

NEW ZOOPAGACEAE DESTRUCTIVE TO SOIL RHIZOPODS

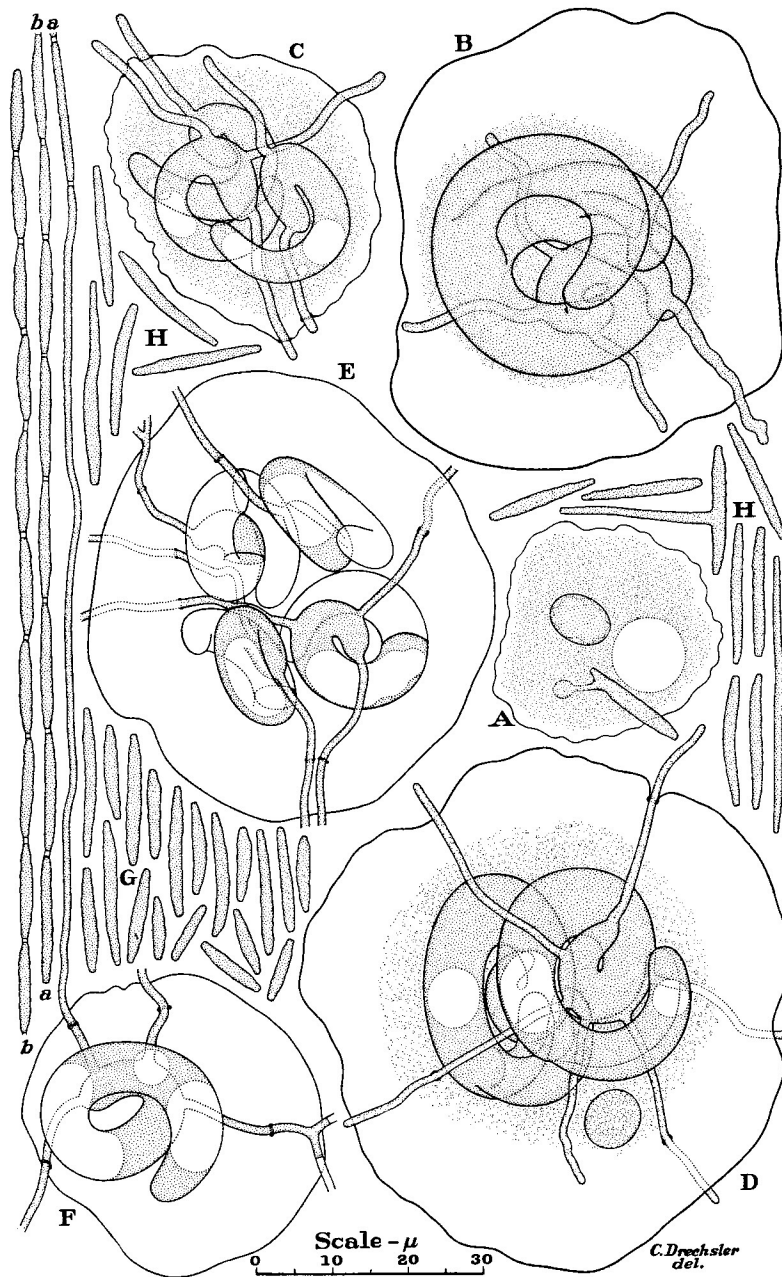
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(WITH 6 FIGURES)

Three species of *Cochlonema* and one species of *Zoopage* are newly described herein, increasing the recorded membership of the Zoopagaceae from 22 to 26. Observations on sexual reproduction in two of the new species of *Cochlonema* now remedy in some degree the inadequacy of detail in the knowledge hitherto available on zygospore formation in that genus. Biological interest attaches perhaps more especially to the other two forms, inasmuch as they subsist on testaceous rhizopods, rather than on *Amoebae* or nematodes, which between themselves provide the source of nourishment for all organisms previously assigned to the family.

COCHLONEMA ODONTOSPERMA

A fungus conspicuous among conidial Phycomycetes for the distinctive sculpturing of its zygosporangia was observed in more than a dozen old maize meal agar plate cultures. All of the cultures in question had been used in the isolation of species of *Pythium* from diseased portions of seed plants, some having been started with decaying parts of water-lily (*Nymphaea odorata* Ait.) leaves collected near Butternut, Wis., late in July 1935, and others with decaying pieces of stems and roots cut from tomato (*Lycopersicon esculentum* Mill.) plants found wilting in the greenhouse early in December 1935. To each of the cultures had been added, besides, pinches of leaf mold taken from supplies of this material collected during July 1935, partly in deciduous woods near Cumberland, Md., and partly in coniferous woods near Butternut, Wis. As the fungus, wherever observed in its earlier development, always began spreading over the substratum from a deposit of leaf mold, its presence in the cultures must have been attributable to

FIG. 1. *Cochlonema odontosperma*.

the forest refuse rather than to the pieces of freshly decaying herbaceous tissue. Whenever encountered it subsisted exclusively as a parasite on what appeared to be a single species of *Amoeba* that, in an approximately rounded shape, measured mostly from 30 to 60 μ in diameter. Although the finely granular protoplasm of the newly infected animals was not unfavorable for microscopic examination, a body of dimensions and structure to encourage interpretation as a nucleus could not usually be made out as clearly as might be desired. An ellipsoidal inclusion discerned in some invaded specimens and revealing a darkish peripheral layer with lumpy thickenings protruding inward (FIG. 1, *A*), appeared the most persuasive among the likely structures that came under observation. Possibly the same structure in a pathological condition may have been represented in a body of comparable size, showing a layer of separate peripheral granules suggestive of chromatin particles, that was seen in some nearly depleted animals (FIG. 1, *D*). With either type of peripheral organization, interpretation was embarrassed by the presence frequently of digestive vacuoles somewhat similar in dimensions, in shape and occasionally even in arrangement of contents; so that for the time being the specific identity of the susceptible animal remains, unfortunately, very uncertain.

Infection of the *Amoeba* is initiated when an adhering conidium thrusts a germ tube through the pellicle and a short distance into the protoplasmic interior. At the tip of the germ tube a globose swelling then puts into appearance (FIG. 1, *A*) and increases in size with the transfer to it of the conidial contents. Completion of the transfer is followed by disarticulation of the globose body, which immediately begins autonomous development, while the empty envelope of conidium and germ tube is promptly expelled. Invasion thus follows the course set forth with more attention to detail in my description of *Endocochlus asteroides* (1) and *E. gigas* (2). Just as in the two species mentioned, the vegetative body here develops as a thick filament, which, whether simple or dichotomously branched, is coiled in a handsome cochleate spiral of one to two turns. Because in this species an empty conidial membrane has never been seen attached to a convolved thallus, separation from the two congeneric forms I described earlier (1)

as *Cochlonema verrucosum* and *C. dolichosporum*, which regularly show such attachment, entails no difficulty.

That the fungus is, indeed, a third member of the genus *Cochlonema*, is plainly revealed in its asexual reproduction. The conidiiferous hyphae are proliferated radially from the outer contour of the spiral body, the one first produced arising close to or often directly from the place of original attachment, and additional ones arising at intervals mostly of 3 to 10 μ in positions successively closer to the growing extremity (FIG. 1, B-F). Naturally the number of such hyphae is variable: a poorly developed thallus that has shared the nourishment available in a small animal with several fellows may produce only a single conidiiferous filament (FIG. 1, E), whereas five (FIG. 1, B), six (FIG. 1, D) or even more may originate from relatively massive vegetative bodies. If the host dies submerged in the substratum, the filaments make their way to the surface, where differentiation somewhat gradually becomes evident in slightly increased width, in regularly spaced constrictions, and in perceptible verrucose sculpturing. The conidia resulting from evacuation of the constrictions and delimitation of the separated protoplasts by end walls, are thus distinguished by minutely warty contours (FIG. 1, F, G, H). Such sculpturing may be virtually absent, however, in the small admixture of longer and narrower spores resulting from segmentation of the little differentiated proximal portions of the aerial prolongations. Since branching occurs, though, of course, not profusely, in the sporogenous portions of the filaments as well as in the sterile submerged portions (FIG. 1, F), branched conidia are occasionally to be found (FIG. 1, H).

Sexual reproduction takes place in some quantity usually during the later stages of an epizoötic, when conidia are strewn about in such abundance that plural infections frequently occur with the result that many individual animals come to harbor two or more thalli of the consistently dioecious parasite. In position of origin the zygophoric hyphae are similar to the conidiiferous filaments, which, moreover, in their proximal portions they exceed little in width. After attaining some length, and especially on passing through the pellicle of the host, they usually widen markedly; further elongation with some bending thereupon bringing about

apical union in pairs, followed soon by fusion (FIG. 2, C, a). Some zygothoric hyphae, to be sure, fail to find an unengaged mate (FIG. 2, A, e, f, g; C, e), and then may continue to grow a little, often with the bizarre erraticness elsewhere familiar in instances of such frustration. Now and again three sexual hyphae, with a fine disregard of propriety, come together in a triple union (FIG. 2, A, d). In any case, conjugation is followed by the budding forth of a globose excrescence from one of the hyphae, generally at some distance from the union (FIG. 2, A, a-d). This excrescence, the young zygosporangium, remains smooth until about fully grown, when 20 to 35 warty prominences appear on the spherical surface (FIG. 2, B, a-d), soon to become modified individually like the crown of a grinding tooth with two, three or four recognizable cusps (FIG. 2, C, b-d). The decided increase in thickness of wall that takes place during maturation (FIG. 2, D, a-d; E, a-f) is no doubt to be attributed to the deposition of a zygosporangium wall proper, which, at least under the difficult optical conditions brought about by the pronounced sculpturing, appears indistinguishably fused with the zygosporangial envelope.

An epithet composed of two words meaning "tooth" and "seed" respectively, would seem appropriate for the fungus.

***Cochlonema odontosperma* sp. nov.**

Hyphae alitae 4-10 μ crassae, simplices vel semel vel bis dichotomae, semel vel bis spiraliter convolutae. Conidia cylindracea, utrimque attenuata, rarius paulo ramosa, plerumque minute verrucosa, 8-36 μ longa, 1.2-2.0 μ crassa, in catenulas saepe 10-30-sporas digesta. Hyphae zygosporiferae 20-45 μ longae, basi 1-1.5 μ crassae, sursum 3-4 μ crassae, utraque ex alia hypha alita enata. Zygosporangia sphaeroidea, 8-10 μ diam., membrana 20-35 dentibus columellaribus, minute bicornibus vel tricuspibus vel minute quadrifidis, 1-1.5 μ altis et latis ornata. Zygosporae paulo flavidae, membrana circa 1-1.2 μ crassa cum membrana zygosporangii verisimiliter concreta, quacum conjunctim loculum 6-7 μ diam. circumdat.

Amoebas 30-60 μ latas enecans et consumens, habitat in humo silvarum prope Cumberland, Maryland, et Butternut, Wisconsin.

Vegetative hyphae 4 to 10 μ in diameter, frequently simple or once bifurcate, but only rarely twice bifurcate, coiled beautifully in a spiral of 1 to 2 turns. Conidia cylindrical, tapering at both ends, rarely branched, mostly minutely warted, 8 to 36 μ , mostly 10 to 20 μ (average 16 μ) long, and 1.2 to 2 μ (average 1.6 μ)

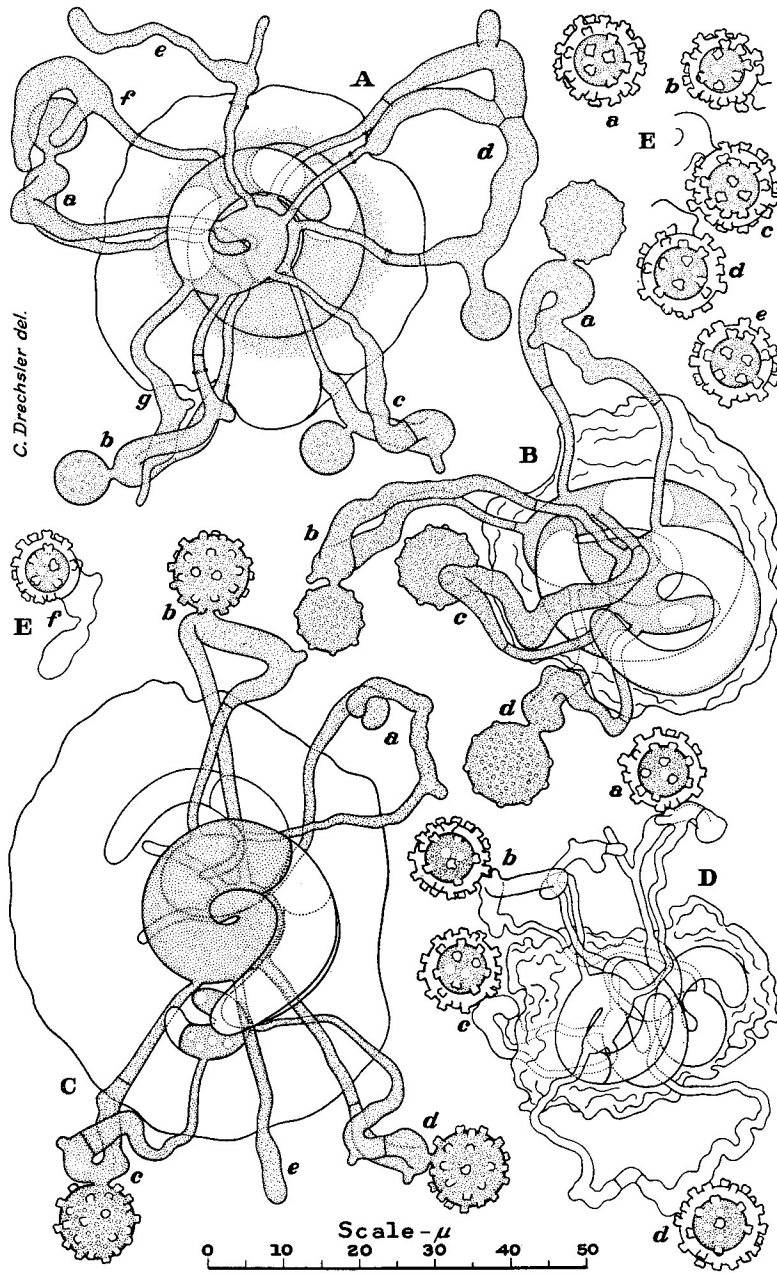


FIG. 2. *Cochlonema odontosperma*.

wide, formed in chains in numbers varying mostly from 10 to 30. Zygophoric hyphae 20 to 45 μ long, 1 to 1.5 μ wide at the base and 3 to 4 μ toward the distal end, each of a conjugating pair arising from a separate assimilative hypha. Zygosporangium subspherical, 8 to 10 μ in diameter, its membrane ornamented with 20 to 35 columnar toothlike protuberances, mostly 1 to 1.5 μ in height and in width, and bearing 2, 3 or 4 minute cusps. Zygo-spores somewhat yellowish, having a proper wall perhaps about 1 to 1.2 μ in thickness, that appears indistinguishably adnate to the zygosporangial membrane, together with which it surrounds a locule 6-7 μ in diameter.

Occurring in leaf mold, infecting and consuming *Amoebae* 30 to 60 μ in diameter, near Cumberland, Md., and Butternut, Wis.

COCHLONEMA MEGASPIREMA

Of the three species of *Endocochlus* hitherto described, *E. gigas* is easily the most impressive, surpassing its two known congeners in the bulk and elaborately helicoid convolution of its thallus, as well as in the abundance of sexual and asexual reproductive apparatus produced therefrom. This luxuriance, as was pointed out in the original description, is made possible by the size and substantial composition of the host animal, *Amoeba terricola* Greef (*sensu strictiore*), a rhizopod, which, if not strictly of rare occurrence in old agar plate cultures, certainly does not seem to develop there in considerable numbers as frequently as might be expected from its reputedly general distribution in the soil. The animal, easily identified by the characteristic structure of its large nucleus (FIG. 3 A, n) was observed in quantity in some plate cultures as one of the numerous organisms superimposed on *Pythium* mycelia that had promptly grown out from decaying pieces of leaves of the white water lily collected near Butternut, Wis., late in July 1935. To a number of cultures thus infested were added some pinches of partly decayed tomato leaves picked up from the ground in a greenhouse near Beltsville, Md. In these cultures, two weeks later, the entire population of the rhizopod, consisting perhaps of a hundred individuals, was being exterminated by an endoparasite of most extraordinary appearance.

Development of the parasite begins, as could be determined from observations on a few favorable incipient infections, much like

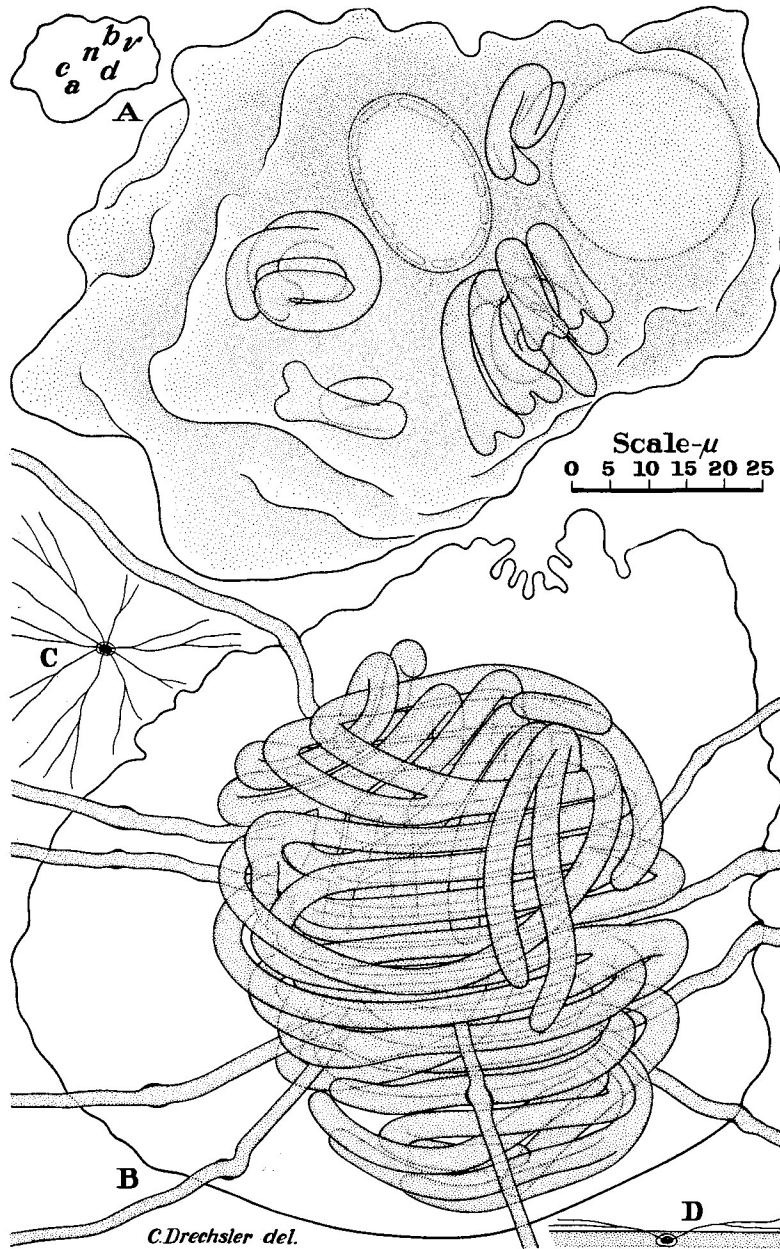


FIG. 3. *Cochlonema megaspirema*.

development of *Endocochlus asteroides*, *E. brachysporus* Drechsl., *E. gigas* and *Cochlonema odontosperma*: a germ tube, thrust into the animal by an adhering conidium, giving rise to an apical globose body, which, after receiving all the conidial contents, becomes detached to proceed with autonomous growth. On attaining a length of approximately $10\ \mu$ the young thallus, like the thalli of other endoparasitic members of the Zoöpagaceae, curves abruptly to commence the spiral windings that thereafter are continued until the protoplasmic materials of the host are finally exhausted. However, while in the other endoparasitic forms a marked widening of the thallus is evident at the first turn if not before, in the present species the filament maintains an approximately constant width little greater than that of the newly disarticulated globular body. The much greater length of filament thus made necessary contributes to more frequent branching and to far more elaborate coiling; so that vegetative bodies with one to two bifurcations and as many turns (FIG. 3, *A*, *a*, *b*, *c*) represent very early stages of development, and even a thallus with two successive turns and three successive dichotomies (FIG. 3, *A*, *d*) may be still relatively immature. When a single thallus has completed appropriation of the contents of a large animal (FIG. 3, *B*), it appears as an intricate mycelial coil too thick to be seen through, though the elements exposed to view in the upper aspect and at the periphery indicate sufficiently that the number of successive dichotomies certainly can not be less than four or five. Of course, much less impressive development results when a number of thalli share the contents of a relatively small host animal (FIG. 4, *A*).

Asexual reproduction always takes place in quantity, beginning as soon as the host animal has been brought to a stop, usually at some depth in the agar substratum. Even while the last protoplasmic remnants of the *Amoeba* are being appropriated, a number of filaments are put forth from the coiled thallus. These perforate the substantial pellicle of the host after the manner of an appressorium, and then continue to elongate toward the surface of the substratum, their contours becoming in increasing measure irregularly and minutely warty (FIG. 4, *B*, *a-c*). After emergence into the air, elongation is continued in a nearly horizontal direction (FIG. 4, *B*, *c-d*) until a length usually of several milli-

meters has been reached (FIG. 3, C, D). Sporulation thereupon takes place as in other catenulate members of the family, that is, through the withdrawal of contents from the short, slightly constricted isthmi perceptible at rather regular intervals in the aerial prolongations (FIG. 4, B, e-g), followed by the laying down of septa at both ends of the protoplasts thus separated (FIG. 4, B, d-k). Frequently a proximal part of an aerial prolongation is not immediately converted into conidia, instead growing out anew from below the lowermost conidium to give rise to a filament that in due course similarly yields a chain of spores. Repetition of the same process several times in each of the hyphal outgrowths coming from the thallus, in the end brings about a somewhat arachnoid display of catenated conidia with a total bulk seemingly far in excess of what might be expected from the volume of the underlying vegetative coil, even though this volume is in many instances obviously very considerable.

In general appearance the conidia (FIG. 4, C, a-q) bear most resemblance to those of *Zoopage phanera* Drechsl., though usually they are somewhat shorter and noticeably more coarsely sculptured. Their slightly tapering and bluntly rounded or truncate ends recall *Z. nematospora* Drechsl., and, as in the latter species, the little constricted empty connections between the members of a chain reveal the mode of sporulation with satisfying clearness.

Sexual reproduction took place in only one of the cultures, and there only very sparingly. The process shows similarity to that set forth in my description of *Bdellospora helicoides*, the distally widened zygothoric hyphae, of which each in a pair arises from a separate thallus, becoming interinvolved in a few helicoid turns. One of the conjugating hyphae is usually somewhat in advance of its mate, and thus alone provides the forefront of the interinvolved helices from which the zygosporangium buds forth as a sessile globose excrescence (FIG. 4, D, a-d). The fully grown zygosporangium, like the homologous structure of *B. helicoides* is ornamented with warty protuberances. In spite of diligent search it was not possible to find mature sexual apparatus whose connection with the fungus under consideration was attested by positional relationship to a pellicle recognizable as pertaining to *Amoeba terricola*. A single cluster of mature zygospores encountered after

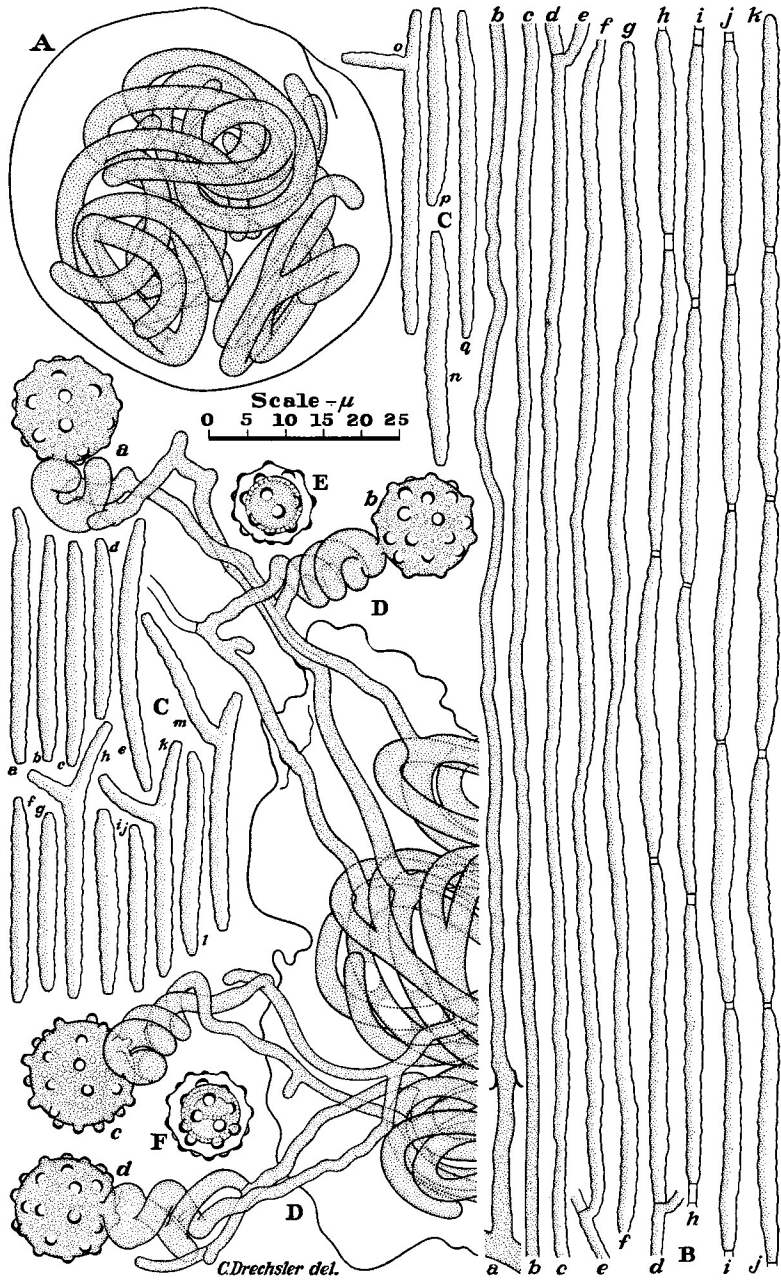


FIG. 4. *Cochlonema megaspirema*.

the disappearance of the pellicle had made their identification uncertain, probably belonged to the parasite even though their dimensions were somewhat smaller than might have been expected. They showed a thick zygospore wall, which, fused indistinguishably with the warty zygosporangial envelope, inclosed a locule containing a parietal layer of coarse granules and a large central reserve globule (FIG. 4, E, F).

While I was a student in the Cryptogamic Laboratories of Harvard University 20 years ago, the late Professor Thaxter took occasion to show me under his microscope a very well developed thallus either of the present fungus or of a fungus exceedingly similar to it. In reply to an inquiry as to the nature of so amazing a structure he remarked that "Its name is enigma." The meager information I retained of the incident, on which, nevertheless, Dr. W. H. Weston and Dr. D. H. Linder acted with much kindness, proved insufficient to locate the preparation in the collections left at Harvard by the distinguished mycologist. It seems probable that the specimen shown me in 1916 appeared adventitiously in a mount of some other fungus, perhaps when the living material had already been discarded, giving no opportunity for relating the curious thallus to a spore form, or even for identifying the substantial enveloping membrane as the pellicle of a parasitized terricolous *Amoeba*. As Thaxter demonstrably used an unpublished term "Aenigma" in a sense quite alien to any possible application suggested in the oral remark quoted above, a name made up from two words meaning "large" and "coil" respectively, is proposed for the fungus.

***Cochlonema megaspirema* sp. nov.**

Hyphae alitae 2.5-4.5 diam., saepe, praecipue ubicumque solitariae in animalibus magnis luxuriantes, longae, quater vel quinquies repete dichotomae, in spiram miram circumplicantes. Conidia verrucosa, anguste cylindracea vel filiformia, interdum ramosa, utrimque paulo attenuata, 20-45 μ longa, 1.6-3 μ crassa, in catenulas longas, simplices vel furcatas digesta. Hyphae zygosporiferae circa 50-80 μ longae, deorsum interdum aliquam ramosae et circa 2 μ crassae, sursum circa 4 μ crassae et binae inter se bis vel quater spiraliter circumplicantes. Zygosporangia 10-15 μ diam., flavida, 20-30 verrucis .8-1.5 μ altis 1.5-2 μ latis ornata.

Amoebam terricolam (sensu strictiore) enecans, habitat in foliis semi-sepultis putrescentibus *Lycopersici esculenti*, prope Beltsville, Maryland.

Vegetative hyphae 2.5 to 4.5 μ (average 3.6 μ) in width, often and more especially on developing singly in large animals, conspicuously long, repeatedly bifurcate 4 or 5 times and wound rather compactly in coils of numerous individual turns. Conidia distinctly warty, narrowly cylindrical or filiform or sometimes branched, slightly tapering toward the ends, 20 to 45 μ (average 31 μ) long and 1.6 to 3 μ (average 2.3 μ) wide, produced in numbers up to 50 or more in long, simple or branched chains, wherein they are separated from one another by evacuated portions of filament usually about 1.3 μ wide and .5 to 3 μ (mostly about 1 μ) long. Zygothoric hyphae often about 50 to 80 μ long, proximally sometimes branched and measuring about 2 μ in width, distally widening to about 4 μ and winding about one another in pairs 2 to 4 times, each of a pair originating from a separate thallus. Zygosporangium sessile on the conjugating filament providing the forefront of the spiral, 10 to 15 μ in diameter, nearly colorless or faintly yellowish, its wall ornamented with 20 to 30 warty protuberances .8 to 1.5 μ high and 1.5 to 2 μ wide.

Occurring as a destructive parasite of *Amoeba terricola* (in a more restricted sense) in partly buried decaying leaves of *Lycopersicon esculentum* near Beltsville, Md.

ZOOPAGE TRYSPHERA

A member of the Zoopagaceae subsisting on testaceous rhizopods appeared in several old maize meal agar plate cultures to which had been added a few pinches of leaf mold collected in deciduous woods near Butternut, Wis., late in July 1935. Mixed with other forms of microscopic life, *Geococcus vulgaris* Francé (4) had become rather uniformly, even if somewhat sparingly, distributed on the surface of the agar substratum. Marked concentration of these animals, often in conspicuous linear arrangement and always in restricted areas bordering on one or another of the deposits of leaf mold, revealed the extension of predacious mycelia from the decaying rubbish. As conidial apparatus of the *Fusarium*-like hyphomycete I described earlier (3) under the binomial *Dactylella passalopaga* was nowhere to be seen, a closer examination was made, which brought to light, instead, a delicate species of *Zoopage* much more commonplace in its predacious habit.

Capture was effected manifestly through mere adhesion of the animals on the narrow mycelial filaments (FIG. 5, A; B, a-f; C, a).

If, as may be presumed, yellow adhesive material similar to that produced by related fungi was operative here, its recognition was rendered difficult in the presence of a yellowish plug, often of considerable bulk, in the mouth of each captive, where it had been secreted apparently in an effort to resist invasion. In each instance, nevertheless, a very delicate branch from the axial hypha traversed the plug, and after growing a short distance into the interior of the animal, widened and branched dichotomously a number of times to give rise to a well differentiated haustorium through which the protoplasmic contents were gradually appropriated.

Asexual reproduction of the fungus (FIG. 5, *C, b; D, a-d*) was rather scanty owing probably in part to the meager supply of *Geococcus vulgaris* available in the cultures. In dry mounts the conidia (FIG. 5, *E*) could be seen to be covered with minute warts, which, however, for the most part became invisible in moist preparations. As in some other catenulate members of the family, the 2 or 3 proximal conidia in the better developed chains were usually longer, narrower, and less regularly sculptured than those borne in more distal positions.

Because of its relatively small dimensions and a generally frail appearance throughout, the species may be aptly described under a name meaning "delicate."

Zoophage tryphera sp. nov.

Mycelium ramosum, sparsum; hyphis hyalinis, .7-1.3 μ crassis; haustoriis pedicellatis, pedicello 2-7 μ longo, .5-.7 μ crasso, saepe sursum incrassato, aliquot ramulos repetitive dichotomos .8-2.5 μ crassos sursum attenuatos ferente. Conidia minute verrucosa, elongato-fusoidea, 6-22 μ longa, 1.2-2.2 μ crassa, in catenulis plus minusve erectis ex apice sterigmatum brevium sed saepe ramosorum oriunda, in quaque catenula saepius quina usque quina dena. Zygosporae ignotae.

Geococcum vulgarem capiens et consumens, habitat in humo silvarum prope Butternut, Wisconsin.

Mycelium branched, sparse; hyphae hyaline, .7 to 1.3 μ wide; haustoria pedicellate, the pedicel mostly 2 to 7 μ long and .5 to .7 μ wide, often broadening markedly before bifurcating into branches up to 2.5 μ wide, which in turn bifurcate once, twice or three times, usually with progressive attenuation of the elements successively formed to a width of .8 to 1.3 μ at the tips. Conidia very minutely

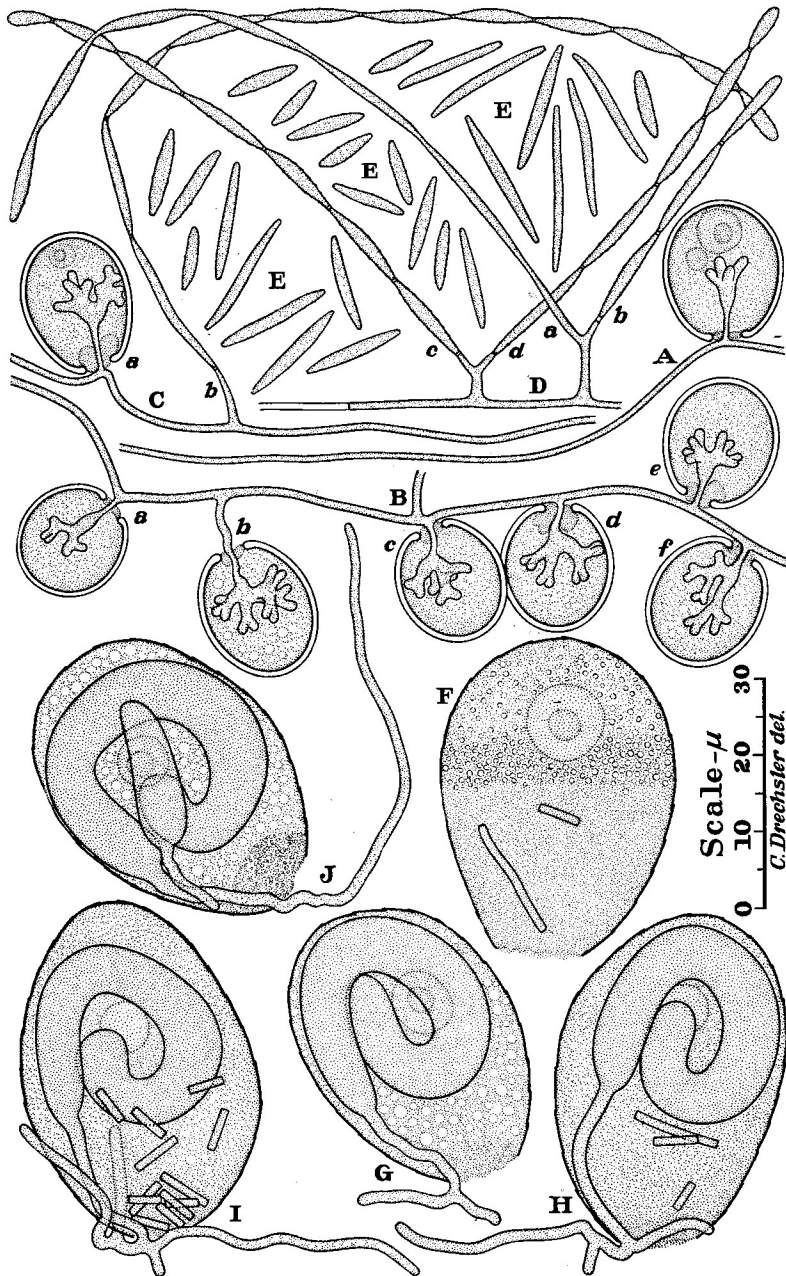


FIG. 5. A-E, *Zoopage tryphera*; F-J, *Cochlonema cylindricum*.

warted, mostly elongated spindle-shaped, 6 to 22 μ (average 13 μ) in length, 1.2 to 2.2 μ (average 1.7 μ) in width, produced in numbers usually from 5 to 15 in more or less erect chains arising from short yet sometimes branched sterigmata. Zygosporangia unknown.

Occurring in leaf mold, capturing and consuming *Geococcus vulgaris*, near Butternut, Wis.

COCHLONEMA CYLINDRICUM

A morphologically very distinctive species of *Cochlonema* made its appearance several times in aging maize meal agar plate cultures originally planted with largish pieces of decaying stem and root tissue cut from tomato plants found wilting in the greenhouse early in December 1935, evidently as the result of root-rot and foot-rot injury. The fungus in question subsisted parasitically on a testaceous rhizopod of the genus *Euglypha*. A somewhat more regularly ovoid contour, and aperture scales neither thickened nor incurved at their tips, readily distinguished the host animal from the congeneric *E. laevis* Perty, cited earlier (3) as prey of *Dactylella passalopaga*. In the dimensions of its glabrous test and of its scales, as well as in the size and position of its nucleus, the rhizopod corresponded well to the description of *E. denticulata* Brown as given by Wailes (5), and is therefore referred to that species. It first attracted my attention by feeding on the oöspores of *Pythium ultimum* Trow scattered abundantly through the agar substratum; in each case applying its mouth to the oöspore wall, digesting a hole through the wall in the area thus circumscribed, and then drawing out the degenerating granular contents, as if by suction. Unlike *Geococcus vulgaris*, which attacks oöspores in precisely the same manner, the animal multiplied rather slowly, its numbers in any of the 4-inch Petri dishes probably not exceeding 100 after a period of 35 days, when destruction by the parasite first became noticeable. Complete extermination followed in less than a week.

Infection of the individual rhizopod results when a conidium of the fungus is ingested (FIG. 5, *F*) that on germination gives rise to a thick spiral thallus (FIG. 5, *G-J*) very similar to the thalli of *Cochlonema verrucosum* and *C. dolichosporum*. After the animal's contents have been partly assimilated, the empty spore

membrane frequently becomes visible as a cylindrical appendage attached endwise to the thallus (FIG. 6, *A-C*) indicating that in this species germination is approximately terminal rather than lateral. Attachment, moreover, is at the end of the swollen filament that occupies not the central but the more outward position in the spiral; the cochleate shape here manifestly coming about through introversion of the growing distal portion, rather than through circumvolution as in congeneric forms. This departure from the habit of growth usual in the genus is, perhaps, to be related to the presence of the enveloping rounded test, and to freedom from the continuous indiscriminate rolling entailed in the movement of pelliculate *Amoebae*. Frequently two thalli develop in an infected animal (FIG. 5, *J*; 6, *A*), and even three have been observed in a few instances. Though additional conidia are often ingested (FIG. 5, *H, I*), these for some reason fail to germinate, long remaining visible in the protoplasm of the rhizopod without undergoing any evident change.

Asexual reproduction of the fungus begins usually before the conclusion of vegetative development, being initiated apparently as soon as the host animal has become too feeble to move about, though generally a considerable portion of its substance may still await appropriation. A narrow hypha arising from the older extremity of the thallus makes its way to the mouth of the rhizopod, from which it emerges often with some branching and an abrupt change in direction (FIG. 5, *G-J*). Penetration into the substratum is usually not extensive, all later growth being in most instances wholly aerial (FIG. 6, *A*). In places where several infected animals have been halted fairly close together, the filaments proceeding from them often become more or less entangled with one another in rangy curling loops, to provide a woolly display much more profuse than might be expected from the volume of the subjacent thalli. As each of the filaments attains definitive length it becomes converted into a chain of sharply truncate cylindrical spores (FIG. 6, *B-E*). A second filament may grow out from below the proximal member of the chain to give rise to a second conidial chain. Through repetition of such development, additional chains are produced until the progressive evacuation of the underlying thallus has been completed, leaving only a num-

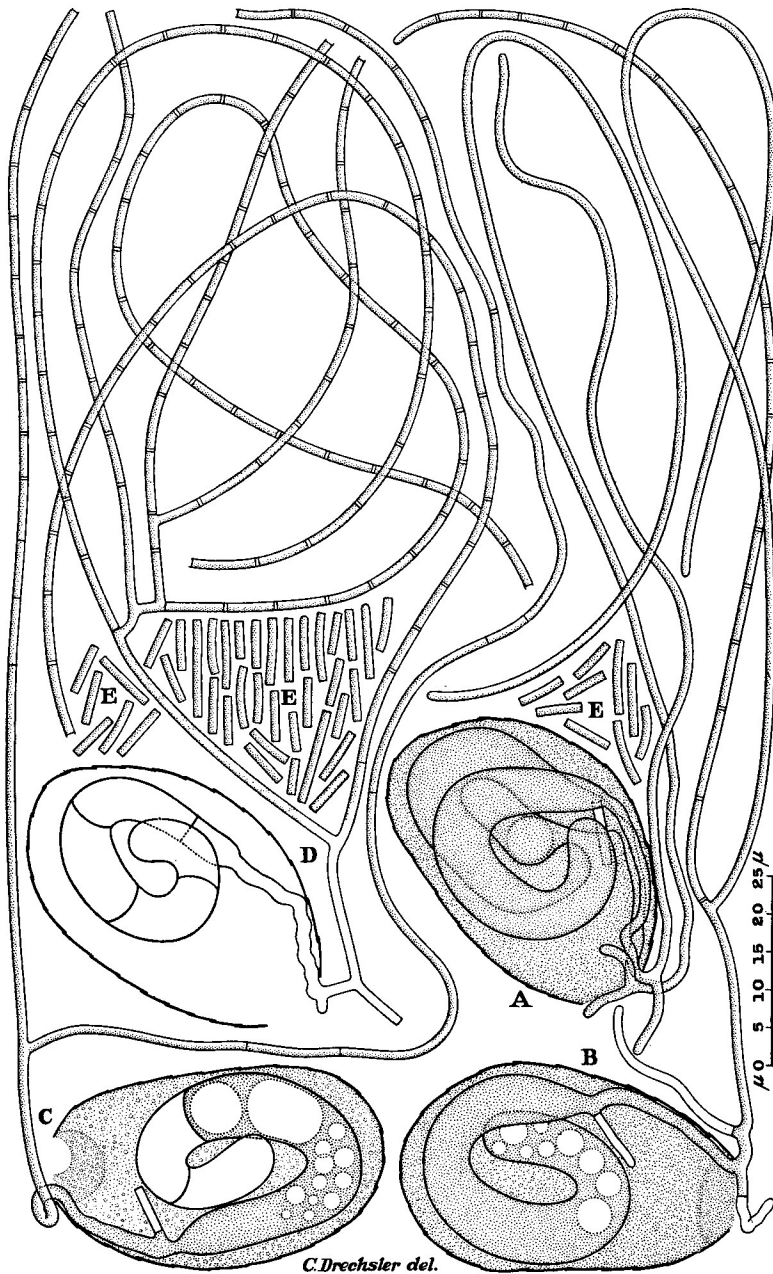


FIG. 6. *Cochlonema cylindricum*.

ber of successive cross-wall in the empty cochleate envelope (FIG. 6, D).

Cochlonema cylindricum sp. nov.

Hyphae alitae 5–8.5 diam., simplices, semel vel bis introrsum spiraliter convolutae. Conidia hyalina, cylindracea, utrimque abrupte truncata, recta vel leniter curva, 4–17 μ longa, 1.1–1.3 μ crassa, in catenulas longas, simplices vel basi paulo ramosas, flexuosas, saepe inter se aliquanto intricatas connexa. Zygosporae ignotae.

Euglypham denticulatam enecans habitat in radicibus putrescentibus *Lycopersici esculenti* prope Beltsville, Maryland.

Vegetative hyphae mostly 5 to 8.5 μ in diameter, spirally convoluted in a circinate coil of 1 to 2 turns. Conidia hyaline, cylindrical, abruptly truncate at both ends, straight or slightly curved, 4 to 17 μ , mostly 5 to 10 μ (average 7.2 μ) long and 1.1 to 1.3 μ wide; produced in large numbers in long, flexuous, simple or basally branched, sometimes distally intertwined chains, wherein they are separated by evacuated but not constricted portions of filament mostly about .3 μ long. Zygosporae unknown.

Parasitic on *Euglypha denticulata* and occurring in decaying roots of *Lycopersicon esculentum* near Beltsville, Md.

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EXPLANATION OF FIGURES

Fig. 1. *Cochlonema odontosperma*; drawn with the aid of a camera lucida at a uniform magnification; $\times 1000$ throughout. A, A small susceptible *Amoeba* being infected by a germinating conidium; close to the contractile vacuole is shown a body believed to be the host nucleus. B, A twice bifurcate thallus that has attained its rather unusually large dimensions by de-

veloping alone in an animal of good size; from the outer profile of its older portion have been produced five young conidiiferous filaments. *C*, Three small thalli putting forth from the relatively small animal in which they have developed, one, two and three conidiiferous filaments respectively. *D*, Two thalli, each once bifurcate, which have nearly depleted their host; one of the thalli putting forth six conidiiferous filaments. *E*, Four simple thalli whose contents have been largely used up in asexual reproduction, the resulting conidial chains not being shown from lack of space. *F*, A simple thallus partly depleted of contents in asexual reproduction, one of the shorter conidial chains being shown in sections; *a* and *b* representing corresponding points in these sections. *G*, A random assortment of conidia. *H*, An assortment of conidia, including mostly branched, filamentous, and relatively large specimens.

Fig. 2. *Cochlonema odontosperma*; drawn with the aid of a camera lucida at a uniform magnification; $\times 1000$ throughout. *A*, Sexual hyphae from two thalli in an exhausted animal, three pairs, *a*, *b* and *c*, having conjugated to form each a young zygosporangium; *d*, a somewhat unusual triple union; *e*, *f*, *g*, zygothoric hyphae that have failed to make contact with a free mate. *B*, Two thalli that have given rise to four pairs of sexual hyphae, *a-d*; each pair having produced a fully grown zygosporangium showing an early stage in the formation of protuberances. *C*, Three thalli from which have come a pair of young sexual hyphae distally in contact with one another, *a*; three pairs of older sexual hyphae, *b*, *c*, *d*, that have each produced a zygosporangium with fully grown protuberances; and a young unmated sexual hypha, *e*. *D*, Four mature zygosporangia, *a-d*, together with the empty sexual hyphae, the evacuated vegetative thalli and the collapsed pellicle. *E*, Mature zygosporangia, *a-f*, showing variation in size and sculpturing.

Fig. 3. *Cochlonema megaspirema*. *A*, Specimen of *Amoeba terricola* in active movement, though infected with four young vegetative thalli, *a-d*; *n*, nucleus; *v*, contractile vacuole; drawn with aid of camera lucida, $\times 1000$. *B*, A well developed vegetative thallus with the proximal portions of 10 conidiiferous filaments thrust through the substantial pellicle of a depleted large specimen of *A. terricola*; drawn with aid of camera lucida, $\times 1000$. *C*, Sketch showing radial arrangement of conidiiferous filaments about the underlying thallus. *D*, Sketch showing course of conidiiferous filaments through substratum and recumbent posture of aerial prolongations.

Fig. 4. *Cochlonema megaspirema*; drawn with the aid of a camera lucida at a uniform magnification; $\times 1000$. *A*, Three relatively small thalli within the pellicle of a wholly depleted specimen of *Amoeba terricola*. *B*, Conidiiferous filament drawn in sections, the contiguity of which is indicated by the letters *a-k*; *a-c*, submerged proximal portion; *c-d*, little differentiated proximal portion of aerial prolongation; *d-h-k*, chain of spores resulting from conversion of the well differentiated distal portion of the filament as at first produced; *e-g*, differentiated branch growing from below the basal member of the mature conidial chain. *C*, A random assortment of conidia, *a-g*, showing variation in size and shape. *D*, Portions of three thalli with four pairs of distally interinvolved sexual hyphae that have produced four fully grown zygosporangia, *a-d*, respectively. *E*, *F*, Zygosporangia with mature zygosporangia, considered as probably belonging to the fungus.

Fig. 5. Drawn with the aid of a camera lucida at a uniform magnification; $\times 1000$ throughout.

A-E, Zoopage tryphera: *A*, Portion of hypha with an incompletely developed haustorium inside of a captured specimen of *Geococcus vulgaris*. *B*, Portion of hypha with six captured specimens of *G. vulgaris*, *a-e*, each of which, with the exception possibly of *a*, reveals a fully developed haustorium in its interior. *C*, Portion of hypha showing a fully developed haustorium in the captured specimen of *G. vulgaris*, *a*; and also a chain of conidia on the sterigma, *b*. *D*, Portion of hypha with two branched sterigmata: one bearing an immature sporogenous filament, *a*, in addition to the mature conidial chain, *b*; the other bearing two mature conidial chains, *c* and *d*. *E*, Conidia, showing variation in size and shape.

F-I, Cochlonema cylindricum: *F*, Two conidia shortly after ingestion by a specimen of *Euglypha denticulata*. *G-I*, Specimens of *E. denticulata* each containing a single thallus, which has established contact with the substratum by means of a slightly branched filamentous outgrowth; in *H* and *I* are shown also inside of the animal some ingested conidia that betray no sign of germination. *J*, Specimen of *E. denticulata* with two thalli, the larger having thrust a hyphal outgrowth through the mouth of the host.

Fig. 6. *Cochlonema cylindricum*; drawn with the aid of a camera lucida at a uniform magnification; $\times 1000$. *A*, Specimen of *Euglypha denticulata* containing two thalli, each of which has produced a growing aerial filament. *B*, Specimen of *E. denticulata* containing a thallus that after giving rise to a chain of conidia is supplying material for the continued elongation of a sporogenous branch proliferated from below the proximal member of the chain. *C*, Specimen of *E. denticulata* containing a thallus that has become partly evacuated in the production of two long conidial chains; these chains being shown only in part from lack of space. *D*, Specimen of *E. denticulata* reduced to an empty test in supplying nourishment to a thallus that now is represented only by an empty membrane; four septa were laid down in the membrane during the progressive evacuation that resulted in six long conidial chains shown only in small part from lack of space. *E*, Conidia, showing variation in size and shape.