, Wyoming Territory, July, 1877. 250 diameters. The capsule was crowded with long and short furcate spines like those of the figure.

FIGS. 7–12.—ACANTHOCYSTIS ——— ? With simple spines.

FIG. 7. Bright green individual. Fort Bridger, Wyoming Territory, August, 1877. 750 diameters.

FIG. 8. Green individual. Fort Bridger, July, 1877. 500 diameters.

FIG. 9. A bright red individual. Spring on Darby Creek, Delaware County, April, 1875. 700 diameters.

FIG. 10. A colorless individual. Atco, N. J., October, 1877. 666 diameters.

FIG. 11. Colorless individual. Broad Mountain, Pennsylvania, September, 1876. 500 diameters.

FIG. 12. Colorless individual, with the protoplasmic mass in an encysted condition, enclosed in a spinous capsule. With Ceratophyllum, from Bristol Canal, Pennsylvania, December, 1877. 666 diameters.

FIG. 13. Fragment of membrane, supposed to be a portion of a moulted capsule of Acanthocystis. Fort Bridger, Wyoming, August, 1877. 500 diameters.

FIGS. 14–16.—ACANTHOCYSTIS ——— ? With short pin-like spines.

FIG. 14. Individual, with the interior occupied by a mass of protoplasm containing a nucleus and a vacuole, but emitting no pseudopodal rays.

FIG. 15. An individual with the protoplasm contracted into a ball, floating in a thinner liquor, and exhibiting at the periphery three vacuoles.

FIG. 16. An individual with the interior protoplasmic mass apparently ready to assume the encysted state. All three specimens collected with others in a pond in Fairmount Park, West Philadelphia, August, 1878. 666 diameters.

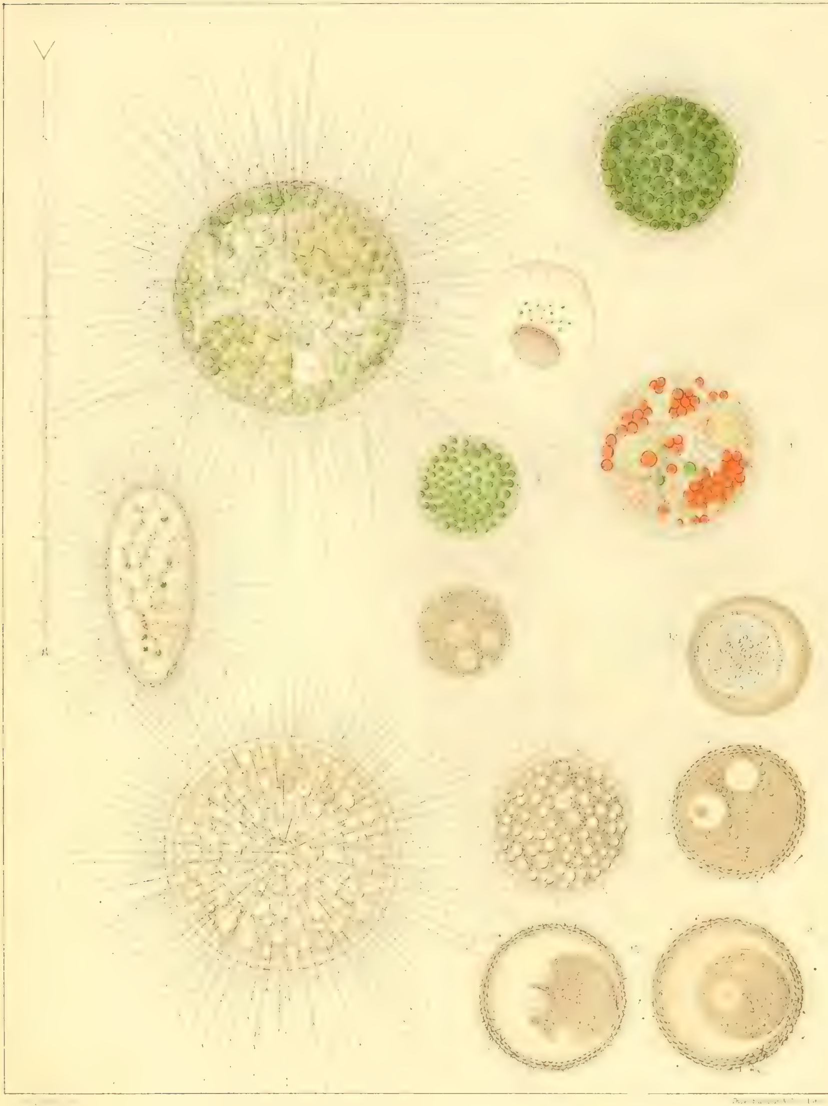

PLATE XLIV.

CLATHRULINA ELEGANS.

FIG. 1. Individual with yellow latticed shell and stem, and interior sarcode ball emitting numerous rays. Absecom pond, New Jersey, October, 1875. 1,000 diameters.

FIG. 2. Specimen of two individuals, the younger with its stem attached to the head of the older. The latticed head of the latter occupied by a large sarcode ball emitting numerous rays, the bases of which together with the ball enveloped in a diffused pale granular stratum. The sarcode mass of the younger head containing large globules. Found among Utricularia. Absecom, N. J., 1875. 750 diameters.

FIG. 3. A young specimen, in which the latticed condition of the shell was not distinguishable. 1,000 diameters. Found with the preceding.

FIG. 4. A still younger individual than the preceding. 666 diameters. Found together with groups detached from the under side of leaves of the White Pond Lily. Hammonton pond, New Jersey, October, 1877.

FIG. 5. A small group in outline. Same locality.

FIG. 6. Specimen with the sarcode forming a quiescent ball in the interior of the uncolored latticed head. Found floating in water from Absecom pond, New Jersey, October, 1875. 1,000 diameters.

FIG. 7. Colored specimen containing two sarcode balls. Sphagnum of Absecom, N. J., February, 1875. 1,000 diameters.

FIG. 8. Colored specimen containing two sarcode balls. Hammonton pond, New Jersey, October, 1877. 666 diameters.

FIG. 9. Specimen of two individuals, with the sarcode encysted in both. Absecom pond, New Jersey, November, 1874. 1,000 diameters.

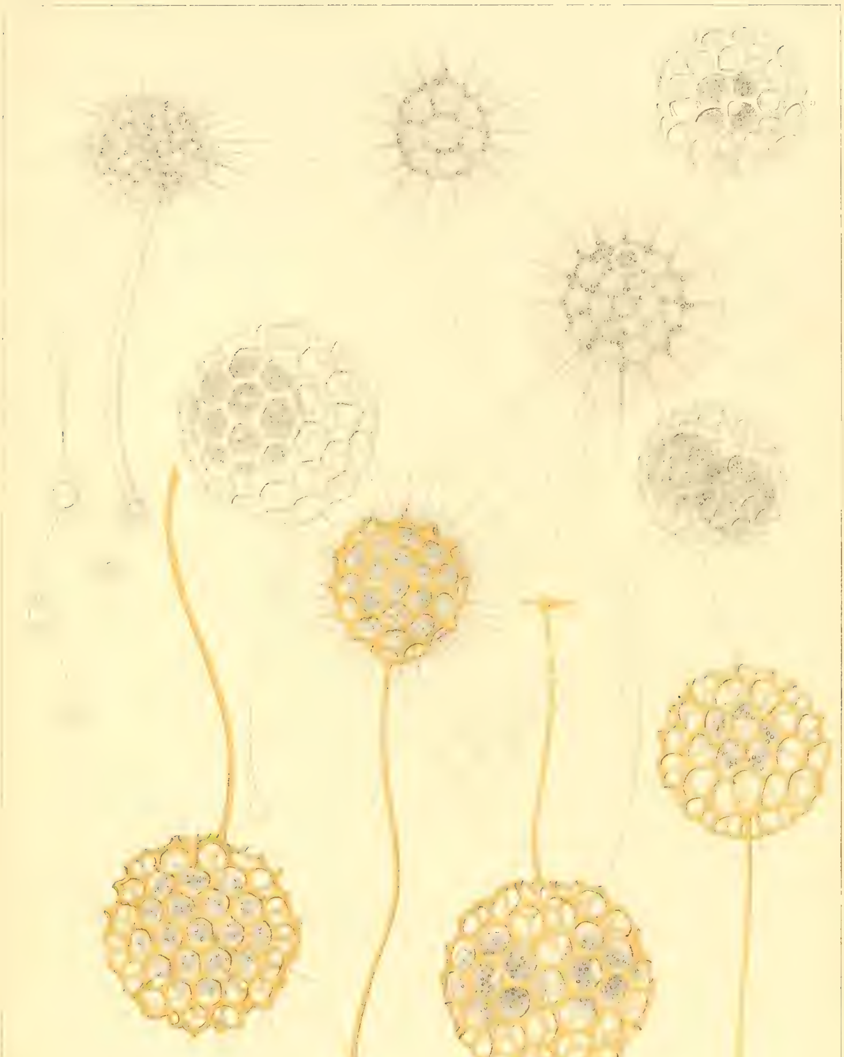

PLATE XLV.

FIGS. 1–3.—HETEROPHRYS?

FIG. 1. Individual from sphagnous swamp, Broad Mountain, Pennsylvania. 500 diameters.
FIG. 2. Individual, from Uinta Mountains, Wyoming, July, 1877. 1,000 diameters.
FIG. 3. Individual, associated with the last. 500 diameters.

FIG. 4.—HETEROPHRYS?

From sphagnum-water, Vineland, N. J., August, 1876. 400 diameters.

FIGS. 5, 6.—HETEROPHRYS?

Successive views of the same individual. Uinta Mountains, Wyoming, August, 1877. 1,000 diameters.

FIGS. 7, 8.—DIPLOPHRYS ARCHERI?

Two views of the same specimen. Swamp-water, Broad Mountain, Pennsylvania, September, 1876. 500 diameters.

FIG. 9.—HYALOLAMPE FENESTRATA.

From sphagnum, Absecom, N. J., June, 1877. 500 diameters.

FIGS. 10–16.—VAMPYRELLA LATERITIA.

FIGS. 10, 11. Two views of the same individual; the former as first observed, the latter as seen two hours subsequently. Fort Bridger, Wyoming, August, 1877. 500 diameters.

FIG. 12. Individual, from Absecom pond, New Jersey, September, 1875. 800 diameters.

FIG. 13. Individual, found with that of figs. 10, 11. 500 diameters.

FIG. 14. Individual, from Fort Bridger, Wyoming, July, 1877. 500 diameters.

FIG. 15. Individual, containing bright green algæ. Spring on Darby Creek, Delaware County, Pennsylvania, April, 1875. 500 diameters.

FIG. 16. Individual, from bog-water, Longacoming, N. J., October, 1874. 800 diameters.

FIGS. 17, 18.—HYALODISCUS RUBICUNDUS?

FIG. 17. Individual, from ooze of Cooper's Creek, Camden, N. J., May, 1874. 600 diameters.
FIG. 18. Individual found with the preceding. 1,000 diameters.

PLATE XLVI.

FIG. 1.—RAPHIDIOPHRYS. Probably *R. viridis*.

An individual which appeared bright green under lower powers. Ditches below Philadelphia, June, 1874. 370 diameters.

FIG. 2. A nearly colorless individual. Same locality. 500 diameters.

FIG. 3. A colorless individual. Found with Spongilla, in Schuylkill River, Philadelphia, August, 1874. 500 diameters. A more highly magnified spicule seen in the left.

FIGS. 4–6.—HETEROPHRYS MYRIAPODA?

FIG. 4. A bright green individual, excepting the color, closely resembling an *Actinophrys sol*. Absecom pond, New Jersey, May, 1877. 250 diameters.

FIG. 5. A bright green individual. Vineland, N. J., August, 1876. 500 diameters.

FIG. 6. A bright green individual. From sphagnum-water. Absecom, N. J., May, 1877.

FIGS. 7–10.—HETEROPHRYS?

FIG. 7. An individual showing a very great variability in the condition of the rays. Absecom mill-pond, New Jersey, September, 1874. 500 diameters.

FIGS. 8, 9. Two views of an individual exhibiting successive changes of shape. Found with the former. 1,000 diameters.

FIG. 10. A bright pea-green individual, with changeable form of body. Absecom pond, New Jersey, May, 1877. 250 diameters.

FIGS. 11–13.—HETEROPHRYS? Probably of the same species as the former.

FIG. 11. A green individual, containing segments of Lyngbya, which have become red as a result of digestion. 1,000 diameters. Ditch at roadside, near Darby, Pa.

FIG. 12. A small individual, containing a large body, probably food, of unknown character. Broad Mountain, Pennsylvania. 500 diameters.

FIG. 13. An individual, containing apparently a number of unicellular algæ variously colored. Found with that of fig. 11. 1,000 diameters.

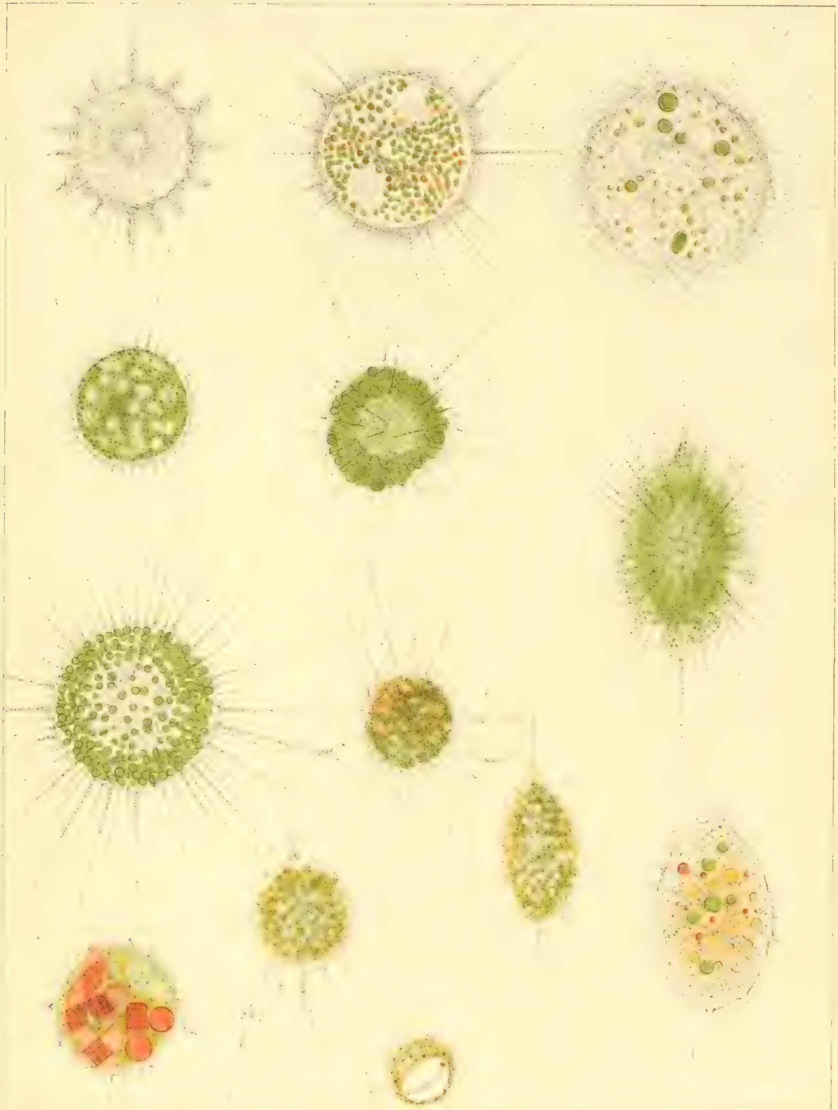

PLATE XLVII.

FIGS. 1–4.—GROMIA TERRICOLA.

FIG. 1. Individual with a multitude of extended pseudopodal rays forming an intricate net. The body of the animal has attached posteriorly a quantity of sand and dirt. From among moist moss, in company with Rotifers, &c., in crevices of the pavement in the yard of my house, Philadelphia, June, 1874. 200 diameters.

FIG. 2. A second individual found in company with the former.

FIG. 3. A third individual with few pseudopodal extensions. Also found with the preceding. The arrows indicate the course of currents of the protoplasm. 200 diameters.

FIG. 4. Portion of the pseudopodal rays of a Gromia more highly magnified than in the preceding. The arrows indicate the course of flow of currents of the protoplasm with granules. As seen under Hartnack's No. 11 immersion objective lens.

FIGS. 5–12.—BIOMYXA VAGANS. 250 diameters.

FIGS. 5, 6, 7. Three successive views of the same individual.

FIGS. 8, 9. Two successive views of another individual.

FIG. 10. A third individual. This and the preceding specimens, from sphagnum collected at Absecom, N. J., in the autumn and preserved in a glass case during the winter. March, 1875.

FIGS. 11, 12. Two views of an individual, exhibiting successive changes of form. From Sphagnum, Broad Mountain, Pennsylvania, September, 1876.

PLATE XLVIII.

BIOMYXA VAGANS. 250 diameters.

FIG. 1. Large individual, containing many minute contractile vesicles together with a number of Closteriums. The larger circular spaces are vacant and were produced by the closing of meshes of the protoplasmic net. The arrows indicate the course of the protoplasmic currents. From sphagnum, of Absecom, New Jersey, collected in the autumn of 1874 and preserved in a glass case during the winter. Observed March, 1875.

FIGS. 2, 3. Two successive views of a small individual, found with the former, and supposed to be a detached fragment.

FIGS. 4–6. Three successive views of an individual. Observed in the same sphagnum as the former.

FIGS. 7–9. Three successive views of another individual. Also from the same sphagnum.

FIGS. 10–14. Five successive views of an individual. From sphagnum of Broad Mountain, Pennsylvania, September, 1876.

FIGS. 15–17. Three successive views of an individual. From sphagnum of Atco, N. J., April, 1877.

FIGS. 18–20. Three successive views of an individual. It contained a distinct granular nucleus, and is suspected to pertain to the same organism as the former specimens. Found with the preceding in sphagnum of Atco, N. J.

FIG. 21. Supposed to be a condition of Biomyxa. It contains a nucleus, several contractile vesicles, and numerous darkly defined granules.

FIGS. 22–25. Four successive views of another individual of the same kind. As first seen, fig. 2, the creature discharged a large mass of excrementitious matter.

The subjects of figs. 21–25 were found, with many others of the same kind, together with multitudes of minute desmids, in a clear gelatinoid substance, adherent to the glass case in which was preserved a large bed of sphagnum, collected in the autumn at Absecom, N. J. April, 1877.