THE AQUATIC FUNGI OF THE LAKE ITASCA REGION

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INTRODUCTION

This account is a first attempt at compiling an annotated list of aquatic fungi of the Lake Itasca region. As such, it is incomplete (as all compilations subsequently prove to be), hence its intent is merely to provide a guide to those species encountered. Future collections undoubtedly will yield many species suspected to occur in this region but which are as yet uncovered.

The aquatic fungi are a notoriously difficult group because of their ephemeral nature and the paucity of precise information about them. As a group, they embrace a wide diversity of forms, from the unspecialized unicell that converts entirely into a single reproductive unit to the extensive, mycelial type of growth in which many reproductive centers are formed. Although there is great morphological variation, there is also a degree of remarkable similarity--even among representatives of separate and distinct orders. Consequently, there is no simple formula for the identification of these organisms. This, coupled with the fact that these fungi are seldom seen in the field (and can never be identified save through microscopic observation), makes their taxonomy laborious and often uncertain.

The common morphological denominator for the aquatic fungi is the production of an indefinite number of motile spores (planonts; zoöspores) in a sporangium. Whether the fungus is collected from water or soil (as many are), it is aquatic provided its asexual spores are motile.

Motility is effected by one or two flagella on the planonts, and it is in this most fundamental feature that the chief difficulty in identifying unknowns lies. Orders, indeed classes of aquatic fungi, are established on the characteristic of flagellar insertion on the planont (among other features, of course), hence flagellation becomes the very first character that must be determined. There are ways of circumventing this observational step in some measure, but critical, definitive or revisionary taxonomy dictates that flagellation be determined in all instances. The importance of these organelles is illustrated in the following paragraph.

Modern systematists of the fungi will usually recognize five classes replacing the time-honored (but hardly adequate) Class Phycomycetes:

Class Chytridiomycetes.....	Single, posterior flagellum
Class Hyphochytridiomycetes.....	Single, anterior flagellum
Class Plasmodiophoromycetes.....	Two laterally or terminally attached heterokont flagella
Class Oömycetes[1].....	Two laterally or terminally attached isokont flagella
Class Zygomycetes.....	Flagella absent

Irrespective of the similarity in gross structural features among certain members of the Chytridiomycetes and Oömycetes, for example, the fundamental distinction remains the number and insertion of the flagella. Similarly, filamentous fungi are grouped with unicellular ones (as in the Chytridiomycetes) because all possess planonts with a single flagellum directed posteriorly (see classification to orders).

OCCURRENCE AND COLLECTION

Occurrence:--

The aquatic fungi occur as saprobes or parasites on various plants and animals or their parts, and in water or in soil. Some are in a sense amphibious, others are so well advanced in the evolutionary scheme of things that they exist solely in vascular plants, and members of one group do not even produce motile spores. Obviously there is no rule of thumb to apply in determining what does and does not constitute an aquatic existence. Fortunately, this problem is seldom bothersome in matters of identification.

While some aquatic fungi are indeed uncommon, the supposed rarity of these organisms is largely attributable to uncertain knowledge of proper collection methods. In natural habitats these fungi utilize a wide variety of substrates--algae (filamentous, unicellular, or colonial), other aquatic fungi, decaying plant debris (roots, stems, leaves), microscopic animals and their eggs, exuviae of aquatic insects, to name a few--and direct microscopic examination of these substrates, while laborious, is often the only way to find certain species.

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[1]Class Phycomycetes according to some authorities.

Collection:--

Algae, planktonic or nonplanktonic, are brought to the laboratory and examined directly, "cultured" in gross quantity, or baited. Only dead or obviously dying algae are likely to yield fungi. Small amounts of algae, placed in Petri plates filled about half-full of distilled water or sterile pond water, are allowed to incubate at 22-25°C in diffuse light for a few days (5-10). These cultures when examined often show scattered or abundant infestation. Chytridiomycetes and Oömycetes predominate in such cultures, but it should be remembered that not all collections will yield fungi! (Phycologists will usually part with cherished material if informed that the algae may be infected.)

A second method for obtaining fungi from algae is to bait cultures (such as those just described) with bits of boiled algae (Cladophora, Chara, Nitella, for example), sterilized pine pollen or bits of boiled, soft, herbaceous stem material. A half-dozen or so bits of bait can be added, but large quantities create nutritive conditions in the dishes that favor fouling by increasing populations of bacteria and protozoans. Heavily contaminated soil-water or alga-water cultures simply will not yield aquatic fungi; this seems at variance with the fact that many will grow in fouled environments!

Algae may be sought anywhere in the waters of the Itasca area. Particularly fruitful sources are plants from plankton tows in the various lakes, the floating "scum" on ponds, pools and shorelines, and the moribund algae fortuitously attached at the water line to emergent culms of various grasses, rushes, sedges, and Typha. Among the local algae of most promise are members of these genera: Cladophora, Chlamydomonas, Oedogonium, Ulothrix, Mougeotia, Spirogyra, Zygnema, Closterium, Asterionella, Staurastrum, Chara, Nitella, Vaucheria, Melosira, Navicula, Pinnularia, Synedra, Tabellaria, Euglena (including encysted individuals), and Nitzschia. The Cyanophyceae also harbor aquatic fungi, but in far less frequency than do the filamentous greens, the desmids and the heterokont groups. Dead cells of Chara and Nitella, for instance, very seldom fail to contain the chytrids Diplophlyctis intestina and Entophlyctis helioformis.

Two points should be borne in mind in the examination of local algae. First, the fungi which attack these plants seem to show a seasonal "preference." Summer collections, therefore, may show a very different mycoflora than do spring or fall collections. There is simply no general way of predicting what will occur, and when! Second, fungi will be found in the algal cells and on the surfaces (though in these cases, a portion of the fungus' thallus will penetrate the cells). Thus, one must

be alert to endobiotic as well as epi-endobiotic forms (a few species which attack algae or occur on bits of bait will be interbiotic, with their sporangia produced in the water rather than on the substrate surface).

One of the surest ways of collecting aquatic fungi is by the addition of "bait" to gross cultures of soil, water, and plant debris. Gross cultures are prepared in Petri plates. A teaspoonful of soil or plant debris is sufficient; to this is added enough distilled water or sterile pond water to fill the dish about half-full. If water samples are to be baited, about 10 ml of the sample is sufficient; again fill the dishes about half full of distilled or sterile pond water. Soil and debris should be stirred to break up large clumps, and the baits added.

Collections may be made in any area--dry soils from cultivated fields or woods, wet soils from the edge of ponds, streams, lakes, roadside ditches, or sediment and debris from various bodies of water. Water, similarly, can come from any area; stirring up the sediment before the samples are collected usually results in a greater yield of fungi. Soils from wooded areas are slightly less satisfactory than are those from wet areas, and, of course, sandy soils are far less suitable than are loam soils. Soils from below moss mats, around roots of vegetation, and under forest litter (hardwood types are better than coniferous ones) harbor aquatic fungi. Soils may be collected in paper or disposable plastic bags; water samples are best taken in small vials or bottles (15-25 ml is sufficient).

There are two possible sources of difficulty encountered in collecting-culturing. The tendency to put large amounts of the samples in dishes must be avoided. Samples of water that are not to be baited within two or three hours after collection should be baited in the field since the planonts are usually short-lived. Simply place the bait in the vials or bottles before collecting the water samples. This increases the chances of planonts settling and germinating on the substrates while in transit.

Many types of bait can be used. The commonest substrates are pine pollen (dry and sterilized), cellophane (unwaterproofed or boiled), snake skin, human skin, boiled grass leaves (any grass except those with a hard or glabrous epidermis), boiled algae, hempseed (sesame seed may be substituted), and human hair (blond, baby hair is best). These baits are used in the following manner:

Pollen: scatter grains on the surface with a dry needle; yield in two days.[1]

Cellophane: boil 1/4 inch squares of any cellophane for about two minutes; two or three pieces per plate, submerged if possible; yield in 3-7 days.

Snake skin: cut cast, dried skin into approximately 1/4 inch squares; two or three pieces per plate, submerged if possible; yield in 3-10 days. (Same for human skin.)

Grass leaves: cut short lengths (1/4-3/8 inch); boil for 2-3 minutes; three or four pieces per plate, submerged if possible; yield in 7-10 days.

Hair: scatter short pieces (1/2 inch long, approximately) on the culture water surface (those fungi which attack keratinized material are slow to develop--allow two weeks at a minimum).

Hempseed: boil whole hempseed for about one minute in distilled water; remove them from the water and cut them into halves across the narrow diameter; put cut seed on filter paper and allow them to dry if they are to be kept, otherwise use immediately after cutting; float cut surface down or submerge in the culture water; yield in 2-4 days; no more than 3 or 4 pieces per culture.

Sesame: drop directly in culture dish; no more than 3 or 4 seeds per dish; yield in 2-4 days.

Filamentous aquatic fungi which usually grow on hempseed bait may invade any of the other substrates. While pollen for example, is used primarily for collecting the nonfilamentous species, the filamentous forms may invade masses of pollen to the exclusion of others. The same may be said for snake skin, grass leaves and cellophane. Under no circumstances should large quantities of bait be used in culture dishes, and it is usually wisest to bait one dish with only one kind of substratum.

A few hints on observation of yields from baited cultures are in order. In particular, one should not fail to examine the scum that develops at the edge of the culture dish as the gross culture "ages"; microscopic animals (rotifers and nematodes) and their eggs collect in this scum and on occasion are invaded by fungi. Any insect exuvium should also be examined, since this is a favorite substratum for some uniflagellate species and for members of the genus Aphanomyces (biflagellate).

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[1]Yield times are approximations; temperature and the degree of fouling will modify the times given. It is best to look at the substrates occasionally during incubation, and if they have not yielded, return them to the gross cultures for further "incubation."

Pollen: Remove from water surface with a small wire loop, and mount directly on slide, with coverslip.

Cellophane, grass leaves, and snake skin: Remove from dish, place in cover of dish and drop distilled water on the surfaces to wash away debris. Mount on a slide, and cover. Search along the edges for emergent hyphae; chytridiaceous species usually develop on the leaf surfaces. Reduced light is usually best for observation; scan with the 10x objective, then with 44x or oil immersion lens for structural details. (Grass leaves should be teased apart into two or three slender strips for better observation.)

Hempseed (or sesame): Remove bait showing cottony growth at the cut surface. Place the infested seeds in the top of the Petri plate, and wash the hyphae with a stream of water from a wash bottle or a dropper. Pour off the wash water and float the colony in a small amount of distilled water in the plate cover. Put the plate cover on the microscope stage, and determine the gross morphology with the 10x lens. This procedure is the preferred method for seeing spore discharge and the relationships of the parts of the sexual apparatus in the filamentous water molds. Sporangia containing spores may sometimes be induced to discharge by dropping distilled water in their vicinity. To observe structural details, pick off a mass of hyphae with forceps, mount them in a drop of water on a slide, put on an additional drop (from a few inches above the slide to spread out the hyphae), and add a coverslip. Hyphae, particularly of the water molds, may be infected by other fungi; such parasitic forms are commonly endobiotic, and often occur in those portions of the hyphae nearest the substratum.

Twigs and fruits support populations of a number of species, and the only way to secure these fungi is to collect submerged materials, or place such substrates in traps. In the Itasca area, submerged twigs are common in lakes, ponds and streams. Pieces of these--the bark must be intact--are collected, kept moist during transit, and searched directly for fungi in the laboratory. Fungi occurring on twigs usually develop in granular or gummy pustules, visible to the eye, and twigs from lakes and stagnant ponds often have a different mycoflora than do those from streams, so several habitat types should be sampled.

It is often helpful to incubate twigs in water for a few days to encourage growth of certain fungi. Place three or four twigs in a large jar of distilled water, cover the jar with a plastic bag, and incubate the gross culture at about 20-23^{o}C for 5-7 days. This procedure will favor some species, but will not usually yield species of Monoblepharis. Collect twigs (birch, ash and aspen in this area are particularly suitable) from cool, clear, quiet streams. Place two or three, 4-6" segments in a quart jar nearly full of distilled water, cover it loosely with plastic, and incubate for 1-2 weeks at 11^{o}C. This favors the development of Monoblepharis.

A reasonably foolproof method for collecting fungi inhabiting twigs and fruits is trapping. Trap baskets are constructed of screening, and any shape of container will suffice provided the twigs or fruits are not crowded inside. The baskets may be closed with soft wire. Place a washed apple in the basket, or three or four segments (4"-6" long) of freshly collected hardwood twigs sterilized in distilled water (merely to water-soak them). Submerge the traps in a concealed place along streams or in ponds or lakes, anchoring the traps to submerged rocks or branches with soft wire (individual strands of multistrand copper or galvanized wire are suitable). Within two to four weeks (perhaps a bit longer for twigs) the substrates in such traps become invaded by pustule-forming aquatic fungi.

Twigs and fruits should be washed gently before the pustules are picked. However, species of Pythium (biflagellate) sometimes occur in the slime which is washed off, so this material should be examined. Pustules are picked from the substratum with forceps, mounted on a slide, teased apart with dissecting needles, and covered with a coverslip. It should not be assumed that all pustules on a single twig or fruit are of the same fungus; small as well as large pustules should be examined. Two, three, or even four species (representative of as many genera) may occur in a single pustule.

Other collecting-trapping methods are extant, but the foregoing constitute the most satisfactory ones--and provide the greatest yields. It is well to be guided by the fact that almost any bits of dead and decaying organic matter can harbor fungi, and, no matter how laborious, should be searched for these organisms. It is wise to save cultures for several days or weeks, and examine the baits periodically; some of the best and rarest representatives of these curious organisms are discarded in the sink!

That observations leading to identification may be fraught with difficulties can be attributed to many factors--the variability of the fungi themselves for one thing--but two stand out. In the first place it must be recognized that fungi in common with other organisms go through developmental stages. Many stages can therefore be expected, but only the mature fungus can be identified. Secondly, although these fungi are known to occur on particular substrates, they often develop also on totally unexpected materials. In such cases, their morphology is frequently drastically changed: mycelial forms have reduced, rhizoid-like hyphae (or no clearly detectable filaments at all), interbiotic species produce sessile sporangia, and vegetative portions may be reduced to very small, irregular structures. Moreover, as fungi age, their hyphae or thalli often become aborted, irregular and contorted.

Collecting materials (or baiting cultures) for aquatic fungi is one thing, finding them in the baits, detritus, or moribund algae quite another. It is well to be guided by the fact that many of these fungi are small and inconspicuous (some less than ten or fifteen microns in diameter), and cannot be found by casual observation. Before searching substrates, the material should be washed gently, teased apart (if bulky or filamentous), and only small amounts placed on slides. Any hyaline (or faintly pigmented) structures on or in substrates should be suspect and examined at high magnification. Some "alien bodies" in collections will prove to be dead algae, protozoan cysts, pollen grains and the like, but each foreign substance obviously not part of the substratum should be examined carefully. Frequently on bits of bait clusters of spherical, hyaline cells (3-8 μ or so in diameter) will appear; these are generally the encysted planonts of aquatic fungi.

CULTURE

Ordinary identification procedures seldom require that aquatic fungi collected be isolated and cultured on artificial semisolid media, but critical revisionary studies of certain groups cannot be done save through the propagation of at least unifungal cultures. Many aquatic fungi, particularly in the Pythiaceae, Saprolegniaceae, and Blastocladiales, can be isolated and grown by ordinary agar culture methods (although there are time-saving techniques which ease the burden of work). The greater number of aquatic species, however, have never been isolated and propagated in unifungal or pure culture, because they seem to be refractive toward culture, but more likely because mycologists have not yet devised suitable nutritive concoctions nor discovered the precise sets of environmental conditions favoring growth.

Culture methods are usually cumbersome and require time (and patience) to perform. The most suitable source for a detailed summary of culture techniques is to be found in Sparrow's monumental work on aquatic Phycomycetes (Second Edition, pp. 27-38; Univ. of Michigan Press, 1960). References cited by him are particularly useful.

While isolation usually may be avoided in identification, it should be recalled that two or more fungi may occupy the same substrates. One must be alert to recognize this condition when it appears: the Saprolegniaceae are notorious offenders in this regard, and frequently share substrates with species of Pythium to compound the problem. When the characteristics of such fungi cannot clearly be determined, recourse must be had to single spore isolation. The least one can do, however, is to remove infested baits or other substrates from gross cultures and put them in sterile, distilled water in sterile Petri plates to which are

added pieces of similar baits. This will often favor the development of more extensive populations of one species over another, but it is hardly foolproof.

TERMINOLOGY

The mental tools for identification of aquatic fungi really consist of a series of terms and knowledge of their application. Therefore some attention must be given to the key descriptive words in use in the study of these organisms. In common with studies of other groups of fungi, a terminology sometimes unique to the aquatic species has developed. It is assumed, of course, that most basic biological descriptive terms--clavate, obpyriform, saccate, catenulate, hyphal, thallus, and the like--are already at hand. Mastery of the following terms as they are needed will ease the burden of identification and reduce the chances of erroneous decisions.

AMPHIGYNOUS: with the antheridial branch or cell basal to the oögonium. The branch or cell appears as a collar around the base of the oögonium.

ANDROGYNOUS: An antheridial branch arising from the stalk of the oögonium to which it is attached.

ANTHERIDIAL BRANCH: The slender hypha that bears a distal antheridial cell. For origin types see androgynous, diclinous, monoclinous.

ANTHERIDIAL CELL: That portion of an antheridial branch cut off from the filament; usually apical, and attached to the oögonium by the tip, the side, or by finger-like projections. When an antheridial branch is lacking, the cell is usually simply referred to as an antheridium; if the cell is delimited immediately below an oögonium its origin is said to be HYPOGYNOUS.

APLEROTIC: Not filling the oögonium; usually used in reference to species of Pythium.

APOPHYSIS: An intramatrical (endobiotic) subsporangial, vesicle-like swelling; characteristic of certain chytrids.

BASAL CELL: The lower portion of the thallus of certain blastocladiaceous and leptomitaceous fungi and attached to the substratum by rhizoids or holdfast filaments. In some species the basal cell is stout and obvious (like a tree trunk), but in others it is hypha-like and hardly distinguishable from the remainder of the thallus.

CENTRIC: With the discharge tube arising centrally from the sporangium (usually refers to olpidioid sporangia). The term is also applied to a particular oöspore type--see OÖSPORE.

COMPANION CELL: A small, spherical or subspherical, hyaline cell attached to resting spores. Diagnostic for species of Olpidiopsis.

ENDOBIOTIC: The thallus occurs entirely within the substratum. (In the case of eucarpic species, only a portion of the fungus may be endobiotic.)

EPIBIOTIC: That portion of the thallus occurring outside the substratum.

EPI-ENDOBIOTIC: A portion of the thallus occurs outside the substratum, and a portion occurs within.

EUCARPIC: Thallus from a single spore converts into one or more reproductive cells and a vegetative or assimilative portion (usually within the substratum).

HOLOCARPIC: Thallus from a single spore converts entirely into a single reproductive unit without any vegetative portions.

HYPOGYNOUS: See ANTHERIDIAL CELL.

INTERBIOTIC: The reproductive centers (sporangia or resting spores) occur free from the substratum; attached by rhizoids at some distance.

INTRAMATRICAL: Occurring within the substratum, as opposed to EXTRAMATRICAL (occurring outside the substratum); commonly used with reference to the filamentous fungi.

MONOCENTRIC: The development of a thallus, from a single spore, into one reproductive center. (A holocarpic fungus is always monocentric, but a eucarpic one may not be.)

MONOCLINOUS: An antheridial branch arising from the same hypha as the oögonium to which it is attached, but not from the oögonial stalk. This is not the same antheridial branch origin as "androgynous," but in the literature the two terms are often found to be used interchangeably.

OLPIDIOID: Having the appearance of Olpidium sporangia, that is, endobiotic, hyaline, smooth-walled, spherical to ellipsoidal or elongate, and provided with one or more discharge tubes, but without rhizoids or other vegetative parts.

OÖGONIUM: A spherical, subspherical, ovoid, pyriform, ellipsoidal, or ovate cell bearing internally one or more fertilized zygotes, the oöspores. In position, oögonia may be lateral, terminal, or intercalary, and on occasion (in Saprolegnia in particular) may develop inside old sporangia. Oögonia may or may not have attendant antheridia, and may or may not be ornamented with spines, warts or bullations.

OÖPLASM: In certain of the biflagellate species, the oögonial content is "divided" into two regions. The central portion, often containing one or more highly refractive globules of oil, is the oöplasm. (See PERIPLASM.)

OÖSPORE: The fertilized "egg" or zygote, contained (one or more) in an oögonium. Three major types of oöspores are recognized, depending upon the pattern of deposition of refractive oil reserve within the cell:

(a) CENTRIC: With one or two peripheral layers of very small oil droplets surrounding the central oöplasm.

(b) SUBCENTRIC: With one layer of small oil droplets on one side of the inner periphery of the oöspore, and two or three layers on the opposing side, or a lunate grouping of small droplets on one side of the inner periphery.

(c) ECCENTRIC: With one large oil globule disposed on one side of the inner periphery and not entirely enclosed by the protoplast.

OPERCULATE: Opening by the dehiscence of a small, preformed lid or operculum; usually terminal on sporangia, and sometimes remaining tenuously "hinged" to the sporangial wall.

ORIFICE: The opening through which spores or sporangial contents are discharged into the surrounding medium. Structurally develops by dissolution (or release of an operculum).

A. sessile on the sporangial surface, hence is called a PORE; or

B. at the apex of a short, papilla-like evagination, the EXIT (or DISCHARGE) PAPILLA; or

C. at the apex of a prolonged tubular evagination, the EXIT (or DISCHARGE) TUBE.

ORNAMENTED: Provided (densely or sparingly) with spines, fibrils, warts, bullations, or papillae. This term can apply to sporangia, oögonia or resting spores. A distinction is usually made between obviously ornamented structures and those whose outer surface is merely roughened or wrinkled.

PARAGYNOUS: Having lateral antheridial branches, that is, the antheridial branch attached to the side of the oögonium; a descriptive feature of species of Phytophthora.

PEDICELLATE: On a short stalk. Commonly seen in the Rhipidiaceae as short stalks below the sporangia or oögonia.

PERIPLASM: The outer portion of the oögonial cytoplasm in some biflagellate species. Usually very distinct from the oöplasm, and often appearing as a series of "cells" surrounding the oöplasm, or as a reticulum.

PITS: Small, thin portions in the oögonial walls of Saprolegniaceae. Pits may occur only under the points of attachment of antheridial cell. Most easily detected in optical section. Pits are also found on external surfaces of resting spores or resting sporangia; they are then minute punctations.

PLANONT (ZOÖSPORE, SPORE): A flagellated, uninucleate, reproductive cell.

PLEROTIC: Filling the oögonium; used chiefly in reference to the Pythiaceae.

POLYCENTRIC: The development of a thallus, from a single spore, into two or more reproductive centers. (Only a eucarpic fungus can be polycentric, but it may be monocentric.)

PROLIFERATING: Renewed. When used in reference to sporangia applies to the manner in which new or additional sporangia are produced.

PROSORUS: A cell from which a sporangium or group of sporangia (producing planonts) arise; attached to the sporangia(um).

RESTING SPORE: Any spherical, thick-walled, sometimes ornamented, spore-like, endobiotic or epibiotic cell. [These may be the result of sexual reproduction, but in many cases, their origin is obscure. Resting spores may or may not be associated with sporangia; often they are found without any connection to any nearby thallus. If resting spores produce planonts on germination they are called resistant sporangia. On snake skin and cellophane baits, one often finds spherical, thick-walled cells that appear to be resting spores. Close examination usually shows these "spores" to be within a larger cell; in such cases the resting spores are in reality the oöspores of a water mold (Saprolegniaceae).]

RHIZOID: "Root"-like, filamentous, branched or unbranched, finely tapering or irregular processes arising from the base or sides of thalli. Tapering, very slender processes are typical of rhizoids, but in some fungi (chytrids) the rhizoids are reduced to untapered, peg-like or strap-like structures.

SPORANGIUM: A cell producing an indefinite number of planonts endogenously; usually considered to be the product of asexual reproduction. Many variations in shape, size and position occur. The same may be said for the mechanism by which the sporangium opens to release its contents: by dissolution of one or more pores or papillae, or by release of a lid or operculum. Subtended by rhizoids in some aquatic fungi, and by hyphae or basal cells in others. May or may not be ornamented.

SYMPODIAL: Hypha renewed by lateral outgrowth from immediately below a terminal sporangium. Such lateral growths usually result in elongation and continuation of the hypha which then forms an additional, terminal sporangium. Sporangia laterally positioned on hyphae usually indicate sympodial branching as the means for hyphal or sporangial renewal. In some instances the sympodial branch will be short and itself branched at the tip. Groups of sporangia formed on such branches produce a cluster resembling a cyme.

CLASSIFICATION AND IDENTIFICATION[1,2]

The existence of aquatic fungi as subjects for taxonomy suffers the usual vagaries of disagreement, by taxonomists, of the limits for proper--and scientifically sound--categories above the species level. Indeed, several systems of classification at the higher taxon levels are extant, and arguments for the adoption of any one of these systems can be made. Some schemes of classification, however, seem to reflect more clearly than others, the modern viewpoints of relationships, although none is entirely suitable.

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[1]Descriptions and key characters are incomplete, and are intended to characterize only those species recovered in the Itasca region. They are not to be considered adequate for all species in any particular genus. The same may be said for substrates reported.

[2]Taxa known only from the bog area north of upper Red Lake are marked by an asterisk.

For ordinary, routine identification, one need not be concerned with the theory of classification of aquatic fungi--this is better left to the evolutionist-taxonomist--but some scheme is mandatory if unknowns are to be categorized and properly named. The accepted procedure, of course, is to construct a dichotomous key through which successively more restrictive characterizations may be followed. Being artificial, keys are seldom wholly satisfactory, and reflect interpretations as much as tangible morphological features.

The schematic representatives to follow of the chief groups of aquatic fungi depart from the traditional key format. The limits of groups will not enjoy agreement among mycologists, but the scheme is useful for introducing those points at which groups are separated, and those features which they share in common. Of course the fungi themselves do not conform necessarily to any scheme, hence no key or diagram can be expected to allow for all morphological variations. Only the most commonly encountered species are considered, and it should be recalled that mycelial, pseudomycelial, and holocarpic fungi may share one and the same class or order.

Schematic presentation of key characters for most major orders follow in succession the characterization of the classes.

It will be noted in the schematic diagram to classes that the Zygomycetes are conspicuously absent. Save for one representative, the fungi in this class are not aquatic, and, indeed, even the exception is not aquatic in the usual sense. Since the species in question, Ancylistes closterii, has been collected in the Itasca region, its position in the general classification of aquatic fungi warrants explanation.

Ancylistes closterii produces nonflagellate conidia that are forcibly discharged, but it occurs in Closterium in an aquatic habitat and its conidia germinate there. At one time this genus was relegated to a separate order--Ancylistales--and positioned near the Lagenidiales because of gross similarities in thallus structure of its species to certain lagenidiaceous ones. In 1938, with confirmation of the conidial rather than zoosporic nature, Ancylistes was placed, and correctly so, in the Entomophthoraceae of the order Entomophthorales (inhabitants of insects, orchid seeds, fructifications of higher fungi, animal excrement, and other substrates). Ancylistes is the last genus treated in this account, but does not appear in any subsequent classification key or scheme.

It is recognized that specimens collected do not discharge planonts on demand, and observation of the flagella is often difficult under ordinary gross culture conditions. As indicated

earlier, there are ways of circumventing the need for seeing the flagella and discharge, although none is entirely satisfactory and all often fail at critical points. However, some hints which at least suggest groups or genera to consider in identifying a particular unknown may make the process of identification less burdensome.

A. THALLUS FILAMENTOUS

(1) Distinct hyphae: suspect Monoblepharidales, Saprolegniaceae, Leptomitaceae, or Pythiaceae. If the filaments seem foamy in internal aspect, consider Monoblepharis and Gonapodya; stout filaments over 2 or 3 mm long are likely to be Saprolegniaceae; filaments constricted at intervals are leptomitaceous or represent species of Gonapodya, and slender filaments should be suspected as growth of pythiaceous fungi.

(2) Thallus hypha-like but endobiotic: quite possibly a Lagenidium; if catenulate, suspect Hyphochytrium, Ancylistes or Myzocytium.

B. THALLUS WITH A BASAL CELL

(3) Stout, often obvious basal cell (fungi on apples and twigs usually): most likely to be members of the Blastocladiales or Mindeniella.

(4) Slender basal cell (hyphal in general aspect rather than tree-trunk like): consider the Rhipidiaceae (the reproductive cells will be on short pedicels).

C. THALLUS NOT FILAMENTOUS

(5) Entirely endobiotic and holocarpic: consider Olpidium, Olpidiopsis, Achlyogeton, Woronina, Rozella, Micromyces.

(6) Endobiotic but eucarpic, with branched or unbranched rhizoids: likely to be Diplophlyctis or Entophlyctis.

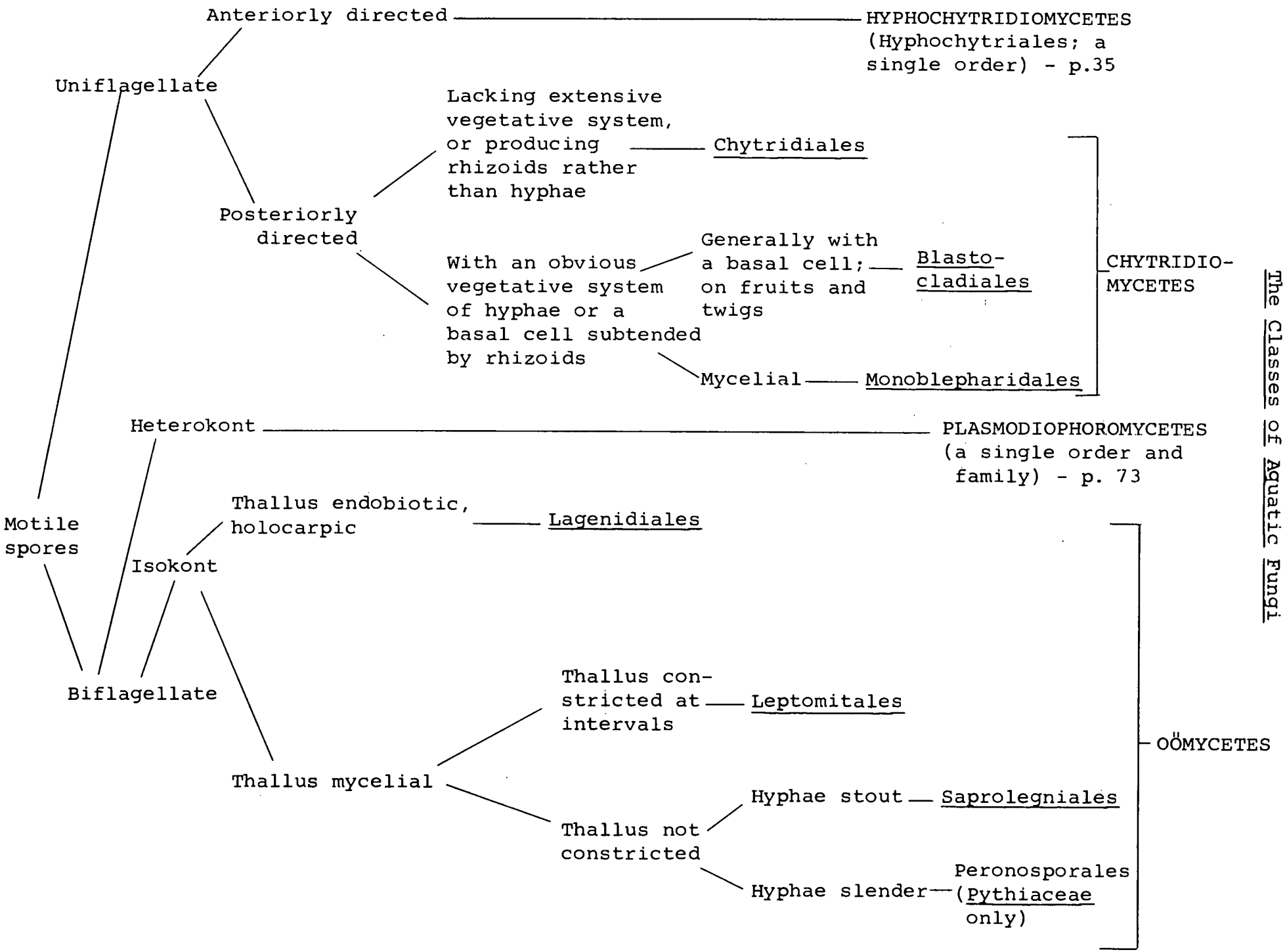
(7) Epi-endobiotic, with rhizoids and apophysis but no operculum: possible genera are Blyttiomyces, Phlyctochytrium, Rhizoclosmatium, Rhizidiomyces.

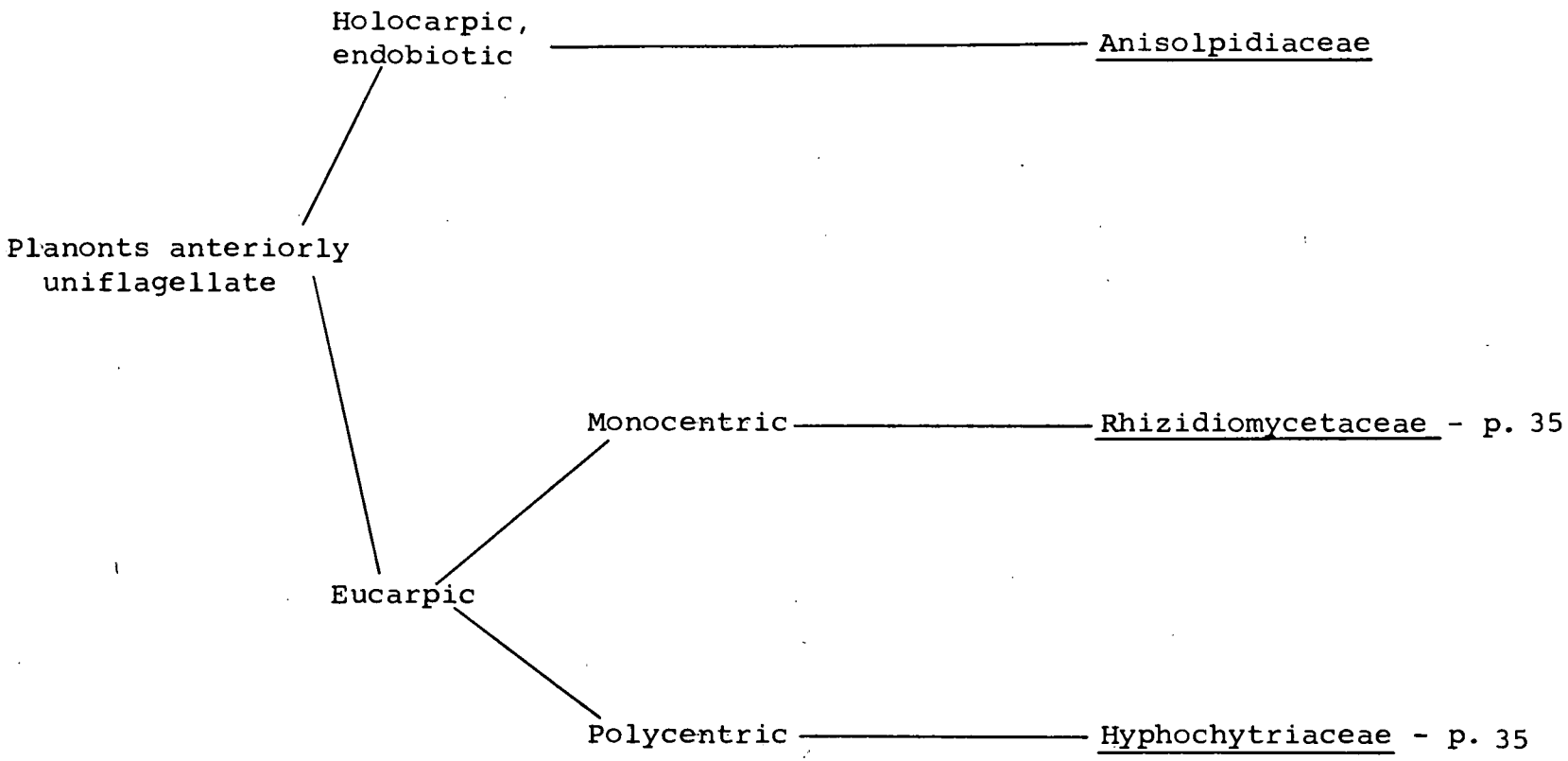
(8) Epi-endobiotic, with rhizoids but no apophysis or operculum: suspect Phlyctidium, Rhizophydium, Podochytrium, Obelidium, Rhizidiomyces.

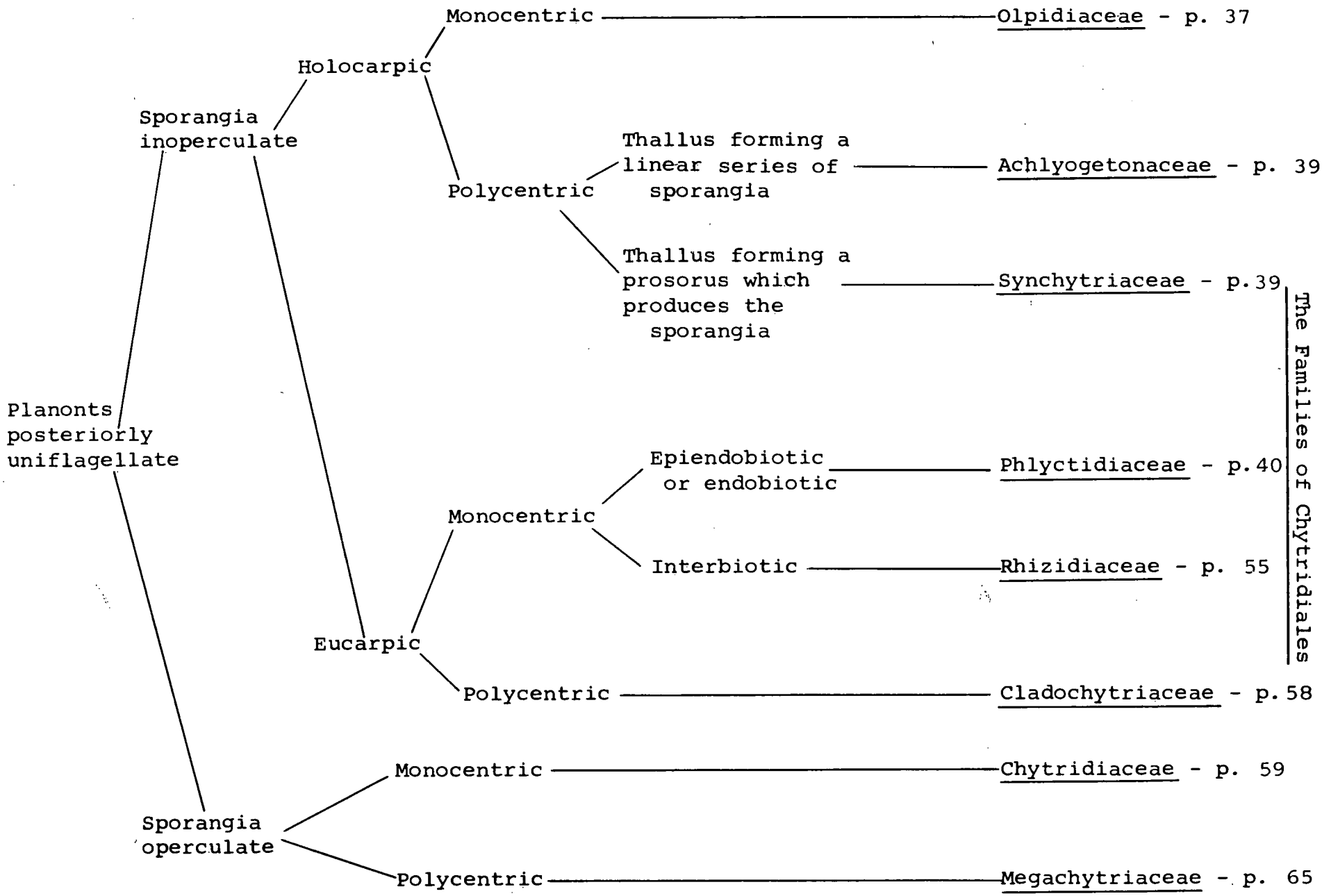
(9) Sporangium with an operculum: definitely Chytridiaceae or Megachytriaceae.

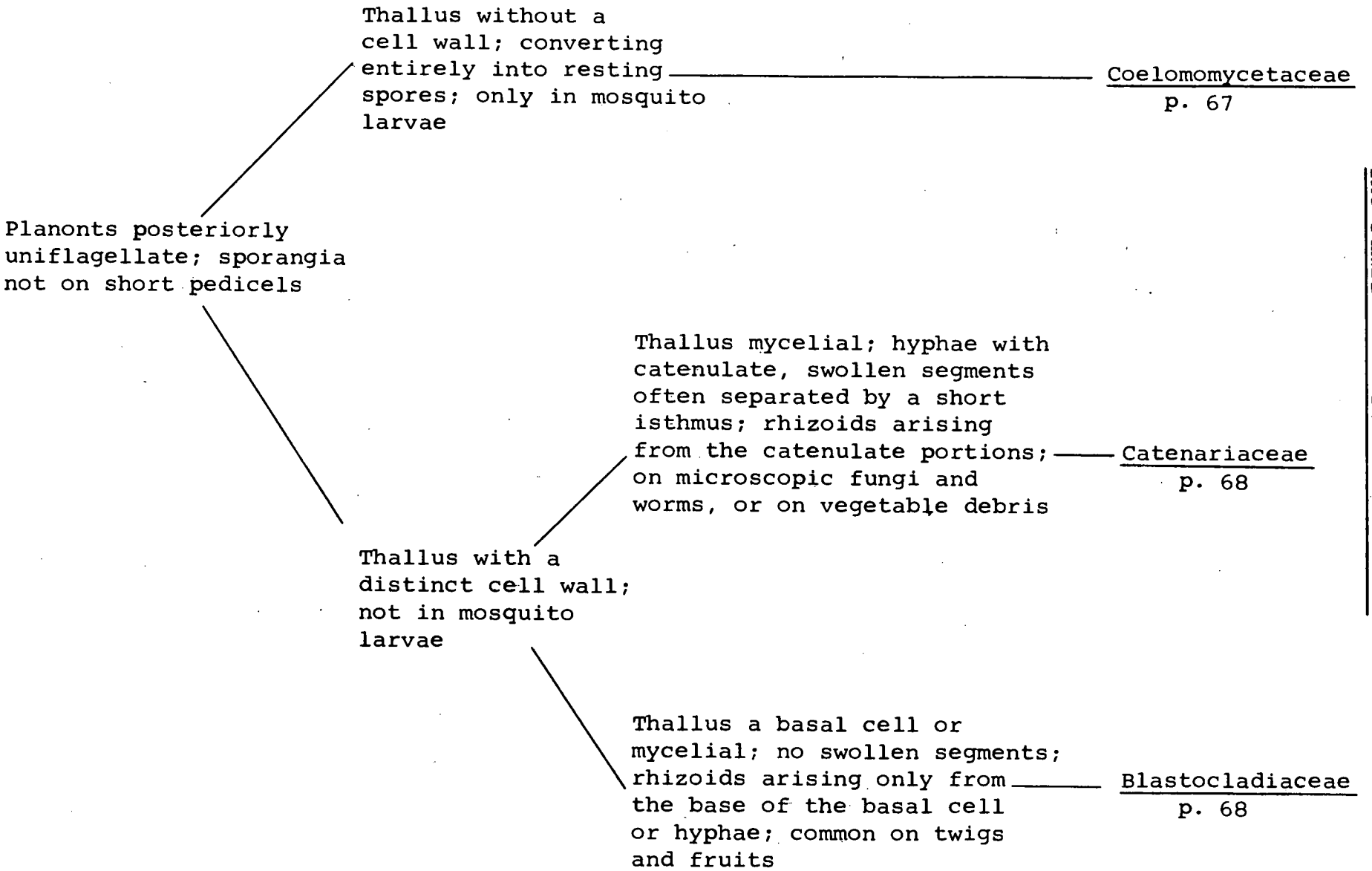
(10) Sporangia having two or more main rhizoidal axes: consider Rhizidium or Rhizophlyctis.

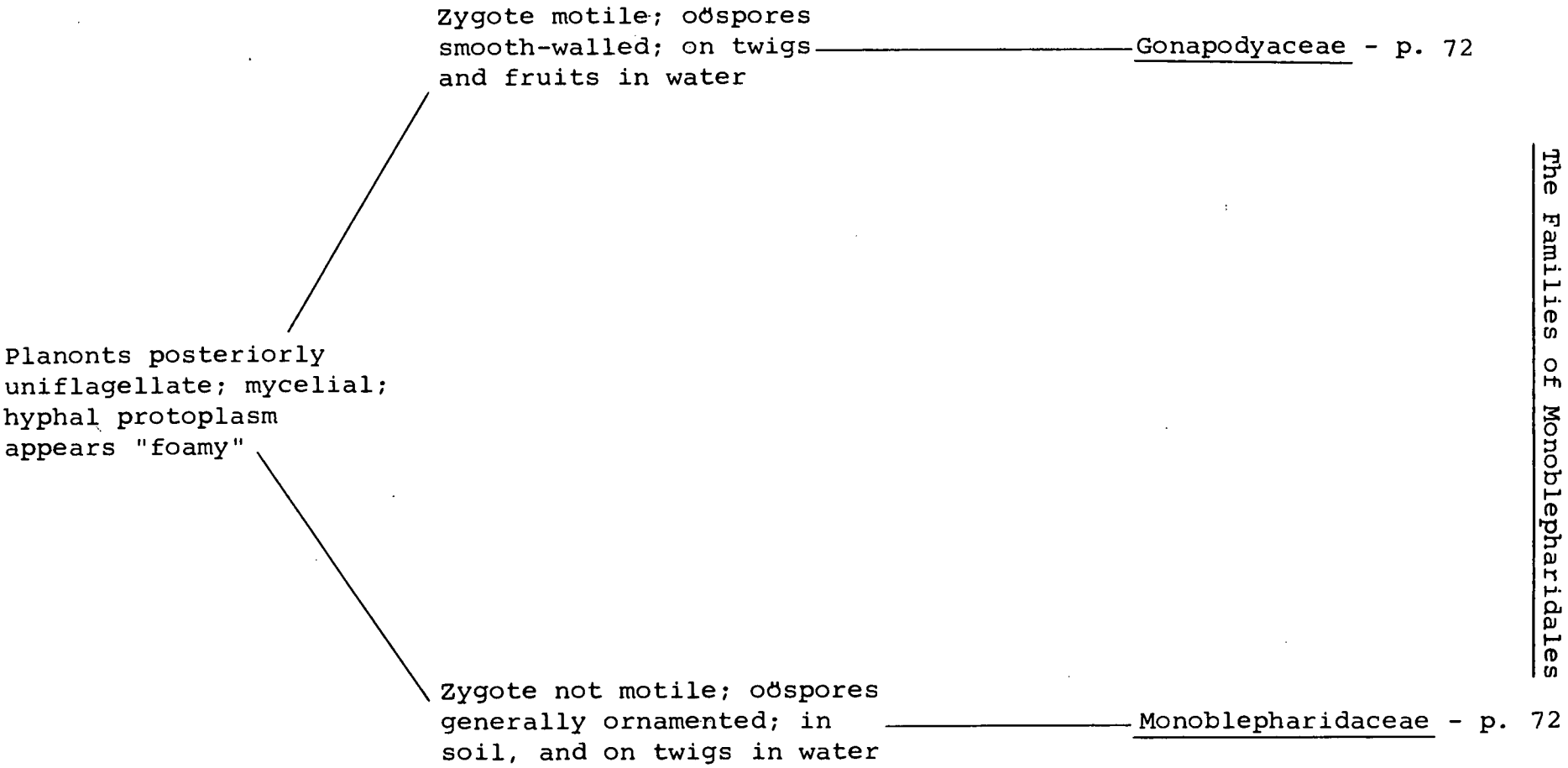
(11) Endobiotic or epi-endobiotic, polycentric (many reproductive centers) and with extensive rhizoids: consider Hyphochytrium, Cladochytriaceae, Megachytriaceae, and Catenariaceae.

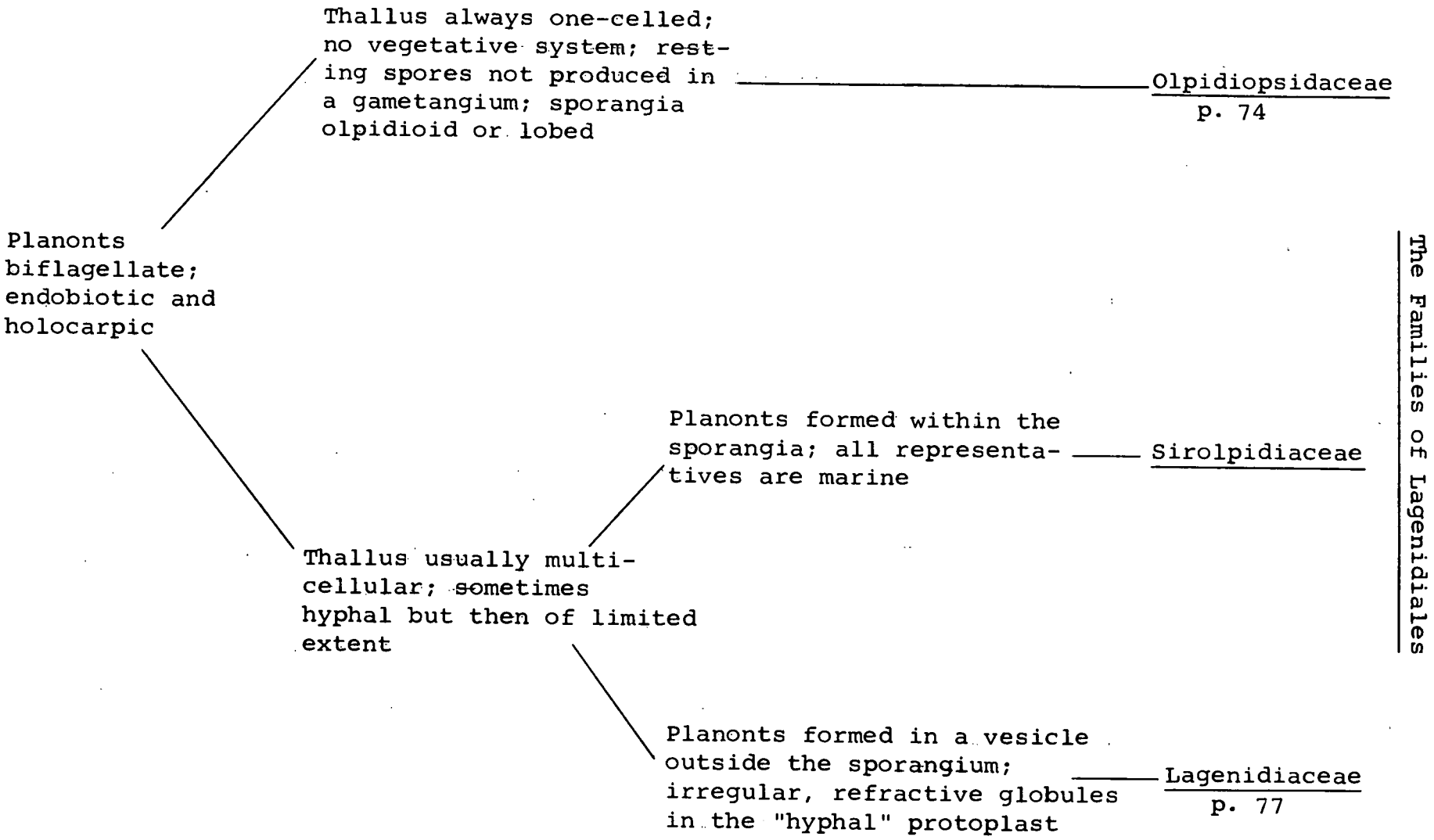

Motile spores
Uniflagellate
Anteriorly directed
HYPHOCHYTRIDIOMYCETES (Hyphochytriales; a single order) - p.35
Posteriorly directed
Lacking extensive vegetative system, or producing rhizoids rather than hyphae
Chytridiales
With an obvious vegetative system of hyphae or a basal cell subtended by rhizoids
Generally with a basal cell; on fruits and twigs
Blasto-cladiales
Mycelial
Monoblepharidales
CHYTRIDIO-MYCETES
Heterokont
PLASMODIOPHOROMYCETES (a single order and family) - p. 73
Biflagellate
Isokont
Thallus endobiotic, holocarpic
Lagenidiales
Thallus mycelial
Thallus con-stricted at intervals
Leptomitales
Thallus not constricted
Hyphae stout
Saprolegniales
Hyphae slender
Peronosporales (Pythiaceae only)
OÖMYCETES

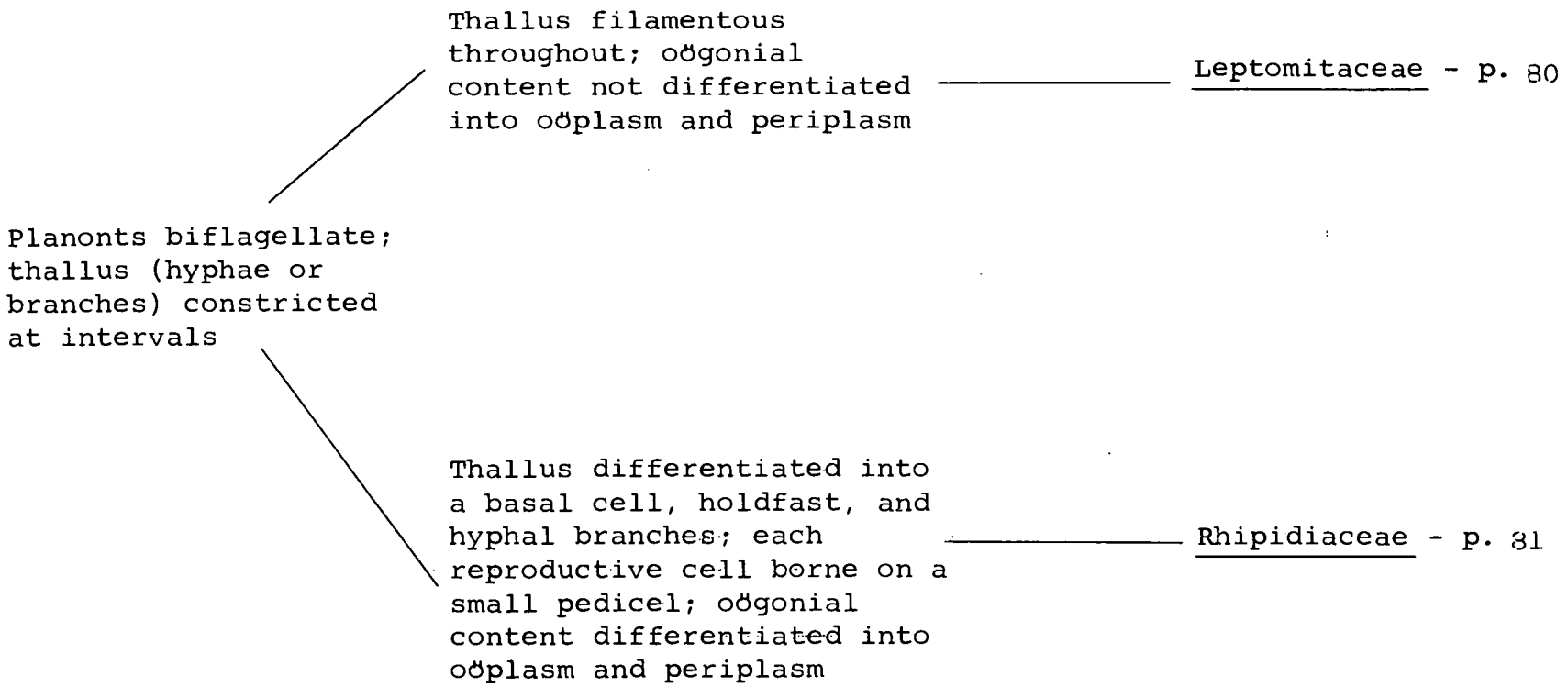

Holocarpic, endobiotic
Anisolpidiaceae
Planonts anteriorly uniflagellate
Monocentric
Rhizidiomycetaceae - p. 35
Eucarpic
Polycentric
Hyphochytriaceae - p. 35

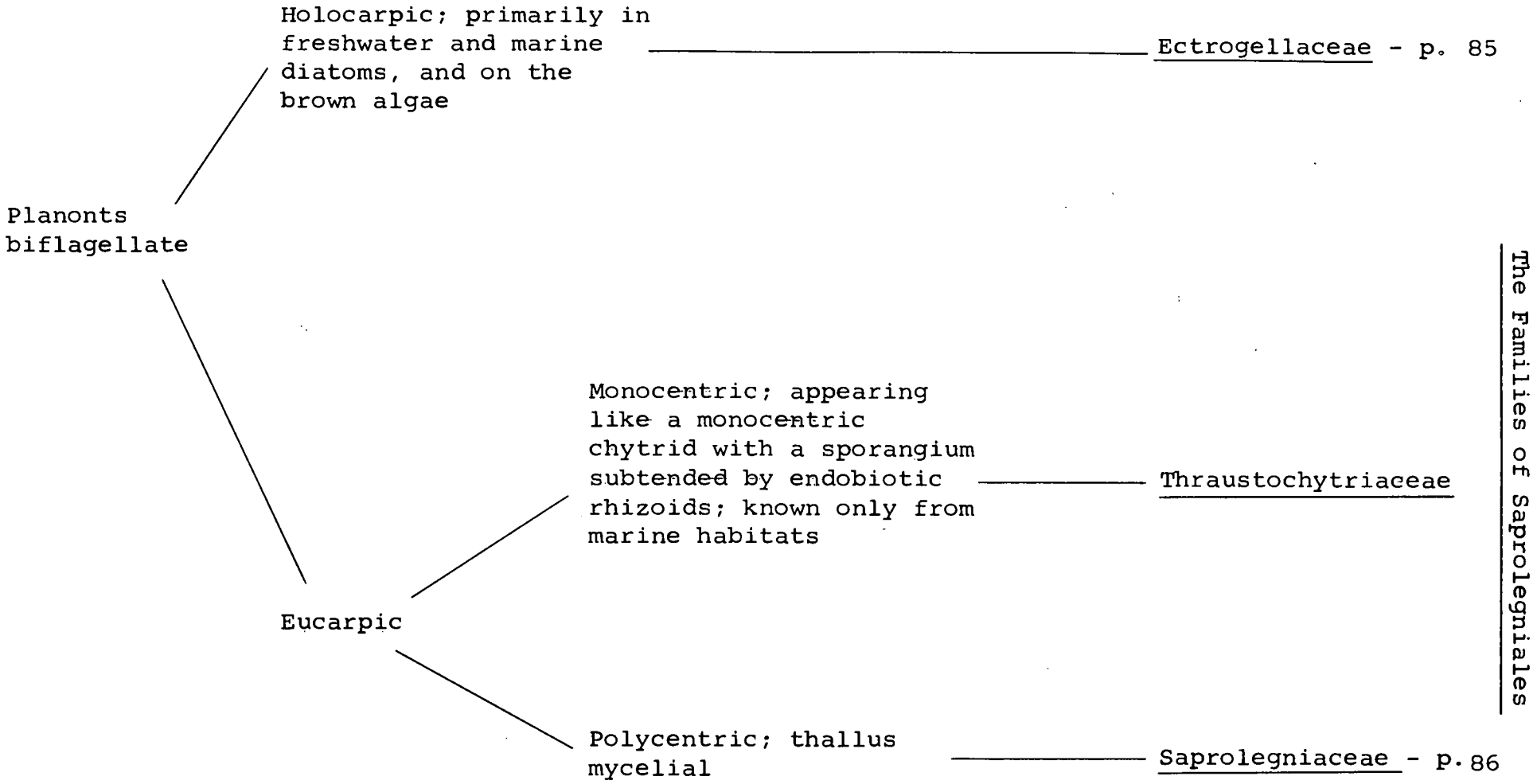

Planonts posteriorly uniflagellate
Sporangia inoperculate
Holocarpic
Monocentric
Olpidiaceae - p. 37
Polycentric
Thallus forming a linear series of sporangia
Achlyogetonaceae - p. 39
Thallus forming a prosorus which produces the sporangia
Synchytriaceae - p. 39
Eucarpic
Monocentric
Epiendobiotic or endobiotic
Phlyctidiaceae - p. 40
Interbiotic
Rhizidiaceae - p. 55
Polycentric
Cladochytriaceae - p. 58
Sporangia operculate
Monocentric
Chytridiaceae - p. 59
Polycentric
Megachytriaceae - p. 65
The Families of Chytridiales


Planonts posteriorly uniflagellate; sporangia not on short pedicels
Thallus without a cell wall; converting entirely into resting spores; only in mosquito larvae
Coelomomycetaceae
p. 67
Thallus with a distinct cell wall; not in mosquito larvae
Thallus mycelial; hyphae with catenulate, swollen segments often separated by a short isthmus; rhizoids arising from the catenulate portions; on microscopic fungi and worms, or on vegetable debris
Catenariaceae
p. 68
Thallus a basal cell or mycelial; no swollen segments; rhizoids arising only from the base of the basal cell or hyphae; common on twigs and fruits
Blastocladiaceae
p. 68


Planonts posteriorly uniflagellate; mycelial; hyphal protoplasm appears "foamy"
Zygote motile; oöspores smooth-walled; on twigs and fruits in water
Gonapodyaceae - p. 72
Zygote not motile; oöspores generally ornamented; in soil, and on twigs in water
Monoblepharidaceae - p. 72

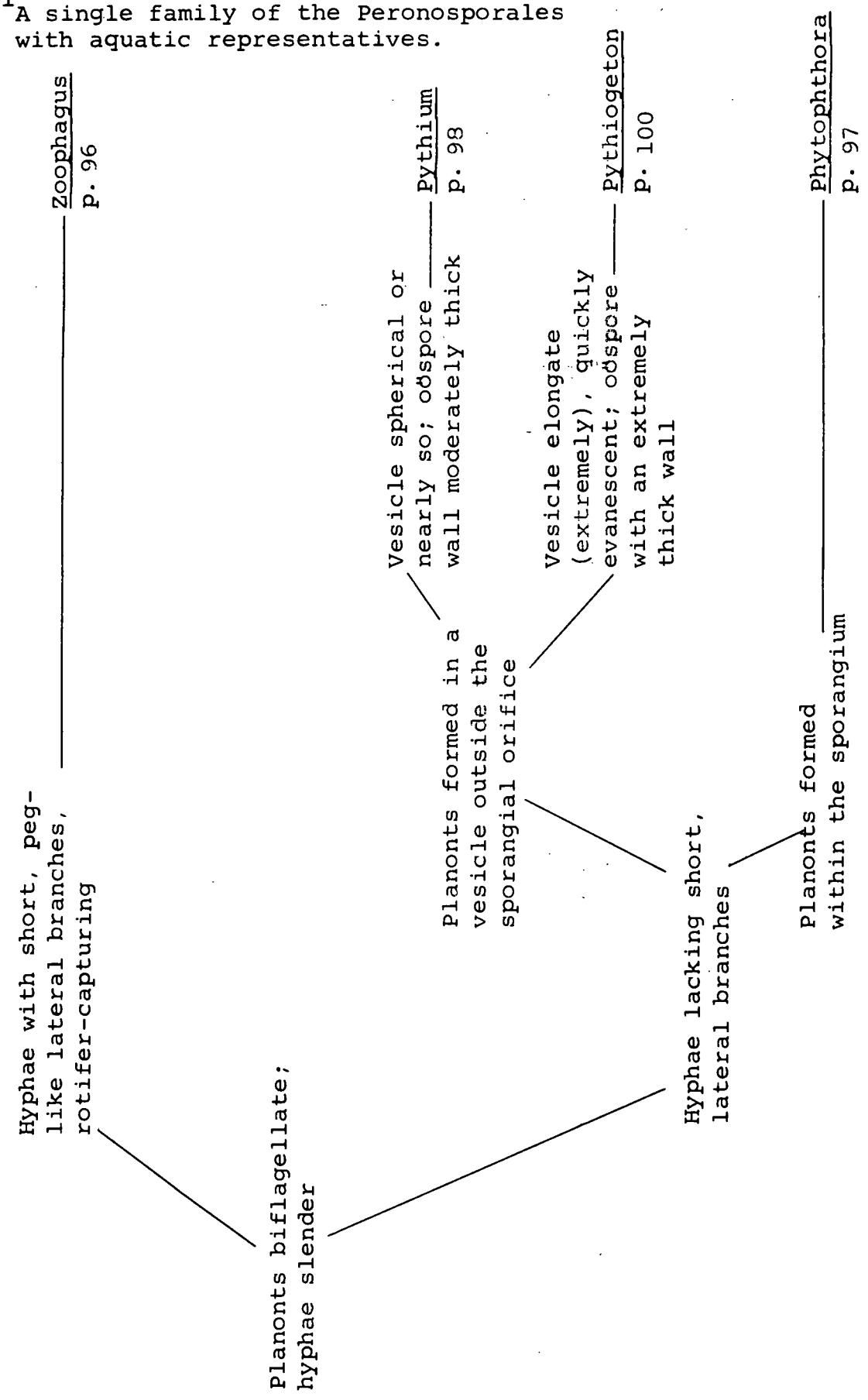

Thallus always one-celled; no vegetative system; resting spores not produced in a gametangium; sporangia olpidioid or lobed
Olpidiopsidaceae
p. 74
Planonts biflagellate; endobiotic and holocarpic
Planonts formed within the sporangia; all representatives are marine
Sirolpidiaceae
Thallus usually multicellular; sometimes hyphal but then of limited extent
Planonts formed in a vesicle outside the sporangium; irregular, refractive globules in the "hyphal" protoplast
Lagenidiaceae
p. 77


Planonts biflagellate; thallus (hyphae or branches) constricted at intervals
Thallus filamentous throughout; oögonial content not differentiated into oöplasm and periplasm
Leptomitaceae - p. 80
Thallus differentiated into a basal cell, holdfast, and hyphal branches; each reproductive cell borne on a small pedicel; oögonial content differentiated into oöplasm and periplasm
Rhipidiaceae - p. 81


Holocarpic; primarily in freshwater and marine diatoms, and on the brown algae
Ectrogellaceae - p. 85
Planonts biflagellate
Monocentric; appearing like a monocentric chytrid with a sporangium subtended by endobiotic rhizoids; known only from marine habitats
Thraustochytriaceae
Eucarpic
Polycentric; thallus mycelial
Saprolegniaceae - p. 86

The Genera of Pythiaceae[1]

[1] A single family of the Peronosporales with aquatic representatives.



KEY TO THE GENERA OF AQUATIC FUNGI

The following key to those genera[1] known to be represented is entirely artificial. Any structural or substrate features most likely to assist in identification are used freely to group and differentiate among taxa. Major variations are accounted for by keying some genera through more than one couplet series.

1. Thallus a system of branched, tubular, intra- or extramatrical hyphae, or rhizoidal and having more than one reproductive center, or consisting of an obvious filamentous or tree trunk-like or distally expanded branched or unbranched basal cell..... 2

1. Thallus not a system of branched, tubular filaments, but if tubular thallus is unbranched; thallus not consisting of an obvious basal cell; if rhizoidal, the thallus is monocentric.....37

2. Thallus a system of hyphae having constrictions at intervals or consisting of a filamentous or tree trunk-like basal cell..... 3

2. Thallus a system of hyphae without constrictions, or polycentric and consisting of an extensive rhizoidal system with or without terminal or intercalary swellings.....12

3. Basal cell present; filamentous or tree trunk-like or expanded distally..... 4

3. Basal cell absent; filamentous throughout, the filaments constricted at intervals..... 8

4. Basal cell filamentous, giving rise distally to an umbel or whorl of sporangia at the apices of hypha-like branches .....SAPROMYCES-p. 82

4. Basal cell tree trunk-like, or clavate; thick walled..... 5

5. Basal cell branched distally..... 6

5. Basal cell not branched distally..... 7

6. Sporangia smooth-walled only; oöspore wall reticulate and appearing shrunken.....RHIPIDIUM-p. 84

6. Sporangia both smooth- and spiny-walled; oöspore wall appearing like a ring of small cells around a central oöplasm.....ARAIOSPORA-p. 84

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[1] Ancylistes, an entomophthoraceous fungus with conidia rather than motile spores, is not included; occurs in Closterium.

7. Sporangia (and resting spores if produced) on short stalks arising from the basal cell.....MINDENIELLA-p. 83

7. Sporangia (and resting spores if produced) sessile on the basal cell.....BLASTOCLADIA-p. 70

8. Thallus intramatrical; in leaves of wild rice (bait).....SEPTOCHYTRIUM-p. 66

8. Thallus extramatical; on hempseed, apples, or twigs..... 9

9. Sporangia merely undifferentiated segments of hyphae; on hempseed.....LEPTOMITUS-p. 80

9. Sporangia differentiated from the hyphae which bear them.....10

10. Sporangia long and pod-shaped, inflated proximally, and sometimes tapering distally to a blunt apex; hyphal segments often showing a "foamy" or reticulate pattern in the cytoplasm.....GONAPODYA-p. 72

10. Sporangia cylindrical, ovoid, pyriform or ellipsoidal.....11

11. Sporangia cylindrical; oöspore single in an oögonium, and rough-walled.....SAPROMYCES-p. 82

11. Sporangia ovoid, pyriform or ellipsoidal; oöspore single in an oögonium, but smooth-walled.....APODACHLYA-p. 81

12. Thallus consisting of tubular filaments without constrictions; hyphae usually extramatical (in two genera intramatrical).....13

12. Thallus consisting primarily of rhizoids with or without terminal or intercalary swellings; polycentric; usually intramatrical.....32

13. Thallus intramatrical.....14

13. Thallus extramatrical.....15

14. In rotifers.....ZOOPHAGUS-p. 96

14. In algae, pine pollen, or grass leaf baits..LAGENIDIUM-p. 77

15. Thallus small in extent, consisting of branched and irregular hyphae forming small "centers" on snakeskin bait, and converting entirely into a sporangium with planonts, or into endogenous resting spores..LEPTOLEGNIELLA-p. 87

15. Thallus very extensive, and not converting entirely into a sporangium or into endogenous resting spores, and not producing small, branched, irregular "centers" on snakeskin bait...16

16. On submerged fruits or twigs, or on snakeskin bait or insect exuviae, or in grass leaf baits.....17

16. Not occurring on fruits, twigs, snakeskin baits or in grass leaf baits; on hempseed or in pollen.....26

17. Planonts formed within the sporangium, and clustering (when released) into a spherical "ball" at the exit orifice; terminal pairs of male and female gametangia absent.....18

17. Planonts formed inside or outside the sporangia or within pairs of male and female gametangia, or sporangia absent, and the hyphae terminated by thick-walled, pitted, brown resting sporangia.....19

18. Planonts in a single row in the sporangium..APHANOMYCES-p.88

18. Planonts not in a single row in the sporangium...ACHLYA-p.92

19. Planonts formed in a vesicle outside the sporangium (undifferentiated protoplast exuding from the sporangial exit orifice, and there maturing into spores); resting spores and gametangia that produce planogametes absent.....20

19. Planonts formed within the sporangium; if sporangia are absent, pairs of terminal male and female gametangia, or thick-walled, brown, pitted resting sporangia (meiosporangia) are present.....21

20. Undifferentiated, discharged protoplast forming a spherical vesicle outside the exit orifice; sporangia not attached asymmetrically to the hyphal apex..PYTHIUM-p. 98

20. Undifferentiated, discharged protoplast forming an elongate or subcylindrical vesicle outside the exit orifice; sporangia attached asymmetrically to the hyphal apex.....PYTHIOGETON-p.100

21. Thick-walled, brown, pitted resting sporangia or pairs of terminal, cylindrical male and female gametangia present..22

21. Thick-walled, brown, pitted resting sporangia or terminal male and female gametangia absent.....23

22. Whole aspect of thallus is arborescent (i.e., like a tree, consisting of a basal "trunk" and many distal branches bearing sessile, thick-walled, brown, pitted resting sporangia; pairs of gametangia absent; on fruits.....BLASTOCLADIA-p.70

22. Whole aspect of thallus not arborescent; branched hyphae terminated by thick-walled, pitted, brown resting sporangia or terminal pairs of gametangia present; on snakeskin bait in water cultures of prairie soils .....ALLOMYCES-p. 69

23. Hyphal cytoplasm showing internally a foamy or reticulate pattern.....MONOBLEPHARIS-p. 72

23. Hyphal cytoplasm not foamy or reticulate.....24

24. Sporangia renewed internally, hence often showing a nested pattern, or renewed by extension of the hypha through an old sporangium.....25

24. Sporangia renewed sympodially; planonts discharged from the sporangium individually and leaving intact (in the sporangium) their cysts, hence the empty sporangium has a net-like internal aspect.....DICTYUCHUS-p. 95

25. Sporangia ovoid, limoniform, pyriform, or ellipsoidal, but not cylindrical; oögonia always with a single oöspore .....PHYTOPHTHORA-p. 97

25. Sporangia cylindrical or clavate; oögonia with more than one oöspore.....SAPROLEGNIA-p. 90

26. Planonts in a single row in the sporangium which is undifferentiated from the hypha bearing it, and the planonts forming within the sporangium (not in an endogenous vesicle).....27

26. Planonts not in a single row in the sporangium, but if so, they form and mature in an endogenous vesicle outside the sporangial exit orifice.....28

27. Planonts swimming away immediately on discharge...LEPTOLEGNIA-p. 89

27. Planonts, on discharge, clustering in a small, loose, spherical cluster at the exit orifice of the sporangium, and then emerging individually from cysts, leaving the cyst walls intact in a cluster.....APHANOMYCES-p. 88

28. Hyphae very slender; sporangia filamentous, ellipsoidal or pyriform, or lobed and branched; oögonia with a single oöspore; planonts forming in a spherical vesicle outside the sporangial exit orifice.....PYTHIUM-p. 98

28. Hyphae stout; sporangia clavate or long cylindrical; or pyriform and with an apical papilla; planonts forming within the sporangium prior to discharge; oögonia usually with many oöspores.....29

29. Planonts leaving the sporangia in mass through an apical orifice.....30

29. Planonts emerging from the sporangia laterally, and individually, and leaving intact cyst walls within the sporangium (giving the sporangium a net-like aspect).....DICTYUCHUS-p. 95

30. Planonts encysting in a loose, hollow sphere at the exit orifice.....ACHLYA-p. 92

30. Planonts swimming away immediately on discharge.....31

31. Sporangia cylindrical or clavate; renewed by internal proliferation.....SAPROLEGNIA-p. 90

31. Sporangia oval, spherical, or pyriform, and provided with a conspicuous apical papilla; renewed by sympodial branching.....PYTHIOPSIS-p. 89

32. Thallus, either hypha-like or rhizoidal, producing at intervals terminal and intercalary swellings of various sizes in the rhizoids or hypha-like system.....33

32. Thallus, either hypha-like or rhizoidal, not producing at intervals terminal and intercalary swellings of various sizes.....36

33. Sporangia operculate, with or without an apophysis; occurring on cellophane or grass leaf baits.....34

33. Sporangia inoperculate; occurring in Chara or grass leaf baits (but the terminal sporangia are then apophysate).....35

34. Rhizoidal system without septa, except where reproductive cells are formed, and the rhizoids not constricted at these septa.....NOWAKOWSKIELLA-p. 66

34. Rhizoidal system septate, and the rhizoids constricted at these septa.....SEPTOCHYTRIUM-p. 66

35. In cells of Chara .....HYPHOCHYTRIUM-p. 36

35. In grass leaf bait (terminal sporangia apophysate) .....CLADOCHYTRIUM-p. 58

36. Sporangia produced in pairs; of two types: smooth and papillate; sporangia not separated by isthmuses; on snakeskin bait.....POLYCHYTRIUM-p. 59

36. Sporangia produced in a linear series separated by isthmuses; not in pairs or of two types; in eggs of microscopic animals.....CATENARIA-p. 68

37. Thallus (sporangia or resting spores, or both) holocarpic and endobiotic or epibiotic.....38

37. Thallus (sporangia or resting spores, or both) eucarpic and endobiotic or epi-endobiotic.....50

38. In Lemna.....(?)REESIA-p. 36

38. In substrates other than Lemna.....39

39. Occurring in other aquatic fungi.....40

39. Occurring in substrates other than aquatic fungi.....43

40. Sporangia or resting spores, or both, occurring in segments induced in the host hyphae.....41

40. Sporangia or resting spores, or both, not occurring in segments in the host hyphae.....42

41. Resting spores small (4-8 μ in diameter) and not spiny; segments of the host hyphae very few, and usually only one at the host hypha apex.....WORONINA-p. 73

41. Resting spores larger (10 μ or more in diameter) and spiny; segments of the host hyphae many.....ROZELLA-p. 37

42. Sporangia lobed and tubular; resting spores absent.....PETERSENIA-p. 74

42. Sporangia spherical to ellipsoidal; resting spores present and ornamented, and usually accompanied by an attached companion cell.....OLPIDIOPSIS-p. 75

43. Occurring only in mosquito larvae.....COELOMOMYCES-p. 67

43. Not occurring in mosquito larvae.....44

44. Thallus tubular and hypha-like, and often of limited extent.....45

44. Thallus not tubular and hypha-like.....49

45. Occurring on the surface of snakeskin bait, and forming branched, lobed "centers".....LEPTOLEGNIELLA-p. 87

45. Not occurring on snakeskin bait.....46

46. Thallus occurring in diatoms; planonts encysting at the exit orifice in a small, spherical cluster .....APHANOMYCOPSIS-p. 85

46. Thallus not occurring in diatoms..... 47

47. Mature thallus consisting of sporangia in a linear series, but not disarticulating..... 48

47. Mature thallus consisting of one sporangium that is tubular and either lobed, unlobed, branched or unbranched LAGENIDIUM-p.77

48. Spores, on discharge, encysting at the orifice of the discharge tube in a spherical cluster, and emerging from the cysts individually; in Cladophora .....ACHLYOGETON-p. 39

48. Spores, on discharge, clustering at the orifice of the discharge tube but not encysting; swimming away and not leaving empty cysts; in Closterium.....MYZOCYTIUM-p. 77

49. Sporangia produced from an ornamented prosorus lying free in the host cell.....MICROMYCES-p. 39

49. Sporangia not produced from a prosorus; lying free in the host cell or substratum, but having a single discharge tube, and either spherical, ellipsoidal, pyriform or ovoid .....OLPIDIUM-p. 37

50. Thallus (sporangium and rhizoids) entirely endobiotic.....51

50. Thallus consisting of an epibiotic sporangium and endobiotic rhizoids or haustorium (i.e., epi-endobiotic).....53

51. Sporangia apophysate (in Chara and Nitella or boiled grass leaf bait).....52

51. Sporangia without an apophysis (in Chara and Nitella) .....ENTOPHLYCTIS-p. 44

52. Sporangia flattened, depressed, somewhat kidney-shaped; occurring in boiled grass leaf bait .....NEPHROCHYTRIUM-p. 61

52. Sporangia spherical or subspherical, but not flattened or depressed; occurring in Chara and Nitella .....DIPLOPHLYCTIS-p. 43

53. Sporangium apophysate.....54

53. Sporangium lacking an apophysis.....61

54. Apophysis compound (i.e., two or more occurring in catenulate fashion).....CATENOCHYTRIDIUM-p. 61

54. Apophysis simple (i.e., single).....55

55. Occurring on Ceratium.....AMPHICYPELLUS-p. 62

55. Occurring on substrates other than Ceratium.....56

56. Parasitic on other aquatic fungi.....RHIZIDIOMYCES-p. 35

56. Not parasitic on other aquatic fungi.....57

57. Occurring on snakeskin bait or on insect exuviae.....58

57. Not occurring on snakeskin bait or on insect exuviae.....59

58. Occurring on snakeskin bait; apophysis spherical or subspherical.....CHYTRIOMYCES-p. 62

58. Occurring on insect exuviae; apophysis broadly fusiform, pyramidal or clavate, or occasionally subspherical.....RHIZOCLOSMATIUM-p. 57

59. Sporangium provided with a conspicuous apical papilla that is not the discharge papilla; discharge pore(s) formed subapically or laterally.....BLYTTIOMYCES-p. 45

59. Sporangium lacking an apical papillus, but if one is present, it becomes the discharge apparatus.....60

60. Sporangium operculate.....CHYTRIDIUM-p. 63

60. Sporangium inoperculate.....PHLYCTOCHYTRIUM-p. 46

61. Occurring on other aquatic fungi.....62

61. Not occurring on other aquatic fungi.....63

62. Most conspicuous reproductive structure a resting spore; resting spore divided once transversely, with proximal half empty and distal half filled with cytoplasm and many small oil droplets.....SEPTOSPERMA-p. 43

62. Most conspicuous reproductive structure a nonseptate sporangium; if resting spores are present these are not septate.....RHIZOPHYDIUM-p. 48

63. Thallus very large (100 μ or over, in length); occurring on submerged apples.....MACROCHYTRIUM-p. 60

63. Thallus small (under 100 μ), or if large, not occurring on submerged apples.....64

64. Occurring on insect exuviae.....OBELIDIUM-p. 56

64. Not occurring on insect exuviae.....65

65. Sporangia produced on cellophane or snakeskin baits or on hair (bait).....66

65. Sporangia epibiotic on algae.....68

66. Sporangia occurring on snakeskin or hair; one rhizoidal axis produced.....RHIZOPHYDIUM-p. 48

66. Sporangia occurring on cellophane bait; more than one rhizoidal axis produced.....67

67. Total rhizoidal system having one major axis and two or more secondary axes that are not as stout; sporangia not pigmented .....RHIZIDIUM-p. 57

67. Total rhizoidal system having two or more major axes, arising from two or more places on the sporangial wall; the axes are nearly equal in aspect; sporangia reddish .....RHIZOPHLYCTIS-p. 58

68. Sporangium with a small but conspicuous basal "cell" below the sporangium and slightly constricted from it; usually attached to substratum by a slender, needle-like stalk; only on diatoms.....PODOCHYTRIUM-p. 44

68. Sporangium without a basal"cell"; on diatoms and other algae.....69

69. Sporangium operculate.....CHYTRIDIUM-p. 63

69. Sporangium inoperculate.....70

70. Endobiotic system consisting of an unbranched, non-tapering haustorium which is peg-like, saccate, discoid, or bulbous.....PHLYCTIDIUM-p. 54

70. Endobiotic system branched or unbranched, but if unbranched tapers distally and is not saccate, discoid, or bulbous.....71

71. Sporangial wall bearing a conspicuous subapical papilla-like structure (the persisting portion of the planont which produced the sporangium); only on Zygnema..SCHERFFELIOMYCES-p. 45

71. Sporangial wall lacking a conspicuous subapical, papilla-like structure (papillae may be present, but these function in planont discharge, unlike the papilla-like apparatus in Scherffeliomyces); on algae other than Zygnema..RHIZOPHYDIUM-p. 48

RHIZIDIOMYCETACEAE

(The following genus is the only one currently firmly assigned to this family; other genera are only doubtfully included.)

Rhizidiomyces Zopf

THALLUS eucarpic, monocentric, epi-endobiotic; consisting of an epibiotic sporangium subtended by an endobiotic apophysis forming distally into a branched rhizoidal system, or without an apophysis. Sporangium sessile, inoperculate. Planonts forming within the sporangium or at the orifice of the discharge tube. Resting spores not known. On oögonia of Saprolegnia.

The single known species in the Itasca region--R. apophysatus Zopf--is recognized by the long, cylindrical, apical or subapical discharge tube. Other species in the genus do not have an apophysis.

Short of observing motility of the planonts (they are anteriorly uniflagellate), there is no certain way of distinguishing species of Rhizidiomyces from many of the Chytridiales. Epibiotic sporangia on water mold oögonia--of Achlya as well as Saprolegnia species--are likely to be Rhizidiomyces apophysatus.

HYPHOCHYTRIACEAE

Key to the Genera

A. Eucarpic, polycentric; relatively broad, branched hyphae, sometimes with crosswalls, ramifying in the substratum; sporangia terminal or intercalary; in Chara.....Hyphochytrium (p. 36)

A. Holocarpic, monocentric; amoeboid protoplast becoming walled and converting into a sporangium with one or several elongate discharge tubes; in Lemna.....(?)Reesia (p. 36)

Hyphochytrium Zopf

THALLUS mycelial, eucarpic, polycentric, intramatrical; consisting of broad hyphae that are occasionally septate, and many intercalary and terminal swellings, some of which convert into sporangia; discharge tubes long. Planonts fully or partially formed within the sporangium. Resting spores thick-walled. In Chara.

There is but one species known in this area, H. catenoides Karling. Superficially it resembles a species of Catenaria by reason of its intercalary sporangia separated by isthmuses. The sporangia are elongate, oval, or spherical, and clearly are olpidioid (although connected). From Catenaria, this Hyphochytrium is distinguished by the absence of rhizoids on the sporangia, and, of course, the planonts are anteriorly rather than posteriorly uniflagellate as in the former genus.

Planont cleavage is effected in undifferentiated protoplast extruded from the sporangial discharge tube.

Hyphochytrium catenoides has not been found in the abundance in Chara that one expects with Diplophlyctis intestina and Entophlyctis helioformis. These two species possess rhizoids, a feature absent in H. catenoides.

(?)Reesia Fisch
(Hyphochytriaceae?)

THALLUS endobiotic, holocarpic, monocentric; amoeboid and initially without(?) a wall. Sporangia solitary in the host cells; hyaline, smooth, ovoid. Resting spores spherical, thick-walled, smooth; yellowish; each containing a single, large, refractive globule. In moribund cells of Lemna minor.

Two species have been described, R. amoeboides Fisch and R. lemnae (Fisch) Karling. The Itasca collection seems nearest the former.

The amoeboid thallus, 8-16 μ in diameter, is to be found in the epidermal cells of L. minor. In plants kept in the laboratory several days, or in specimens subjected to some drying, resting spores are visible; these apparently germinate, but the

precise mechanism remains obscure. Posteriorly uniflagellate planonts were observed coming from sporangia in some preparations although it is not certain that these are of the Reesia. If so, the genus is misassigned if retained in the Hyphochytridiomycetes.

Further study of the curious organism in Lemna is obviously necessary since critical details of development are wanting. There is good evidence that the amoeboid and sporangial stages may not even be of the same organism! Until the full developmental pattern is chronicled, the genus, its species, and their taxonomic position are in doubt.

An alga, Chlorochytrium lemnae, is known to parasitize Lemna. The alga grows inter- rather than intracellularly hence should be easily distinguishable from the Reesia.

OLPIDIACEAE

Key to the Genera

A. Sporangia ovoid, spherical, or pyriform; not filling the host cell.....Olpidium (p. 37)

A. Sporangia filling the host cell and assuming its shape; host hyphae becoming segmented.....Rozella (p. 38)

Olpidium (Braun) Rabenhorst

THALLUS consisting of endobiotic, holocarpic sporangia and resting spores. Sporangia spherical, ellipsoidal, ovoid, or pyriform; usually with a single discharge tube. Planonts posteriorly uniflagellate. Spherical, thick-walled resting spores sometimes present. In algae and pine pollen (bait).

KEY TO SPECIES

A. In algae.....B

A. In pine pollen.....O. pendulum Zopf

B. Sporangium subspherical or broadly ellipsoidal; discharge tube centric, swollen where it meets the alga wall; in Closterium and Cosmarium .....O. endogenum (Braun) Schroeter

B. Sporangium spherical, ellipsoidal or ovoid; discharge tube centric or nearly so, isodiametric throughout; in Cladophora and Spirogyra..... ..... O. entophytum (Braun) Rabenhorst

Fungi in the genus Olpidium are small and occur entirely within the substratum except for the apex of the discharge tube. The sporangia are devoid of any rhizoids or other vegetative portions, hence the fungus converts entirely into a reproductive cell.

Species of Olpidiopsis may be confused with Olpidium since representatives of both genera can occur in similar substrates. These genera cannot always be accurately separated save by observing the flagella on the planonts. The motile spores of Olpidiopsis are biflagellate in contrast to the uniflagellate condition in Olpidium. (But see Olpidiopsis.)

Olpidium endogenum occurs in Ophiocytium from Red Lake Bog as well as in Closterium from the same locality.

Rozella Cornu

THALLUS endobiotic, holocarpic; initially indistinguishable from the host content, subsequently becoming walled(?), and developing sporangia or resting spores in linear series in the host hypha; sporangia with one or more exit tubes. Resting spores small, spherical to ovoid, pigmented, thick-walled, smooth or spiny. In hyphae and reproductive cells of other aquatic fungi.

A single species, R. achlyae Shanor, in hyphae of Achlya sp. on twigs and on hempseed bait in soil-detritus samples from the edge of ponds.

Hyphae segmented into dolioform, linear series of "cells," filled (or empty or only partially filled) with dark, spherical, spiny resting spores, make it easy to recognize this Rozella. Whether the host hyphal segments are sporangia of the Rozella each with a distinct and separate wall, or whether the parasite induces the host to segment directly is yet to be discovered. Determining such a feature is unnecessary for identification.

Rozella achlyae hardly seems distinguishable from R. septigena Cornu, except by host. Future cross-inoculation studies may show this to be an untenable distinction.

(See remarks under Olpidiopsis and Woronina, species of which also occur in filamentous aquatic fungi.)

ACHLYOGETONACEAE
(A single genus known to be represented)

Achlyogeton Schenk

THALLUS endobiotic, holocarpic; tubular, and converting by transverse septation into a linear series of sporangia. Sporangia inoperculate, olpidioid; each with a single discharge tube. Planonts encysting at the orifice of the discharge apparatus. In Cladophora.

A single species, A. entophytum Schenk.

This species of Achlyogeton is not the only endobiotic, holocarpic one which produces a linear series of sporangia: the single species of Septolpidium, and the biflagellate Myzocytium proliferum do likewise. The distinctions are fine but critical. In A. entophytum, the tubular thallus produces sporangia simultaneously (and they do not disarticulate) rather than successively as in Septolpidium (known thus far only in diatoms). Myzocytium proliferum does not produce spores which encyst at the exit orifice--though they do cluster there--as does A. entophytum. If spore discharge has occurred in specimens at hand, empty cysts around the exit tube opening identify the Achlyogeton, since no such cysts are left when the planonts of Myzocytium swim away.

Separate olpidioid sporangia of various sizes in single alga cells cannot be Achlyogeton, even though they may be in a somewhat linear series. In such cases, the fungus is most likely to be a species of Olpidium.

SYNCHYTRIACEAE
(A single genus known to be represented[1])

Micromyces Dangeard

THALLUS endobiotic, holocarpic, initially without a wall; amoeboid; rounding up and becoming smooth- or spiny-walled (the prosorus), and germinating to produce a simple or compound sorus (the sporangia). Sporangia inoperculate; with one or more discharge pores; thin- or thick-walled; angular when compound. Spores amoeboid and only occasionally uniflagellate when released from the compound sporangia. In Mougeotia and Spirogyra.

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[1]Members of the genus Synchytrium, all obligate parasites of flowering plants, undoubtedly occur in the Itasca region but have not been sought.

KEY TO SPECIES[1]

A. Prosorus ornamented with numerous, slender, sharply tapering, short spines up to 8 μ long; causing hypertrophy; in Mougeotia.....M. zygogonii Dangeard

A. Prosorus ornamented with a few slender, straight or curved sharply tapering long spines up to 21 μ long; no significant hypertrophy; in Spirogyra.....M. longispinosus Couch

While resting spores are produced by these species of Micromyces, none appeared in the rather sparse collections.

The two species are easily recognized (though not so satisfactorily distinguished) by the small, spiny prosori lying free in infected cells. Micromyces zygogonii seems always to induce hypertrophy, the lateral swelling suggesting an early stage in scalariform conjugation by the host.

Among the fragments of dead Spirogyra from Red Lake bog, several filaments were invaded by an unidentified species of Micromyces. Only the resting spore stage was present, hence the determination remains questionable. Its description follows:

"Resting spores hyaline but densely protoplasmic; thick-walled; spherical; 12-19 μ in diameter; outer surface provided with isodiametric, rod-like ornamentations (without acute apices) that may branch once; ornamentations not arranged in a helical pattern; other features unknown."

Among the reported species of the genus, Micromyces spirogyrae Skvortzow best accommodates the fungus in Spirogyra. However, Skvortzow's fungus is also incompletely known, and therefore is a questionable member of the genus.

PHLYCTIDIACEAE

Key to the Genera

A. Sporangium epibiotic (subtended by an endobiotic vegetative/rhizoidal system).....B

A. Sporangium endobiotic (rhizoidal system and sporangium within the substratum).....C

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[1]See also, Micromyces sp., following.

B. Resting spore divided transversely into two cells by a septum; proximal portion empty, distal portion densely protoplasmic and containing many refractive oil droplets; parasitic on other chytrids.....Septosperma (p. 43)

B. Resting spore not divided transversely; unicellular; epi-endobiotic or endobiotic.....D

C. Rhizoidal system or axes arising from an apophysis.....Diplophlyctis (p. 43)

C. Rhizoids arising directly from the sporangium; nonapophysate.....Entophlyctis (p. 44)

D. Encysted planont, or a portion of it, persisting and appearing as a part of the mature or discharged epibiotic sporangium.....E

D. Encysted planont sometimes persisting, but not conspicuously visible as a part of the mature or discharged epibiotic sporangium.....F

E. Persisting part of planont forming a small but conspicuous basal "cell" below the sporangium and slightly constricted from it; epibiotic sporangium and its basal "cell" usually attached to the substratum by a slender stalk (the epibiotic portion of the otherwise endobiotic rhizoids); rhizoids sparsely branched and fine and limited, or small and strap-like; on diatoms.....Podochytrium (p. 44)

E. Persisting part of planont forming a small but conspicuous papilla subapically on the sporangium; sporangium sessile; endobiotic portion a short, slightly tapering tube branched distally into short, tufted or bushy rhizoids; on Zygnema.....Scherffeliomyces (p. 45)

F. Sporangium apophysate (apophysis is endobiotic).....G

F. Sporangium without an apophysis.....H

G. Sporangium with a conspicuous, apical papillus; discharge pore(s) sub-basal or lateral.....Blyttiomyces (p. 45)

G. Sporangium lacking a conspicuous, apical papillus that is not a discharge papillus (if an apical papillus is present, this becomes the discharge apparatus); exit papillus usually terminal or subterminal.....Phlyctochytrium (p. 46)

H. Endobiotic rhizoids branched to varying degrees, and usually tapering.....Rhizophydium (p. 48)

H. Endobiotic rhizoids never branched or tapering hence like a haustorium; commonly a "double-contoured" tube, an irregular sac-like apparatus, or spherical, digitate, or papilla-like .....Phlyctidium (p. 54)

Two subfamilies may be recognized, separated by the characters given in couplet A of the foregoing key: Entophlyctoideae for the endobiotic taxa, and Phlyctidioideae for the epi-endobiotic ones.

Members of Rhizophydium and Phlyctidium are most commonly encountered hence it is important to recognize the fine but critical distinction between the two genera. Sparrow's very practical criterion is followed here:

> if the endobiotic portion is almost isodiametric or is expanded distally, but in any case is unbranched throughout, the fungus is placed in Phlyctidium;
>
> if the endobiotic portion is not isodiametric throughout and is not expanded but is branched (sparingly or abundantly), the fungus must be assigned to Rhizophydium.

Frequently it is difficult to detect the rhizoidal system in the substratum, and the two genera approach one another through certain species. Rhizophydium sphaerotheca, for example, has an unbranched haustorium-like rhizoid that could easily be mistaken for one produced by a Phlyctidium. That of the Rhizophydium, however, tapers distally to a point, and it is on this very minute feature that the fungus rests in Rhizophydium rather than Phlyctidium.

Septosperma Whiffen

THALLUS eucarpic, extramatrical. Sporangia spherical, ovoid or ellipsoidal. Resting spores elongate, clavate or ellipsoidal; divided by a cross wall into an empty proximal portion and a distal portion containing protoplasm and oil droplets. "Rhizoids" bulbous or discoid. Parasitic on Rhizophydium and Rhizophlyctis.

A single species known in the Itasca region: S. rhizophydii Whiffen.

Sporangia of this fungus have not been seen in the collections, but the resting spores are common on occasion on Rhizophydium or Rhizophlyctis (not identified) growing on snakeskin bait in gross cultures of soil (5-7 days). However, absence of sporangia does not prevent recognition and identification. The two-celled resting spore is very striking and easily detected on the surface of the host fungus. (The host species, on snakeskin, are not so easily recognized since they do not develop the characteristic morphology. Even if the host fungus is not clearly discernible, the presence of the two-celled resting spores confirms that a species of one or the other genera is present also.)

Diplophlyctis Schroeter

SPORANGIUM endobiotic, eucarpic, monocentric, inoperculate; subtended by a rhizoidal system; apophysate; discharge tube in part extramatrical. Resting spores endobiotic, thick-walled; borne like the sporangia. In Chara and Nitella.

A single species, D. intestina (Schenk) Schroeter.

Hardly any dead Chara fragments fail to harbor this fungus, a situation comparable to that for Entophlyctis which this species resembles. The distinction is clear-cut: D. intestina produces apophysate sporangia; the species of Entophlyctis do not.

While Diplophlyctis and Entophlyctis are common in Chara and Nitella, they can easily be overlooked if preparations are improperly made. Freshly collected specimens of the stoneworts should be separated and placed in Petri plates with sufficient water to cover the plants. Leave the dishes in diffuse daylight for 5-7 days or until white portions of the plants appear. Break off segments of the whitened plants, place them on a slide in water, and tease the segments into shreds or small pieces. Examine those partially or completely separated cells, under high power, nearest the edge or ends of the segments. In these cells,

the sporangia are most easily seen.

Fungi other than those in Diplophlyctis and Entophlyctis can also be found in the stoneworts. Filamentous fungi that have been found in Chara cells have not been identified.

Representatives of the genera Catenaria and Nephrochytrium have been reported elsewhere in the stoneworts.

Entophlyctis Fischer

SPORANGIUM endobiotic, eucarpic, monocentric, inoperculate; subtended by a rhizoidal system; not apophysate; discharge tube in part extramatrical. Resting spores endobiotic, thick-walled, borne like the sporangia. In Cladophora, Nitella, and Chara.

KEY TO SPECIES

A. Rhizoids arising from a single basal axis; sporangium spherical, broadly ellipsoidal, or pyriform.....E. confervae-glomeratae (Cienkowski) Sparrow

A. Rhizoids arising from 3-12 stout, main axes formed at any point on the sporangium; sporangium spherical or ovoid.....E. helioformis (Dangeard) Ramsbottom

Entophlyctis confervae-glomeratae may have more than one basic rhizoidal axis, but in such instances, the "secondary" axes are small, and arise near the base of the sporangium. In E. helioformis, the rhizoids are not extensive (in the local material, perhaps once- to three-times branched); they originate from any point on the sporangium, hence are not basal as are the occasional several axes in E. confervae-glomeratae.

Entophlyctis helioformis is to be found in cells of almost any dead material of Nitella and Chara. Diplophlyctis intestina can also occur in these stoneworts; see that species for comments on the feature separating it from Entophlyctis.

Podochytrium Pfitzer

THALLUS epi-endobiotic, monocentric, eucarpic; epibiotic portion consisting of the remnant of the planont and an expanded apical portion; endobiotic portion a slender, sparingly branched or strap-like rhizoid. Sporangium developed from the upper expanded portion of the encysted planont; usually not sessile, but "sitting" on the extramatrical part of the rhizoidal system; inoperculate. On diatoms.

KEY TO SPECIES

A. Sporangium clavate or obpyriform; rhizoids delicate, branched.....P. clavatum Pfitzer

A. Sporangium broadly clavate or obpyriform; often lying parallel to the host cell; rhizoids coarse and strap-like .....P. emmanuelense (Sparrow) Sparrow and Paterson

While these species seem not to be common, when they do occur on diatoms they are very abundant on individual specimens.

The chief recognition feature for the Podochytrias is the small, sterile basal cell expanded apically into a sporangium. This is more obvious in P. clavatum than in P. emmanuelense, since the latter often lies laterally, hence sessile, on the host wall. The general appearance is one of a clavate cell, with a constriction and rounded cell at the base, attached to the substratum by a needle-like peg. The sporangia of both species are small, having lengths in the neighborhood of 19-26 u.

Scherffeliomyces Sparrow

THALLUS epi-endobiotic, eucarpic, monocentric; consisting of an inoperculate sporangium to which is attached a persisting remnant of the planont, and a rhizoidal system. Rhizoids branched, bushy; arising distally from a slender, subsporangial, epibiotic stalk. Planonts discharged through a single, subapical papilla; clustering in a mass at the orifice before swimming. Resting spores thick-walled, borne like the sporangia. On Zygnema.

A very sparse development of S. leptorrhizus* Johns on dead Zygnema; all sporangia had discharged.

The sporangia of S. leptorrhizus are ovoid or subspherical, and 18-23 u in diameter. The fungus was recognized by the papilla-like protrusion from the upper portion of the sporangium. This "papilla" is in reality the persistent cyst of the planont from which the sporangium and its rhizoids develop. Discharge of spores is not effected through this cyst remnant, but through a subapical pore (papilla ?). The epibiotic portion of the thallus is distinct: a short, tube-like or peg-like protrusion branched distally into numerous, short, bushy rhizoids. The sporangia often collapse after spore discharge.

Blyttiomyces Bartsch

THALLUS epi-endobiotic, monocentric, eucarpic; consisting of an epi-biotic sporangium subtended by one or more apophyses the distal one

of which bears branched rhizoids. Sporangium ornamented, inoperculate, conspicuously apiculate; cut off from the endobiotic system by a septum; discharge pore(s) sub-basal or lateral. Planonts formed within the sporangium. Resting spores endobiotic, produced by growth and encystment of an apophysis. On Spirogyra and pollen.

KEY TO SPECIES

A. Sporangial wall covered with short spines; on Spirogyra.....B. spinulosus (Blytt) Bartsch

A. Sporangial wall provided with raised helical bands; on pollen.....B. helicus* Sparrow and Barr

Of the two species, B. helicus is the most distinctive, being easily recognized by the apical papillus on the broadly ovate, sessile sporangium, and most particularly by the broad, helical bands on the sporangial wall. Blyttiomyces helicus is known to occur only on pine pollen bait in bog water samples.

The sporangial ornamentations on B. spinulosus are short, dense, and narrow (almost fibrillar in the collection at hand).

Blyttiomyces species may be distinguished from other epi-endobiotic, monocentric, eucarpic chytrids by the conspicuous sporangial apiculus. The apiculus is not the site of spore discharge, however, since lateral or sub-basal exit pores are produced by the sporangia.

Blyttiomyces spinulosus superficially resembles the sporangia of some species of Phlyctidium and Rhizophydium; the apophysate nature of Blyttiomyces excludes it from these genera.

Phlyctochytrium Schroeter

THALLUS epi-endobiotic, monocentric, eucarpic; consisting of an epibiotic sporangium subtended by an endobiotic apophysis and rhizoids. Sporangium inoperculate; with one or more discharge pores. Planonts formed endogenously. Resting spores borne like the sporangia; thick-walled. On algae.

KEY TO SPECIES

A. Sporangium wall without ornamentations; smooth.....B

A. Sporangium wall ornamented (teeth, spines, or flange-like protrusions).....E

B. Sporangium small (under 10 μ in diameter); apophysis as large as the sporangium; on Spirogyra .....P. equale* Atkinson

B. Sporangium large (over 10 μ in diameter); apophysis may be large and conspicuous but never equal in diameter to the sporangium; on Spirogyra and Oedogonium C

C. Sporangium spherical or pyriform; apophysis bulbous and subtended by conspicuous rhizoids; discharge pore sessile on the sporangial wall, i.e., lacking an exit papillus or tube; on Spirogyra .....P. hallii Couch

C. Sporangium subspherical, ovoid, or hemispherical, or becoming angular and truncated; apophysis conspicuous and broadly expanded and flattened, or inconspicuous and appearing merely as a slight swelling at the juncture of rhizoids with the base of the sporangium.....D

D. Apophysis conspicuous, broad and flattened; a single, apical, broad discharge papilla produced; on Spirogyra and Oedogonium .....P. lagenaria (Schenk) Domjan

D. Apophysis inconspicuous and much reduced; sporangium provided with two oppositely placed, distal, sessile or elevated discharge papillae; on Oedogonium (possibly also occurring on Spirogyra).P. biporosum Couch

E. Sporangial wall ornamented with broad, flange-like bosses, each of which is toothed distally, and an inner ring of four very small, diverging, bipartite teeth surrounding the apical discharge pore; on Cladophora.....P. bullatum Sparrow

E. Sporangial wall ornamented with teeth variously disposed but not on flange-like bosses; on Cladophora or Spirogyra.....F

F. Sporangium provided with four refractive, converging, plain teeth equally disposed around the apical exit orifice; sporangia reaching 24 u high by 16 u in diameter; on Cladophora.....P. planicorne Atkinson

F. Sporangium provided with four non-refractive, non-converging but deeply incised and bipartite teeth disposed around the apical exit orifice; sporangia small, 8-10 u high by 6-11 u in diameter; apophysis small, spherical or inconspicuously fusiform; on Spirogyra.....P. quadricorne* (de Bary) Schroeter

Rhizophydium Schenk

THALLUS epi-endobiotic, monocentric, eucarpic; consisting of an epibiotic sporangium subtended by endobiotic, branched rhizoids or tapering, haustorium-like "rhizoid." Sporangium with one or more discharge pores or papillae; inoperculate; without an apophysis. Planonts formed within the sporangium. Resting spores, when present, borne like the sporangia; thick-walled. On a variety of algae, other aquatic fungi, and baits.

This is the largest genus of the Chytridiomycetes, and is a complex group with some barely separable species. Fungi assigned to Rhizophydium are inoperculate and rhizoidal like Phlyctochytrium, but the sporangia lack an apophysis.

The key is patterned after that devised by Sparrow in which the genus is divided into five sections chiefly on the basis of sporangial shape. A completely workable key accounting for all variants is probably impossible to achieve (reflecting no doubt the inability of the fungi to conform to description!), but from a practical standpoint, some emphasis on substrate or host is helpful.

KEY TO SPECIES

A. Sporangium obpyriform, obovoid, cylindrical, fusiform, ellipsoidal or angular (and the long axis at right angles or nearly so to the substratum, but at least not upright); not spherical, urceolate, conical, pyriform, flask-shaped, or ovoid; on Stigeoclonium, diatoms (Synedra; Navicula), and human hair (bait).....B

A. Sporangium spherical, ovoid, subspherical, urceolate, angular and upright, pyriform, conical, or flask-shaped; on desmids, blue-green algae, pine pollen (bait), Asterionella, Fragilaria, Pandorina, filamentous greens, snakeskin (bait), and other aquatic fungi.....E

B. Sporangium obovate, obovoid, or obpyriform; on Stigeoclonium (sessile; rhizoid very delicate and short, and appearing to arise from a very small swelling at the base of the sporangium; 8-16 u high x 16-30 u in diameter)[1].....R. ovatum Couch

B. Sporangium fusiform, cylindrical, ellipsoidal, or angular and generally with the long axis parallel to or at an angle to the host cell.....C

C. Sporangium angular, nodular, or fusiform or pyriform but with hump-like lobes giving it a gibbose appearance; nearly upright or tilted, but always irregular in appearance; on Navicula or on human hair (bait in muck soil).....D

C. Sporangium fusiform, usually slightly tilted; on Synedra and possibly also on other diatoms (sessile or on a short stalk; rhizoids extensive; sporangia 10-15 u high x 4-8 u in diameter) .....R. fusus (Zopf) Fischer

D. Sporangium angular and nodular due to the several (2-9 or more) raised discharge papillae; gibbose; on human hair (rhizoids sparingly branched, arising from more than one point on the base of the sporangium; 10-25 x 15-50 u)..R. nodulosum Karling (n.1)[2]

D. Sporangium with hump-like lobes giving them an irregular, gibbose aspect; on Navicula; having a single, terminal broad papilla (rhizoids much-branched from a main basal axis; 18-33 u long x 10-17 u in diameter) .....R. gibbosum (Zopf) Fischer (n.1)

E. Sporangium pyriform, flask-shaped, conical, or spherical, but if spherical becoming urceolate [urn-shaped] at discharge.....F

E. Sporangium spherical and not becoming urceolate at discharge, or subspherical, ovoid, or angular and upright.....K

---

[1]Features in ( ) are descriptive rather than antithetic key characters.

[2]See additional descriptive notes, following.

F. Sporangium spherical and becoming urceolate [in one species slightly pyriform] at discharge; rhizoids branched or unbranched, but if the latter always tapering; on Spirogyra [may be expected also on Oedogonium and Mougeotia], pine pollen bait, or on oögonia of Saprolegniaceae.....G

F. Sporangium pyriform [some may be slightly flattened or anatropous, but in such cases there are two or three elongate discharge papillae]; some sporangia very small; on snakeskin bait, Spirogyra, or Pandorina.....I

G. Rhizoids branched; on pine pollen (one broad, prominent apical papilla; 10-24 μ in diameter; rhizoidal branches arising from a central, elongate axis)..R. pollinis-pini (Braun) Zopf (pro parte) (n. 2)

G. Rhizoids unbranched; on Spirogyra [should also occur on Oedogonium and Mougeotia] and on oögonia of Saprolegniaceae.....H

H. On Spirogyra (sporangia subspherical, ovoid, or urceolate; apical papilla broad, protruding; 6-20 μ in diameter) .....R. sphaerocarpum (Zopf) Fischer (n. 3)

H. On oögonia of Saprolegnia diclina (sporangia spherical or ovoid and becoming slightly pyriform after discharge; 10-21 μ in diameter) .....R. carpophilum (Zopf) Fischer (n. 4)

I. Sporangia distinctly pyriform; not flattened or anatropous, and not producing more than one discharge papilla; in one species sporangium is prolonged apically into a curved discharge papilla; sporangia very small, 5-8 μ in diameter.....J

I. Sporangium basically pyriform, but appearing slightly flattened or anatropous because of one, two, or three elongate, lateral exit tubes (rhizoids much branched; sporangia thick-walled; 6-10 x 14-16 μ); on snakeskin bait, but also reported on moribund rotifers.....R. apiculatum Karling

J. Sporangium very small, not exceeding 6 μ in diameter; apical papilla broad and forming a single pore on deliquescence; sessile; rhizoids very fine and tenuous; on Spirogyra.....R. minutum Atkinson

J. Sporangium 8-12 μ high x 6-7 μ in diameter; prolonged apically into a slightly curved discharge papilla; sessile; rhizoid very slender, unbranched; on dead Pandorina..R. simplex (Dangeard) Fischer

K. Sporangium wall ornamented; sporangium small [about 10 μ in diameter] or larger [12-42 μ in diameter] (rhizoids extensive, delicate, branched, arising distally from a haustorium-like tube or a main axis); on Spirogyra, Oedogonium, and on human hair [bait].....L

K. Sporangium wall without ornamentations.....M

L. Ornamentations short, stout, simple, bifurcate, obtuse, rounded, or pointed at the ends (ornamentations 2-36 μ long; sporangium sessile; rhizoids extensive, branched; resting spores spherical or oval, about 6-12 μ in diameter, or larger; thick-walled, covered with conspicuous warts or bullations); on human hair (bait in soil culture).R. keratinophilum Karling

L. Ornamentations only on upper half or one-third of sporangium; long, slender, hair-like, unbranched [rarely branched ?] (sporangium spherical, sessile; rhizoids delicate, much-branched, arising from distal end of a penetration tube; discharge papilla apical or subapical); on Spirogyra and Oedogonium .....P. chaetiferum Sparrow

M. Mature sporangia [containing detectable planonts] or discharged ones very small; 3-10 μ in diameter; on Asterionella and Fragilaria.....N

M. Mature sporangia larger than 10 μ in diameter; occurring on substrates other than Asterionella and Fragilaria.....O

N. Sporangia 4-9 μ in diameter; on Asterionella formosa (sporangial wall deliquescing apically to discharge planonts; rhizoidal system limited, fine, tenuous, branched or once-branched) .....R. planktonicum Canter (n. 5)

N. Sporangia 3-10 μ in diameter; on Fragilaria (sporangial wall deliquescing in 1-3 places to form small pores through which planonts are discharged; rhizoid thread-like, unbranched or once-branched).....R. fragilariae Canter (n. 6)

O. Thallus occurring on algae; if on diatoms, not on Asterionella or Fragilaria.....P

O. Thallus occurring on pine pollen (sporangia sessile, spherical or subspherical, with 2-5 small but obviously protruding papillae which become the discharge pores; sporangia small, and seldom exceeding 15-18 μ in diameter; sometimes very slightly angular after discharge; rhizoidal system extensive, branched, usually obscured by the contents of the substratum).....R. sphaerotheca Zopf (n. 2)

P. Thallus occurring on blue-green algae.....Q

P. Thallus occurring on algae other than blue-greens.....R

Q. Sporangium spherical but becoming angular on discharge; rhizoidal system delicate, unbranched or sparingly branched; 2-3 discharge papillae present (sporangia 10-20 μ in diameter); on Oscillatoria.....R. subangulosum (Braun) Rabenhorst (n. 7)

Q. Sporangium spherical [and also becoming angular], broadly ellipsoidal, or weakly obpyriform; rhizoidal system very extensive, stout, broad, sparingly branched, invading several cells (sporangia 9-21 μ in diameter); on Oscillatoria .....R. megarrhizum Sparrow (n. 7)

R. Sporangium spherical (2-4 discharge papillae on upper portion of sporangium); rhizoids extensive, branched, arising from a short stalk or from the tip of a small tube barely penetrating into the cell's cavity; 15-35 μ in diameter [reported to be up to 50 μ]; discharge pores often sessile if papillae are absent; on Cladophora, Oedogonium, Spirogyra, and Closterium .....R. globosum (Braun) Rabenhorst (n. 7,8)

R. Sporangium long-ovoid to broadly citriform, but not spherical; one apical papilla; rhizoids delicate, short and not extensive;

sporangia 10-30 μ high x 10-20 μ in diameter; on oögonia of dead Oedogonium (may also be expected to occur on Spirogyra, Draparnaldia, Tribonema, and Ulothrix).....R. mammillatum* (Braun) Fischer

n. 1 Rhizophydium gibbosum and R. nodulosum. Both species produce gibbose (humped, hunched) sporangia. The former, having only a single exit papilla, is not irregular-angular like the latter which has several such protrusions. Rhizophydium nodulosum has been found only on hair baited in muck soil; a species of Chytridium is reported to be parasitic on this fungus.

n. 2 Rhizophydium pollinis-pini and R. sphaerotheca. Occurring on the same substrate type--pine pollen--these two species are separated on the basis of the number of discharge pores. The sporangia of R. pollinis-pini may be spherical when immature, but after discharge they are urceolate. Two to five protruding papillae are in evidence on the sporangia of R. sphaerotheca immediately prior to discharge.

n. 3 Rhizophydium sphaerocarpum. Several species, varieties or forms very possibly constitute this species; it is a collective one, occurring on some of the same substrate species which harbor R. globosum. As the species is interpreted here it is limited to those specimens which (1) develop on filamentous algae and (2) produce spherical or subspherical sporangia that after discharge are urceolate.

n. 4 Rhizophydium carpophilum. Should be expected on other species of Saprolegnia as well as on species of Achlya and Dictyuchus. Limited to development on the oögonia.

n. 5 Rhizophydium planktonicum. Occurring on Asterionella formosa locally. Like R. fragilariae, the sporangia are extremely small, mature ones being 4.5-9.5 μ in diameter. A stalked flagellate, bearing a barely detectable collar occurs also on Asterionella specimens, and frequently along with the fungus. Careful examination will distinguish specimens of each even though they are remarkably similar in size.

n. 6 Rhizophydium fragilariae. The sporangia are very small: 3-10 μ in diameter. Discharge is effected through pores dissolved in the wall. The minute size makes this species difficult to detect on Fragilaria.

n. 7 Rhizophydium subangulosum and R. megarrhizum. The distinction between these two species, both occurring on Oscillatoria, rests on the rhizoidal system. Epibiotic, angular sporangia with extensive, obvious rhizoids are R. megarrhizum; similar sporangia with poorly developed or sparse rhizoids that do not extend among many cells of the host are of R. subangulosum. Rhizophydium subangulosum often cannot be distinguished morphologcally from R. globosum; reliance must of necessity be placed on host difference since the latter is not known to occur on Oscillatoria.

n. 8 Rhizophydium globosum. This is very likely a collective species the limits of which have not been established. The name should for the moment be restricted to those specimens which produce spherical, sessile sporangia with 2-4 discharge papillae in their upper half. Fungi producing spherical sporangia on pine pollen should be excluded.

Phlyctidium (Braun) Rabenhorst

THALLUS epi-endobiotic, monocentric, eucarpic; consisting of an epibiotic sporangium subtended by an endobiotic, peg-like, tubular, clavate or discoid, unbranched haustorium.[1] Sporangium inoperculate; with one or more discharge pores or papillae; without an apophysis. Planonts formed within the sporangium. Resting spores borne like the sporangia; thick-walled. On algae.

KEY TO SPECIES

A. Wall of sporangium ornamented with short, sharp spines (sporangium small, usually about 10 μ in diameter; sessile, spherical, or ovoid; haustorium an unbranched tube)[2]; on Cladophora.....P. spinulosum Sparrow

A. Wall of sporangium without ornamentations.....B

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[1] As used here, a tubular or expanded endobiotic evagination anchoring the sporangium to the substratum and functioning in absorption from the host cell; analagous to the "rhizoidal" system in other chytrids.

[2] Characteristics in ( ) are species descriptive rather than antithetic key features.

B. Sporangium attached laterally to substratum; sessile, asymmetrical and irregular in outline but generally broadly pyriform or broadly ovoid and strongly arched or reflexed and seeming to curve around the host filament; (on Stigeoclonium)....P. anatropum Sparrow

B. Sporangium not attached laterally to the substratum, and not anatropous (reflexed or arched).....C

C. Sporangium urceolate; with a broad, apical discharge pore; 15 μ in diameter or more; haustorium tubular; (on Spirogyra).....P. olla Sparrow

C. Sporangium spherical or ovoid; 5-8 μ in diameter; haustorium bulbous or discoid; (on Tribonema) .....P. bumilleriae* Couch

The most readily recognized Phlyctidium is P. anatropum by reason of its arched, curved, reflexed or bent sporangia laterally appressed to the outside of the host cell. Phlyctidium spinulosum, because of its small size, is easily overlooked in spite of the echinulate sporangial wall.

There is no way of distinguishing P. olla from Rhizophydium sphaerocarpum save through observation of the endobiotic portion of the thallus. Both have urn-shaped (urceolate) sporangia. Although the Rhizophydium is slightly smaller (6-18 μ in diameter as opposed to 12-15 μ high by 15-18 μ in diameter for sporangia of P. olla) positive separation can be had only by the characteristics of the endobiotic portion. The haustorium of P. olla is tubular and inflated; that of R. sphaerocarpum is often haustorium-like, but is slender and tapers to an acute distal apex which may branch.

Identity of the Phlyctidium on Tribonema is tentative pending further collection and study. In sporangial size and the bulbous haustorium, the fungus agrees well with Couch's species and no other. The host, however, is quite different (Bumilleria versus Tribonema).

RHIZIDIACEAE

Key to the Genera

A. Rhizoidal system arising from a thick-walled, cup-like basal portion of the sporangium

(superficially resembles an apophysis, but its thick wall and cupulate appearance is not characteristic of an apophysis).....Obelidium (p.56)

A. Rhizoidal system arising from an apophysis, or from one or more places on the surface of the sporangium.....B

B. Rhizoids arising from an apophysis.Rhizoclosmatium (p.57)

B. Rhizoids having one or more axes, but not arising from an apophysis.....C

C. Total rhizoidal system having one major axis (two or more additional secondary axes may be present, arising from the lateral wall of the sporangia, but these are not as stout as the main axis).....Rhizidium (p.57)

C. Total rhizoidal system consisting of several major axes, most of nearly equal aspect, arising from several places on the sporangial surface.....Rhizophlyctis (p.58)

Obelidium Nowakowski

THALLUS monocentric, eucarpic, consisting of a sporangium with a thickened, cup-like base and subtending a few main axes of rhizoids. Sporangium inoperculate; planonts emerging through a lateral pore below a single, solid, prominent, refractive, apical spine. On submerged insect exuvium.

Obelidium is a monotypic genus; O. mucronatum Nowakowski.

The careful observer will recognize this species immediately. The small (20-24 μ high), ovoid, erect sporangia are prolonged distally into a conspicuous, tapering, sharp-pointed apex. There are several axes to the much-branched rhizoids.

Superficially the basal portion of the sporangium suggests an apophysis. However, the base is cup-like, and appears thick-walled when viewed in optical section.

In one collection, the sporangia of O. mucronatum were found scattered among hyphae of Aphanomyces in the same exuvium. It should be borne in mind, therefore, that other fungi may obscure this one on the substratum.

Rhizoclosmatium Petersen

THALLUS eucarpic, monocentric, consisting of an apophysate (broadly fusiform, subspherical, pyramidal or clavate) sporangium subtended by extensive, much-branched, delicate rhizoids. Sporangium inoperculate; discharge pore usually basal. Planonts forming in the sporangium, emerging in a vesicle then swimming away. Resting spores thick-walled; borne on rhizoids like the sporangia. On submerged insect exuviae.

This is a small genus of three species, one of which is marine. Only Rhizoclosmatium globosum Petersen is known to occur here; it is widely collected, and the most ubiquitous of the chytrids on exuviae.

Although the aspect of this species suggests a Phlyctochytrium the substratum is very different: the Rhizoclosmatium occurs on exuviae, the Phlyctochytrias (at least in this region) occur on algae.

Rhizidium Braun

THALLUS eucarpic, monocentric, consisting of a sporangium subtended by one main rhizoidal axis, and two or more secondary ones (in the species here); forming in the medium with the rhizoid tips only attached to the substrate. Sporangium inoperculate; nonapophysate. Planonts swarming in a vesicle outside the sporangial orifice. Resting spores thick-walled; borne on rhizoids like the sporangia. On cellophane bait.

Rhizidium varians Karling is the only species thus far recovered.

This species distorts to some extent the modern concept of the genus since specimens more often than not have two or more major rhizoidal axes, rather than a tap root-like single axis. Separating this species from the next, Rhizophlyctis rosea, therefore must depend in the final analysis on other characters (see R. rosea). The foregoing key to genera represents in a sense the ideal separation.

In the material at hand the sporangia are very large (65-120 μ in diameter) and produce profuse and much-branched rhizoids. Resting spores were absent in all the collections.

Large, slightly irregular sporangia with 2 or more discharge pores or papillae (giving the whole sporangium an angular aspect) and profusely-branched, stout rhizoids--on cellophane--are usually sufficient characters on which to base an identification.

Rhizophlyctis A. Fischer

THALLUS eucarpic, monocentric, consisting of a sporangium and several stout, branched or unbranched rhizoidal axes arising from it. Sporangia inoperculate; producing one or more discharge pores. Planonts formed within the sporangium. Resting spores thick-walled; borne on rhizoids like the sporangia. On cellophane bait (forming minute but distinctly rose-red granulations on the surface) in gross cultures of soil.

A single ubiquitous species: R. rosea (de Bary and Woronin) Fischer.

The sporangia of this species can, like those of Rhizidium varians, be quite large--up to 250 μ in diameter. Moreover, the multi-axis nature of the rhizoidal system in this Rhizophlyctis hardly separates satisfactorily all specimens from the Rhizidium. However, the rose-red color of the sporangia (before discharge) is distinctive.

Additional morphological work needs to be done on R. rosea, even though it is well-known from numerous collections around the world. Some investigators have described endooperculation in the fungus. (An endooperculum is a thin, hyaline membrane at the base of the discharge apparatus. Rupture of this membrane results in spore release.) Whether endooperculation is a regularly occurring feature is open to question, but the generic affiliation would change should this characteristic prove to be constant.

CLADOCHYTRIACEAE

Key to the Genera

A. Vegetative portion of thallus predominantly rhizoidal (though extensive), and possessing conspicuous irregular swellings and septate turbinate cells .....Cladochytrium (p. 58)

A. Vegetative portion of thallus predominantly hyphal, occasionally septate, but conspicuous swellings and turbinate cells absent; sporangia smooth and tuberculate.....Polychytrium (p. 59)

Cladochytrium Nowakowski, pro parte

THALLUS eucarpic, polycentric, largely endobiotic; consisting of an extensive, much-branched rhizoidal system (extending through many cells) with irregular swellings, prominent turbinate cells and intercalary sporangia or resting spores. Sporangia intercalary

or terminal (and apophysate) on short branches; inoperculate; proliferating; discharge tube present, persisting. Resting spores thick-walled, smooth (or spiny in some species); borne like the sporangia. In grass leaf bait.

There is but one species known in the area, C. replicatum Karling.

While collected only once (from a wet soil sample at the edge of "Ice House Pond"), the fungus was abundant in boiled grass leaves. The absence of an operculum separates this genus (and its species) from the Megachytriaceae.

Since the turbinate cells are obvious, this feature becomes the chief one for recognition.

Polychytrium Ajello

THALLUS eucarpic, polycentric, largely extramatrical; consisting of coarse, branched, extensive, hypha-like filaments which often also form rhizoids distally and laterally, and terminal or intercalary sporangia; turbinate cells or other conspicuous swellings absent. Sporangia often borne in pairs; some smooth-walled and ovoid, pyriform, obpyriform, ellipsoidal, or cylindrical; others spherical and conspicuously tuberculate; inoperculate; apophyses absent. Planonts formed within the sporangia, clustering at the exit tube orifice on emergence. On snakeskin bait in gross culture of bog water.

Polychytrium aggregatum Ajello is the only species in the genus. Previous records suggest that the fungus occurs only in bogs.

The tuberculate sporangia (15-25 μ in diameter) constitute the most conspicuous feature of this fungus. They may be mistaken for immature oögonia of a tuberculate Achlya, but of course they do not produce oöspores and the subtending "hyphae" are in part rhizoidal. Prior records include Brazil, Michigan, and North Carolina (unpublished).

CHYTRIDIACEAE

Key to the Genera

A. Occurring on submerged fruits; epi-endobiotic; the sporangium terminal on the broad apex of a conspicuous tap root-like, tubular rhizoidal axis, and separated from it by a concave cross wall which appears to form a slight flange at its junction with the wall.....Macrochytrium (p. 60)

A. Not occurring on submerged fruits, and sporangium not terminating a stout, conspicuous, tubular rhizoidal axis.....B

B. Sporangium epibiotic, rhizoids endobiotic.....C

B. Sporangium and rhizoids endobiotic. Nephrochytrium (p. 61)

C. Sporangium with a compound apophysis (two or more apophyses in chains subtending the sporangia) .....Catenochytridium (p. 61)

C. Sporangium with or without an apophysis, but if apophysate, only one apophysis is produced.....D

D. Occurring on Ceratium; sporangia small (6-16 μ in diameter).....Amphicypellus (p. 62)

D. Occurring on substrates other than Ceratium.....E

E. Occurring on snakeskin bait (and in insect exuviae); resting spore epibiotic.....Chytriomyces (p. 62)

E. Not occurring on snakeskin bait or in insect exuviae (locally); resting spore endobiotic..Chytridium (p. 63)

and Chytridium

The key characters separating Amphicypellus, Chytriomyces,/ (couplets D and E) may prove to be untenable--as distinctions among taxa (of the aquatic fungi) on substrate differences sometimes are. The position of the resting spore with respect to the substratum is the only sure way of separating Chytridium and Chytriomyces, but since resting spores are not always found associated with the sporangia reliance must for practical reasons be placed on substratum.

The habitat of the one species of Macrochytrium clearly separates it from other taxa in the family; the morphology of the plants suggests affinities with the blastocladiaceous fungi.

Macrochytrium Minden

THALLUS epi-endobiotic, monocentric, eucarpic; epibiotic portion forming a broadly ellipsoidal, subspherical or cylindrical sporangium cut off from the endobiotic portion by a concave septum. Sporangium operculate, the lid persisting after discharge; usually large (locally only 80-160 μ long by 60-110 μ in diameter). Rhizoidal system consisting of a coarse, long (200-300 μ), tubular axis divided basally into a complex of thick-walled, much-branched, root-like intramatrical system. On submerged fruits (locally in "Ice House Pond").

There is but one species in the genus: M. botrydioides Minden.

This fungus is the largest and perhaps the most spectacular of the monocentric, operculate chytrids. The single sporangium and its persistent operculum, terminating a tap root-like rhizoidal axis is distinctive. Resting spores are borne like the sporangia but were absent in the material at hand.

Though apparently not rare, M. botrydioides is easily overlooked on submerged fruits since it seems to be mixed in frequently with plants of Mindeniella. It can be found, however, by careful preparation of pustules: washing the pustules with a stream of water, and teasing apart the plants making up the cluster in the pustule.

All of the material at hand is much smaller than described for the species, but this is apparently not unusual; very small specimens are frequently seen in good developments of the fungus. Locally, the fungus has been found only in the stagnant water of "Ice House Pond" where considerable decaying vegetable matter occurs. A Denmark collection of this species came from a similar habitat.

Catenochytridium Berdan

THALLUS epi-endobiotic, eucarpic, monocentric; consisting of a globose, operculate, epibiotic sporangium subtended by a catenulate series of apophyses ending distally in a profusely branched rhizoidal system. Planonts emerging in mass and remaining quiescent for a time before swimming. Resting spores borne like the sporangia. On grass leaf bait in gross culture of agricultural soil.

Catenochytridium carolinianum Berdan is the only species to have been found in this region.

Specimens are easily recognized by the multiple apophyses (2-9 in a series). The fungus occurred on the bait after two and one-half weeks in gross culture.

Nephrochytrium Karling

THALLUS endobiotic, eucarpic, monocentric; consisting of a subspherical, flattened, depressed, or kidney-shaped sporangium subtended by an apophysis and coarse, much-branched, extensive rhizoids. Sporangia with one or more discharge tubes; apophysis small and spherical or long and tubular or spindle-shaped, and at right angle to the sporangium. Resting spores thick-walled; borne and shaped like the sporangia. On boiled grass leaf bait in gross culture of farm soil from the prairie region west of Lake Itasca.

This fungus remains unidentified to species. In shape and size the sporangia are clearly comparable to those of N. appendiculatum, but that species has been reported to occur only in Chara and Nitella. The substratum, in any event, is like that in which N. aurantium occurs, but in other features there is no substantial agreement. Since resting spores were not present in the material, there is no way to be certain of the identity of the collection with any of the known species in the genus.

The depressed, kidney-shaped sporangia may be considered the chief recognition feature of Nephrochytrium sp.

Amphicypellus Ingold

THALLUS monocentric, eucarpic, epi-endobiotic; consisting of an epibiotic sporangium and its apophysis, and an endobiotic rhizoidal system. Sporangium spherical; apophysate; operculate. Rhizoids of 2-4 main axes divided distally into fine, delicate branches. Planonts completing maturation outside the exit pore. On Ceratium.

This is a monotypic genus: A. elegans Ingold.

Only preserved material (on Ceratium from Elk Lake) was seen. The operculate nature of the sporangium--an earlier point of contention--has been confirmed by other investigators.

Small (6-16 μ diameter) spherical sporangia, with an epibiotic apophysis make A. elegans easily identifiable.

Chytriomyces Karling

THALLUS epi-endobiotic, monocentric, eucarpic; consisting of an epibiotic sporangium with or without an apophysis, and an endobiotic, branched rhizoidal system. Sporangium operculate; sessile. Planonts discharged into a vesicle before swimming. Resting spores epi-endobiotic, borne like the sporangia; thick-walled. On snakeskin bait (also reported to occur on exuviae, on diatoms, and on other fungi) in gross soil cultures.

One species, and that a very sparse development with two accompanying resting spores--C. aureus Karling--has been found locally. It is scarcely distinguishable on hasty examination from certain species of Chytridium or from Amphicypellus. Indeed, this particular Chytriomyces has no explicit feature to separate it from Amphicypellus save that of size and substratum.

Perhaps the only satisfactory way of distinguishing Chytriomyces aureus from species of Chytridium known locally is sporangial color. The undischarged sporangia of C. aureus are golden red. This is the most substantial separating feature if resting spores are not found. The resting spores of Chytriomyces are epi-endobiotic; those of Chytridium are endobiotic.

Chytriomyces hyalinus, a common inhabitant of bogs (collected on chitinous bait and on exuviae) should occur locally; it has not been thus far recovered. (See Sparrow, "Aquatic Phycomycetes," Second Ed., p. 541. Univ. Michigan Press: Ann Arbor. 1960.)

Chytridium Braun[1]

THALLUS epi-endobiotic, monocentric, eucarpic; consisting of an epibiotic, sessile sporangium subtended by an endobiotic rhizoidal system which is branched or unbranched, and with or without apophyses. Sporangium operculate. Resting spores endobiotic; thick-walled; often borne on a rhizoidal system. On algae.

KEY TO SPECIES

A. Sporangium apophysate; apophysis endobiotic and giving rise distally to the rhizoidal system.....B

A. Sporangium not apophysate; endobiotic rhizoidal system arising directly--and basally--from the sporangium.....F

B. Sporangium bearing a single, solid, apical spine, the mucronate operculum (sporangium ovate or pyriform; sessile or on a very short stalk; on Oedogonium)[2]
.....C. mucronatum* Sparrow and Barr

B. Sporangium without an apical spine, i.e., not having a mucronate operculum.....C

C. Sporangial wall completely smooth; without spines or lateral protuberances (sporangium sessile, spherical, subspherical, ovoid or urceolate; rhizoids much branched, stout, arising from a conspicuous apophysis; large apical pore formed on dehiscence of the operculum; on Cladophora)
.....C. lagenaria Schenk (pro parte)

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[1]Unless the operculum is seen, many of the species of Chytridium can easily be confused with members of Rhizophydium, Phlyctochytrium and other genera in the Phlyctidiaceae. The operculate nature of the sporangium is therefore diagnostically critical.

[2]Characteristics in ( ) are descriptive supplements, not antithetic key characters.

C. Sporangial wall with a small, bulbous or papillate protuberance at some point on its surface [the protuberance is the remnant of the planont cyst from which the sporangium developed].....D

D. Sporangium gibbose, somewhat tubular, erect, decumbent or situated at an oblique angle on the host cell (spore cyst basal; apophysis spherical or flattened, rhizoids arising laterally and oppositely; on Cladophora).....C. gibbosum Scherffel

D. Sporangium not gibbose, but may be procumbent; sporangium ovoid, ellipsoidal, pyriform, or obovoid (apical papilla prominent or low and somewhat obscure; rhizoids sparingly- or much-branched; on Oedogonium).....E

E. Sporangium distinctly obovoid; planont cyst attached to the sporangium wall by a narrow isthmus; apical papilla low and inconspicuous; sporangium erect on the host wall; rhizoidal axes rarely branched (sporangia usually larger than those of the next species).....C. oedogonii Couch

E. Sporangium ovoid, ellipsoidal, or pyriform, but not obovoid; erect or procumbent on the host wall; apical papilla prominent; planont cyst positioned basally or sublaterally on the sporangium wall, but not connected to it by a narrow isthmus; rhizoidal axes branched, extensive, occasionally extending into adjacent host cells, and sometimes becoming extramatrical; sporangia about 15 μ high by 10-12 μ in diameter.....C. schenkii (Schenk) Scherffel

F. Sporangium not apophysate, but subtended by a stout, tubular, irregularly inflated, endobiotic stalk branched distally into tenuous and much-branched rhizoids; sporangium ovoid or narrow urceolate; operculum with a conspicuous umbo that is not prolonged into a spine; on oögonia of Oedogonium (rhizoids often extending into the oöspore or zygote).....C. olla Braun

F. Sporangium not apophysate, and not subtended by a stout, tubular, irregular, endobiotic stalk; rhizoids arising directly from the base of the sporangium; sporangium pyriform, narrowly obpyriform, or pestle-shaped, but not ovoid, urceolate or spherical.....G

G. Sporangium narrowly obpyriform, often on a short, extramatrical stalk, and upright or tilted; rhizoids extremely delicate, or seen only as a slender endobiotic thread; sporangium with or without a knob-like base; apical operculum smooth, convex or arched; on Tribonema and on diatoms.....H

G. Sporangium narrowly pyriform; tilted on the substratum; usually asymmetrical; rhizoids tenuous, branched or (?)unbranched; on Spirogyra[1] (may also occur on Mougeotia and Zygnema).....C. sphaerocarpum Dangeard

H. On Tribonema.....C. lagenula Braun (pro parte)

H. On Synedra, Nitzschia, and Fragilaria (may also occur on Tabellaria and Melosira).....C. versatile Scherffel

Only operculate, epiendobiotic, monocentric fungi can be properly assigned to Chytridium as this genus is currently defined. Discharged sporangia without opercula may be of a Chytridium species without a persistent operculum, or a member of the Phlyctidiaceae. As the key indicates, some species are apophysate while others are not, hence this feature must be determined in identification.

The collection of Chytridium gibbosum is apparently the first record of its occurrence in North America.

MEGACHYTRIACEAE

Key to the Genera

A. Rhizoidal system very extensive and well developed, but without septa except where the reproductive cells are formed.....Nowakowskiella (p. 66)

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[1] Filamentous algae are the usual substrates for this very small fungus. However, one collection unquestionably of this species occurred on discharged ascospores floating in a baited gross culture of soil and water!

A. Rhizoidal system very extensive and well developed, and septate at intervals in addition to septa at regions where the reproductive cells are delimited; portions cut off by septa are frequently constricted at the septa.....Septochytrium (p.66)

Nowakowskiella Schroeter

THALLUS eucarpic, polycentric; endobiotic, extramatrical, or both; consisting of very extensive, stout and well-developed non-septate rhizoids bearing irregular or turbinate swellings, some of which are rudiments of the sporangia or resting spores. Sporangia borne by the rhizoids as terminal or intercalary segments; spherical, ovoid, or pyriform; operculate; generally apophysate. Resting spores thick-walled; borne like the sporangia. On cellophane bait in soil cultures.

KEY TO SPECIES

A. Swellings in rhizoids (turbinate or irregular) not septate; resting spores smooth-walled .....N. elegans (Nowakowski) Schroeter

A. Swellings in rhizoids (turbinate or irregular) distinctly septate, and often forming small but conspicuous masses of cells suggesting pseudoparenchyma; resting spores verrucose.....N. ramosa Butler

Both species produce extensive rhizoidal colonies, strongly polycentric, but N. elegans is the commoner of the two. The sporangia and turbinate cells are abundant and prominent, and in a vigorous culture there are numerous stages in the development of sporangia.

Butler's species produces small "pads" of small cells along the rhizoids. These masses, pseudoparenchymatous in general aspect, are multiseptate turbinate cells. In other features (since resting spores more often than not are absent), N. elegans and N. ramosa are very similar.

Septochytrium Berdan

THALLUS eucarpic, polycentric; consisting of very extensive, stout and well-developed rhizoids that are septate and constricted at intervals, and intercalary swellings. Sporangia borne by the rhizoids as terminal or intercalary swellings of various shapes; each provided with one stout and conspicuous, operculate discharge tube; apophyses sometimes present. Resting spore thick-walled, borne like the sporangia. In leaves of boiled wild rice (as bait).

One species, S. variabile Berdan, recognized by the constricted segments of the extensive rhizoids.

COELOMOMYCETACEAE

(A family of blastocladiaceous affinities--
with a single known genus)

Coelomomyces Keilin emend. Couch

THALLUS obligately parasitic in mosquito larvae; mycelial (and branched), but without septa, rhizoids, or wall; upon maturity forming thick-walled, smooth or ornamented resistant sporangia (resting bodies); these sporangia germinating by rupture of the thickened outer wall (a thin, smooth inner wall is present but difficult to detect) followed by gelatinization of the inner wall. In larvae of Anopheles locally.

There appear to be two species in mosquito larvae in this area, although others are certain to be recovered if extensive collections are made. The following key is based solely on the undischarged sporangia since developmental stages were not observed.

Finding the fungi in larvae presents no difficulty--although many specimens may have to be examined. Water containing larvae is brought into the laboratory. Individuals moving sluggishly or not at all (settling) are mounted on a slide and the abdominal portion pulled away from the thoracic-head segments. Tease the abdominal portion apart, then cover the preparation with a coverslip. Sporangia are found in the hemocoele of the insect.

In dealing with highly specialized fungi such as these, it is always wise to become familiar with the morphology of the host. Distinguishing fungus from host tissue is often impossible unless the structure of the host is first understood.

KEY TO SPECIES

A. Outer wall of sporangium with 5-8 narrow, unpitted bands; sporangia oval, 30-35 μ x 40-55 μ; outer layer brownish...C. lativittatus Couch and Dodge

A. Outer wall of sporangium with four prominent ridges which do not anastomose, but give the cell a quadangular, lobed, or multiangular aspect; 12-20 x 20-40 μ; ridges with closely set pits suggesting the striations on diatom valves; outer layer light brown .....C. quadrangulatus var. quadrangulatus Couch

CATENARIACEAE

(One genus and species represented)

Catenaria Sorokin

THALLUS eucarpic, endobiotic, polycentric; often extensive and hypha-like (but with rhizoids), branched or unbranched, and with septa delimiting reproductive and vegetative portions. Sporangia delimited as segments of the thallus, and separated by narrow isthmuses; catenulate; generally possessing a single discharge tube; pyriform, oval, ellipsoidal, spherical or slightly irregular and bursiform; planonts endogenously formed. Resting spores thick-walled, borne like the sporangia, and functioning like a sporangium. In eggs of a microscopic animal (unidentified).

The only species found in the Itasca region, C. anguillulae Sorokin, is (if the term can be properly applied to fungi) omnivorous. It has been reported in or on a variety of substrates such as Anguillulae, Gordius, Nitella, Chara, grass leaves and snakeskin, eggs of mites, rotifers (and their eggs) and nematodes, liverworts, and infusoria. The substratum in which the fungus has been found locally is possibly eggs of mites, in water.

Catenaria anguillulae is very positively polycentric; it may be recognized chiefly by the narrow isthmuses which connect the reproductive cells. Endochytrium species lack the inter-sporangial connections, are more strongly rhizoidal than Catenaria, and are operculate which C. anguillulae is not.

See Hyphochytrium catenoides, also occurring in the Itasca region.

BLASTOCLADIACEAE

Key to the Genera[1]

A. Thallus consisting of an unlobed, unbranched, filamentous basal cell producing distally dichotomously-formed pseudoseptate branches; setae not produced; general aspect of growth resembles the filamentous Saprolegniaceae; distinct gametangia and dark or pale brown, punctate meiosporangia produced terminally on separate thalli, but becoming lateral by sympodial or dichotomous branching; in gross cultures of soil.....Allomyces (p. 69)

[1] See supplemental note, page 71.

A. Thallus consisting of a simple (tree trunk-like), lobed or branched basal cell which can produce secondary, hypha-like (but nonseptate) branches bearing terminal, sessile sporangia, or without branches and producing sessile sporangia and punctate resting spores sessile on the end of the basal cell; setae present or absent; gametangia unknown; on submerged fruits.....Blastocladia (p. 70)

The growth habit of the species in these genera found in the Itasca area are very different: stout, dendroid plants in pustules (Blastocladia), slender, filamentous plants on bait in soil cultures (Allomyces).

Allomyces Butler

The key characters describe sufficiently, for recognition, the representative of this genus, Allomyces macrogynus (Emerson) Emerson and Wilson, but a note on culturing the fungus for speciation is not inappropriate.

Allomyces macrogynus has been found but twice (gametangia in one instance, meiosporangia in another), and in both cases on snakeskin bait in a water culture of soil from a cereal crop field in the prairie area west of Lake Itasca. It has not appeared on hempseed bait although this is the usual substratum on which to collect species of the genus. Collections on snakeskin (or on hempseed) usually must be further cultured if the gametangial-bearing hyphae are to be found, at least in any abundance. A simple procedure provides the thallus that produces gametangia and gametes (gametothallus; haploid):

Remove the infested bait from gross culture, place it on filter paper in the bottom of a Petri plate, and allow it to air dry for two or three days. Cut the filter paper (bearing the dry Allomyces) into a small square, and place paper and substratum in a clean dish. Add distilled water to the dish (about one-half full), and float two or three hempseed halves in the water. Cover the dish, and observe in two or three days for the production of hyphae on the hempseed. These hyphae should produce terminal gametangia from which gamete discharge may often be observed if the colonies are examined under low power, intact on the substratum. Within 4-7 days, additional hyphae should develop on the hempseed, intermingled with those of the gametothallus. Hyaline, single, terminal or lateral mitosporangia and brown to yellow-brown, single, terminal or lateral, thick-walled, punctate meiosporangia should be in evidence. Hyphae bearing such cells are parts of the sporo-

thallus (diploid). Repeated drying and wetting of the meiosporangia will permit the development of the gametothallus at will, hence the cultures of Allomyces may be saved and repropagated as wanted. It is wise, however, to clean the initial culture by growing hyphae on cornmeal agar, and then transferring bacterial-free hyphal tips back to hempseed in water (remove a plug or square of agar bearing hyphal tips, place the plug or square in a dish, add distilled water and float hempseed halves in the water).

Allomyces macrogynus is recognized by the terminal male gametangium subtended by an adjacent, longer female gametangium. It is possible that A. arbuscula occurs in the area; if so, it can be identified by its terminal female gametangium and subterminal male.

Blastocladia Reinsch

The key characters are sufficient for recognition of species in this genus; on submerged apples and twigs, in traps. (Can be collected on twigs in "Ice House Pond"; mixed with Rhipidium or Mindeniella in pustules.)

KEY TO SPECIES

A. Basal cell clavate or globose; if lobed, the branches are clavate; sporangia usually cylindrical.....B

A. Basal cell cylindrical; branching repeatedly at the apex to form two to several slightly tapering branches; sporangia with a prominent beak (apical papillus); whole thallus open and ramose.....B. ramosa Thaxter

B. Basal cell clavate (even if reduced in diameter); if lobed or simply branched, these are also clavate..B. pringsheimii Reinsch

B. Basal cell globose, with a short stalk or none; not branched or lobed.....B. globosa Kanouse

Blastocladia pringsheimii is the common representative on submerged apples where it may often occur in pustules intermixed with Mindeniella spinosa. The distinction between Blastocladia species and Mindeniella (aside from uniflagellate versus biflagellate planonts) is clear cut and obvious on careful examination. The sporangia and resting spores of all species

of Blastocladia are sessile on the basal cell (or its branches); in Mindeniella, these structures always occur on short pedicels (stalks) attached to and part of the basal cell.

Numerous variations in extent and configuation of the basal cell occurs in B. pringsheimii, particularly in the smaller or incompletely-formed individuals.

One small and poorly developed series of specimens of what is possibly Blastocladia prolifera was recovered from pustules on one apple submerged in Lake Itasca. The collection was too scanty and the specimens too ill-defined morphologically to confirm the identity. It is accordingly a doubtful determination.

Supplemental note on the Blastocladiaceae

In a single collection of soil (baited with snakeskin) from agricultural prairie land near Waubun, a fungus developed which has characteristics recalling Blastocladiopsis parva (Whiffen) Sparrow. The development on the bait surface was too sparse to be identified with confidence, but its similarity to this monotypic genus is too strong to be ignored. A description follows:

"Thallus filamentous, sparse, lacking a conspicuous basal cell, lying on the surface of the substratum; consisting of a few dichotomously branched hyphae anchored to the substratum by a system of coarse but not extensive rhizoids; hyphae each terminated by a pyriform cell in which lies loosely a single, spherical or ovoid, yellow or amber, smooth-walled, unpitted resting spore."

There were no sporangia. Superficially the fungus suggests a water mold such as a Dictyuchus with a single oöspore in the oögonium. The resting spores are assuredly not like an oöspore, lacking as they do the oil deposit pattern of water mold "eggs." Absence of sporangia is characteristic of B. parva; in any case they are rarely observed.

Blastocladiopsis parva has been reported in the literature only from tropical, subtropical or southern temperate soils. This rather restricted distribution throws some doubt--but not conclusive--on the tentative identification proposed.

GONAPODYACEAE

(A single genus represented)

Gonapodya Fischer

THALLUS mycelial; irregularly or dichotomously branched; usually extensive, attached to the substratum by coarse rhizoids; hyphae consisting of moniliform segments separated by constricted pseudosepta, and occasionally showing a reticulate or "foamy" pattern of cytoplasmic distribution. Sporangia terminal and sessile on the hypha or on a very conspicuous cylindrical constriction; long, pod-shaped, inflated proximally, sometimes tapering distally to a blunt apex; proliferating internally. Gametangia borne terminally in fascicles; female gametangia similar in shape and position to the sporangia, male gametangia smaller and more slender; proliferating internally. On twigs and apples (in traps).

Gonapodya prolifera (Cornu) Fischer, occurring locally, is a rather common and variable species most likely to be found accompanying Rhipidium, Mindeniella, and Sapromyces on twigs or apples in foul, stagnant water ("Ice House Pond"). It is inconspicuous, and may be mistaken on casual observation for immature or somewhat branched and aborted specimens of other fungi in the same pustules. Specifically, however, it is recognized by the pod-like segments of the hyphae separated by deep constrictions and short "isthmus-like" pseudosepta. The sporangia (the only reproductive structures observed) are likewise pod-shaped or siliquiform.

Gonapodya polymorpha Thaxter, the less common member of the genus should occur here; it may be sought in quiet waters with a minimum of stagnation and fouling.

Although the Gonapodyas have constricted hyphae, and thus might be thought to be members of the Leptomitales, the planonts are uniflagellate and the constrictions do not contain cellulin plugs as do those of the leptomitaceous fungi.

MONOBLEPHARIDACEAE

(A monogeneric family)

Monoblepharis Cornu

HYPHAE slender, branched or unbranched; content disposed in a reticulate fashion giving the filaments a foamy internal aspect.

Sporangia terminal, cylindrical; renewed by internal proliferation or sympodially. Oögonia terminal or intercalary; pyriform to spherical; possessing a well-defined, broad, apical papilla; single egg produced. Antheridia cylindrical, bearing a few endogenous antherozoöids. Oöspheres, after fertilization, remaining in the oögonium or emerging from it (but not motile); thick-walled. On twigs in clear, cooler waters.

KEY TO SPECIES

A. Antheridia hypogynous or (in young plants) on branches separate from the oögonia .....M. macrandra (Lagerheim) Woronin

A. Antheridia exigynous (i.e., arising on the oögonial wall).....M. polymorpha Cornu

These fungi have proven to be extremely sparse, although they must surely occur in abundance in many aquatic habitats locally. Depauperate specimens of the two species were found once on a birch twig incubated at 11°C for three and one-half weeks.

Recognition of Monoblepharis is relatively simple: slender hyphae with a reticulate or foamy cytoplasm. Distinguishing the two species may prove difficult if older material is secured. The sporangia (absent in the material at hand) in both are long and cylindrical, and the oöspores are provided with similar bullations on the wall surface. Antheridial origin thus becomes the chief feature on which determinations are made.

PLASMODIOPHORACEAE

(A single genus known to be represented)

Woronina Cornu

THALLUS endobiotic, holocarpic; converting into several to many spherical, hyaline sporangia in delimited portions of the host hyphae; segments of host hyphae swollen and slightly irregular. Sporangia small, 10-15 μ in diameter, thin-walled; provided with an inconspicuous, short exit papilla. Cysts produced in some hyphal segments; yellow-brown, subspherical to slightly angular; 4-8 μ in diameter; thick-walled. In Saprolegnia sp. on submerged twig.

Woronina polycystis Cornu.

This species, like others in the Plasmodiophoraceae, produces biflagellate, heterokont planonts, but these were not seen in the material at hand. Cysts, however, were plentiful and it is on this basis that the species were identified. Cystosori of resting spores were absent, although in aged material such spherical or cylindrical clusters of small, brown, angular spores might be expected to occur.

Casual observation of infected hyphae would suggest that the numerous spore-like sporangia in the distal portion of the filaments were merely cysts of undischarged Saprolegnia planonts. The size of these sporangia of Woronina is at least twice that of encysted Saprolegnia spores.

OLPIDIOPSIDACEAE

Key to the Genera

A. Sporangia lobed and tubular; possessing more than a single discharge tube; resting spores unknown.....Petersenia (p. 74)

A. Sporangia spherical or ellipsoidal; possessing a single discharge tube; resting spores often present, these thick-walled and ornamented and usually accompanied by one or more small, attached companion cells.....Olpidiopsis (p. 75)

Petersenia Sparrow

THALLUS endobiotic, holocarpic; converting into a tubular, irregular, lobed sporangium with two or more discharge tubes. Resting spores unknown. In the apices of hyphae of Achlya sp. on a submerged twig.

A single representative, P. irregulare (Constantineanu) Sparrow.

Apparently uncommon if not rare, having been found only once. The small, lobed sporangia in the swollen tips of Achlya hyphae are quite different from the spherical or ellipsoidal ones of Olpidiopsis which may also occur in Achlya mycelium.

The identity of the fungus in the single collection must remain tentative; planont discharge was not observed. This particular Petersenia is known to discharge its spores following

a short period of motility within the sporangium; the planonts swim away from the exit orifice immediately upon emergence.

Olpidiopsis Cornu

THALLUS endobiotic, holocarpic; converting into sporangia or resting spores, or both. Sporangia olpidioid, spherical, ellipsoidal, or fusiform, rarely long or short cylindrical; one to several discharge tubes; smooth walled or spiny. Resting spores smooth or ornamented; spherical or oval; endobiotic; thick-walled; with or without companion cells. Parasitic in Saprolegniaceae (in this region).

KEY TO SPECIES

A. Resting spore smooth or with a distinctly spiny or serrate wall, or provided with fibril-like ornamentations.....B

A. Resting spore wall undulate or provided with bullations; not spiny; in Achlya hyphae.....O. incrassata Cornu

B. Companion cell smooth-walled.....C

B. Companion cell with a spiny wall; in Achlya (flagellata) and A. prolifera (on submerged twigs).....O. varians Shanor

C. In Saprolegnia..O. saprolegniae var. saprolegniae (Braun) Cornu

C. In Achlya or Aphanomyces.....D

D. In hyphae of Achlya.....E

D. In hyphae of Aphanomyces.....F

E. Resting spores sparingly spiny, but these joined basally to form a reticulate pattern over the wall surface; sporangia fusiform, ellipsoidal, or cylindrical.....O. fusiformis Cornu

E. Resting spore wall undulate or serrate, or provided with fibrillae or broad spines, but if spiny, these not united basally to form a reticulum; sporangia spherical, oval, or ellipsoidal.....O. achlyae McLarty

F. Resting spores ornamented with conspicuous, coarse spines; wall hyaline or faintly yellowish; sporangia oval to spherical; companion cells frequently oval or ellipsoidal.....O. luxurians Barrett

F. Resting spores ornamented with short, fine spines or with wart-like protrusions; wall distinctly brown; sporangia spherical or ellipsoidal.....O. aphanomycis Cornu

These curious, endophytic, parasitic fungi consist of two "phases": the sporangia and resting spores. These two portions of the thallus are not connected, and do not necessarily (unfortunately) always occur together in the same filaments of the host fungus. It is therefore sometimes impossible to conclude with certainty that separate sporangia and resting spores even in adjoining filaments are of the same species--and the resting spores of some species can be distinguished from one another only with the greatest difficulty. Some attention has been given to cross inoculation studies to determine if there is or is not some measure of host specificity. These studies have not provided conclusive evidence in all cases. The foregoing key, based as it is on resting spore characters and host, is somewhat idealistic.

Since the sporangia are olpidioid, they cannot, if spore discharge is not seen, be identified with Olpidiopsis. Species of Olpidium and Anisolpidium have remarkably similar sporangia. Thick-walled (usually ornamented) resting spores with one or more attached companion cells are certain to be Olpidiopsis (but some specimens and species lack companion cells!)

See also, Rozella and Woronina.

Olpidiopsis fusiformis has been recovered thus far only in hyphae of Achlya sp. growing on submerged fruits (in Lake Itasca).

The separation of O. luxurians and O. aphanomycis will likely prove to be untenable; indeed the species are hardly sufficiently distinct enough to be maintained as separate entities.

LAGENIDIACEAE

Key to the Genera

A. Thallus unbranched, strongly constricted at septa; sporangia occurring in bead- or link-like chains, not disarticulating....Myzocytium (p. 77)

A. Thallus branched or unbranched; when septate, not constricted; segments often irregular, but not a link-like series.....Lagenidium (p. 77)

Myzocytium Schenk

THALLUS endobiotic, holocarpic, tubular, unbranched; converting into one sporangium or dividing transversely into a linear series of link-like, connected sporangia. Sporangium with a single discharge tube; planonts completing maturation in a spherical mass at the exit orifice, then swimming away without encysting. In Closterium.

A single species known to occur in the region: M. proliferum Schenk.

This fungus has been reported elsewhere in Spirogyra, Mougeotia and Cladophora, and should be sought locally in specimens of these algae.

Myzocytium proliferum produces oöspores in sporangium-like gametangia. The oöspores lie free in the gametangium, and have a thick wall and conspicuous oil droplet.

From Achlyogeton entophytum, which it resembles, this species is distinguished by lack of an encystment stage of the planonts at the exit orifice. The distinctions between M. proliferum and Ancylistes closterii, also an invader of Closterium, are treated in the discussion of the latter.

Lagenidium Schenk

THALLUS endobiotic, holocarpic; one-celled or saccate or extensive and sparingly branched; entire thallus or segments of transversely septate saccate cells converting into sporangia or gametangia; cytoplasmic content usually containing numerous, irregular, refractive bodies. Sporangia provided with a single discharge tube. Planonts formed within the sporangium or in an extramatrical vesicle. Gametangia produced as segments of the thallus, shaped like the sporangia; oöspore formed loosely in the female gametangium; male

gametangium adjacent. Oospore thick-walled; bearing a large, refractive oil globule. In Oedogonium, Nitzschia, Spirogyra, and pine pollen (also in grass leaves used as bait, and in Wolffia).

Species of Lagenidium seem relatively common in the Itasca region. However, the genus is a particularly difficult and complex one, and the habitats of its species often makes it difficult to determine morphological details in situ. Accordingly, and for practical reasons of identification, the key to species is in large measure based on host (or substratum) rather than morphology.

Saccate, tubular, or even short hypha-like thalli in various algae should be suspected as members of Lagenidium, although this is by no means an unalterable clue to their presence. Lagenidium and Myzocytium specimens, when they fail to sporulate or are otherwise poorly developed, often may not be classified confidently in either genus. In Closterium alone, a Lagenidium, a Myzocytium, a species of Olpidium, and Ancylistes closterii, occur locally--though fortunately not in the same specimens!

KEY TO SPECIES

A. Thallus not septate; forming a single reproductive unit (sporangium or gametangium); not extensive and mycelial (but may be lobed or sparingly branched) and when in filamentous algae not extending from cell to cell; in Nitzschia (likely also in Synedra) and in vegetative cells of Oedogonium.....B

A. Thallus usually septate and then forming more than one reproductive center (or if forming a single sporangium or gametangium, then occurring in pine pollen), or extensive and mycelial; not known locally to occur in diatoms, but occurring in green algae, Conjugatae, desmids, and pollen (bait).....C

B. In Nitzschia (and probably also in Synedra); thallus tubular, predominantly unbranched or with short, tubular, finger-like branches lying parallel to the long axis of the host; discharge tube short, thick-walled, and functioning in forcing apart the diatom valves .....L. brachystomum* Scherffel

B. In Oedogonium; thallus irregularly saccate or ovoid, sometimes with broad, finger-like lobes, occasionally simply tubular; discharge tube short, not thick-walled, constricted in its position through the host wall.....L. oedogonii Scherffel

C. Thallus very extensive and mycelial; branched; sometimes expanded and irregular or twisted; ramifying through several host cells when in filamentous algae, then sparingly branched; in Closterium and Oedogonium.....D

C. Thallus tubular and often contorted, irregular, and simply branched or lobulate; septate even though forming a single sporangium (in pine pollen); occurring in pine pollen, in zygospores of Spirogyra, and in the vegetative cells of Spirogyra (may also occur in the vegetative cells of Oedogonium but then not mycelial and extensive, and not extending through several cells).....E

D. In Closterium; thallus septate, mycelium-like, extensive and branched; discharge tube with a pronounced spherical or sub-spherical swelling just beneath the host wall.....L. closterii de Wildeman

D. In Oedogonium; thallus septate, mycelium-like, extensive and sparingly branched but extending through several host cells; discharge tube lacking a spherical or sub-spherical swelling below the host wall .....L. marchalianum de Wildeman

E. In pine pollen; thallus tubular, contorted, spherical, or with irregular lobes, sometimes ovoid or ellipsoidal; becoming septate to produce (usually) a single sporangium or gametangium.....L. pygmaeum* Zopf

E. In vegetative cells of Spirogyra or in the zygospores of Spirogyra; thallus forming more than one sporangium, regularly or irregularly tubular and often lobulate.....F

F. In zygospores of Spirogyra; thallus with thick, refractive septa; irregularly contorted; sporangia more than one .....L. entophytum (Pringsheim) Zopf

F. In vegetative cells of Spirogyra (may occur also in Oedogonium and Mougeotia); thallus not extensive; tubular, with short or long clavate, crooked or irregular branches; 1-8 or 10 sporangia commonly produced; thallus occupying a single host cell .....L. rabenhorstii Zopf

Several unidentified species of Lagenidium have appeared in collections. One in Wolffia, and a second in grass leaf bait (in gross culture of prairie soil) have not been completely characterized, and stages in the developmental morphology are obscurely known.

LEPTOMITACEAE

Key to the Genera

A. Sexual apparatus absent; hyphae constricted and coarse; sporangia merely undifferentiated apical portions of hyphae.....Leptomitus (p. 80)

A. Sexual apparatus present; hyphae constricted but delicate; sporangia obviously differentiated from the hyphae, and pedicellate.....Apodachlya (p. 81)

Leptomitus Agardh

THALLUS filamentous, the hyphae constricted, with branches arising at the constrictions. Sporangia cylindrical, terminal or arising in basipetalous fashion; formed from unspecialized segments of the hyphae or their branches. Planonts in a single row in the sporangium; swimming away immediately on discharge. Sexual apparatus absent. On various bits of organic matter in polluted waters or waters of high organic content (collected on hempseed bait).

A single species, L. lacteus (Roth) Agardh, with characteristics of the genus.

Thus far known only from hempseed bait in water and organic detritus at the sewage inflow at the disposal ponds. (See remarks under Apodachlya.)

Apodachlya Pringsheim

THALLUS mycelial throughout, the hyphae distinctly constricted, often much branched. Sporangia differentiated from the hyphae, pedicellate, ovoid, pyriform or ellipsoidal, terminally or sympodially arranged. Oögonia with a single oöspore, and subtended by a link-like antheridial cell. On submerged twigs and fruits.

KEY TO SPECIES

A. Planonts not encysting at sporangial orifice.....A. brachynema (Hildebrand) Pringsheim

A. Planonts encysting[1] at sporangial orifice.....A. pyrifera Zopf

There are other morphological features which serve to distinguish these two species, but the key shows the chief distinction.

From Leptomitus lacteus, which rarely if ever occurs in the same waters as members of Apodachlya, the two known species are distinguished by these features: (1) oögonia are produced (absent in Leptomitus), and (2) the sporangia are differentiated from the hyphae (in Leptomitus they are cylindrical and have the same diameter as the hyphae, or are only very slightly larger).

These two species occur commonly in pustules (on twigs incubated at 20-23° C for 3-7 days) containing coarse, long hyphae of an Achlya species; the Apodachlya filaments, in mass, have a lustrous, gray cast.

RHIPIDIACEAE

Key to the Genera

A. Basal cell poorly differentiated; thallus filamentous; giving rise apically to hyphae-like branches (sometimes irregular and contorted) which produce the reproductive cells distally; obvious constrictions at the juncture of basal cell with the first order of branches, and at other distal branches.....Sapromyces (p. 62)

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[1]The cysts may be empty, indicating that the spore has gone into a motile phase.

A. Basal cell well-defined and usually stout.....B

B. Basal cell giving rise to hyphal branches that may be constricted at their juncture with the basal cell; hyphal branches often giving the upper portion of the thallus an umbellate aspect.....C

B. Basal cell not giving rise to hyphal branches, though the apex of the cell may be slightly branched or lobed (but no constrictions at these lobes); reproductive cells positioned directly on the basal cell on short pedicels..Mindeniella (p. 83)

C. Sporangia smooth-walled; oöspore wall conspicuously reticulate (appearing shrunken and consequently wrinkled).....Rhipidium (p. 84)

C. Sporangia smooth- and spiny-walled; oöspore wall cellular (appearing like a ring of small cells around a central oöplasm).....Araiospora (p. 84)

Sapromyces Fritsch

THALLUS consisting of a poorly differentiated but usually long and filamentous basal cell from the apex of which a few slender and umbellately branched, constricted filaments arise. Sporangia smooth-walled, occurring in whorls or umbels at the tips of the hyphae, or lateral. Oögonia borne like the sporangia; containing a single, rough-walled oöspore; content differentiated into oöplasm and periplasm. Antheridia borne at the tip of short or long prolongations of constricted hyphal segments. On twigs and on submerged apples ("Ice House Pond").

KEY TO SPECIES

A. Antheridia androgynous.....S. androgynus Thaxter

A. Antheridia diclinous.....S. elongatus (Cornu) Coker

These are two of the three known species in the genus. Both occur locally on submerged twigs in cool, clear water (such as La Salle Creek), and in waters with a high organic content.

Recognized by the pedicellate sporangia and the filamentous nature of the basal cell. This cell is much more slender and elongate than the basal cell of Araiospora, hence the whole aspect is one of a sparingly branched mycelium. No spiny-walled sporangia are produced by Sapromyces as is the case in Araiospora.

Fragments of thalli may be confused with Rhipidium. The sporangia of Rhipidium are more spherical, and the oöspore is stellate rather than being merely roughened. In Rhipidium, too, the basal cell (in the species in this area) is usually well-developed and obvious.

Mindeniella Kanouse

THALLUS consisting of a stout, conspicuous basal cell anchored to the substratum by stout, branched, rhizoid-like holdfasts; basal cell narrowly— or broadly-clavate or cylindrical; sometimes with short, broad, lateral lobes; when immature, appearing almost hypha-like; conspicuously and irregularly thick-walled. Sporangia smooth or spiny; clavate, ovate, short-ovoid or short-pyriform; borne on short pedicels (filled with a cellulin plug) directly on the basal cell. Resting spores pedicellate, borne like the sporangia; spiny. On submerged apples and twigs (in traps); abundant in "Ice House Pond."

Both known species occur; they are separated by the following key characters. Plants of the two species may occur intermingled in the same pustules or in separate ones. Mindeniella spinospora is the more abundant of the two.

KEY TO SPECIES

A. Basal cell clavate or cylindrical.....M. spinospora Kanouse

A. Basal cell bent-clavate (inverted boot-shaped, or like a "chicken-leg").....M. asymmetria Johnson

Mindeniella spinospora and Blastocladia pringsheimii can be found in pustules on the same fruits, and in basal cell characteristics seem quite similar. However, the reproductive cells of the Mindeniella are always stalked (on a small pedicel), and there are no setae arising from the basal cell and intermingled with the sporangia. Setae are present in the Blastocladia, and the reproductive cells are sessile.

Mindeniella spinospora has a wide variety of growth forms. Basal cells with lateral, pedicellate sporangia (as well as terminal ones) seem common in some pustules.

Rhipidium Cornu

THALLUS consisting of a well-defined cylindrical main axis or basal cell (sometimes slender and not conspicuous) anchored to the substratum by a branched, filamentous holdfast system; apex thick-walled, expanded, lobed, irregular or branched; hyphal branches, pedicellate at the base, arising from the apex of the main axis. Reproductive cells pedicellate on the branches or on the main axis; single or in umbellate clusters. Sporangia apical and pedicellate, but becoming lateral by sympodial branching from below; possessing a single, apical discharge papilla. Oögonia pedicellate; containing a single areolate or stellate oöspore. Antheridial branche androgynous, monoclinous, or diclinous. On submerged fruits (apples in traps), and on twigs, in traps, in "Ice House Pond."

KEY TO SPECIES

A. Antheridial branch androgynous; the branch short, arched, arising immediately below the oögonium.....R. americanum Thaxter

A. Antheridial branch diclinous.....R. interruptum Cornu

The Rhipidias are among the most striking of the fungi to develop on submerged fruits and twigs where they occur in white, gummy pustules.

The thallus of both species is extremely variable, ranging from an obvious, thickened basal cell to a filamentous one; the apical portion from which the reproductive cells arise is also quite variable. Both species have the same growth habit, and can be distinguished only on the basis of the antheridial branch origin. Specimens lacking the sexual apparatus cannot be assigned with any degree of confidence to either species. Certainly the Rhipidias are readily separated from plants of Blastocladia and Mindeniella (which often occur in pustules on the same substratum), since the common species in these two genera have well-defined basal cells.

Sapromyces species are much more filamentous than are species of Rhipidium, and, of course, have branched (but constricted) hyphae.

Araiospora Thaxter

THALLUS a well-developed basal cell, anchored by branched, contorted endobiotic holdfasts, and terminating in umbellately

branched, constricted, cylindrical filaments on which the reproductive cells are borne. Sporangia in whorls or umbels at the tips of filaments; pedicellate; of two types, smooth and spiny. Oögonia borne like the sporangia; pedicellate; containing a single oospore differentiated into oöplasm and periplasm; shiny, golden in context. Antheridia terminal from unspecialized branches. On submerged twigs (aspen in this area).

A single species known to occur: A. pulchra Thaxter.

While pustules may be formed, and the Araiospora grow in conjunction with other fungi, it most often appears on twigs as separate plants. The growth of the plants is a delicate, symmetrical arborescent habit, and can easily be recognized in gross culture by the golden, finely reticulate oöspores. Seldom collected, but probably not rare.

Broken or incomplete specimens of A. pulchra might be confused with species of Sapromyces or Rhipidium (also in the family Rhipidiaceae). The Araiospora, however, has the two sporangial types, smooth and spiny.

ECTROGELLACEAE

(One genus and species represented)

Aphanomycopsis Scherffel

THALLUS endobiotic, holocarpic; one-celled, broad, tubular, branched or unbranched; becoming a single sporangium, or a portion converting into thick-walled, spherical oöspores (resting spores). Sporangia provided with one or more long, slender discharge tubes that may be thickened at the base (intramatrically). Planonts encysting and clustering at the discharge tube orifice, and then emerging individually from the cysts to become motile.[1] In Pinnularia.

Aphanomycopsis bacillariacearum Scherffel.

Irregular, contorted, tubular and branched, empty, endobiotic thalli (sporangia) with one, two or three extramatrical discharge tubes were found in a preserved collection of phytoplankton previously collected. The two observed instances of clustered cysts at the discharge tube orifice confirm the identity satisfactorily.

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[1] From published descriptive matter; emergence of planonts was not of course seen in the preserved material.

Although the clusters of spore cysts suggest Achlyogeton entophytum, that species has an elongate thallus segmented into a linear series of sporangia, each with its own discharge tube.

SAPROLEGNIACEAE

Key to the Genera

A. Emergent (from the substratum) hyphae absent; hyphae irregular, branched, confined to surface of snakeskin baits; converting into sporangia or resting spores.....Leptolegniella (p. 87)

A. Emergent hyphae present; only a portion converted into sporangia; resting spores absent, but oögonia and antheridia usually present.....B

B. Sporangia terminal on hyphae, filamentous and not distinctly different from the hyphae; spores in a single row.....C

B. Sporangia terminal (or lateral by sympodial branching), but not filamentous; distinctly different from the hyphae, and spores not in a single row.....D

C. Spores emerging singly from the sporangial exit pore and clustering in a spherical mass at the orifice; planonts later emerging singly from the cysts, leaving a spherical cluster of hyaline, empty cysts at the orifice.....Aphanomyces (p. 88)

C. Spores emerging singly from the sporangial exit pore (they are elongate as they move through the sporangium) and swimming away immediately from the orifice.....Leptolegnia (p. 89)

D. Sporangia oval, spherical or pyriform; bearing a single, apical papilla.....Pythiopsis (p. 89)

D. Sporangia elongate, cylindrical, clavate or broadly ovoid; apical papilla absent.....E

E. Planonts, on emergence, swimming away immediately from the exit orifice; renewed by internal proliferation.....Saprolegnia[1] (p. 90)

E. Planonts not swimming away on discharge (clustering at the exit pore) or emerging from the sporangium individually and leaving the cysts intact within the sporangium; renewed by sympodial branching.....F

F. Planonts clustering in a loose, hollow sphere at the sporangial orifice; later emerging individually and swimming away to leave a ball of empty, hyaline cysts at the orifice.....Achlya[1] (p. 92)

F. Planonts not leaving the sporangium as a mass, but emerging individually and leaving the cyst walls intact within the sporangium to give it a net-like internal appearance.....Dictyuchus (p. 95)

Leptolegniella Huneycutt

MYCELIUM intramatrical (on snakeskin, on the surface), consisting of much-branched, irregular hyphae that show occasional septation. Sporangia not differentiated from the vegetative hyphae. Planonts in single rows in the sporangia; emerging and swimming individually. Spherical, thick-walled resting spores formed in undifferentiated hyphae like the sporangia. On snakeskin bait (in cultures of wet soil).

A single species represented: L. keratinophilum Huneycutt.

This fungus forms irregularly branched, somewhat contorted hyphae (that convert to sporangia or bear endogenous resting spores) on the surface of snakeskin bait. The hyphae tend to be conglomerated in "centers" on the substratum.

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[1]The genus Isoachlya has long been recognized as a group in which the representatives have both an internal (as in Saprolegnia) and a sympodial (as in Achlya) mechanism for renewal of the sporangia. The planonts are released and behave like those in Saprolegnia. All valid and recognizable species of Isoachlya have recently been assigned to the genus Saprolegnia, thus reducing Isoachlya to synonymy.

Aphanomyces de Bary

HYPHAE delicate, long, sparingly branched. Sporangia long, filamentous, not proliferating internally; of same diameter as hyphae (formed from undifferentiated hyphae). Planonts in a single row in the sporangium; emerging and encysting in a spherical cluster at the terminal orifice; escaping individually leaving the cysts intact. Oögonia smooth-walled or ornamented; with a single oöspore containing a large, refractive globule. Antheridial branches diclinous, monoclinous, or androgynous. On insect exuviae, and on grass leaves, cellophane and snakeskin baits (in this region).

KEY TO SPECIES

A. Outer surface of oögonial wall smooth.....D

A. Outer surface of oögonial wall roughened, spiny, or tuberculate.....B

B. Oögonial wall merely roughened; spiny or tuberculate ornamentations absent..A. irregulare Scott

B. Oögonial wall ornamented with spines or tubercles.....C

C. Oögonial wall covered with short, sharp-pointed spines.....A. scaber de Bary

C. Oögonial wall covered with short, bluntly-conical tubercles.....A. stellatus de Bary

D. Antheridial branches coiling about the oögonium, its stalk, and its attendant hypha.....A. helicoides Minden

D. Antheridial branches diclinous or monoclinous but not coiling around the oögonium, its stalk, or the attendant hypha.....A. laevis de Bary

Species of Aphanomyces are extremely common, and seldom fail to be found on insect exuviae, or on chitinous baits. They should be sought for on bits of boiled grass leaf baits as well. Aphanomyces laevis predominates.

These fungi are readily recognized by the spores in a single row in the sporangia, or, in the case of discharged sporangia, by the small, spherical clusters of encysted planonts

at the sporangial orifice. Representatives of other genera also have this achlyoid type of spore discharge, or have planonts produced in a single row. In this region, these are:

Achlyogeton and Aphanomycopsis--endobiotic, holocarpic. (Remaining three genera are eucarpic.)

Apodachlya--spores not in a single row, but clustering at orifice.

Leptomitus--spores not clustering at orifice, but in a single row.

Leptolegnia--spores in a single row, but not clustering at orifice. The genus Brevilegnia also has some species with spores in a single row, but not clustering; the planonts escape by sporangial deliquescence. Members of this genus have not been found in the Itasca area.

Scott's monograph (Tech. Bull. 151, Virginia Agr. Exp. Sta., 1961) is taken as the authority for separation and recognition of the three species with ornamented oögonia. His monograph should be consulted for specifics.

Leptolegnia de Bary

HYPHAE slender, sparingly branched, septate at points of origin of reproductive cells. Sporangia terminal, cylindrical, of the same diameter as the hypha; sometimes branched; renewed by sympodial branching; planonts in a single row, elongate while emerging through the sporangium, and swimming immediately upon discharge. Oögonia (when present) smooth or warted, lateral, unpitted, generally spherical or subspherical. Antheridia (when present) diclinous or androgynous. Oöspores one per oögonium; eccentric. On hempseed bait in gross cultures of muck soil and detritus.

Leptolegnia caudata de Bary is the only species thus far recovered from soil locally. It is characterized sexually by beaked (slightly apiculate) oögonia, a single oöspore, and diclinous antheridial branches.

Some nonfruiting specimens have been collected: Leptolegnia sp.

Pythiopsis de Bary

HYPHAE branched, slender. Sporangia terminal, but renewed sympodially by lateral ones from hyphae below discharged ones; oval, spherical, or pyriform, with a distinct apical papilla.

Oögonia resembling the sporangia when immature; spherical, oval, or pyriform; walls smooth, wavy or papillate, unpitted; producing one to a few oöspores. Antheridial branches arising near the oögonia; predominantly androgynous. On twigs and grass leaves (bait).

None of the specimens has been identified to species, lacking as they do, the sexual apparatus. On the basis of sporangial characters alone, most material seems to be allied to Pythiopsis cymosa de Bary.

Distinguished from Pythium species (which have rather similar slender hyphae) by the distinctly apiculate sporangia, and the Saprolegnia-type planont discharge.

Saprolegnia C. G. Nees

HYPHAE stout, branched, septate at points of origin of reproductive cells. Sporangia terminal; elongate, clavate or fusiform; proliferating internally in a "nested" manner, but also partially emerging from old sporangia through the orifice; planonts escaping through an apical (generally) pore and swimming away immediately upon release. Oögonia (when present) variously borne; lateral, terminal, or intercalary; wall smooth or ornamented, pitted or unpitted; generally spherical, oval or pyriform. Antheridial branches androgynous, monoclinous, diclinous, or hypogynous, when present. Oöspores one to many per oögonium; thick-walled; centric or subcentric. On hempseed in gross cultures of soil and water, and occasionally on snakeskin baits.

KEY TO SPECIES

A. Antheridial branches absent, but antheridial cell cut off basal to the oögonium as part of the oögonial stalk.....S. hypogyna Pringsheim

A. Antheridial branches present, of androgynous, diclinous, or monoclinous origin.....B

B. Antheridial branches predominantely diclinous (oögonial wall pitted only under the points of attachment of the antheridial cells; or sparingly pitted elsewhere; oögonia occasionally intercalary and then commonly in chains)[1]..S. diclina Humphrey

[1]Remarks in ( ) are not strict antithetic key characters; they are intended as additional descriptive matter sometimes useful in determinations.

B. Antheridial branches monoclinous, androgynous, and diclinous, but with at least two types generally present, and not predominantly diclinous.....C

C. Oögonial wall with numerous, conspicuous pits (oöspores commonly filling the oögonium; antheridial branches monoclinous, diclinous, and androgynous in varying proportions; oögonia rather commonly developing in old sporangia, hence cylindrical).....S. ferax (Gruithuisen) Thuret

C. Oögonial wall with few pits, and these often inconspicuous (antheridial branches rarely or very seldom diclinous; oöspores occasionally developed in terminal portions of hyphae above intercalary oögonia, or in the upper portion of the oögonial stalk, giving the oögonium the appearance of having a short basal neck).....D

D. Oögonia generally with 5-10 oöspores (oögonial stalks seldom longer than the diameter of the oögonia; antheridial branches not abundant, and usually not themselves more than once-branched, oöspores usually about 25 μ in diameter; oögonia often with a short neck--a portion of the oögonial stalk in which one or two oöspores lie).....S. monoica Pringsheim

D. Oögonia generally with 2-6 oöspores (oöspores usually about 30 μ in diameter or larger; intercalary oögonia sometimes produce oöspores in the portion of the hypha extending distal to the oögonium--oöspores in a row in hyphal tips).....S. litoralis Coker[1]

The inadequacies of the foregoing key are more real than apparent. Published keys are out of date, and the most recent treatment revising the speices concepts has not been released. Thus, the key characters employed constitute much expanded limits of the species (last monographed in 1923) in line with new information and characteristics of the specimens at hand. The monograph by R. L. Seymour (to be published in 1968, in Nova

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[1] Probably not distinct from S. ferax.

Hedwigia) should be consulted for an authoritative account of the genus.

For purposes of the account of species in the Itasca area, Saprolegnia ferax and S. mixta are considered synonymous; the same may be said for the complex of forms and variants earlier (1937) considered to be either S. diclina or S. delica. There is no adequate separation of these complexes. Locally, S. ferax (=S. mixta) and S. diclina (=S. delica) are the most common of the Saprolegnias.

Specimens of Saprolegnia lacking the sexual apparatus should be expected to occur frequently in gross cultures baited with hempseed and even grass leaves. Such material cannot, of course, be identified at the species level.

Fish fry and fingerlings are occasionally infected locally by water molds, and it is common practice to identify the fungus as S. parasitica Coker. Such determinations may be erroneous since species of Saprolegnia other than parasitica infect fish, as do several Achlyas. The name parasitica should be applied only to those individuals which produce oögonia having the characteristics of S. parasitica; specimens which do not "fruit" sexually are better designated Saprolegnia sp.

Achlya C. G. Nees

HYPHAE stout, branched, septate at points of origin of reproductive cells. Sporangia terminal,[1] elongate, clavate, cylindrical, or fusiform; renewed by sympodial branching; planonts clustering in a hollow sphere at the apical (usually) discharge pore, encysting then emerging individually from cysts and swimming. Oögonia (when present) variously borne; lateral, terminal, or intercalary; wall smooth or ornamented; pitted or unpitted; generally spherical, oval, or pyriform. Antheridial branches androgynous, monoclinous, or diclinous, when present. Oöspores one to many per oögonium; thick-walled; centric, subcentric, or eccentric. On hempseed in gross cultures of soil and water, and occasionally on snakeskin baits, and on twigs.

KEY TO SPECIES

A. Oöspores centric or subcentric.....B

A. Oöspores eccentric.....C

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[1] In species of this genus, and others (except Saprolegnia) the sporangia become lateral as sympodial branching proceeds.

B. Oöspores centric; antheridial branches androgynous, arising near the oögonium, and commonly two per oögonium.....A. racemosa Hildebrand

B. Oöspores subcentric; antheridial branches usually androgynous, but themselves branching hence more than two per oögonium commonly.....A. polyandra Hildebrand

C. Oögonial wall ornamented with truncate (tapering-cylindrical) protrusions (12-15 μ long) that are thin-walled at the apex; oögonial stalk recurved or bent (arched); antheridial branches generally androgynous....A. recurva Cornu

C. Oögonial wall smooth on outer surface; not ornamented; oögonial stalks not recurved or arched.....D

D. Hyphae with large, inflated lateral swellings which do not produce endogenous oöspores; swellings containing moderately dense cytoplasmic accumulation hence are very light brown under transmitted light; antheridial branches sometimes coiling around the oögonial stalks.....A. diffusa Harvey ex Johnson

D. Inflated, lateral swellings absent.....E

E. Oögonia large and inflated, often over 100 μ in diameter, and never completely filled with oöspores; oögonial stalks long (2-3 times longer than the diameter of the oögonium; 1-24 (mostly 6-12) oöspores per oögonium; oöspores infrequently maturing.....A. inflata Coker

E. Oögonia not large and inflated, usually under 100 μ in diameter.....F

F. Oögonial stalks long, bent or recurved (arched); oöspores generally 1 or 2 per oögonium; antheridial branches androgynous or monoclinous.....A. orion Coker and Couch

F. Oögonial stalks short, not bent or recurved; oöspores usually more than two per oögonium.....G

G. Antheridial branches strictly diclinous (in this species are very abundant, and cover much of the oögonium).....A. prolifera C. G. Nees

G. Antheridial branches monoclinous, androgynous, or diclinous (of all three origin types, or of two types, or predominantly of one type) but never strictly diclinous.....H

H. Oöspheres[1] maturing to become eccentric; oöspores generally filling the oögonium.....I

H. Oöspheres[1] usually not maturing (but a few do show the eccentric condition); oöspores seldom filling the oögonium.....J

I. Antheridial branches predominantly monoclinous (rarely of any other origin); oögonial wall pitted under the points of attachment of the antheridial cells and at other places as well .....A. americana Humphrey

I. Antheridial branches predominantly diclinous (infrequently monoclinous, but not androgynous); oögonial wall pitted only under the point of attachment of the antheridial cells.....A. klebsiana Pieters

J. Antheridial branches generally diclinous, and occasionally monoclinous as well, but not androgynous.....A. flagellata Coker

J. Antheridial branches generally androgynous as well as monoclinous, but not diclinous.....A. conspicua Coker

The Achlyas with eccentric oöspores and smooth-walled oögonia are a particularly difficult complex of species, often requiring unifungal culturing before they can be identified confidently. Unfortunately, there are no practical guides to determining the species, hence reliance must be placed largely on many observations and considerable judgment. This is particularly true for the species having two or three antheridial origin types or predominantly one type but occasionally a second.

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[1]The oösphere is the "female" gamete before fertilization. After fertilization, it becomes the zygote which, during maturation, becomes the oöspore with its characteristic pattern of oil deposit. Oöspheres which do not mature have several oil droplets of varying sizes in them.

Achlya prolifera has been collected in the Itasca region only on submerged twigs, where it occurs in abundance and often intermingled with Phytophthora and Pythium. So far as we are aware, A. prolifera does not produce the sexual apparatus while on twigs. "Fruiting" specimens can be obtained by transferring the fungus to cornmeal agar and then to hempseed in water. The species forms antheridia and oögonia in 5-7 days, in hempseed culture.

Nonfruiting Achlyas are common in the region. Individual colonies may represent opposite mating strains of A. bisexualis or A. ambisexualis. Short of applying mating techniques to determine this, the nonfruiting specimens can only be identified as Achlya sp.

Dictyuchus Leitgeb

HYPHAE stout, branched, septate at points of origin of reproductive cells. Sporangia terminal, elongate, clavate, or cylindrical; renewed by sympodial branching; often disarticulating from the hyphae; planonts emerging singly from the sporangium, leaving a net of intact cyst walls. Oögonia (when present) lateral, smooth-walled, generally spherical. Oöspores one per oögonium; eccentric. Antheridial branches present or absent. On hempseed bait in gross cultures of soil and water, and on twigs.

KEY TO SPECIES

A. Oögonia present; antheridia present and of diclinous origin.....D. monosporus Leitgeb

A. Oögonia present, borne on long, lateral stalks; antheridia absent.....D. anomalus Nagai

Other species undoubtedly occur locally. Dictyuchus monosporus is the species most commonly encountered on submerged twigs, but like Achlya prolifera must be propagated on hempseed to induce formation of the sexual apparatus.

Members of the genus are readily recognized by the net-like sporangia formed by the individual emergence of the planonts from their cysts. In D. monosporus (and some others) the sporangia readily disarticulate from the hyphae and float free on the surface of water in culture dishes.

PYTHIACEAE

Key to the Genera[1]

A. Parasitic in rotifers; extramatrical hyphae provided with short, lateral branches adapted for capturing rotifers.....Zoophagus* (p. 96)

A. Not parasitic in rotifers; hyphae lacking short lateral branches or pegs.....B

B. Planonts formed within the sporangium .....Phytophthora (p. 97)

B. Planonts formed in a vesicle outside the sporangial orifice.....C

C. Vesicle spherical or nearly so.....Pythium (p. 98)

C. Vesicle extremely elongate.....Pythiogeton (p.100)

Zoophagus* Sommerstorff

THALLUS consisting of delicate, extensive, sparingly-branched hyphae (extramatrical) bearing short (about 20 μ x 3 μ), lateral, peg-like branches. Intramatrical hyphae branched, contorted and irregular, partially or completely filling the host. Sporangia formed from undifferentiated segments of the intramatrical hyphae; provided with rather broad discharge tubes which are extramatrical distally. In rotifers.

The species, Z. insidians* Sommerstorff, is carnivorous and remarkably adapted to capturing rotifers by means of short, lateral pegs on the extramatrical hyphae. Any sedentary rotifers in the vicinity of hyaline, slender hyphae should be scanned for possible infection by this fungus.

The nearest species, in terms of carnivorous nature, is in the genus Sommerstorffia: S. spinosa. It, too, has a capturing apparatus, but the filaments are sharply pointed. Moreover, the sporangia are long and slender and have an achlyoid type of discharge (i.e., with the spores encysting in a cluster at the exit tube orifice).

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[1]Appears in chart form on p. 25.

Phytophthora de Bary

MYCELIUM branched, hyphae slender, often bearing small irregular, spherical, or ellipsoidal swellings. Sporangia terminal; ovoid, limoniform, pyriform or ellipsoidal; possessing a blunt, non-papillate apex or a broad, prominent, apical papilla; renewed sympodially or by internal proliferation resulting in nesting of the sporangia, or by extension of the sporangiferous hypha through a discharged sporangium. Planonts formed within the sporangium. Oögonia terminal, spherical, containing a single aplerotic or plerotic oöspore. Antheridial branches usually amphigynous, but sometimes paragynous, or both. On twigs.

KEY TO SPECIES

A. Sporangia ovoid or broadly pyriform with a blunt apex; renewed by internal proliferation resulting either in sessile, "nested" sporangia (one within another) or by growth of the sporangial bearing hypha through the sporangium .....P. gonapodyides (Petersen) Buisman

A. Sporangia ovate to broad fusiform; renewed by sympodial branching....P. fischeriana (Höhnk) Sparrow

While most species of Phytophthora are parasitic on various angiospermous plants, a few (including the two collected on twigs) are saprophytic on plant materials. Other species undoubtedly occur in this area.

The two species develop on twigs left in jars of distilled water, at 20-22°C for 3-5 days, and were usually found associated with Achlya or Dictyuchus (water molds). Phytophthora gonapodyides is the commonest and most readily recognized of the two, with its nests of two or more empty sporangia, or with prolongations of the sporangial-bearing hyphae through empty sporangia.

Phytophthora fischeriana may not be a valid species; its status has been questioned. It is very near P. syringae, but this needs confirmation.

It should be recalled that the fundamental distinction between species of Phytophthora and Pythium is in the spore discharge mechanism. In Pythium the planonts form from the discharged sporangial protoplast outside the orifice of the discharge tube or papilla.

Pythium Pringsheim

THALLUS consisting of well-developed, slender, branched hyphae with or without toruloid elements; nonseptate except where reproductive cells are delimited. Sporangia of three types: filamentous and not differentiated from the hyphae, a series of terminal lobulations with a filamentous discharge tube, or spherical to pyriform terminal cells well differentiated from the hyphae; sometimes renewed internally. Planonts forming in a vesicle outside the exit orifice from the undifferentiated sporangial protoplast. Oögonia terminal or intercalary; usually spherical, but ellipsoidal to limoniform when intercalary; smooth walled or ornamented. Antheridial branches, when present, hypogynous, monoclinous, or diclinous. Oöspores usually single (rarely 2 or 3), plerotic or aplerotic, bearing a single, large refractive globule; wall smooth or finely reticulate. On a wide variety of substrates; known to occur locally on hempseed, submerged twigs and apples, grass leaves, snakeskin and dead organic detritus in gross cultures; also developing occasionally on masses of pollen bait in gross culture.

The Pythiums are quite common in the Itasca region, and should be expected to appear in many gross cultures. Hardly any piece of hempseed bait fails to harbor some Pythium hyphae; these filaments are slender and usually are seen in abundance near the substrate surface among the mycelial elements of water molds.

Most of the representatives collected failed to develop the sexual apparatus in the gross cultures hence could not be identified. Only those species in the following key could be positively determined (all occurred on hempseed bait). It is well to recognize that only the saprobic soil- and water-inhabiting forms are reported; some species are parasitic on vascular plants, and have not been investigated locally.

KEY TO SPECIES

A. Sporangium filamentous or lobulate.....B

A. Sporangium spherical or ellipsoidal.....D

B. Sporangium lobulate; hyphae with catenulate bodies absent, terminal or intercalary swellings lacking or rare; antheridial branches monoclinous.....P. torulosum Coker and Patterson

B. Sporangium filamentous (not differentiated from the hypha producing it).....C

C. Oögonial wall smooth; antheridial branches monoclinous and diclinous; antheridial cell slightly swollen and clavate; lateral, inflated outgrowths on hyphae.....P. monospermum Pringsheim

C. Oögonial wall ornamented with a few papillae; oögonia often catenulate; antheridial branches absent.....P. papillatum Matthews

D. Oögonia and antheridial branches present.....E

D. Oögonia and antheridial branches absent[1].....G

E. Oögonial wall echinulate; oögonia terminal or intercalary, spherical to cylindrical; sporangia often catenulate; antheridial branches monoclinous, but when lacking, antheridial cell hypogynous.....P. echinulatum Matthews

E. Oögonial wall smooth.....F

F. Antheridial branches monoclinous (arising from some distance below the oögonium and not adjacent to it) and diclinous; oögonia terminal or intercalary; sporangia spherical to oval, terminal or intercalary.....P. debaryanum Hesse

F. Antheridium arising immediately below the oögonium and sessile, or on a diclinous branch; antheridial cell expanded; oögonia terminal (rarely intercalary); sporangia terminal and spherical or intercalary and dolioform...P. ultimum Trow

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[1]It should not be assumed that specimens which key through this portion of the couplet are always of the two species so keyed. The sporangial characters of the material at hand should accommodate reasonably well the features given in couplet G, or the identification with the two species would be questionable.

G. Sporangia proliferating internally; possessing a distinct apical papilla; hypha widened below the sporangium; sporangial hypha undulating; sporangia typically not nesting, but produced apically on a continuation of the hypha through a discharged sporangium.....P. undulatum Petersen

G. Sporangia not proliferating; spherical, catenulate, sessile or on short stalks; hyphae tend to become septate in old or fouled cultures.....P. intermedium de Bary

Pythium undulatum may be mistaken for a Phytophthora species (gonapodyides in this region) unless careful attention is given to the sporangia. In both species, the sporangia proliferate internally. Those of Pythium undulatum tend to be narrowly ellipsoidal (though ovoid or obpyriform ones occur), and, before discharge are typically apiculate. The hypha immediately below the sporangium is swollen or expanded. In the Phytophthora the sporangia are characteristically ovoid or broadly pyriform, lack an apiculus, and the hypha below them is not expanded.

One collection of a fungus tentatively assigned to Pythium is singled out for particular reference. The hyphae are pythiaceous, but only one discharged ellipsoidal sporangium was observed, and it is not certain that it was associated with the oögonia in the same preparation. The oöspores (single in an oögonium) are plerotic and extremely thick-walled (3-4.1 μ). This fungus, in dead culms of Typha, should be sought again and further morphological details determined.

Pythiogeton Minden

MYCELIUM abundant, hyphae delicate, branched. Sporangia terminal or intercalary; commonly asymmetrical and bursiform (pouch-like); usually with the long axis nearly perpendicular to that of the attendant hypha; discharge tube slender and prolonged. Oögonium with a single oöspore possessing a conspicuously thickened wall. On grass leaves (bait).

KEY TO SPECIES

A. Sporangia broadly bursiform; discharge tube tending to be nearly parallel with the axis of the attendant hypha.....P. utriforme Minden

A. Sporangia narrowly bursiform; discharge tube tending to be nearly at a right angle to the axis of the attendant hypha.....P. ramosum Minden

The two species known to occur in the Itasca region are easily distinguishable from other filamentous groups by the fact that the sporangia (particularly those having discharged) appear to be attached laterally to the hyphal apex. The discharge tube is elongate and often slightly irregular, giving the whole cell a distinctive pouch-like shape.

Oögonia have been found on P. utriforme. Pythiogeton ramosum has not been found to produce oögonia, but in the Itasca material, immature, oögonia-like cells were observed; none developed to a mature state.

Species in this genus are poorly defined and separated. Identification to species is therefore always uncertain.

ZYGOMYCETES

ENTOMOPHTHORALES

Entomophthoraceae

(A single genus of this large family is treated; see remarks on p. 14.)

Ancylistes Pfitzer

THALLUS intramatrical, consisting of one to several septate, tubular, branched and anastomosing hyphae; hyphal segments constricted faintly or prominently at the septa, and with irregular swellings elsewhere. Extramatrical hyphae produced by the segments; protruding through the host wall; slender, slightly irregular, short or long; producing a conidium at the apex. Conidia spherical, hyaline; forcibly ejected when protruding above the surface of the water. Zygotes (oval, spherical, smooth or warted, thick-walled) produced by lateral or scalariform conjugation. In Closterium.

All three species of Ancylistes are parasitic in desmids; A. closterii Pfitzer is the only one thus far recovered in this region.

Generally, in the specimens obtained, the hyphae filled the desmid, hence structural details were difficult to determine. The slender, protruding, extramatrical conidiophores are the chief recognition feature. In sparsely developed material these

hyphae may be short and inconspicuous and suggest the extramatrical discharge tubes of Myzocytium proliferum. However, the intramatrical sporangia do not show the bead-like, linear arrangement of the endobiotic sporangia of M. proliferum.

Olpidium endogenum also occurs in Closterium, but the sporangia of that species do not fill the invaded desmid, the discharge tubes are centric, and are expanded where they penetrate the cell wall. Moreover, the sporangia of O. endogenum are subspherical or broadly ellipsoidal in contrast to the cylindrical, somewhat irregular ones of the Ancylistes.

LIST OF SUBSTRATES

The fungi in the foregoing account are listed here alphabetically by substratum on or in which they have occurred. The lists provide a quick reference to species which may be expected on particular substrates.

Algae

Achlyogeton entophytum (Cladophora)
Amphicypellus elegans (Ceratium)
Ancylistes closterii (Closterium)
Aphanomycopsis bacillariacearum (Pinnularia)
Blyttiomyces spinulosus (Spirogyra)
Chytridium gibbosum (Cladophora)
C. lagenaria (Cladophora)
C. lagenula (Tribonema)
C. mucronatum (Oedogonium)
C. oedogonii (Oedogonium)
C. olla (Oedogonium)
C. schenkii (Oedogonium)
C. sphaerocarpum (Spirogyra)
C. versatile (Synedra, Nitzschia, Fragilaria)
Diplophlyctis intestina (Chara; Nitella)
Entophlyctis confervae-glomeratae (Cladophora)
E. helioformis (Chara; Nitella)
Hyphochytrium catenoides (Chara)
Lagenidium brachystomum (Nitzschia)
L. closterii (Closterium)
L. entophytum (Spirogyra)
L. marchalianum (Oedogonium)
L. oedogonii (Oedogonium)

Algae (continued)

L. rabenhorstii (Spirogyra)
Micromyces longispinosus (Spirogyra)
Micromyces sp. (Spirogyra)
M. zygogonii (Mougeotia)
Myzocytium proliferum (Closterium)
Olpidium endogenum (Closterium; Cosmarium; Ophiocytium)
O. entophytum (Cladophora, Spirogyra)
Phlyctidium anatropum (Stigeoclonium)
P. bumilleria (Tribonema)
P. olla (Spirogyra)
P. spinulosum (Cladophora)
Phlyctochytrium biporosum (Oedogonium)
P. bullatum (Cladophora)
P. equale (Spirogyra)
P. hallii (Spirogyra)
P. lagenaria (Spirogyra; Oedogonium)
P. planicorne (Cladophora)
P. quadricorne (Spirogyra)
Podochytrium clavatum (Diatoms)
P. emmanuelense (Diatoms)
Rhizophydium chaetiferum (Spirogyra, Oedogonium)
R. fragilariae (Fragilaria)
R. fusus (Synedra)
R. gibbosum (Navicula)
R. globosum (Cladophora; Oedogonium; Spirogyra; Closterium)
R. mammillatum (Oedogonium)
R. megarrhizum (Oscillatoria)
R. minutum (Spirogyra)
R. ovatum (Stigeoclonium)
R. planktonicum (Asterionella)
R. simplex (Pandorina)
R. sphaerocarpum (Spirogyra)
R. subangulosum (Oscillatoria)
Scherffeliomyces leptorrhizus (Zygnema)

Twigs

Achlya prolifera
Achlya sp.
Apodachlya brachynema
A. pyrifera
Araiospora pulchra
Blastocladia pringsheimii
Dictyuchus monosporus
Dictyuchus sp.
Gonapodya prolifera
Monoblepharis macrandra
M. polymorpha
Phytophthora fischeriana
P. gonapodyides
Pythiopsis cymosa(?)
Pythium spp.
Rhipidium americanum
Saprolegnia sp.
Sapromyces androgynus
S. elongatus

Fruits

Apodachlya pyrifera
Blastocladia globosa
B. pringsheimii
B. (?)prolifera
B. ramosa
Gonapodya prolifera
Macrochytrium botrydioides
Mindeniella asymmetria
M. spinospora
Phytophthora sp.
Pythium spp.
Rhipidium americanum
R. interruptum
Sapromyces elongatus

Aquatic Phanerogams

Lagenidium sp.
(?)Reesia amoeboides
Pythium spp.

Insects, Rotifers, and Exuviae

Aphanomyces irregulare
A. laevis
A. scaber
A. stellatus
Catenaria anguillulae
Coelomomyces lativittatus
C. quadrangulatus var. quadrangulatus
Obelidium mucronatum
Rhizoclosmatium globosum
Zoophagus insidians

Hempseed (bait)

Achlya americana
A. conspicua
A. diffusa
A. flagellata
A. inflata
A. klebsiana
A. orion
A. polyandra
A. prolifera
A. racemosa
A. recurva
Achlya sp.
Dictyuchus anomalus
D. monosporus
Leptolegnia caudata
Leptolegnia sp.
Leptomitus lacteus
Pythium debaryanum
P. echinulatum
P. intermedium
P. monospermum
P. papillatum
P. torulosum
P. ultimum
P. undulatum
Saprolegnia diclina
S. ferax
S. hypogyna
S. litoralis
S. monoica
Saprolegnia sp.

Pollen (bait)

Aphanomyces laevis
Blyttiomyces helicus
Lagenidium pygmaeum
Olpidium pendulum
Pythium spp.
Rhizophydium pollinis-pini
R. sphaerotheca

Snakeskin (bait)

Achlya spp.
Allomyces macrogynus
Aphanomyces laevis
A. helicoides
A. stellatus
(?) Blastocladiopsis parva
Chytriomyces aureus
Leptolegniella keratinophilum
Polychytrium aggregatum
Pythium spp.
Rhizophydium apiculatum

Hair (bait)

Rhizophydium keratinophilum
R. nodulosum

Cellophane (bait)

Aphanomyces irregulare
A. laevis
Nowakowskiella elegans
N. ramosa
Rhizidium varians
Rhizophlyctis rosea

Grass Leaves (bait)

Aphanomyces laevis
Catenochytridium carolinianum
Cladochytrium replicatum
Lagenidium spp.
Nephrochytrium sp.
Pythiogeton ramosum
P. utriforme
Pythiopsis cymosa (?)
Pythium spp.
Saprolegnia spp.
Septochytrium variabile

Other Aquatic Fungi

Olpidiopsis achlyae
O. aphanomycis
O. fusiformis
O. incrassata
O. luxurians
O. saprolegniae var. saprolegniae
O. varians
Petersenia irregulare
Rhizidiomyces apophysatus
Rhizophydium carpophilum
Rozella achlyae
Septosperma rhizophydii
Woronina polycystis

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Descriptions appear on pages underlined.

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