BIOLOGICAL OBSERVATIONS ON THE MARINE FUNGI OF WOODS HOLE WATERS

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INTRODUCTION

While the rôle played by marine bacteria in the decomposition of organic complexes is appreciated by all interested in a study of the ocean, the activities of fungi in this respect are practically unknown. Indeed, it may be justly said that the very existence of fungi which complete their whole life history in the sea is not known to most students of marine biology.

Occasional references to these rare and peculiar organisms may be found in the European literature from the 1860's onward. In the accounts of the early students of the seaweeds certain structures generally supposed by them to be the reproductive organs of the algæ were described and figured, which in many cases have been found to be, in reality, extraneous, parasitic fungi. In fact, practically all of the few marine fungi thus far found have been described as parasites or saprophytes of various marine algæ.

Representatives of four groups of the fungi have been discovered in marine waters, namely, the Myxomycetes (Labyrinthuleæ), Phycomycetes, Ascomycetes, and Fungi Imperfecti. Of the alga-inhabiting species which are truly parasitic or hemi-parasitic, those of the Phycomycetes seem to predominate. Many of these are not only able to initiate the infection of a healthy host, but once the alga has been killed have the capacity to live saprophytically on the dead contents, often in company with bacteria and Protozoa which have entered as secondary agents of destruction.

Only two papers have thus far appeared which deal at all extensively with marine fungi (Petersen, 1905; Sparrow, 1934) and both of these are concerned with forms collected in northern Europe. Twenty-three different organisms are described in these papers, all but one of which (*Pythium marinum* Sparrow) are ordinarily included in the order Chytridiales of the Phycomycetes. In our own waters two undoubted Phycomycetes have thus far been reported from the Pacific coast

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[1] Contribution No. 99.

(Zeller, 1918), while the Atlantic side has apparently yielded but a single one (Martin, 1922). Recently, Papenfuss (1935) has mentioned a chytridiaceous parasite of the brown alga *Ectocarpus siliculosus* Dillw. which he states attacked about 50 per cent of the unilocular sporangia, but he does not name the organism. This material was collected in the vicinity of Woods Hole, Mass.

The present investigation was initiated with two points in mind : first, to determine whether or not marine Phycomycetes were actually present in Atlantic coastal waters—a point not altogether evident from the extant literature—and secondly, to determine, if such were found, the nature and extent of their activities in the cycle of decomposition of marine organic complexes. This paper embodies the results of the work done mainly during the summer of 1934, and, to a lesser extent, a portion of the summer of 1935 on the first of these objectives and includes not only an enumeration of the fungi found in the vicinity of Woods Hole, Mass., but in addition, pertinent notes on their morphology, life history, and taxonomy.

Fungi Collected

1. *Labyrinthula sp.* Saprophytic in cells of *Rhizosolenia spp.*, bottom of Great Harbor, August 14, 1934.

In debris dredged from the bottom of Great Harbor during a heavy " flowering period " of diatoms, large numbers of *Rhizosolenia spp.* were found in various stages of decomposition. In these cells there were often found the motile stage of a *Labyrinthula* (Text Fig. 35), sometimes in company with a Protomyxa-like protozoan, or a small chytrid. The fusiform swarm cells of the *Labyrinthula,* which were 12 μ long by 5 μ in diameter, made their way in and upon the algal cells by gliding along their tenuous pseudopodia. The most anterior of these cells, which was not preceded by any protoplasmic attenuation, displayed remarkable powers of amœboid movement. No solid particles could be detected within the swarm cells.

The uncertain taxonomic status of the species of this peculiar group does not allow of any specific designation of the present form. Morphologically it does not seem very different from *Labyrinthula macrocystis* described from marine algæ by Cienkowsky (1867), from the common inhabitant of diseased *Zostera* (Renn, 1934), nor, indeed, from certain fresh-water forms.

Very frequently in the debris which collects in the bottom of aquaria containing marine algæ, species of *Labyrinthula* are observed, and it is probable that they occur much more frequently than records in the literature indicate—a fact also evident from Miss Jepps's (1931) paper.

No cases of actual parasitism of algæ by these forms were observed, and at Woods Hole, at least, the organism on *Rhizosolenium* appears to lead a saprophytic existence. Experiments to test the pathogenicity of various strains of *Labyrinthula* are greatly needed.

2. ?*Labyrinthula Chattoni* Dangeard. Parasitic(?) in *Cladophora sp.*, vicinity of Woods Hole, throughout the summer.

Very commonly in material of *Cladophora* which has been maintained in the laboratory for some time there will be found occasional greyish cells within which are rosettes of highly refractive material, generally surrounding a central mass of compacted brown granules—the remains of the host chloroplasts. These rosettes are divided radially into a varying number of segments from which at maturity numerous very minute amœboid bodies emerge. According to Dangeard (1932), these are the motile spores of the fungus, and he has figured numbers of spindle-shaped bodies which unite to form a net-plasmodium. In the present material no fusiform shape was ever assumed by the spores, although the bodies from which they emerged—considered by Dangeard to be sori—resembled closely those of his species; neither was a net-plasmodium formed, and for these reasons the writer considers a further study of the Woods Hole fungus necessary before definitely naming it.

3. *Protomyxa*-like parasite of *Bryopsis*. Parasitic in *Bryopsis plumosa*, vicinity of Woods Hole, summer of 1934, June, 1935; New Bedford Harbor, Mass., July 24, 1934.

In the course of studies made on a fungous parasite of *Bryopsis* (*Sirolpidium*) there was frequently found an exceedingly virulent parasite which is undoubtedly a protozoan. However, since the animal occurred in such abundance and very often in competition with the fungus, both usually consuming the entire contents of infected cells, it would seem of interest to include it here.

Infected cells were readily noted by their blackened appearance, a pathological symptom also produced by the fungus. The method of entrance of the parasite and the nature of the unit accomplishing this were not determined. Once established, the organism gradually enveloped part or all of the algal content which soon became discolored within its body. The shape of the invader was variable but in general resembled a giant amœba from any part of the surface of which delicate, often strongly contractile threads emerged. Very marked movement of these threads could be detected and frequently broadly fusiform or spherical enlargements containing algal material could be seen moving along them

(Plate I, Fig. 6) in much the same " trolly-wire " fashion as that observed in *Labyrinthula*.

In exhausted algal cells the animal seemed to go into a resting stage and to surround itself with a slightly thickened, rigid pellicle. The engulfed host contents were by now nearly black, and it was these cylindrical bodies with rounded ends which were so evident macroscopically.

A similar organism has been found very frequently in decaying *Rhizosolenia spp.* dredged from the bottom of Great Harbor and in dead cells of *Ectocarpus* from Gay Head.

4. *Ectrogella perforans* H. E. Petersen. Parasitic in *Licmophora abbreviata*, summer of 1934, June, 1935; *Striatella unipunctata*, summer of 1934, June, 1935; vicinity of Woods Hole; New Bedford harbor, July 24, 1934; Gay Head, Martha's Vineyard, Mass., July 16, 1934.

This virulent parasite is the commonest marine fungus in the vicinity of Woods Hole and during the summer it is almost impossible to find stands of *Licmophora* and *Striatella* not heavily infected with it. It not only occurs in all the littoral regions in the immediate vicinity of Woods Hole but has also been found in equal abundance in New Bedford Harbor and Gay Head. It is probable that it will be found along our coasts wherever the host plants grow. During the month of July in particular the fungus may occur in epidemic proportions (Plate III, Fig. 2). As many as 88 per cent of the diatoms (*Licmophora*) in a single mount containing many hundreds have been observed to be infected.

Since the present form presents no significant differences in morphological features from that recently described by the writer (1934) from Danish material found in the littoral of the Kattegat, it will not be dealt with in detail here, save for certain hitherto unknown phases.

In both *Licmophora* and *Striatella* there was ordinarily present in one infected diatom only a single, spherical, highly refractive thallus, although occasionally 2–5 were observed. This varied from 25–35 μ in diameter and lay loosely in the center of the host cell.

A good opportunity was afforded in several instances to determine the method of entrance of the parasite into the host cell, a feature not previously observed. Heavily infected colonies of diatoms contained many cells, to the outer surfaces of which adhered numerous minute (3 μ in diameter) quiescent cystospores of the fungus. The small size of these bodies made observations difficult, but in several cases spores were found from each of which a tenuous, needle-like penetration tube had emerged and had pierced the host wall. It is probable that, like other parasitic chytrids, the contents of the spore then flowed through the tube

into the algal cell, leaving the wall of the cyst outside. Such empty cystospores were found, although the actual passage of material into the cell was not witnessed. Once inside, the refractive fungous protoplasm soon assumed a central position in the host cell, possibly attaching itself to the nucleus of the diatom. Growth into the mature, somewhat spherical sporangium then ensued. The star-like arrangement of the chloroplasts of the host was soon destroyed and, as the fungus developed, their individual structure was broken down and their normal color lost. At no time was any host material observed to be ingested directly nor did the fungus exhibit any signs of amœboid motion. As the *Ectrogella* increased in size, the disintegrating host material usually became collected around the periphery of the parasite, where it gradually became reduced to a small amount of granular, chestnut-brown residue. The nature of this unassimilated material is not known.

There then took place a transformation of the contents of the thallus into innumerable, minute zoöspores. These were discharged through 1–5 stout tubes into the water. A point of great morphological and taxonomic interest was determined from the spores of this material. Petersen (1905) states that in this species they are anteriorly uniciliate, the cilium being directed posteriorly when the spore is in motion. In the Danish material previously observed, the writer (1934) was unable to determine the ciliation, but at Woods Hole, the spores were found to be biciliate. This finding was confirmed in many instances. The body of the zoöspore is pyriform, somewhat curved, and at the narrower, forwardly directed end there is usually a refractive droplet. The two, perhaps anteriorly attached, cilia are directed oppositely when the spore is in motion. The relative lengths of these two structures could not be determined. Motion through the water was of an uneven, twisting character. The resemblance of these spores to those of *Sirolpidium* (Sparrow, 1934) is very marked.

From these observations, the parasite can now with real reason be placed in the genus *Ectrogella* as amended by Scherffel (1925).

At no time during the process of disintegration of the host cell could the presence of any other type of organism be detected. Bacteriological stains were employed to determine whether or not bacteria assisted in the process of disintegration, but none was ever observed. Indeed, the fungus had apparently so completely absorbed the available nutriment that even after infected cells had become broken or had fallen apart, bacteria and Protozoa were seldom seen feeding on the residual material.

It was very evident that not only could the fungus initiate the infection, but once inside, could bring about, unaided by other agencies, the almost complete disintegration of the contents. Further, the thallus,

derived from a single zoöspore, at maturity became transformed into a myriad of swimming spores, each of which was potentially able to infect another diatom. Hence, in a region with an abundance of favorable host material, the rapid and widespread dissemination of the parasite could be quickly accomplished.[2] Indeed, it is remarkable in view of the high percentage of infection observed, that the two species of diatoms were able to maintain themselves at all. It is hoped that a more comprehensive study of this disease can be made in the future.

5. *Eurychasmidium tumefaciens* (Magnus) n. gen. Parasitic in the nodal cells of *Ceramium diaphanum*, Sheep Pen Cove, Woods Hole, August 27, 1934, collected by C. Jao; Little Harbor, Woods Hole, August 29, 1934, collected by the author.

Eurychasmidium n. gen. Plasmodial thallus entirely intramatrical, one-celled, filling the distended host cell, forming at maturity many discharge tubes which pierce the host wall; zoöspores biciliate, encysting near the sporangium after discharge, ultimately emerging as motile zoöspores. Resting spores not observed.

Thallus plasmodialis, omnino intramatricalis, unicellulatus, cellulam matricis distentam implens, maturitate formans multa ostiolata perforantia parietem cellulæ matricis; zoosporæ biciliatæ, encystantes extra sporangium post emissionem, e cystis emergents velut sporæ motiles. Sporæ perdurantes non observatæ.

Eurychasmidium tumefaciens (Magnus) comb. nov.
　　Syn. *Chytridium tumefaciens* Magnus.
　　　　Olpidium tumefaciens (Magnus) Berl. et de Toni.

Thallus filling the host cell; spherical or irregular and lobed; producing a marked enlargement of the host cell and stimulating the host to form clusters of lateral branches; becoming transformed into a single sporangium, the spherical ones 100–110 μ in diameter, the lobed examples up to 110 $\times$ 200 μ long. Zoöspores formed within the sporangium (ciliated?), upon discharge through as many as 30 discharge tubes forming a dense motionless cluster near the sporangium; encysting, the somewhat loosely disposed cysts being angular and 4 μ in greatest width; emerging from the cysts after a period of quiescence as ellipsoid, biciliated spores, 3 μ in diameter by 5 μ in length. Resting spores not observed.

This remarkable fungus which usually attacked only the nodal cells of the *Ceramium* possesses many points of interest. In its method of

[2] One curious evidence of the virulence of this fungus was noted. In a mount containing many swimming spores, a species of *Vorticella* was observed which had captured 10 or more zoöspores. The latter instead of being digested by the animal, had reversed the process and had absorbed the contents of the protozoan and were forming sporangia!

infection, developmental features, and effect on the host cell it resembles to a marked degree *Eurychasma Dicksonii* (Sparrow, 1934). However, it differs from this genus since it always remains intramatrical, since the zoöspores undergo a period of encystment outside the sporangium, not inside, as in *Eurychasma,* and since it produces adventitious lateral branches and a more marked swelling of the host cell (Plate I, Fig. 1).

The earliest stages observed in the development (Text Figs. 14, 15) showed an already well-established thallus easily distinguishable in the distended host cell by the presence of numerous irregular, refractive bodies. As growth proceeded, the disintegrated chloroplast material became more granular while the host protoplasm assumed a vacuolate character (Text Fig. 18). Coincident with the increase in size of the fungus there was a strong distention of the host cell (Text Fig. 17).

Infection is unquestionably initiated by the zoöspore, probably in the same manner as described for *Ectrogella perforans.* While actual observations on this point were lacking, there were occasionally observed instances similar to Text Fig. 16, in which the empty cyst and remains of the penetration tube were still present on the infected cell. The sequence of changes ensuing in the fungous protoplasm itself as growth proceeded were entirely similar to those described by Petersen (1905) for *Eurychasma,* including the characteristic " stade écumeux " (Text Fig. 19).

During enlargement of the host cell, a pronounced thickening of the algal wall material was noted. Also, certain adjacent nodal cells were stimulated to divide and there was produced in the vicinity of an infected cell a number of curved, stunted, lateral branches which gave a " bushy " appearance to the region (Plate I, Fig. 1). Such places could easily be detected with a hand-lens. Since the fungus was not observed to form any rhizoidal system, but was confined to a single cell, it would seem that some sort of substance was produced in infected cells which diffused to adjacent ones and stimulated them to abnormal growth.

Occasionally, infected apical cells of *Ceramium* were found with 2–6 thalli in them, probably the result of multiple infection. If these were produced by the same fungus as found in the nodal cells, it is interesting to note that here, very little hypertrophy occurred.

Unfortunately, the final stages in the formation of the zoöspores and their discharge from the sporangium through many discharge tubes were not observed, in most cases evacuation of the spores having taken place before the preparations were made. Nor could means be found to promote maturation and discharge of sporangia under observation. Hence, it is not known whether the spores emerge by ciliary action or are forced out of the sporangium. Once emerged, however, they form a dense

cloud around the infected filament, each spore being surrounded by an angular wall (Text Fig. 21). These cystospores are not connected with one another as they appear to be in the sporangium of *Eurychasma* but are loosely disposed in the medium (Text Fig. 20). After an unknown period of quiescence the protoplasm of each of these cysts emerges, probably through a pore formed in the wall, and undergoes near the empty shell a rocking and fashioning which terminates with the production of the fully formed spore. The body of the spore is somewhat elliptical, generally possessing a single, minute refractive droplet, and two cilia—the latter point being determined from a study of killed and stained material. Further observations on the orientation, length, and points of attachment of these cilia are needed.

This fungus is a true parasite, initiating and carrying to completion the destruction of the host cell unaided by other agencies. Unlike certain other marine fungi, however, it does not seem able to continue its destruction of the alga after the latter has been noticeably weakened, as, for example, by remaining under laboratory conditions for a time. The remainder of the host plant, save in the immediate vicinity of an infected cell appears unaffected by the incursion of the fungus.

6. *?Petersenia sp.* Saprophytic in *Ceramium diaphanum,* Little Harbor, Woods Hole, August 29, 1934.

In material of *Ceramium diaphanum* which had been kept in the laboratory in an aquarium for several weeks, there was found a " Pleotrachelus "-like fungus, probably to be regarded as a saprophyte in the alga. In contrast to the previously described fungus on this alga, the present form was found only in the internodal cells and in further distinction was never observed to produce any hypertrophy of the host.

One to many thalli of varying size ($20-96\,\mu$ in diameter) were formed in a single internode (Plate II, Fig. 4). While maintaining in general a spherical shape, these thalli occasionally assumed irregular forms, though no lobed examples were found.

The mature sporangium was characterized by its relatively large size, attaining frequently a diameter of $96\,\mu$ or more, although occasional specimens measured only $20-25\,\mu$. At maturity up to ten or more narrow, distally tapering, radiating discharge tubes (about $7\,\mu$ in diameter) were formed (Plate II, Fig. 3) which bored through the cell wall of the alga. Zoöspores and resting spores were not observed, and hence the exact generic disposition of the fungus awaits the results of further investigations. If, as is probable, the swarmers are found to be biciliate, affinity with *Olpidiopsis* and more especially *Petersenia* would be indicated.

7. *?Petersenia sp.*   Parasitic in eggs of a microscopic animal (rotifer?),
Sheep Pen Cove, Woods Hole, August, 27, 1934.

Adherent to filaments of *Ceramium diaphanum* there was an abun-
dance of eggs of a microscopic animal, probably belonging to the
Rotiferæ, members of which were swarming in the mount.   Some of
these were parasitized by a fungus allied to *Petersenia* and *Olpidiopsis.*
The thallus occupied the whole of the interior of the egg and at ma-
turity was transformed into a single sporangium 50 μ long by 20 μ in
diameter.   This was provided with 1–3 broad (8 μ in diameter), short,
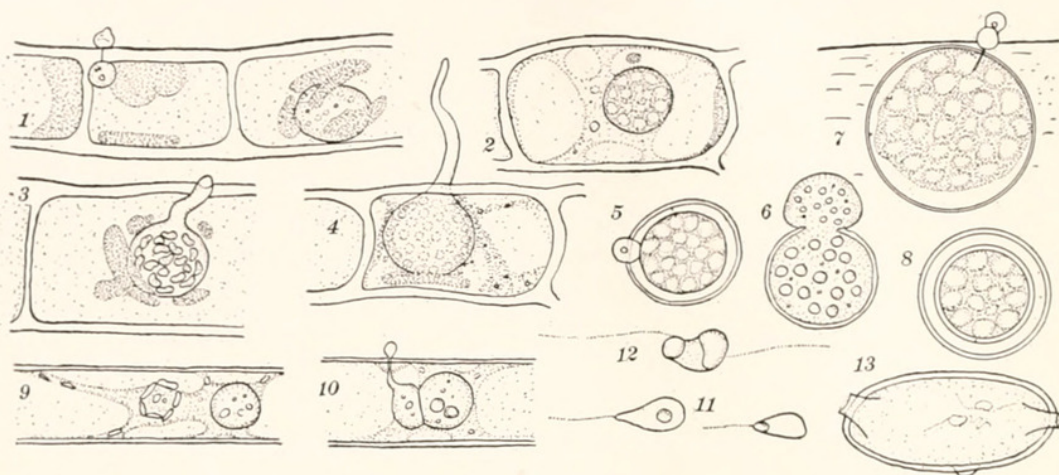
TEXT FIGS. 1–13.   Figs. 1–8, *Petersenia Andréei;* Fig. 1, early stage in the
formation of the thallus in *Ectocarpus,* the collapsed cyst of the infecting zoöspore
and the penetration tube still present, a more mature thallus is seen in the right-
hand cell, × 376; Fig. 2, more mature thallus containing characteristic refractive
bodies, × 376; Fig. 3, mature, unopened sporangium showing some of the zoöspores
which are actively moving within it, × 376; Fig. 4, mature sporangium with long
extramatrical discharge tube, × 376; Fig. 5, mature resting spore with male cyst
adherent to it, × 600; Fig. 6, conjugation of thalli previous to resting spore forma-
tion, × 525; Fig. 7, immature resting spore with two cystospores, which have ap-
parently conjugated, attached by a penetration tube to it, × 760; Fig. 8, ma-
ture resting spore showing interpretation of wall structure, × 600. Figs. 9–11,
(?)*Olpidium sphacellarum;* Fig. 9, young, spherical thallus in hair of *Sphacelaria,*
× 525; Fig. 10, young thallus attached to nucleus of host cell, the cyst of the in-
fecting zoöspore and penetration tube still persistent, × 525; Fig. 11, interpreta-
tion of two zoöspores, free-hand.   Fig. 12, *Petersenia Andréei,* interpretation of
zoöspore, free-hand.   Fig. 13, *Petersenia sp.* in egg of rotifer, discharged spor-
angium containing a few zoöspores, × 376.

discharge tubes (Text Fig. 13).   The actual formation and discharge
of the zoöspores was not witnessed, although a number of these bodies
which had failed to emerge were observed within the sporangia.   These
were reniform, of the " laterally biciliate " type, 4 μ long by 2 μ in
diameter, and were very similar to those formed by *Pythium.*

No bacterial or other biological agencies appeared to assist in the
destruction of the eggs.   It is hoped that more material of this fungus

can be found in order that a further study of its method of infection, as well as the formation and discharge of the zoöspores can be made. From the ciliation of the spores there seems little question of its relationship to *Petersenia*.

8. *Petersenia lobata* (Petersen) Sparrow. Parasitic on *Callithamnion roseum*, growing on *Chorda filum*, dredged from between East Chop and West Chop Lighthouses, Vineyard Haven, August 22, 1934; Sheep Pen Cove, Woods Hole, August 23, 1934.

This peculiar fungus was abundant in certain tufts of the host, but it was never observed to attack all the plants on a single *Chorda*. Cells near the base of the tuft were most frequently infected.

The predominating type of thallus found in this material was cylindrical with rounded ends, although there occurred numerous lobed examples, often of very bizarre appearance (Plate II, Figs. 1, 2).

A morphological and taxonomic discussion of this fungus has recently been given by the writer (1934) and since no unusual features were displayed by the American material, it will not be repeated here.

In the early stages of invasion of the host cell, the parasite is unassisted by other organisms. However, in old infections, an abundance of bacteria and Protozoa are always found and it seems probable that the fungus initiates the destruction of the host cells, being aided in later stages by these other agencies.

9. *Petersenia* (*Olpidiopsis*)*Andréei* (Lagerheim) comb. nov.
    Syn. *Pleotrachelus Andréei* Lagerheim, 1899.
   *Pleotrachelus ectocarpi* Jokl, 1916.

?Parasitic in *Ectocarpus siliculosus*, dredged off Gay Head, Vineyard Sound, July 16, 1934; Great Harbor, Woods Hole, August 24, 1934.

Frequent examples of extensive infection of host plants were found in the material from Gay Head, and quite commonly large fronds were observed with nearly every cell showing evidence of fungous activity. Such plants were easily recognized by their slightly greener appearance. So extensive was the infection that it could not be determined whether the fungus was the primary cause of the destruction of the alga, or whether it was only a saprophyte.

There was little doubt as to the method of entrance of the fungus. Numerous examples similar to Text Fig. 1 were observed which clearly showed that the zoöspore, after coming to rest on the surface of the host, had gained entrance by the formation of a penetration tube through which the content of the spore passed into the interior. It was the disorganized condition of the host cell contents even in early stages

of infection which seemed to indicate that the fungus was probably only weakly parasitic or even saprophytic.

Further development involved the enlargement of the thallus (Text Fig. 2), accompanied by a gradual disintegration of the host contents. One to three thalli were usually formed in a single cell. The mature sporangia lay loosely in the host cell and were generally spherical and 18–20 μ in diameter (Text Fig. 4). A single discharge tube, 4–5 μ in
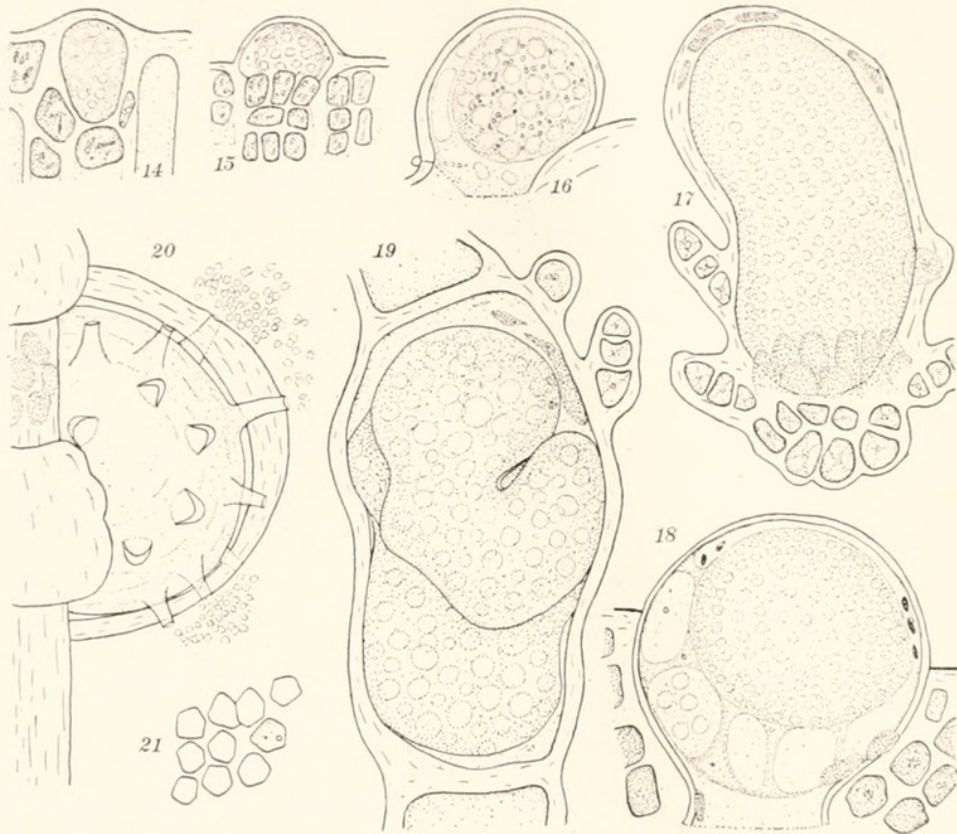
TEXT FIGS. 14–21. *Eurychasmidium tumefaciens*. Figs. 14, 15, early stages in the formation of the thallus in *Ceramium diaphanum*, × 225; Fig. 16, more mature thallus showing at the bottom of the left-hand side the remains of the infecting zoöspore and its penetration tube, × 376; Figs. 17–19, strongly hypertrophied host cells with vacuolate thalli of the fungus in them, Fig. 19 shows one of the infrequently formed lobed thalli, all × 225; Fig. 20, empty sporangium showing the many discharged tubes formed and a few of the encysted zoöspores, the latter formed a dense cloud around the sporangium, × 225; Fig. 21, cysts formed by the discharged zoöspores, from all but one of which the spore has emerged, × 760.

diameter, was formed which often extended for as much as 78 μ out into the water. Occasionally, the tube did not achieve a correct orientation, in which case it passed through a number of host cells before reaching the outside.

The zoöspores were fully formed within the sporangium by a process of progressive cleavage. After maturation, and before dissolution of

the tip of the discharge tube, they underwent a prolonged period of violent individual movement and " milling around " (Text Fig. 3). Upon the opening of the discharge tube they escaped by their own efforts from the sporangium. In their morphology, these spores (Text Fig. 12) are strikingly like those of *Pontisma* (Sparrow, 1934), being irregularly piriform, arched, $5\,\mu$ long by $3\,\mu$ in diameter, and possessing at the narrow, forward end, as well as at the broader posterior one, a strongly refractive region. As has been suggested for *Pontisma*, a broad central, transverse groove and a " doubling-over " of the ends may account for this peculiar appearance. However, because of their small size, observations on moving spores are difficult. From the more anterior part of the groove there arise two cilia which appear to be of nearly equal length and are disposed in opposite directions along the long axis of the spore. These observations confirm Petersen's (1905) brief statement that the spores are laterally biciliate.

The spores moved in an erratic manner through the water. In hanging drop cells many of them germinated, each giving rise to a single, slender, very irregular tube, often of considerable length ($30\,\mu$).

Resting spores occurred in abundance (Plate I, Fig. 8). It will be recalled that in the Danish material of what is probably the same species, the writer (1934) showed that resting spore formation was apparently preceded by a conjugation between thalli of unequal size, the contents of the smaller passing into the larger which became the resting body. In the present fungus a similar phenomenon was observed in many instances and there seems little question that the resting spores are produced as a result of a sexual act almost identical with that found in the genus *Olpidiopsis*. Communication between the two cells was affected by the formation of a pore, no evidences of a definite fertilization tube ever being found. While, in general, the two conjugating thalli were more nearly equal ($12\,\mu$, $23\,\mu$) (Text Fig. 6) than was observed in the Danish material ($17\,\mu$, $5\,\mu$), occasionally they differed greatly in size ($20\,\mu$, $8\,\mu$) (Text Fig. 5).

The mature resting spore was spherical, 20–$23\,\mu$ in diameter, and appeared to be surrounded by a thick wall. However, under high magnification it was seen that this apparent wall could be resolved into the following structures: an outer, very definitely thickened membrane surrounding the whole, an inner membrane of the same thickness surrounding the refractive contents, and between them, a clear zone (Text Fig. 8). Whether the spore itself is to be regarded as relatively thin-walled and resting within a larger structure, or whether all of these parts are fused into a common surrounding layer, is not clear. Further observa-

tions on the development of the resting spore will be necessary to clarify this point.

Another puzzling feature was the absence in some cases of companion cells on the mature resting spores. Either the cyst was hidden from view by the body of the spore, or it soon disintegrated, or conjugation occurred in some other manner. Some evidence in favor of the latter case is given by the condition shown in Text Fig. 7. Here, attached to an immature resting spore by a tenuous penetration tube, are the cysts of two zoöspores which apparently have conjugated. It is entirely possible that after this process the merged plasma entered the host and there formed the resting spore.

In material of *Ectocarpus* in a floating *Chorda* complex collected in Great Harbor, Woods Hole, what appeared to be germinated resting spores were found. In the process of germination, the inner wall had apparently been absorbed, a long evacuation tube formed, and the contents, undoubtedly in the form of zoöspores, had been discharged through it.

EXPLANATION OF PLATE I

All photographs were made from living material with the exception of Plate I, Figs. 3, 5, and Plate II, Figs. 4, 5, which were made from material mounted in glycerine and stained with eosine. The approximate magnifications are given in each instance.

FIG. 1. *Eurychasmidium tumefaciens*, parasitic in *Ceramium diaphanum*. Two hypertrophied cells are shown; the right-hand filament has produced lateral branches in response to the incursion of the fungus. The indistinctness of the right-hand figure is due to the presence of a cloud of spores which has just been discharged from the sporangium. × 80.

FIG. 2. *Thraustochytrium proliferum*, saprophytic on *Bryopsis plumosa*. The right-hand figure is a sporangium with the spores about to be discharged; the highly refractive body at the base of the sporangium is the fundament of the new sporangium which will develop after discharge of the spores. The left-hand figure may possibly be an immature resting spore. × 380.

FIG. 3. (?)*Olpidium sphacellarum*, parasitic in *Sphacelaria cirrhosa*. An empty sporangium with two lateral, oppositely placed discharge tubes. × 330.

FIG. 4. *Sirolpidium bryopsidis*, in *Bryopsis plumosa*. Typical olpidioid thalli formed from the fragmentation of an originally filamentous thallus. × 380.

FIG. 5. *Pontisma lagenidioides*, saprophytic in *Ceramium diaphanum*. Habit of the segmented thallus in the alga. × 380.

FIG. 6. *Protomyxa*-like animal parasitic in *Bryopsis*. The delicate pseudopodium of the animal bearing a large spherical and two small, fusiform enlargements may be seen extending from the top to the bottom of the photograph. × 380.

FIG. 7. *Sirolpidium bryopsidis* in *Bryopsis*. Thalli after 24 hours exposure to dripping sea-water. Compare with Fig. 4, which is under completely submerged conditions. × 380.

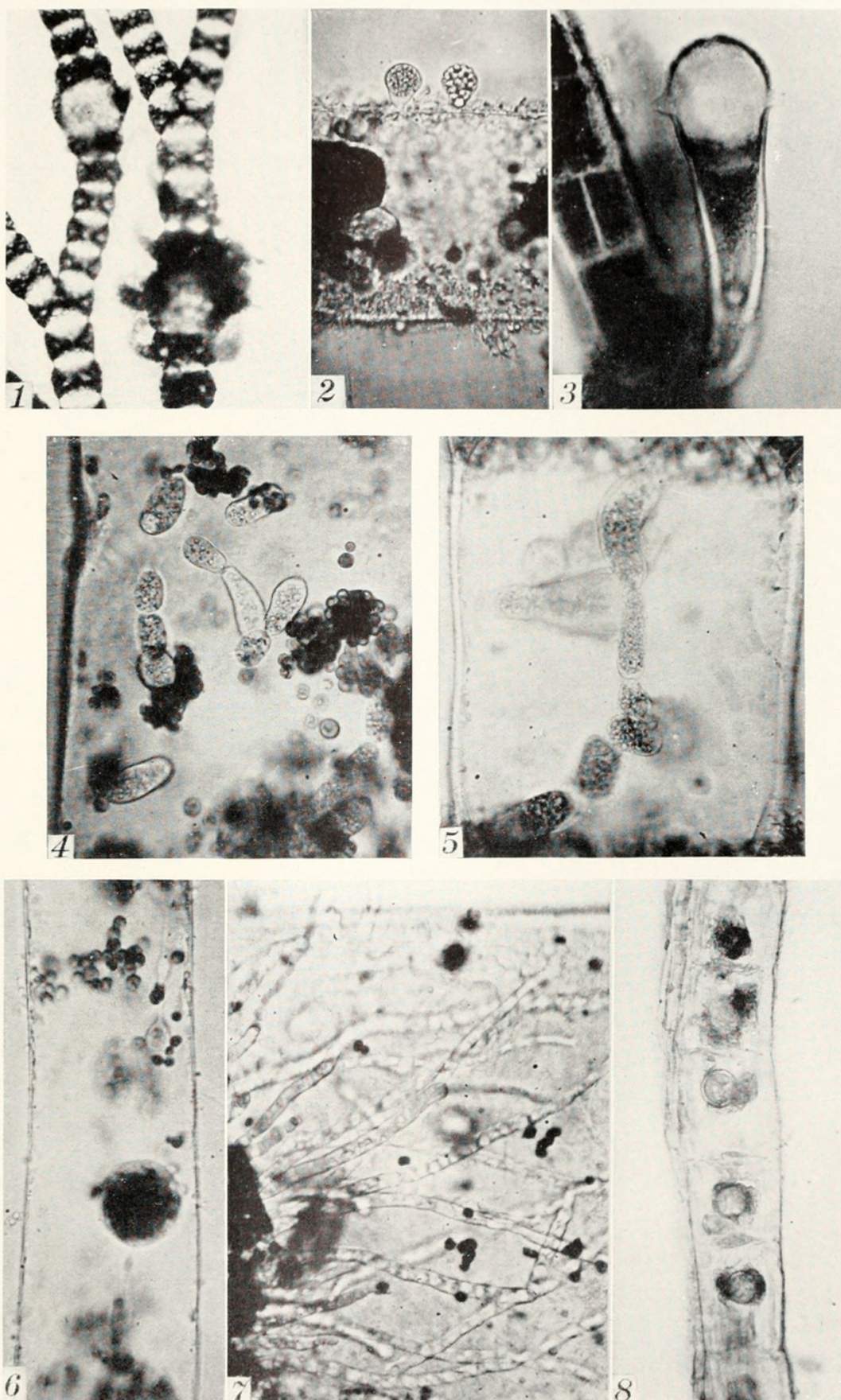FIG. 8. *Petersenia Andréei*, parasitic (?) in *Ectocarpus*. Resting spores in cells of filament. × 250.

PLATE I

While a *Protomyxa*-like organism was abundant in certain cells of the *Ectocarpus*, the parts of the host occupied by the fungus were free from the animal, and, so far as could be determined, from other biological agents of disintegration as well.

10. (?)*Olpidium sphacellarum* Kny.   Parasitic on *Sphacelaria cirrhosa*, Pine Island, Woods Hole, June 24, 1934.

This fungus was found in only one collection of the alga, although a search was made for it throughout the time the host was available.   It attacks chiefly the apical cells of the lateral branches (sporangia?) and the colorless setæ.   The rest of the plant appears immune and is not visibly affected by the presence of the fungus.

Early stages in the development were found, particularly in the colorless setæ.   The infecting unit is the zoöspore, which comes to rest on the host, encysts, and produces a tenuous tube which penetrates the algal wall and through which the contents of the spore are conducted into the cell.   In many cases the young thallus attaches itself to the nucleus of the host cell (Text Fig. 10).   It then gradually enlarges into a spherical (Text Fig. 9), or often cylindrical structure with rounded ends.   No hypertrophy is evident.   In infected lateral branches (sporangia?), however, a pronounced swelling occurs (Plate I, Fig. 3, Plate II, Fig. 5).   The disintegration of the cell contents is almost complete and there is generally left only a mass of irregularly-shaped, colorless granules. The mature sporangia are nearly spherical and 35–45 μ long by 30–35 μ in diameter.   One, or occasionally 2–3 short, stout tubes, 8–10 μ in diameter, are formed through which the mature zoöspores are discharged.   Before these are ejected they undergo a period of active swarming, eventually being liberated very rapidly at the dissolution of the tip of the discharge tube.   They are minute, being 4 μ long by about 2 μ in diameter, and have a somewhat piriform body (Text Fig. 11), near the broader end of which there is a prominent refractive globule. The position of this globule may change while the spore is motile.   Com-

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EXPLANATION OF PLATE II

FIGS. 1, 2. *Petersenia lobata*, in *Callithamnion roseum*. Two thalli, showing the peculiar lobing sometimes encountered. × 260.

FIG. 3. *Petersenia sp.*, saprophytic in *Ceramium diaphanum*. An empty sporangium with three discharge tubes visible. × 260.

FIG. 4. Same fungus, showing the spherical, immature thalli and several discharged sporangia. × 260.

FIG. 5. (?)*Olpidium sphacellarum*, parasitic in *Sphacelaria*. Two thalli, one in the colorless hair, the other in the hypertrophied tip of the lateral branch. × 330.
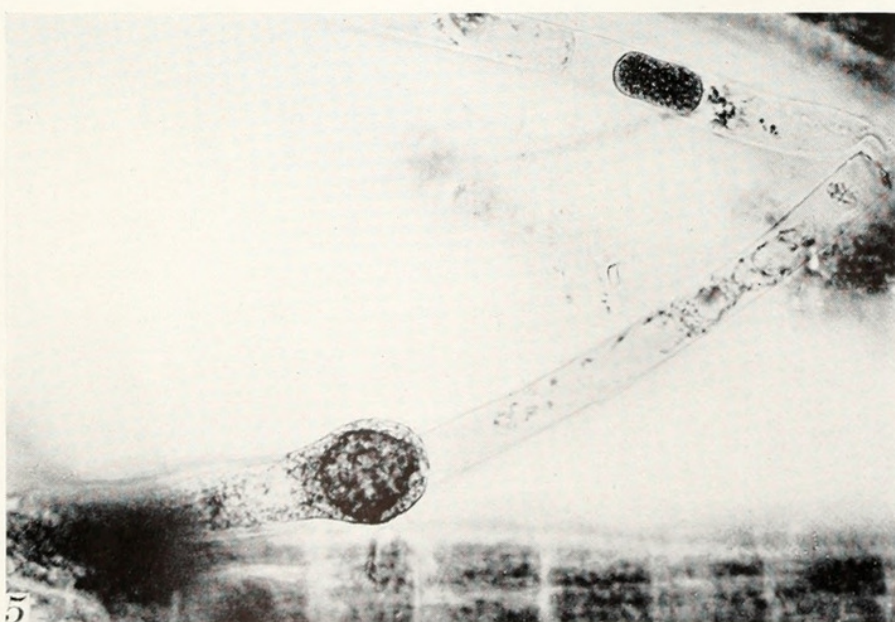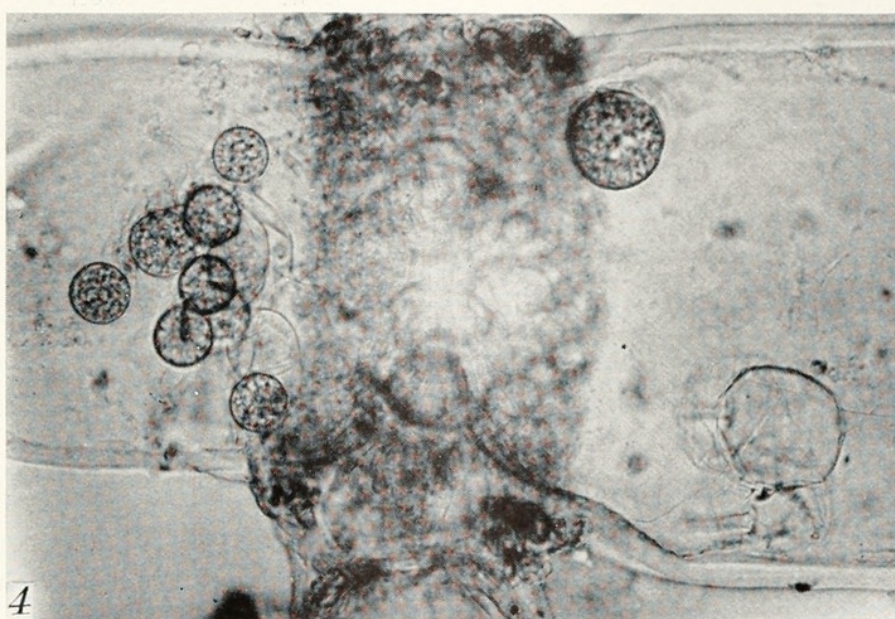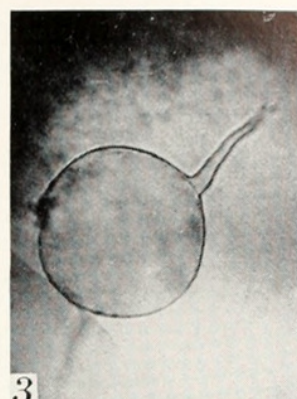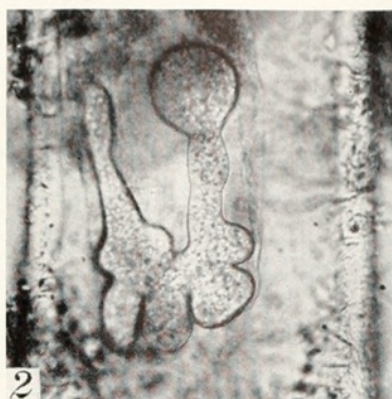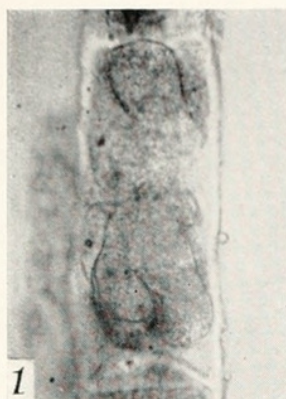
PLATE II

plete data on the ciliation of these spores were not obtained. It is certain that they possessed a very prominent, forwardly directed cilium which appeared to remain nearly stationary during the period of motility. It is probable that another, rapidly vibrating, possibly shorter, posteriorly directed cilium was also present but escaped detection. The zoöspore exhibited a very peculiar type of movement which was characterized by periods of even, forward progression, alternating with sudden stops and change of direction. There appeared to be practically no rotation of the body during movement.

The fungus was a true parasite, invading only the healthy cells of the host and accomplishing alone the disintegration of the contents. With the decline of the alga under laboratory conditions no further fungous activity was noted.

While considered a species of *Olpidium,* it is evident from what is known of the ciliation of the spores that this fungus bears only a superficial resemblance to this genus. If, as is highly probable, the zoöspores are found to be biciliate, it should be placed near *Olpidiopsis* and *Petersenia.*

11. *Pontisma lagenidioides* Petersen.   (?)Saprophytic in the internodal cells of *Ceramium diaphanum,* Little Harbor, Woods Hole, July 8, 1934.

Since details of the morphology of this species have been given in a recent paper (Sparrow, 1934), they will not be repeated here. No significant differences from the Danish material were apparent, except for the fact that the Woods Hole fungus (Plate I, Fig. 5) could at the most be called only weakly parasitic on the *Ceramium.* Indeed, only after the alga had been maintained in the laboratory for several weeks did the fungus appear in appreciable quantity. While occasional thalli were formed in apparently living cells free from other organisms, they occurred more commonly in dead and somewhat desiccated algæ along with bacteria and Protozoa.

12. *Sirolpidium bryopsidis* (de Bruyne) Petersen. Parasitic in *Bryopsis plumosa,* Woods Hole, throughout the summer, 1934; June–July, 1935; *Cladophora sp.* (saprophytic?), Woods Hole, July 1, 1935.

EXPLANATION OF PLATE III

FIG. 1. Plant of *Bryopsis plumosa* infected with *Sirolpidium bryopsidis.* The blackened areas caused by the fungus may be seen particularly well along the axes of the lateral branches. About natural size.

FIG. 2. *Ectrogella perforans,* parasitic in *Licmophora abbreviata.* A stand of the diatoms heavily infected with the fungus. Infected cells may be distinguished by the light, spherical sporangia of the *Ectrogella* within them. × 260.

PLATE III

As in the preceding case, the Woods Hole material of this fungus showed no morphological differences from that found in Danish waters (Sparrow, 1934) and this phase of the organism will not be dealt with again here. It might be noted, however, that the zoöspore effects penetration of the host cell exactly as in (?)*Olpidium sphacellarum*.

Macroscopically, heavily infected plants may be recognized by the presence of blackened areas along the fronds (Plate III, Fig. 1). The general aspect of the fungus in the alga is shown in the photomicrograph (Plate I, Fig. 4). While early in the course of the infection the fungus undoubtedly acted alone in the entering and the breaking down of the algal contents, in later stages it was often accompanied by swarms of bacteria and Protozoa. Mention has been made already (p. 238) of the peculiar Protomyxa-like animal which often competed with the fungus. Indeed, in some cases this association was so constant that had this animal not been entirely absent in the Danish material, it might easily have been supposed to be a phase in the life history of the *Sirolpidium*.

Since this fungus, by reason of the somewhat filamentous nature of its thallus, seemed the most suitable of these marine fungi for the purpose, attempts of a very preliminary nature were made to culture it. It had been previously noted that if infected *Bryopsis* plants were put in close contact with air, such as allowing water to drip over them rather than to submerge them entirely, the fungus underwent a remarkable transformation in body structure. Instead of the formation of typical olpidioid thalli (Plate I, Fig. 4), there were formed definitely filamentous, ramifying hyphæ (Plate I, Fig. 7). The resemblance of these to the hyphæ of the higher Phycomycetes was very striking.

Pieces of *Bryopsis* containing such hyphæ were placed in various nutrient solutions to determine whether or not further vegetative growth could be induced. Dextrose, mannose, galactose, and fructose were used in Seitz-filtered sea-water solutions of 0.5 per cent and 1.0 per cent and maintained at 19–20° C. Certain protein solutions were tried but fouled too rapidly from bacterial action to be of use. The amount of extramatrical growth was used as a criterion for the efficacy of the particular solution. Suitable controls in Seitz-filtered sea water alone were also set up. Since it was soon found that only the dextrose had a pronounced effect on growth, further solutions of this sugar were made up to determine its most favorable concentration. The results of these preliminary trials are given in Table I.

From these data it can be seen that the lower concentrations of sugar were most effective in stimulating extramatrical growth, whereas the higher concentrations, while they were not lethal to the fungus, seemed

to have been definitely inhibitory. Attempts were then made to culture *Sirolpidium* on a solid medium by placing bits of the alga containing extramatrical growth on 0.5 per cent and 1.0 per cent dextrose solutions to which had been added either 0.5 per cent or 1.0 per cent agar. Further growth could not be induced. Studies on the cultivation of *Sirolpidium* are being continued with the hope that from the data obtained from this particularly favorable fungus a method can be devised for getting a number of these organisms into culture. If this can be accomplished, then specific information can be obtained regarding the nature of the activities carried on by these marine fungi.

TABLE I

Extramatrical growth of Sirolpidium in dextrose solutions at 19–20° C.

Solution per cent	Effect on growth			
	24 hours	48 hours	56 hours	80 hours
0.0 (control)	Practically none.	No change.	No change.	No change.
0.5	Excellent growth, up to 100 μ.	Up to 197.5 μ.	No change.	No change; mycelium fragmenting.
1.0	Good growth; up to 62–87 μ.	Up to 112 μ.	No change.	No change; mycelium fragmenting.
1.5	Very little; up to 20–30 μ.	Up to 100–137 μ.	Up to 140 μ.	Up to 175 μ.
2.0	None.	None.	Up to 20 μ.	No change.

13. *Chytridium polysiphoniæ* Cohn. Parasitic on *Polysiphonia fibrillosa,* Woods Hole, August 27, 1934; saprophytic on *Ceramium rubrum,* Woods Hole, August 24, 1934.

Details of the morphology and reproduction of this species are given in a previous paper (1934) by the writer. On *Polysiphonia* (Text Fig. 31), the Woods Hole fungus was an undoubted parasite, whereas it was only saprophytic on *Ceramium,* as was indicated by the whitened and disorganized contents of the alga. Bacteria and Protozoa were abundant in cells of the latter alga, but were absent in infected cells of the *Polysiphonia.*

14. *Chytridium megastomum* Sparrow. Parasitic on *Ceramium diaphanum,* Woods Hole, August 24, 1934.

No morphological differences from the Danish fungus (Sparrow, 1934) could be observed in this material. The sporangia occurred in great numbers on all parts of the alga; bacteria and Protozoa were, how-

ever, absent. An interesting feature of the parasitism of this fungus was the fact that the *Ceramium* appeared at the time of observation unaffected by the presence of the *Chytridium*. It seems probable, however, that even though the fungus itself did not exert a marked effect on its host, the innumerable punctures in the cell wall of the alga laid it open to entrance and attack by bacteria, and later, Protozoa. Such a sequence did occur when infected plants were maintained in a laboratory aquarium, but this does not necessarily indicate that such also takes place under natural conditions.

15. *Pleolpidium* (*Rozella*) *marinum* n. sp. Parasitic on *Chytridium polysiphoniæ*, Woods Hole, August 27, 1934.

In material of *Chytridium polysiphoniæ* parasitic on *Polysiphonia fibrillosa*, occasional sporangia were observed which were of larger diameter (30–45 μ) and possessed a thicker wall and more oleaginous contents than others. In several instances these were seen to discharge motile bodies through 1–3 pores (Text Fig. 33). The spores were minute, 3 μ long by 2 μ in diameter, ellipsoid, posteriorly uniciliate, and in contrast to those of *C. polysiphoniæ*, lacked a refractive oil droplet in their content. After a period of swarming, certain ones settled down on the surface of the sporangia of *C. polysiphoniæ* and were observed to produce a fine penetration tube (Text Fig. 32). Further development was not witnessed.

While this fungus might at first sight be considered a multiporous species of *Rhizophidium*, it is in reality a parasite of the *Chytridium*, closely allied to certain fresh-water species usually placed in the genus *Pleolpidium*. Reasons for referring all these species to Cornu's genus *Rozella* have been stated in a previous paper (Sparrow, 1936). Since no marine representatives of this genus have heretofore been described, the fungus is considered a new species, and is termed *Pleolpidium* (*Rozella*) *marinum* n. sp.

Pleolpidium marinum n. sp. Sporangium spherical, completely filling that of the enlarged host plant; 30–45 μ in diameter, at maturity forming 1–3 pores through which the zoöspores are discharged; zoöspores ellipsoidal, 3 μ long by 2 μ in diameter, posteriorly uniciliate, aguttulate. Resting spores not observed.

Parasitic on *Chytridium polysiphoniæ*.

P. marinum sp. nov. Zoösporangium globosum, cellulam matricis distentam omnino implens, 30–45 μ dia., maturitate 1–3 ostiolatis præditum per quæ zoösporæ emittuntur; zoösporæ ellipsoideæ, 3 μ long. v. 2 μ dia., posteriore uniciliatæ, aguttulatæ. Sporæ perdurante non observatæ.

16. *Rhizophidium discinctum* Petersen.   Parasitic(?) on *Ceramium diaphanum*, Woods Hole, August 17, 1934.

A fungus probably identical with that found by Petersen (1905) on *Spongomorpha* and *Acrosiphonia* in Scandinavia was found attacking the nodal cells of the *Ceramium* which had been maintained in a laboratory aquarium for a week.   It is probable that the fungus was only weakly, if at all, parasitic on the alga.
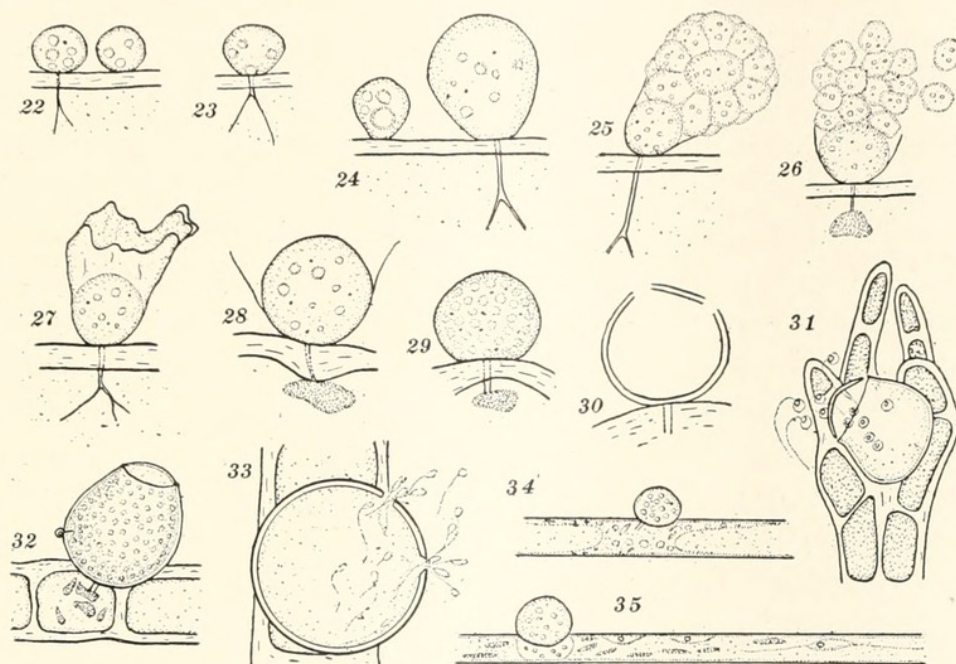
TEXT FIGS. 22-35.   Figs. 22-28, *Thraustochytrium proliferum,* on *Bryopsis plumosa,* all × 760.   Figs. 22-24, various stages in the development of the sporangium; Fig. 25, mature sporangium showing basal body which will become the fundament of the secondary sporangium; Fig. 26, discharge of the zoöspores after the bursting and deliquescence of the upper part of the sporangial membrane; Fig. 27, discharged primary sporangium with secondary sporangium beginning to enlarge; Fig. 28, more mature secondary sporangium.   Figs. 29-30, *Rhizophidium discinctum* on *Ceramium diaphanum;* Fig. 29, sub-spherical immature sporangium, × 376; Fig. 30, empty sporangium showing angular aspect and thick wall, × 376. Figs. 31-32, *Chytridium polysiphoniæ;* Fig. 31, discharging sporangium on *Polysiphonia,* × 376; Fig. 32, mature sporangium attacked by a zoöspore of *Pleolpidium* (Rozella) *marinum* × 376.   Fig. 33, *Pleolpidium marinum,* Fig. 33, discharging sporangium of the fungus in *Chytridium polysiphoniæ,* × 376.   Figs. 34-35, *Rhizophidium globosum*(?) on *Rhizosolenia sp.;* Fig. 34, sporangium with peg-like intramatrical tube, × 376; Fig. 35, sporangium apparently attached to nucleus of host, swarm spores of *Labyrinthula sp.* also attacking diatom, × 376.

The sporangia are at first spherical or hemispherical (Text Fig. 29), but at maturity, because of the formation of one or two laterally-placed discharge papillæ, become more angular.   In some cases the upper part of the sporangium may be very definitely flattened.   A further characteristic is the thickness of the sporangium wall, a feature very evident

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in discharged sporangia (Text Fig. 30). Because of the density of the host contents and especially because of the thickness of the algal wall, observations on the nature of the intramatrical system were difficult. So far as could be determined, this structure appeared to consist of a rather stout, unbranched tube. However, it is possible that it branched deeper in the host. Because of this uncertainty it is probably better to keep the fungus in the genus *Rhizophidium* than to transfer it to *Phlyctidium,* where, because of the unbranched rhizoid, it might be placed.

Martin's fungus (Martin, 1922), termed by him *Rhizophidium polysiphoniæ* (Cohn) Petersen, is probably referable to this species.

17. *Rhizophidium globosum* (Br.) Schröt.(?). Parasitic on *Bryopsis plumosa,* Woods Hole, August 8, 1934; saprophytic on *Rhizosolenia spp.,* Woods Hole, August 16, 1934.

The sporangia of the form on *Bryopsis* were spherical, 13–18 μ in diameter, and were attached to the host cell by a delicate, scarcely perceptible, branched, intramatrical rhizoidal system. In contrast to *Rhizophidium discinctum,* the even contour of the sporangium was maintained at maturity.

The fungus attacked only healthy cells of the *Bryopsis.* While the parasite at the time of observation did not appear to have any noticeable effect on the host, it undoubtedly paved the way for the more destructive activities of later invaders.

What may possibly be a closely related form was found in some abundance on cells of *Rhizosolenia spp.* dredged from the bottom of Great Harbor during a heavy "flowering period" of diatoms. The sporangia (Text Figs. 34, 35) were globose to sub-globose, 9–12 μ in diameter, and were generally found singly, attached to the mid-region of the diatom. A single, delicate rhizoid penetrated the alga and possibly attacked the nucleus. Discharge of the zoöspores was not observed and hence, the possibility that we are dealing with a species of *Chytridium* cannot be overlooked.

The fungus on *Rhizosolenium* was found only on obviously disintegrating diatoms, generally in company with a species of *Labyrinthula* (Text Fig. 35) and a *Protomyxa*-like animal. Flagellates were also frequently observed in such cells. No bacteria could be demonstrated in diatoms having both fungus and *Labyrinthula,* or fungus alone, in them.

Both of these fungi are only tentatively referred to the morphologically similar species inhabiting fresh-water algæ.

18. *Thraustochytrium proliferum* n. gen. n. sp.   Saprophytic on *Bryop-sis plumosa,* July 30, 1934; *Ceramium diaphanum,* August 17, 1934; Woods Hole, Mass.

Thraustochytrium n. gen.   Spore upon coming to rest on the host cell encysting and producing an intramatrical rhizoidal system; body of the spore enlarging and becoming the sporangium; spores formed within the sporangium, liberated by the bursting and dissolution of the whole distal portion of the sporangial wall; spores non-ciliate when liberated; new sporangia formed by a process of internal proliferation.   Resting spores not observed.

Thraustochytrium gen. nov.   Spora cellulæ matricis insidens, en-cystans ac systema intramatricale rhizoideum proferens; corpus sporæ se maius faciens atque sporangium exsistens; sporæ intra sporangium factæ et eruptione dissolutioneque totius partis distalis parietis sporangi-alis liberatæ; sporæ non ciliatæ quo tempore liberatæ; nova sporangia ratione proliferationis internæ formatæ.   Sporæ perdurantes non ob-servatæ.

T. proliferum n. sp.   Sporangia smooth, piriform, very thin-walled, resting on the narrow base; 15.6–18 μ high by 10–13 μ in diameter; rhizoid branched or unbranched, of limited extent; zoöspores somewhat angular at discharge, later becoming spherical, 4 μ in diameter.

T. proliferum [3] sp. nov.   Sporangia piriformia, angustæ basi in-sidentia, levia, pariete tenuissimo, 15.6–18 μ longa, 10–13 μ dia., rhi-zoidea ramosa aut non ramosa extensionis parvæ; zoösporæ angulosiores quo tempore emissæ, serius sphæroideiores exsistentes, 4 μ dia.

The developmental features of this interesting fungus (Text Figs. 22–24) (Plate I, Fig. 2) are in the main similar to those of *Chytridium* and *Rhizophidium*.   However, in the *Thraustotheca*-like discharge of the zoöspores and in the proliferation of the sporangium it possesses two very distinctive characteristics.   A further peculiarity is its method of internal proliferation.   After the cleavage of the zoöspores there can generally be seen a larger protoplasmic unit occupying the narrow, basal portion of the sporangium (Text Fig. 25).   Upon the bursting and deliquescence of the upper part of the sporangial wall by the enlarging zoöspores (Text Fig. 26), these bodies float away leaving only the basal protoplasm (Text Fig. 27).   This enlarges (Text Fig. 28) and in time becomes a sporangium.   Thus, in contrast to the proliferating sporangia of *Saprolegnia, Pythiomorpha,* etc., the fundament of the secondary sporangium of *Thraustochytrium* is delimited at the time of zoöspore cleavage in the primary body.

There can be no question of the non-ciliate character of the zoöspores at the time of discharge.   However, in mounts containing the fungus occasional posteriorly uniciliate zoöspores have been observed which are

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[3] I am indebted to Prof. R. C. Nemiah for the Latin diagnoses of new genera and species given in this paper.

of the same size as those discharged from the sporangia. Since no other chytridiaceous fungi were found on that particular material of *Bryopsis*, it is entirely possible that after a period of relative quiescence, the spores became ciliate.

Thraustochytrium differs from its closest relative *Rhizophidium*, in the internal proliferation of its sporangia, in its method of zoöspore discharge, and possibly in the possession of non-ciliate spores.

The fungus was found only on very disintegrated plants of *Bryopsis*, where it sometimes occurred with *Sirolpidium*, swarms of bacteria, and Protozoa.

DISCUSSION

If we turn to a broader consideration of the organisms discussed in this paper, certain points of more general interest are apparent.

Perhaps the foremost of these is the fact that fungi are unquestionably demonstrated to be present in our marine waters. Although their occurrence has been recorded almost wholly from the vicinity of Woods Hole, it is highly probable that they will be found generally distributed in the littoral regions of the United States. While the number of species is as yet small, this does not necessarily imply that they are actually rare, either in kind or number. One need only to compare the bibliographies of fresh-water and marine fungi to appreciate the small amount of investigation that has thus far been accorded the latter group. Undoubtedly, more intensive work will reveal many hitherto unrecorded species.

These preliminary investigations would seem to indicate that the fungous flora in the vicinity of Woods Hole does not differ materially from that found on the other side of the Atlantic. Seven of the 13 fungi collected by the writer in the littoral of the Kattegat have been found at Woods Hole. Further indications of a probably widespread distribution of marine fungi are to be found in *Sirolpidium*, now known from the Gulf of Naples, the Kattegat (Denmark), and Woods Hole, in *Petersenia Andréei*, known from King Charles Land (Arctic), Greenland, Denmark, the Adriatic, and Woods Hole, and in *Eurychasmidium*, known from the North Sea near Edinburgh, the Baltic, and Woods Hole. It is also probable that a fungus from the Adriatic termed *Ectrogella Licmophoræ* by Scherffel (1925) is referable to *E. perforans* Pet., in which case that parasite would now be known from the Adriatic, the Baltic, and the vicinity of Woods Hole. The species of *Labyrinthula* reported by Renn (1934) as being associated with the wasting disease of *Zostera* has been observed by the present writer in diseased material of this plant from the Kattegat (1933), from Woods Hole (1934), and

from Plymouth Harbor, England (1935). The organisms from these localities were morphologically indistinguishable. Future work will undoubtedly further corroborate this marked similarity of the floras which is even now so apparent.

Another point of interest is the abundance in the sea of so-called chytridiaceous fungi which possess biciliate zoöspores. While those inhabiting fresh-water algæ are, in the main, uniciliate species (true chytrids), in marine algæ, biciliate forms are more frequently found. From experience in investigating both types of habitat, the writer is inclined to believe that this is a real difference and not an apparent one resulting from the disproportionate amount of work thus far done in the two groups.

As to the question of the abundance of any one species and of the extent to which by its parasitic activities it actually limits the occurrence of a " producer," very little is now known. Of the marine fungi observed by the writer, *Ectrogella perforans* produces the most extensive infection. Indeed, a closer examination of this disease might reveal that, in some instances, it is responsible for the partial or complete disappearance of the diatom from a locality. While it is true that the two diatoms most susceptible to this fungus are littoral types (*Licmophora abbreviata, Striatella unipunctata*), it is not known whether similar epidemics may be produced by *Ectrogella* among pelagic species. In this connection, certain of the peculiar rhythms of " flowering periods " of pelagic diatoms which have been noted in the past and which cannot be attributed to changing physical factors might well be considered from the standpoint of the presence of parasites. Due to the importance of diatoms in their rôle of " producers " in the sea, such a disease as that caused by the *Ectrogella* should be examined in all its aspects, even though at the moment it appears to be confined to littoral algæ. Further, it would be well in the future to give closer attention to the examination of plankton samples for evidences of parasitic organisms, especially during the decline of a " flowering period."

In the formation of " marine humus," as Waksman (1933) has so aptly termed certain types of bottom deposits, future work may show that fungi as well as bacteria play a significant part. It will be recalled that in bottom samples taken in Great Harbor, Woods Hole, during a heavy flowering period of diatoms, two types of fungi were found in some abundance on *Rhizosolenia spp.* (*Labyrinthula* and *Rhizophidium*). Both of these " reducers " were attacking diatoms in all stages of decomposition and many of the algæ must, from their well-organized contents, have either recently fallen to the bottom or had been infected while still alive. Efforts were made to determine whether or not infected

diatoms could be observed in samples from surface tows. While such indeed were found, from the nature of the waters in the vicinity of Woods Hole, subject as they are to strong tidal forces, these cannot be taken as proof of infection under pelagic conditions. It is just as possible that they were swept from the bottom as a result of tidal action. Work on the frequency of occurrence of these bottom fungi will be necessary before any estimate can be made of the extent to which they contribute to the general cycle of decomposition in the " humus."

In considering these fungi from the standpoint of their parasitism, we find a wide variation among them. Certain ones (*Ectrogella perforans, Eurychasmidium tumefaciens, Petersenia sp.* in rotifer eggs, (?)*Olpidium sphacellarum, Pleolpidium marinum, Chytridium megastomum* and *Rhizophidium* (?)*globosum* on *Bryopsis*) were true parasites and attacked, unassisted by other organisms, healthy host plants. None of these was ever observed living saprophytically. Other species (*Rhizophidium discinctum* and *Petersenia Andréei*) were only doubtfully parasitic, whereas, *Labyrinthula Chattoni*(?), *Thraustochytrium proliferum, Rhizophidium globosum*(?) on *Rhizosolenia,* and *Petersenia sp.* on *Ceramium* were saprophytes and were found only on dead algal cells. Until it can be shown experimentally that the *Labyrinthula* on decaying diatoms is the same as that parasitic on *Zostera,* it seems better to regard the two as distinct species. *Sirolpidium bryopsidis* and *Chytridium polysiphoniæ* were facultative saprophytes. It might be interpolated here that, while *Pontisma lagenidioides* was observed to be only saprophytic in the vicinity of Woods Hole, in Denmark the fungus was found to be parasitic as well, and hence it should be classed with *Sirolpidium* and *Chytridium polysiphoniæ* as a facultative saprophyte.

It is a pleasure to acknowledge at this time the continued interest of Dr. S. A. Waksman in the progress of these investigations. The writer is also indebted to members of the Botanical Staff of the Marine Biological Laboratory, particularly to Dr. H. Croasdale, for bringing in material of certain algæ.

Summary

In the foregoing paper are described fifteen species of phycomycetous marine fungi, two myxomycetes, and a *Protomyxa*-like protozoan, all collected in the vicinity of Woods Hole, Mass. Included in these are two new genera and two new species. With one exception, the fungi were either parasites, facultative saprophytes, or saprophytes on various species of marine algæ. One was found parasitizing the eggs of a microscopic animal, probably a rotifer. The results of preliminary at-

tempts to culture *Sirolpidium bryopsidis,* a facultative saprophyte of the green alga, *Bryopsis plumosa,* are reported. None of these fungi, with perhaps the exception of *Rhizophidium discinctum,* has heretofore been known from the United States. The existence of true marine fungi, their work as one of the several types of " reducers " in the sea, and their possible importance in the formation of marine humus are discussed in particular.

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