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5th Floor, Hunt Library
Carnegie Mellon University
4909 Frew Street
Pittsburgh, PA 15213-3890
Telephone: 412-268-2434
Email: huntinst@andrew.cmu.edu
Web site: www.huntbotanical.org

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About the Institute

The Hunt Institute for Botanical Documentation, a research division of Carnegie Mellon University, specializes in the history of botany and all aspects of plant science and serves the international scientific community through research and documentation. To this end, the Institute acquires and maintains authoritative collections of books, plant images, manuscripts, portraits and data files, and provides publications and other modes of information service. The Institute meets the reference needs of botanists, biologists, historians, conservationists, librarians, bibliographers and the public at large, especially those concerned with any aspect of the North American flora.

Hunt Institute was dedicated in 1961 as the Rachel McMasters Miller Hunt Botanical Library, an international center for bibliographical research and service in the interests of botany and horticulture, as well as a center for the study of all aspects of the history of the plant sciences. By 1971 the Library's activities had so diversified that the name was changed to Hunt Institute for Botanical Documentation. Growth in collections and research projects led to the establishment of four programmatic departments: Archives, Art, Bibliography and the Library.

Synchytrium. John S. Karling. 470 pp. illus. Academic Press, New York, 1964. \$17.50.

If a genus were to be created especially to challenge the patience, skill, and determination of the mycologist, one suspects that its name would be *Synchytrium*. The first significant studies of this genus were made just over a century ago by de Bary and Woronin; it hardly seems an exaggeration to say that difficulties have been proliferating ever since. In 1953, Karling noted that of 158 or more species reported in the literature, "less than 25 are completely known and can be classified with certainty." In his monograph, the total number of species is increased to "almost 200, many of which are not fully known." Elsewhere in the text it is stated that "less than half of the 200 or more species are fully known and the identity of the remaining ones is based on incomplete observations and meagre descriptions."

Perhaps the major difficulty—if indeed one may be singled out among many others—lies in establishing reliable criteria for distinguishing the species and even the subgenera. The problems appear to be formidable, and the following citations will reveal something of their magnitude. On cytology: "There is considerable disagreement as to the manner of nuclear and cell division in *Synchytrium*." Also, "very little is known about the size and number of chromosomes . . . of *Synchytrium*." Furthermore, "there are only four good detailed accounts of cytokinesis for the whole group." The problem of sexuality is in at least an equally ambiguous state, as the following excerpts will testify. "Whether a gamete behaves asexually or fuses with another is related to the balance or imbalance of its maleness or femaleness." Further, concerning these whimsical gametes, "their sex character is not constant" and "accordingly, a male gamete may change to a female gamete as it becomes less actively motile." How is the taxonomist to deal with such perversity? No doubt because of factors such as these, sexual reproduction has been studied "intensively" in only three species, namely *Synchytrium*, *Microsynchytrium*, and *Exosynchytrium*.

Concerning the question of host reactions, which are used as one of the salient criteria of classification, Karling has selected 15 categories of responses to serve as a guide, but we are cautioned, "very few of these cellular reactions have been studied intensively" and therefore many reports "may prove to be incorrect or inadequate when . . . investigated closely and carefully." Finally, regarding the fungi themselves and their prosori, sori, sporangia, zoospores, and other structures, we are told that "many of these criteria may be so variable that . . . they have little significant diagnostic value."

In a chapter devoted to systems of classification, we are prepared for the inevitable differences in interpretation, of which nine principal ones are given, beginning with that of Woronin (1868) and ending with that of Kusano (1930). Karling adopts a modification of Fitzpatrick's scheme (1930), to which he has added two subgenera, *Microsynchytrium* and *Exosynchytrium*. The first dichotomy in the key to subgenera is based on a long life cycle—*Microsynchytrium* (36 species), *Mesochytrium* (2 species), *Synchytrium* (*Eusynchytrium*) (1 species, and *Exosynchytrium*) (1 species)—versus a short life cycle—*Pycnochytrium* (19 species) and *Woroninella* (13 species). Seventy-two species are listed as "fully known" and are therefore keyed out, a considerable accomplishment in itself. The remaining species are listed as "incompletely known," "unidentified," "doubtful," or "excluded." The 239 pages on the description of the genus, subgenera, and species are a tour de force on the morphology, taxonomy, and life history of these fungi, as understood to date.

Mycologists are perhaps on least secure ground in discussions of phylogeny, and the chytridiaceous fungi do not lend themselves to special advantage in this area. Karling's treatment is open to objections, many of which, perhaps, may be traced to a paucity of information, which does not favor the development of any particular theory. Readers acquainted with the vagaries of fungus phylogeny will not be surprised to be in-

that "the opposite view is equally plausible."

The book concludes with brief chapters on geographical distribution, a host index, two bibliographies, and author and subject indices. There are a 24-page general bibliography and a separate 39-page bibliography to works on *Synchytrium endobioticum* and the potato-wart disease. Numerous excellent line drawings illustrate the text.

Summing up, Karling's work is the first attempt in about 100 years to gather all pertinent evidence on the genus and to put it into some semblance of order. If, in places, it falls short of evaluating the relative importance of conflicting views, the fault generally lies with the lack of sufficient knowledge to justify taking a firm stand. The author has performed a highly meritorious service by assembling and reviewing evidence and opinions of great diversity. But his greatest contribution is his emphasis on life-cycle studies which must form the basis for a comprehensive taxonomic exposition of the genus. It is precisely in this area that his researches on *Synchytrium*, spanning more than two decades, have left their mark and will continue to give direction to future investigators who may have sufficient competence, persistence, and courage to carry the work forward.

B. LOWY

Louisiana State University
Baton Rouge, Louisiana

CLASSES OF FUNGI

Dictionary	Bessey (1950)	Gäumann (1964)	Alexopoulos (1962)	Kreisel (1969)
Kingdom FUNGI			Kingdom PLANTAE Mycota	Kingdom PROTOBIONTA
Myxomycota 1. Acrasiomycetes 2. Hydromycomycetes 3. Myxomycetes 4. Plasmodiophoromycetes	Mycetozoa		Myxomycotina Myxomycetes Eumycotina Plasmodiophoromycetes	Excluded from fungi Excluded from fungi
Eumycota	Class: Phycomyceteae (5-9)	Archimycetes (4, 5 p.p.) Phycomycetes (5 p.p.-9)		Eumycota
Mastigomycotina 5. Chytridiomycetes 6. Hyphochytridiomycetes 7. Oomycetes		Order: Oomycetes	Chytridiomycetes Hyphochytridiomycetes Oomycetes	Chytridiomycetes Excluded from fungi Excluded as a Class of Chrysophyta (Algae)
Zygomycotina 8. Zygomycetes 9. Trichomycetes	Div. Carpomyceteae	Order: Zygomycetes	Zygomycetes Trichomycetes	Zygomycetes Endomycetes (8 p.p., 9, 10 p.p., 16 p.p.)
Ascomycotina	Class: Ascomyceteae	Ascomycetes Subclass: Prototunicatae (10 p.p., 11 p.p., 14)	Ascomycetes	Ascomycetes
10. Hemiascomycetes			Hemiascomycetidae	
11. Plectomycetes		Subclass: Eutunicatae Group: Unitunicatae (10 p.p., 11 p.p., 12, 13)	Euscomycetidae series Plectomycetes	Euscomycetidae (10-13)
12. Pyrenomycetes 13. Discomycetes 14. Laboulbeniomyces 15. Loculoascomycetes	'The pyrenomycetes'	Group: Bitunicatae Basidiomycetes Subclass: Phragmobasidiomycetes (16, 17a)	series Pyrenomycetes series Discomycetes series Laboulbeniomyces Loculoascomycetidae Basidiomycetes Heterobasidiomycetidae (16, 17a, 17b p.p.)	Loculoascomycetidae Basidiomycetes Phragmobasidiomycetidae (16 p.p., 17a)
Basidiomycotina	Class: Basidiomyceteae	Subclass: Holobasidiomycetes (17b, 18)	Holobasidiomycetidae	Hymenobasidiomycetidae
16. Teliomycetes 17. Hymenomycetes (a) Phragmobasidiomycetidae (b) Holobasidiomycetidae	Subclass: Teliomyceteae Subclass: Heterobasidiomyceteae Subclass: Hymenomyceteae		series Gasteromycetes	Gasteromycetidae Remaining Basidiomycetes (16 p.p., 17a p.p.)
18. Gasteromycetes	'Gasteromyceteae'	Fungi Imperfecti	Form class Deuteromycetes	Endomycetes imperfecti Ascomycetes imperfecti Basidiomycetes imperfecti
Deuteromycotina 19. Blastomycetes 20. Hyphomycetes 21. Coelomycetes	The Imperfect Fungi Moniliales Sphaeropsidales, Mechanconiales			

In this comparison of the classifications of higher taxa in several standard texts names on the same level are synonymous or approximately so. Divisions end in -mycota, subdivisions in -mycotina, Classes in -mycetes, and Subclasses in -mycetidae. The status claimed for irregularly formed names is indicated. The numbers under names in the four right-hand columns are those of the Dictionary groups covered by the names.

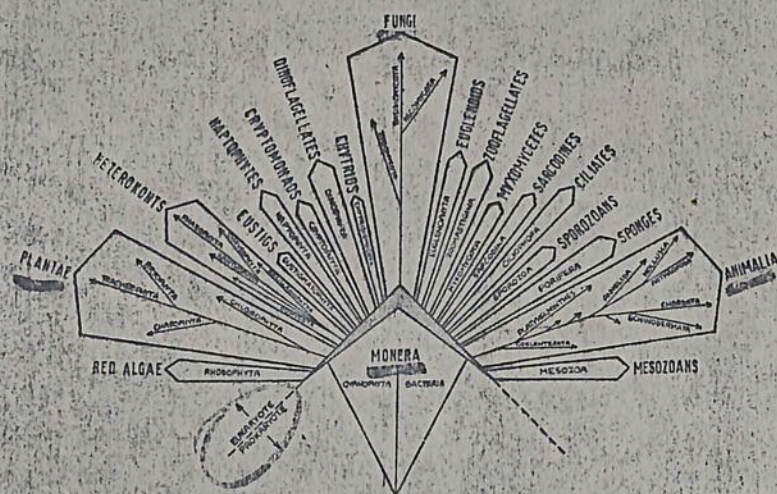


Fig. 6. "Fan" scheme: proposal for a multi-kingdom evolutionary scheme. The stippled area represents the missing link of present-day forms and of the fossil record: the period of cell symbiosis or organelle development.

trypanosomes on the basis of cytological features such as flagellar insertion and mitosis ultrastructure, now strongly supported by close cytochrome C affinity between *Englena* and *Crithidia*). Plantae (including the green algae, Chlorophyta) is placed near the red algae and the heterokonts (e.g. by possession of cellulose in the cell wall) and further from chytrids and Fungi (most, at least, without cellulose; most with chitin in the cell wall). On the other hand, cytochrome c data should perhaps persuade us to push the Plantae and Animalia segments of the fan towards Fungi in the centre.

The phylogenetic grouping of the heterokonts is an important innovation in the scheme, placing organisms with heterokont flagellation *sensu stricto* (which implies numerous other features in common, see Massalski & Leedale, 1969; Hibberd & Leedale, 1971) into one kingdom (containing Phaeophyta, Chrysophyta, Xanthophyta, Bacillariophyta and Oomycota). Eustigmatophyta (species originally in the Xanthophyceae but with fundamentally different organisation, see Hibberd, 1971) are placed in the Phaeophyta.

Figures. — Plants have been assigned to seven kingdoms within the superkingdoms Procaryota and Eucaryota. Bacteria and animals have been tentatively assigned to separate kingdoms for convenience only since they were not considered in detail. The position that divisions have been placed in within each kingdom represents their degree of evolutionary change from the ancestral condition e.g., the Basidiomycota, Tracheophyta, and Phaeophyta are on the same level and represent the present-day culmination of evolutionary development within their respective higher taxa.

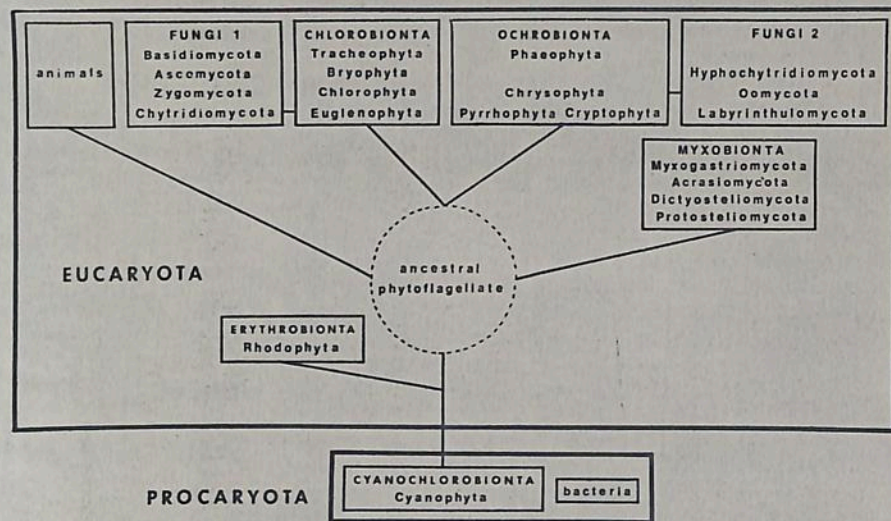


Fig. 1. The classical hypothesis for the origin of the eucaryotic cell by gradual evolutionary change from photosynthetic procaryotes containing chlorophyll *a*.

more heterogeneous and polyphyletic kingdom Protista. Margulis clearly recognizes the heterogeneity of the Protista since she refers to it as a "miscellaneous group of phyla in which profound evolutionary experimentation occurred" (Margulis, 1974). However, her rejection of the criterion of monophyly for the delimitation of kingdoms will preclude general acceptance of her scheme (Jeffrey, 1971; Leedale, 1974) since one of the most widely accepted aims of modern taxonomy is to provide a classification which expresses the natural or phylogenetic relationships of organisms (Davis and Heywood, 1963; Cronquist, 1968; Radford et al., 1974).

The living world clearly cannot be neatly divided into a small number of monophyletic kingdoms because of the tremendous diversity of organisms. The major taxonomic objective of establishing monophyletic assemblages of organisms should not be compromised for the sake of convenience as has occurred with the kingdoms Protista and Protoctista in the Whittaker and Copeland schemes, respectively. Jeffrey (1971) and Leedale (1974) have both proposed multiple kingdom systems based on a more valid taxonomic basis; the former divided the plant world into five and the latter into twelve kingdoms (Table 1). The scheme proposed in this paper (Fig. 1, 2, Table 1) is a modification of the Jeffrey (1971) scheme and avoids the taxonomic inflation of the Leedale "fan" scheme which reduces its practical utility. The increase in the number of kingdoms from five in the Jeffrey scheme to seven in the proposed modification results from the treatment of the fungi which are considered to be at least triphyletic. The Oomycota have been removed from the Chromobionta and placed in a separate kingdom, and the myxomycetes have been assigned kingdom status also.

Dillon (1962, 1963) proposed a novel classification based on the comparative cytology and ultrastructure of the cell over a decade ago. He suggested that all living things should be regarded as members of a single kingdom, which he split into fourteen subkingdoms, seven of which included plants. However, Dillon's ideas were promulgated before the recent large accumulation of ultrastructural data and they have not been supported by other workers. He considered the euglenoids and dinoflagellates to be closely related since they possess nonclassical mitosis, but the mitotic mechanism is now known to be fundamentally different in each group (Leedale, 1970). He also included the red algae, the yellow brown algae excluding the dinoflagellates, the fungi, and multicellular animals in a single subkingdom despite differences in pigmentation, thylakoid structure, and flagellation.

The greatest discontinuity between living organisms is that between procaryotes and eucaryotes (Stanier and Van Niel, 1962). The former lack membrane bounded organelles and the complex 9 + 2 strand flagella; their nuclear material is not complexed with histone proteins; they do not have mitotic and meiotic nuclear division. Bold (1973) placed prokaryotic organisms in a subkingdom Prokaryonta, and pigmented eucaryotic organisms and the fungi in the subkingdoms Chloronta

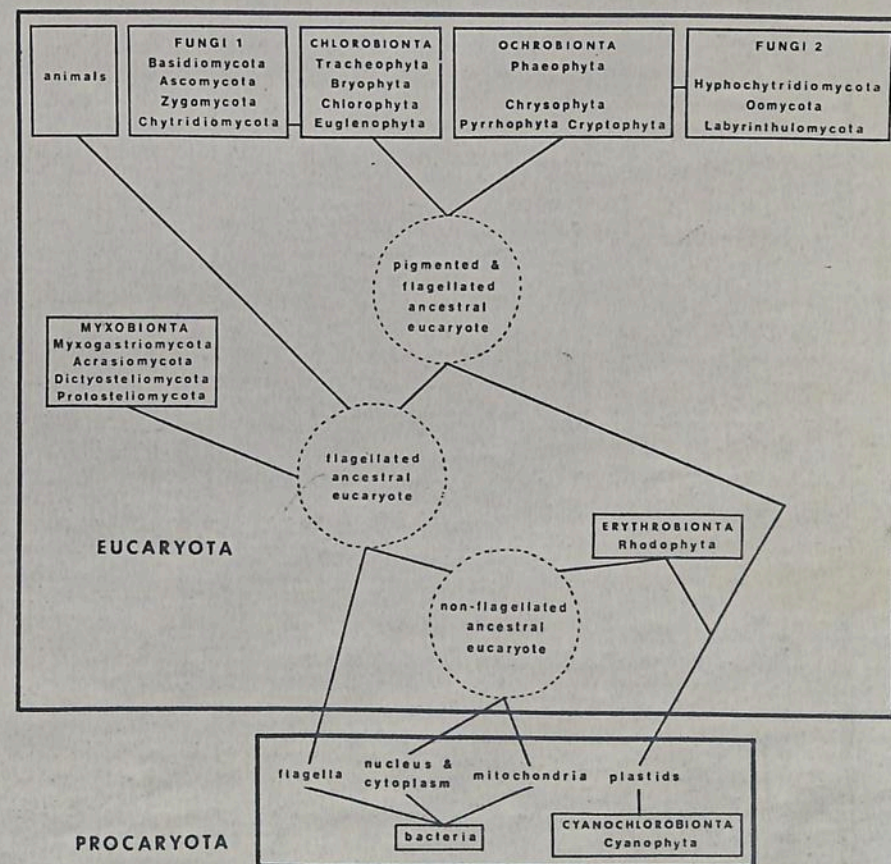


Fig. 2. The endosymbiotic hypothesis for the origin of the eucaryotic cell in which plastids were derived from photosynthetic procaryotes containing chlorophyll *a*, mitochondria from aerobic bacteria, and flagella from spirochaete-like organisms.

that plasmodium containing algae grew much better than plasmodium alone and was much more resistant to acidity.

Whereas it is beyond question that plasmodia engulf solid food particles, positive proof, as we have said, has not as yet been provided that food in solution may also enter through the plasma membrane. Such proof will be difficult to obtain, but unless the intake of droplets of liquid through pinocytosis can be demonstrated to be far more prevalent than present evidence would indicate, it can be assumed that food in solution can be utilized—at least by plasmodia cultured in liquid medium in which all components are dissolved.

LABORATORY CULTIVATION

As we shall see presently, about 10–15 per cent of the known species of Myxomycetes have been cultivated in the laboratory on artificial media from spore to spore. In the majority of cases, no attempt appears to have been made to exclude other organisms. In addition to the myxomycete, therefore, such crude cultures often contain bacteria, fungi, protozoa, and even nematodes. Nevertheless, it is usually true that if a myxomycete completes its life cycle from spore to spore in crude culture, it can be induced to do so in monoxenic culture with a known bacterium. Axenic cultures present an entirely different problem.

Plasmodia or sclerotia brought in from the field can be easily cultured either directly on the substratum on which they were found by placing it in a moist chamber, or on artificial media by placing on agar the material on which the plasmodium was found and allowing it to migrate onto the agar surface. For life-history studies, however, it is desirable to induce the organism to complete its life cycle from spore to spore on artificial media. This has proved extremely difficult with some species and impossible, up to now, with others. The authors, for example, have repeatedly attempted the cultivation from spores of various species of *Ceratiomyxa*, *Cribraria*, *Lycogala*, *Tubifera*, and *Trichia*, always with negative results, and it is probable that other researchers have had the same experience; yet seldom are such failures recorded in the literature, except, in passing, while discussing the successful cultivation of other species. It is possible that more successes might be encountered in this area if investigators would bear in mind that spore germination, zygote formation, and plasmodium formation are different and distinct processes, and that the set of conditions that is optimum for one process may not necessarily be optimum for the others.

Cultivation of Myxomycetes from spores was early recorded by Lister (1901) for *Badhamia utricularis*. Since then, a number of species have

been cultivated by various investigators. It is not the purpose of this treatise to give a complete historical account of the laboratory culture of Myxomycetes, but rather to discuss the situation as it stands at present and to point out areas in which success might be expected and others in which failure is virtually certain with present methods.

For a review of the literature on laboratory culture of the Myxomycetes, the reader is referred to Martin (1940), Hawker (1952), and Alexopoulos (1963). The work of Howard (1931b) deserves special attention, since it represents the first instance in which a simple and sure method of culturing a myxomycete was devised. Much of the very fine and varied research that has been performed with *Physarum polycephalum* was made possible by Howard's work.

CRUDE CULTURES

Cultivation of Plasmodia

Unless otherwise noted, the following remarks apply to phaneroplasmodia only. Phaneroplasmodia found growing in the field or developed in moist chamber (Timnick, 1947) may be cultured and often induced to sporulate. Unfortunately, this does not guarantee that the organism can be cultivated from the spores so produced, viable though these may be.

Wood- or bark-bearing plasmodia should be placed in a plastic bag or other moisture-proof container and brought into the laboratory as soon as possible. Either of two methods may be used to cultivate the plasmodium.

Timnick's Method. A thin slice of the substratum with a portion of the plasmodium may be placed on Knop's agar (Timnick, 1947) or CM/2 agar¹ in a Petri dish, incubated at 20°–25° C, and allowed to spread on the agar. The substratum may then be removed and the plasmodium fed by sprinkling over it sterile, pulverized rolled oats. Agar blocks bearing vigorous plasmodium fans free of fungi may be cut and transferred to new Petri dishes to maintain or propagate the culture. Vigorous plasmodia of some species may be obtained by growing them on oat flake agar.²

Camp's Method. Absorbent paper (filter paper, toweling paper, and so on) is wrapped over the top or the bottom part of a Petri dish which is then placed in a large finger bowl (Camp, 1936). Enough water is poured into the container to keep the paper moist at all times through

¹ See Appendix.

² *Ibid.*

wick action. Material bearing a plasmodial fan or sclerotium is then placed on the paper, and a few, preferably sterile, oat flakes are arranged around the inoculum or pulverized flakes are sprinkled over the paper. The finger bowl is then covered with a glass plate or a second finger bowl, and the culture is allowed to develop. Oat flakes are added as needed and the old ones removed as they mold. Not infrequently those using this method for the first time have a tendency to overfeed. Hence, it should be borne in mind that better results may often be obtained if oat flakes are added sparingly. Whereas some species like *P. polycephalum* do well in moist chamber culture, there are many that will move about over the oats, but the plasmodium will not increase in size. Whether or not a species can be successfully cultured by this method can be determined only by trial.

Cultivation from Spores

Fewer than 15 per cent of the known species of Myxomycetes have been induced to complete their life cycles in crude agar culture from spore to spore. Table 21 lists 55 species the cultivation of which on

Table 21. List of Myxomycetes cultivated in crude agar culture from spore to spore. Names of species are those accepted by Martin and Alexopoulos (1969)

Physarales

Physaraceae

- Badhamia utricularis* (Lister, 1901)
- Badhamia gracilis* (Alexopoulos, unpubl.)
- Fuligo cinerea* (Collins, 1961)
- Fuligo septica* (Scholes, 1962)
- Physarella oblonga* (Gilbert, 1931)
- Cienkowskia reticulata* (Therrien, unpubl.)
- Physarum aeneum* (Aldrich, unpubl.)
- Physarum auriscalpium* (Wollman, unpubl.)
- Physarum bilgramii* (Henney, unpubl.)
- Physarum cinereum* (von Stosch, 1935)
- Physarum compressum* (Gray, 1938)
- Physarum didermoides* (Gray, 1949)
- Physarum flavicomum* (Gray, 1961)
- Physarum globuliferum* (Henney, unpubl.)
- Physarum gyrosum* (Koevenig, 1964)
- Physarum leucophaeum* (Garjeanne, 1953)
- Physarum leucopus* (Schünemann, 1930)
- Physarum melleum* (Alexopoulos, unpubl.)
- Physarum nicaraguense* (Solis, 1962)
- Physarum nucleatum* (Alexopoulos, unpubl.)

* Sporulation was not obtained on agar but only when the plasmodia were transferred to moist, porous flower pots.

Table 21. Continued.

- Physarum nudum* (Rakoczy, 1962)
- Physarum oblatum* (Alexopoulos, unpubl.)
- Physarum polycephalum* (Howard, 1931a)
- Physarum pusillum* (Collins, et al., 1964)
- Physarum rigidum* (Henney and Henney, 1968)
- Physarum serpula* (Indira, 1965)
- Physarum tenerum* (Gray, 1938)
- Physarum venum* (Indira, 1965)

Didymiaceae

- Physarina echinospira* (Alexopoulos and Blackwell, 1968)
- Diderma effusum* (Constantineanu, 1907)
- Diderma hemisphaericum* (Henney, unpubl.)
- Mucilago crustacea* (Schure, 1949) *
- Didymium difforme* (Lister, 1901)
- Didymium iridis* (Cayley, 1929)
- Didymium nigripes* (Skupienski, 1920)
- Didymium ovoideum* (Taylor, unpubl.)
- Didymium squamulosum* (Constantineanu, 1907)
- Didymium trachysporum* (Henney, unpubl.)

Stemonitales

Stemonitaceae

- Diachea splendens* (Indira, 1965)
- Lamproderma scintillans* (Alexopoulos, unpubl.)
- Clastoderma debaryanum* (McManus, 1961b)
- Stemonitis flavogenita* (Alexopoulos, 1959)
- Stemonitis fusca* (McManus and Richmond, 1961)
- Stemonitis herbatica* (Indira and Kalyanasundaram, 1963)
- Stemonitis hyperopta* (Alexopoulos, unpubl.)
- Comatricha laxa* (Wollman and Alexopoulos, 1964)
- Comatricha nodulifera* (Wollman and Alexopoulos, 1968)
- Comatricha typhoides* (Wollman, 1966)

Trichiales

Dianemaceae

- Calomyxa metallica* (Wollman, 1966)

Trichiaceae

- Perichaena depressa* (Wollman and Alexopoulos, 1964)
- Perichaena vermicularis* (Ross, 1967b)
- Arcyria cinerea* (Alexopoulos, 1960a)
- Arcyria denudata* (Gilbert, 1929b)
- Metatrichia vesparium* (Gray, 1938)

Liceales

Liceaceae

- Licea biforis* (Wollman and Alexopoulos, 1964)

Echinosteliales

Echinosteliaceae

- Echinostelium cribrarioides* (Alexopoulos, 1961)
- Echinostelium minutum* (Alexopoulos, 1960b)

agar, starting with spores, has been described in the literature or has been accomplished in the authors' laboratories and has therefore been authenticated by at least one of them. An attempt has been made to cite the first report of the cultivation of a species from spores, but some references may have been missed. Some authors do not make clear whether the culture described originated from spores, and their work is not, therefore, cited in this connection.

It must be emphasized here that even with species that are relatively easy to cultivate, culture from spores is not always successful, and it may be necessary to try several times, using spores from different field collections, before success is achieved. What has been said about spore germination on pages 14-25 is pertinent here.

Criteria for Myxomycete Culture

Claims of having grown a myxomycete in culture from spores cannot be accepted as authentic unless spores are sown on sterile media, and fruiting bodies that closely resemble those from which spores were taken are produced. The mere appearance of a plasmodium in a culture does not constitute evidence that a particular species has been cultivated. Contaminant spores of easy-to-grow species frequently gain entrance to laboratory cultures and give rise to myxamoebal populations that produce plasmodia. There is no known way to identify a myxomycete from plasmodial characters alone.

Vouchers of fruiting bodies produced on artificial media should be deposited in well-known myxomycete collections. Such vouchers may be easily prepared by smearing a 22 × 40 mm cover-slip with white glue, placing on it a block of agar bearing mature, well-formed characteristic fruiting bodies, and allowing the preparation to stand until the agar dries. The cover-slip may then be glued in a box on which the following data should appear: (1) collecting data or herbarium number of original deigma³ from which the spores were taken, (2) medium, (3) date of planting spores, (4) date of germination, (5) date of plasmodium formation, (6) date of fruiting, and (7) name of experimenter. Inasmuch as Myxomycetes in artificial culture often fruit on the side of the container, it is desirable to use 60 × 20 mm plastic Petri dishes for such cultures. If the fruiting bodies to serve as vouchers are produced on the sides of the dish, either the entire dish may be deposited as a voucher, or pieces on which the fruiting bodies are formed may be cut and glued in boxes. Plastic dishes are advantageous in that the agar usually does not adhere to them after it dries. Thus, cultures in which fruiting bodies

³ A particular specimen consisting of one or more fruiting bodies bearing an identifying number by means of which it may be located by subsequent workers.

have been formed may be allowed to dry in the dish by removing the cover; the whole agar disk is then easily lifted out with a pair of forceps.

Spore-to-Spore Culture of Physarales

A number of physaraceous species can be cultured from spores with relative ease. The spores are spread on the surface of CM/2 agar, and the surface is flooded with a thin film of sterile distilled water. When a large population of myxamoebae has developed, the water is poured off, if it has not already dried. If a good bacterial population is present, nothing more need be done until plasmodia become evident under the microscope in from three to six days, at 20°-25° C, depending on the species. If the bacterial population is small, a milliliter of a suspension of *Escherichia coli*, *Aerobacter aerogenes*, or *Flavobacterium* sp. may be poured over the myxamoebae. When plasmodia have been formed, a small amount of sterile, pulverized oats should be sprinkled over the cultures.

When the plasmodia have grown to a large size they should be freed from fungi (see page 224), fed oats until they become vigorous, and then transferred to non-nutrient agar to fruit. With species such as *Fuligo cinerea*, *Didymium squamulosum*, *D. iridis*, *D. nigripes*, *Physarum pusillum*, and *P. didermoides* this appears to be sufficient. Usually they fruit easily. Yellow plasmodia, such as those of *P. polycephalum*, *P. flavicomum*, and *Physarella oblonga*, must be illuminated in order to sporulate (see Chapter 9).

Unfortunately, we do not know the factors that govern sporulation in most species. With *P. polycephalum* in pure culture a procedure has been worked out by Daniel and Rusch (see page 172). Aldrich (1966) was able to induce at will sporulation of fungus-free plasmodia of *P. flavicomum* by using the following method:

1. Grow a vigorous plasmodium and allow to migrate on oat-flake agar plates for a week.
2. Transfer 2-3 cm agar squares bearing plasmodium to standard size Petri dishes containing plain agar and incubate them in the dark for four hours or until the plasmodium has covered the agar surface.
3. Arrange plates under electric lights. Aldrich used 40-watt fluorescent tubes 6 inches from the plates and found that fruiting began 12 hours after the cultures were placed under the lights.

Sporangia developed in this way were typical of the species and contained viable spores. Unfortunately the results are not as predictable when this method is used for other species, such as *P. polycephalum* or *Didymium nigripes*.

Culture of Non-physaraceous Species

Whereas physaraceous species prefer a relatively dry medium, most non-physaraceous species require a film of water under which they develop their plasmodia (Alexopoulos, 1960a). Also, bark-extract agar appears to be more favorable than other types for the cultivation of the Stemonitaceae, the Liceaceae, and, to a lesser extent, the Trichiaceae (Wollman, 1966). At the University of Texas, we have used bark-extract-cornmeal agar⁴ for the cultivation of non-physaraceous species with good results. Noble's agar also has proved to be excellent for some species.

After the sterile agar has solidified in the Petri dishes to be used, spores are spread on its surface and enough sterile distilled water is poured over the agar to form a thin film of liquid. If the small Petri dishes (60 × 20 mm) are used, 3 ml is sufficient. Three drops of a moderately heavy suspension of *Flavobacterium* are added. The cultures are incubated in the dark at 20° C. Sterile water is added to the cultures as needed to keep the agar surface constantly submerged.

When plasmodia are formed—this to be ascertained by examination under the compound microscope, as aphanoplasmodia are all but invisible to the unaided eye and very difficult to see under the stereomicroscope—sterile, pulverized, rolled oats are lightly sprinkled over the cultures. When the plasmodia have become vigorous, the cultures are transferred to a lighted incubator and water is withheld. This is a critical stage in the life of the cultures, and they should be examined rather frequently until fruiting begins. If the plasmodia have not reached the fruiting stage, they will often sclerotize as soon as the surface of the agar is permitted to dry. The film of water should then be restored as soon as possible. If the plasmodia continue to migrate on the dry surface and appear healthy, fruiting is about to take place and nothing more need be done. If the cultures are too wet at the time of fruiting, the fructifications will be aberrant.

Perichaena depressa and *Arcyria cinerea*, among the non-physaraceous species, will generally grow quite readily on various media, such as CM/2. The former species is quite tolerant of great variations in moisture at any stage of development after plasmodia have been formed. It thrives best on a moderately dry agar surface but will form perfect fruiting bodies even under water. In our experience, the young plasmodia of *A. cinerea* sclerotize very quickly if the agar surface dries, but once they become well established they will grow and spread on the agar even after the surface dries. Indira and Kalyanasundaram (1963) report having induced that organism to develop its entire life cycle on a dry

⁴ See Appendix.

agar surface. We have been unable, in repeated attempts, to confirm their results.

Monoxenic Cultures

Monoxenic cultures of Myxomycetes starting from spores are relatively easy to obtain with species that produce large, actively migrating myxamoebae (Ross, 1964). The following procedure developed by Henney (1966) has been in use at the University of Texas for several years.

1. Prepare a spore suspension by crushing one or more sporangia in a sterile screw-cap tube containing 10 ml sterile distilled water, and shake vigorously to facilitate dispersal of spores.
2. Place three drops of the spore suspension near the edge of a standard-size Petri dish containing 3 per cent CM/2 and tilt plate, allowing the suspension to run in a straight line across the center of the dish. Incubate at 25° C.
3. Examine periodically for the formation of a myxamoebal population which should migrate away from the bacteria growing along the inoculation streak.
4. Using a stereomicroscope with a magnification of at least 90×, search the agar surface for places where the myxamoebae appear to be far from any bacterial colony and, using a flamed, fine entomological needle, cut out a small agar block bearing several myxamoebae.
5. Transfer to a Petri dish containing sterile CM/2 and add 0.5 ml of a suspension of *Escherichia coli*.
6. Cut five additional blocks all in the immediate vicinity of the first, and place one in each of five tubes containing the following media:⁵
 - a. Nutrient broth
 - b. Difco AC broth
 - c. Yeast extract broth
 - d. Thioglycolate broth
 - e. Glucose broth
7. Incubate broth cultures at 25° C and examine for turbidity periodically. If bacterial growth develops in any of the media within 30 days, discard the cultures and repeat the entire procedure. If all five test media remain clear, it is safe to assume that a monoxenic culture has been established.
8. During the 30-day test period, the agar culture established (instruction 5) should be watched for formation of plasmodia and these fed with sterile, pulverized oats. The culture should at all times be protected from contamination. When fruiting occurs,

⁵ See Appendix.

new monoxenic cultures may be started from the spores, always using the same bacterium. The culture should be tested periodically by streaking a loopful of myxamoebal/bacterial association or bits of the plasmodium formed on Eosin Methylene Blue agar. If bacterial colonies other than those of *E. coli* develop, the culture should be discarded.

AXENIC CULTURES

Purification of Phaneroplasmodia

Some plasmodia collected in nature or developed from sclerotia or from spores in culture may be purified and grown in axenic or monoxenic culture. Unfortunately, this is true of the plasmodia of certain species only. Usually a large, vigorous, rapidly migrating plasmodium can be purified much more easily than a small, weak, slow-moving one. This implies that not all plasmodia can be induced to grow to a large size. This, in the authors' experience, is true. The plasmodia of certain species, *Physarina echinospora*, for example, could not be induced to grow larger than 1-2 cm in diameter in a large number of attempts over a period of two years. The plasmodia either disintegrated or sporulated but never grew large.

Two methods have been found to be efficient in purifying plasmodia: migration and enrichment (Cohen, 1939). The first method, as employed at the University of Texas laboratory, is as follows:

1. Rid the plasmodium of fungi by allowing it to migrate on plain or CM/2 agar and transferring a fungus-free fan to oat-flake agar.
2. Grow the plasmodium on oat-flake agar until large, vigorous fans develop. Three to seven days are usually required for this step.
3. Transfer a block of agar, about 2 cm square and bearing a vigorous plasmodial fan, to 2 per cent agar containing 1,000,000 units potassium penicillin G and 1 gr streptomycin sulfate per 500 ml agar, and allow to migrate. Six hours is usually long enough for rapidly migrating plasmodia.
4. Transfer to oat-flake penicillin/streptomycin agar⁶ as many times as necessary to purify.⁷

The first of these steps is sometimes very difficult to accomplish. Plasmodia of some species migrate too slowly to get away from the constantly growing fungal hyphae. Plasmodia of other species cannot be induced to leave a fungal colony once they have spread over it. As the fungus grows, the plasmodium remains on it at the periphery of the

⁶ See Appendix.

⁷ For criteria of axenism see p. 226.

colony, probably feeding on the hyphae, and must be watched constantly in the hope of finding a plasmodial lobe or fan protruding beyond the margin of the fungus colony so that it may be cut and transferred. This requires a steady hand and considerable skill in order not to transfer any part of the fungus.

The enrichment method as described by Cohen (1939) is as follows:

1. Washed agar plates⁸ are streaked along a diameter for 5 cm with a suspension of *Saccharomyces ellipsoideus*.
2. A bit of plasmodium is placed at one end of the streak.
3. After reaching the end of the streak on which it migrates, the plasmodium is transferred to a second streak in another plate.
4. Small portions of the plasmodium are inoculated in the test media to test for presence of bacteria.
5. Bacterium-free plasmodia are then allowed to migrate over non-nutrient agar once or twice to free them from yeast.

Until 1963, axenic plasmodial cultures of 11 species had been reported in the literature (Alexopoulos, 1963) as follows: *Badhamia foliicola*, *B. utricularis*, *Physarum polycephalum*, *P. didermoides*, *P. gyrosum*, *Fuligo septica*, *F. cinerea*, *Didymium squamulosum*, *D. nigripes*, *Stemonitis axifera*, and *Licea variabilis*. Since that time Ross (1964) has reported axenic cultures of *Physarum flavicomum* and *Physarella oblonga*, and Henney and Henney (1968) of *Physarum rigidum*. It is important to emphasize, as Alexopoulos (1963) has pointed out, that many of the axenic cultures reported were maintained on killed bacteria or yeasts. To our knowledge, bacterium- and yeast-free cultures of myxomycete plasmodia have been maintained for a relatively long time only by Sobels (1950), Daniel and Rusch (1961), Lazo (1961), Ross (1964 and personal communication), H. Henney (personal communication) and in the laboratory of one of the authors (C.J.A.).

We have found that among several species, the plasmodial purification of which has been attempted in our laboratories, *Physarum polycephalum*, *P. flavicomum*, *P. gyrosum*, and *Physarella oblonga* are easiest to purify and to maintain in axenic culture. Plasmodia of many species are so weakened by the third or fourth transfer that they die unless fed bacteria. *Escherichia coli* serves well as food for such plasmodia, and a presumably monoxenic culture can be established. However, unless one is certain that the plasmodium is growing axenically before *E. coli* is added, he cannot be certain that he has indeed established a monoxenic culture. The literature abounds in claims of axenic and monoxenic cul-

⁸ Plain agar washed for five days in frequent changes of distilled water, squeezed dry in cheesecloth and used to prepare 2 per cent agar. Difco Noble's agar is essentially prepared in this way. It is used exclusively at the University of Texas for this purpose.

tion in yellow-pigmented plasmodia, many investigators have suggested that the pigment(s) is the photoreceptor. While this is a good possibility, it has never been proved, and there is much disagreement about the chemical nature of the pigment. Some investigators have reported the isolation of several pigments from the same species.

From the foregoing brief account and the more comprehensive treatment in the chapters that precede it, it is evident that we possess a considerable body of information about the Myxomycetes. But from the same account it is evident that there are a great many questions yet to be answered. Let us say that at this time we have a good working knowledge of the Myxomycetes, but that there is a great amount of exacting research to be conducted and a great amount of exciting information yet to be gained by future workers. We hope that this volume will assist in giving the student access to knowledge already gained and that this, coupled with his access to existing sophisticated modern techniques (as well as those that will be developed), will lead to the accumulation of more complete information about this fascinating group of organisms.

Appendix

FORMULAE FOR PREPARING VARIOUS MEDIA

1. Bark-Extract Cornmeal Agar (BECM)

Tree bark	50 g
Bacto agar	17.5 g
Cornmeal agar	8.5 g
Distilled water	1000 g

Quercus fusiformis outer bark is used at the University of Texas, but bark from other trees may serve equally well or better for many species of Myxomycetes.

Cut the bark in small pieces, place in a large Erlenmeyer flask with the water, and steam for one hour. Allow flask to stand for one week at room temperature. Filter through filter paper to obtain a clear liquid. Add water to bring volume to 1000 ml. Add agar and autoclave at 15 pounds for 15 minutes.

2. Difco Nutrient Broth

Bacto nutrient broth	8 g
Distilled water	1000 g

3. Half-Strength Cornmeal Agar (CM/2)

Cornmeal agar	8.5 g
Bacto agar	12.5 g
Distilled water	1000.0 g

4. Half-Strength Cornmeal Agar with Three Per Cent Agar (3% CM/2)

Cornmeal agar	8.5 g
Bacto agar	22.5 g
Distilled water	1000.0 g

5. Penicillin-Streptomycin Agar

Bacto agar	20.0 g
Potassium penicillin G	2 million units
Streptomycin sulfate	1.0 g
Distilled water	1000.0 g

Melt the agar in the water by steaming. Add the antibiotics and autoclave at 15 pounds for 15 minutes.

6. Knop's Solution Agar

$\text{Ca}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$	0.8 g
KNO_3	0.2 g
KH_2PO_4	0.2 g
$\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$	0.2 g
FeSO_4 or FePO_4	trace
Bacto agar	20.0 g
Distilled water	1000.0 g

7. Difco AC Broth

Bacto-AC medium	34.0 g
Distilled water	1000.0 g

8. Yeast-Extract Broth

Yeast extract	1.0 g
Distilled water	1000.0 g

9. Thioglycollate Broth

Bacto-Thioglycollate medium ..	24.0 g
Distilled water	1000.0 g

10. Glucose Broth

Glucose	1.0 g
Bacto peptone	1.0 g
Distilled water	1000.0 g

11. Eosin Methylene Blue Agar

Bacto EMB agar	36.0 g
Distilled water	1000.0 g

12. SM/5 Medium (Kerr and Sussman, 1958)

Bacto peptone	2.0 g
Glucose	2.0 g
Yeast extract	0.2 g
K_2HPO_4	0.2 g
KH_2PO_4	0.3 g
$\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$	0.2 g
Bacto agar	20.0 g
Distilled water	1000.0 g

13. Oat-Flake Agar

Place enough oat flakes (rolled oats), preferably the slow-cooking type, in 100×20 mm Petri dishes to form a layer about 5 mm deep in each dish. Pour enough melted, hot, 2 per cent Bacto agar in each dish just to cover the oat flakes. Autoclave for one hour or more at 15 pounds.

14. Oat Flake-Penicillin/Streptomycin Agar

Follow instructions for preceding method, but use penicillin-streptomycin agar instead of plain Bacto agar.

15. Noble's Agar

Difco Special Agar (Noble)	2.0 g
Distilled water	1000.0 g

MYCOTA

(Fungi)

Chlorophyll lacking; nutrition heterotrophic. Assimilative phase varying from a single, uninucleate or multinucleate cell to an often extensive, semi-naked, multinucleate plasmodium or to a mycelium composed of numerous branching and often anastomosing hyphae which may be continuous or septate. Reproductive phase sometimes involving the transformation of the entire assimilative thallus, but more commonly the production of specialized spore-bearing structures, these often organized into fructifications of characteristic form in which spore formation may be associated with nuclear fusion and reduction.

The Mycota may be subdivided as follows:

Assimilative stage a true, free-living plasmodium, at maturity varying from a minute, multinucleate, amoeba-like body of limited motility to a large, strongly motile mass of protoplasm flowing within netted veins and merging at the advancing margin into a continuous protoplasmic film; fructification of sporangia, either separate or united into pseudoaethalia, or of plasmodiocarps or aethalia; rarely (*Ceratiomyxa*) of pillar-like, poroid, or effused sporophores.

Subdivision **MYXOMYCOTINA**

With the single class.

MYXOMYCETES

Assimilative phase characteristically filamentous, with or without septa, sometimes unicellular, uni- or multinucleate, rarely plasmodium-like and then distinguished by characteristic reproductive structures.

Subdivision **EUMYCOTINA**

The Eumycotina includes the classes Phycomycetes (now often subdivided into several classes), Ascomycetes and Basidiomycetes and the artificial or form-classes Deuteromycetes (Fungi Imperfecti) and Lichenes.

Tomentella in einer Entwicklungsrichtung mit glatten Hymenien zu den keulig-korallinischen und schließlich zentral-gestielt und hutförmigen Typen der Gattung *Thelephora*, in einer anderen Reihe mit Stachelhymenium von der resupinaten *Caldesiella* zu den in Hut und Stiel gegliederten *Hydnellum*- und *Sarcodon*-Species. Die *Sarcodon*-Arten sind durch kurzlebige, fleischige Fruchtkörper ausgezeichnet. In einer dritten Reihe finden sich waben- bis porenförmige Hymenien, und zwar bei der resupinaten *Lindtneria* wabige, bei der röhrlingsähnlichen *Boletopsis* röhrige. An den Enden dieser Entwicklungen, für die die heutigen Typen natürlich nur morphologische Symbole, nicht tatsächliche Übergangsglieder sein können, stehen also jeweils fleischige und zentralgestielt-hutförmige Formen. Anders bei den Hymenochaetae, deren Entwicklung offenbar durch die starke Bindung an den Holzabbau in eine andere Richtung gelenkt wurde. Das Hymenophor probiert auch hier alle Möglichkeiten von der glatten Fläche über die Stachel- zur Porenform durch. Die Fruchtkörper streben aber dem Konsolentypus zu, der bereits bei *Hymenochaete* erreicht wird, bei den einjährigen *Inonotus*-Arten mit dem Porenhymenium kombiniert wird und eine gewisse Vollendung in den vieljährigen *Phellinus*-Arten erreicht. Eine Seitenlinie hat auch hier zu zentralgestielten Hüten geführt, nämlich bei der Gattung *Coltricia*. Wie bereits oben dargelegt und an beiden Familien erläutert, ist die Formbildung nach weitgehend ähnlichen Prinzipien verlaufen. Dabei blieben die charakteristischen Eigenschaften der beiden Reihen gewöhnlich erhalten: Die phyletische Differenzierung erfaßt also in erster Linie sekundäre Merkmale.

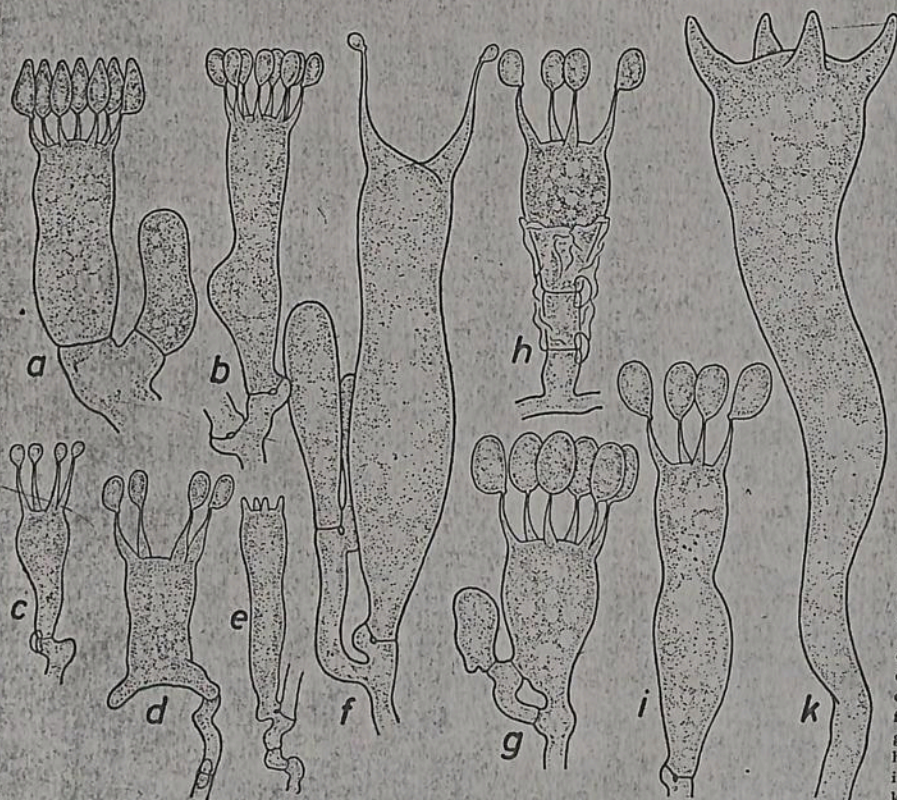


fig. 36: Basidientypen der Corticiae:
a *Botryobasidium*,
b *Sistotrema*,
c *Athelia*,
d *Xenarma*,
e *Phlebia*,
f *Corticium macounii*,
g *Paullicorticium*,
h *Repetobasidium*,
i *Hypoderma*,
k *Vuilleminia* – wie (Orig.).

Gliedern wir innerhalb der *Poriales* alle eindeutig klaren oder sonstwie gut zu umreißen den Entwicklungslinien aus, so bleiben uns zahlreiche Typen über, die nur *ad interim* in künstliche Verwandtschaften eingeteilt werden können. Um ein solches Konglomerat handelt es sich bei der Familie *Corticaceae*, bei der die meisten Arten mit glattem Hymenium untergebracht werden. In diesem Bereich ist das charakteristische Organ, die Basidie, in Sporenzahl und -form noch wenig gefestigt (FIG. 36). Wir finden 2-, 4-, 6- und 8-sporige Basidien, in keuliger, urnenartiger Form, Typen mit sehr dünnen Hyphen und kleinen Basidien, umgekehrt Gattungen – wie *Botryobasidium* – mit sehr weitlumigen Hyphen. In der Familie der *Poriaceae* werden die Formen mit porig-röhrenförmigem Hymenium vereinigt. Daß diese Abgrenzung nicht natürlich ist, versteht sich nach dem Gesagten. Für die in unserem Werk unterschiedenen *Clavariaceae*, die wieder gewisse Beziehungen zu den Cantharellaceen haben, gilt ähnliches. Im übrigen sei auf die Tafeltexte verwiesen. Ökologisch sind die *Poriales* so uneinheitlich wie systematisch. Viele sind Saprophyten, manche Schwächeparasiten, doch finden sich auch Pertho-

differences between the *Tulasnella*, *Ceratobasidium* and *Uthatabasidium* sterigmata are too insignificant to justify placing these genera in three different families, although the *Tulasnella* basidium as a whole represents a strongly advanced 'physiological' type." Donk (1964) now foresees the abolition of the family Ceratobasidiaceae and summarizes his opinion as follows: "The introduction of the Ceratobasidiaceae as a distinct family from both the Tulasnellaceae and Corticiaceae rested on the emphasis of the walls across the bases of the sterigmata of the Tulasnellaceae, and on calling the sterigmata in *Tulasnella* and *Ceratobasidium* epibasidia and in the other 'tulasnelloid fungi,' like *Thanatephorus* and *Uthatabasidium*, sterigmata. I cannot find any reason for not calling them all sterigmata, and therefore there seems no good reason why the Ceratobasidiaceae (as delimited at present) should not be abolished."

The discovery of the tropical genera *Metabourdotia* Olive (1957a) and of *Pseudotulasnella* Lowy (1964) which were found to have basidia with only partial or fragmentary septa, called further attention to forms that are frankly intermediate between the subclasses and to the difficulty of placing them satisfactorily into either of these categories.

Olive (1957a) described his new genus as follows: "Fructification resupinate, waxy-pruinose; gloecystidia present; basidia typically broadly clavate, septate apically, septa incomplete below; basidiospores germinating by repetition." Olive has the following comments to make on the taxonomic position of the genus: "The new genus is believed to occupy a position of primitiveness in the Ceratobasidiaceae, indicating a phylogenetic connection of this family with the Tremellaceae. . . . *Metabourdotia* might just as logically be classified as an advanced member of the Tremellaceae and there can be little doubt of its affinity with that family. . . . The discovery of *Metabourdotia* strongly supports the conclusion of Martin that the Ceratobasidiaceae are closely allied to the Tremellales. At the same time there can be little doubt that Jackson is correct in his statement regarding *Pellicularia* and *Ceratobasidium* that "the two genera approach each other very closely, especially through the parasitic species."

Lowy (1964) described the genus *Pseudotulasnella* as follows: "Fructification resupinate, waxy-gelatinous; gloecystidia lacking; probasidia subglobose, apically cruciately septate, septa incomplete below; mature basidia clavate-capitate, producing tulasnelloid sterigmata; basidiospores germinating by repetition." The following comments are also pertinent. ". . . it is evident that *Pseudotulasnella* bridges the gap between the Tulasnellaceae and the Tremellaceae. Moreover, *Metabourdotia* might easily be classified as a member of the Tremellaceae rather than of the Ceratobasidiaceae where it is more or less arbitrarily placed by Olive. It would seem more at home in the Tremellaceae, having both elongated sterigmata and partially septate basidia, whereas its inclusion in the Ceratobasidiaceae may be justified on the basis of its sharing only one of these characteristics, namely the elongated sterigmata. The exclusion of fungi having septate or partially septate basidia from the Ceratobasidiaceae would also have the advantage of maintaining the family as a more homogeneous group. If *Metabourdotia* is so considered, it provides us with a significant link through which a transition from the Tremellaceae to the Tulasnellaceae by way of *Tulasnella* may have been effected, establishing at the same time, a convincing intermediate stage between the Tremellaceae and the Ceratobasidiaceae." I have since reconsidered my position on this matter and now believe that it would be more desirable to include *Metabourdotia* in the Tulasnellaceae rather than in the Tremellaceae because I would prefer to maintain the homogeneity of the Tremellaceae which includes only taxa with completely divided basidia. Nevertheless, the relationship of *Metabourdotia* to the Tremellaceae remains close.

From this review, I believe it is apparent that a workable solution to the problem

of intermediate forms is urgently needed. A proposal was offered by Talbot (1964) who summarized his recommendations in this manner. "The genera dealt with here are divided among the Tulasnellaceae and the Corticiaceae, the family Ceratobasidiaceae being regarded as superfluous. The subclasses Heterobasidiomycetes and Homobasidiomycetes are not recognized, as it is impossible to suggest characters by which they may consistently be delimited. The characters normally used for delimiting these subclasses are, however, still regarded as of great importance for separating lower taxonomic categories."

I cannot concur in the suggestion that the two subclasses be abolished, because in my judgement this does not solve the problem. I am in accord with the view that the Heterobasidiomycetidae as presently constituted is too heterogeneous an assemblage (including as it does many intermediate forms) to be maintained as a completely effective entity, but there seems little merit in retrogressing to a pre-Patouillardian system and trying to breathe life into a fossilized scheme that has been abandoned by working taxonomists for half a century. While the evidence shows the inadequacy of the present taxonomic arrangement, notably in its inability to cope with fungi having such troublesome attributes as make their assignation to either of the existing subclasses difficult or impossible, the abolition of those subclasses is not, in my opinion, the desirable answer. As I see the problem, there are three courses of action that may be taken in an effort to solve the dilemma. (1) Alter the criteria applicable to the two subclasses in such a way as to admit taxa having intermediate characters. (2) Abolish the subclasses. (3) Erect a new subclass, admitting taxa having characters that are intermediate between the existing subclasses.

The first "remedy" (status quo) has been in effect for some time and is inadequate because no satisfactory way can be devised to avoid having fungi with intermediate or overlapping characters, from impinging on one or the other of the mutually exclusive subclasses. The second suggestion, that of the abolition of the subclasses proposed by Talbot, would have the effect of obscuring the differences that exist between them or at least of deemphasizing these differences to a degree that would be incompatible with the morphological realities. To establish a new subclass, while not entirely free of objection (mostly from the standpoint of precedent) would seem to be the solution of choice. I therefore propose the following rearrangement of the Heterobasidiomycetes.

BASIDIOMYCETES subclass HETEROBASIDIOMYCETIDAE

Taxa with completely divided basidia, having notably enlarged or swollen sterigmata; basidiospores germinating by repetition; basidiocarps frequently with a waxy or gelatinous texture. Examples: Eutremellales: Auriculariaceae, Hyaloriaceae, Phleogenaceae, Sirobasidiaceae, Tremellaceae; Septobasidiales,¹⁸ Uredinales,¹⁹ Ustilaginales.²⁰

BASIDIOMYCETES subclass METABASIDIOMYCETIDAE²¹

Taxa with incompletely divided or aseptate basidia, having notably enlarged or swollen sterigmata; basidiospores germinating by repetition or conidia; basidiocarps with or without a waxy or gelatinous texture. Examples: Metatremellales: Dacrymycetaceae (*Gerinomyces*, *Dacrymyces*, *Dacryopinax*, *Ditiola*); Tulasnellaceae (*Gloeotulasnella*, *Metabourdotia*, *Pseudotulasnella*, *Tulasnella*); Ceratobasidiaceae (*Ceratobasidium*, *Oliveonia*, *Thanatephorus*, *Uthatabasidium*).

¹⁸, ¹⁹, ²⁰ The Septobasidiales, Uredinales and Ustilaginales lie outside the scope of this work.

²¹ First published in Taxon 17: 125. 1968.

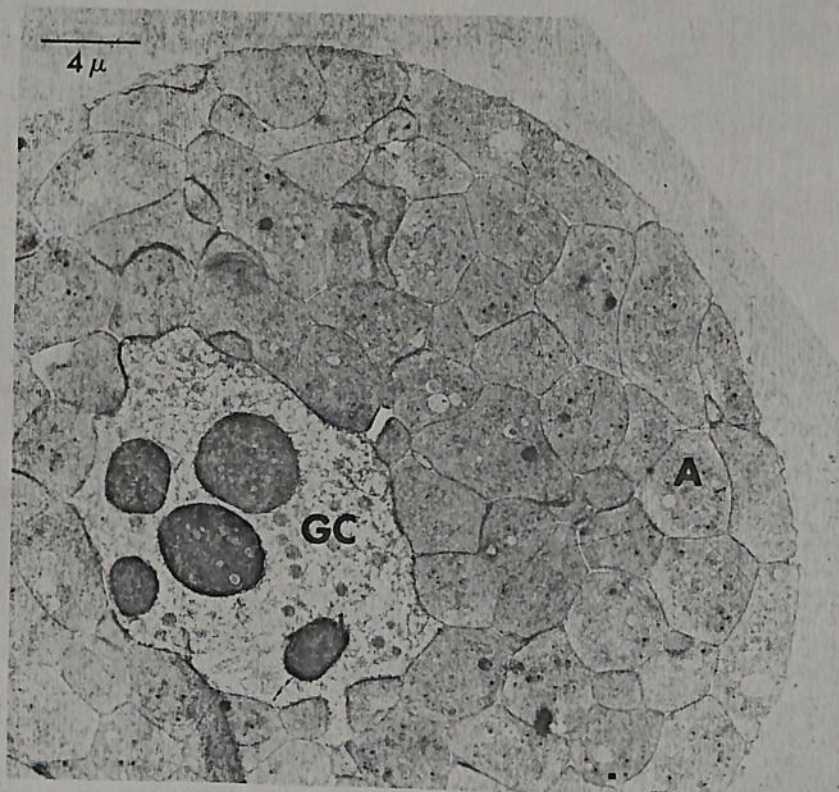


Fig. 112. *Polysphondylium violaceum*; electron micrograph of section through macrocyst, showing central giant cell (GC) with ingested amoebae, surrounded by aggregate of amoebae (A). Primary wall has begun to form. From Erdos *et al.* (1972).

Erdos *et al.* (1972) have found axial elements characteristic of synaptic chromosomes. The latter occur singly or in pairs or groups but have failed to show evidence of central elements. This interesting discovery, supported by the recovery of a sizeable group of recombinant genotypes from heterozygous macrocysts (G. W. Erdos, personal communication), indicates that the macrocysts may be the sites of a sexual process in dictyostelids. The large size of the nucleus leads one to suspect a high degree of polyploidy. The macrocyst cell becomes multinucleate before complete dormancy occurs.

dictyostelia

podium
ell (1967)

uleo-stipes
ell (1967)

ndulum
ell (1967)

aceo-fuscum
ell (1967)

um E. W.
D. sphae-
(1902), with
with rose-
short erect
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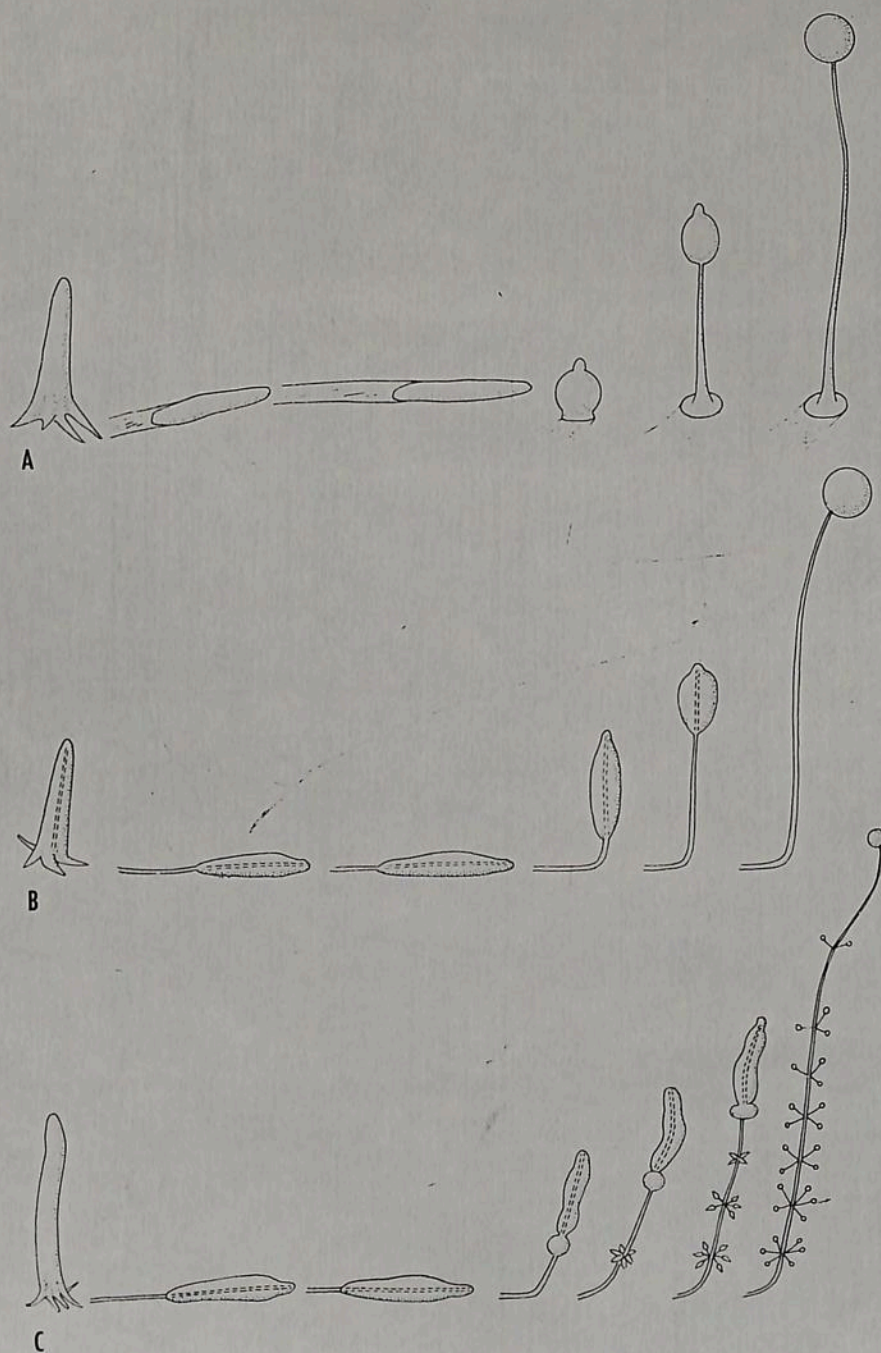


Fig. 84. Sorogenesis in dictyostelids: (A) *Dictyostelium discoideum*; (B) *D. mucoroides* and *D. purpureum*; (C) *Polysphondylium*. Redrawn from Bonner (1957).

Fine structure

✓ Bracker, C.E. & E.E. Butler. 1963. *Mycologia* 55: 35-58.

The ultrastructure and development of
septa in hyphae of Rhizoctonia solani

✓ Moore, R.T. & J.H. Mc Aleer. 1962. Fine structure
of Myxaria 7. *Ann. J. Bot.* 49: 26-94.

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The Fungi, An advanced Treatise. ed. G.C. Ainsworth & A.S. Sussman.

Vol. 1. The Fungal Cell. 1965. Academic Press. 742 pp.

✓ [ch. 5. - The ultrastructure of fungal cells. R.T. Moore. 95-118.]

KEY TO GENERA OF LOUISIANA POLYPORACEAE

1. Sporophore resupinate-----2
1. Sporophore effuso-reflexed, sessile, to stipitate, not resupinate-----4
 2. Pores shallow, sometimes represented only by folds or reticulations over which the hymenium is continuous; waxy to gelatinous hymenium ----- Merulius
 2. Pores well-developed and sterile on their edges-----3
3. Pores relatively large, sunken to unequal depths in context, often with a narrow free margin-----Trametes
3. Pores smaller, their bases forming a continuous line in the context, strictly resupinate-----Poria
4. Spores light to dark brown, truncate and appearing echinulate; pileus with a crust-----Ganoderma
4. Spores not truncate or, if so, then not appearing echinulate; pileus with or without a crust-----5
5. Pores very shallow in mature specimens, separated by narrow ridges or folds over which the hymenium is continuous; waxy or gelatinous hymenium-----Merulius
5. Pores deeper, well-developed, and sterile over their edges-----6
 6. Sporophores perennial; tubes in several layers, especially hard and woody-----Fomes
 6. Sporophores annual or scarcely lasting two or three years; tubes generally not in distinct layers-----7
7. Pore surface of radiating lamellae-----Lenzites
7. Pore surface various but not lamellate-----8
 8. Pores large and hexagonal-----9
 8. Pores smaller, angular, circular, sinuous (daedaloid), but not hexagonal-----10
9. Sporophore sessile-----Hexagona
9. Sporophore stipitate; pores arranged in rows radiating outward from stipe-----Favolus
10. Pore surface sinuous-----Daedalja
10. Pore surface poroid or hydroid; if hydroid, traces of pores usually present along margin-----11
11. Pore surface hydroid-----12
11. Pore surface poroid, edges of pores may be toothed but distinct pores present on hymenial surface -----14
 12. Context white----- Polyporus tulipiferae
 12. Context brown-----13
13. Setae present-----Hydnochaete
13. Setae absent-----Trametes
14. Context not distinct from pore tissue; tubes often sunk to uneven depths-----Trametes
14. Context distinct from pore tissue; tubes not sunken to uneven depths in context but forming a continuous line-----Polyporus

DAEDALIA Pers. ex Fr.

Sporophores coriaceous to corky, never fleshy and soft; context white or light-colored; hymenium of elongated or sinuous pores, sometimes varying toward poroid or lamellate. Overholts reports five species from Louisiana. We have collected and studied two species, one of which has not previously been reported.

1. Pores or interspaces 1 mm or more broad, walls thick, obtuse; on hardwoods----- D. quercina
1. Pores 1-3 per mm, or interspaces less than 1 mm broad, walls thin rarely lamellate-----D. ambigua

FAVOLUS Beauv. emend. Fr.

Fructifications stipitate or substipitate with hexagonal pores arranged in rows radiating outward from the stipe.

1. Pores scarcely visible to the unaided eye, 3-4 per mm; sporophores rarely more than 2 cm diam.-----F. Rhipidium
1. Pores easily visible to the unaided eye-----2
2. Pores usually equally hexagonal; spores 14-20 X 5-8u-----F. cucullatus
2. Pores radially elongate; spores smaller-----3
3. Pileus reniform, reddish at first; stem usually reduced-----F. alveolaris
3. Pileus reniform to flabelliform, never reddish; stem usually distinct-----F. brasiliensis

FOMES (Fr.) Kickx

Pores usually arranged in distinct layers because of perennial growth of sporophore; usually extremely hard and woody when dry; spores are smooth, hyaline to brown. The species with usually truncate spores appearing echinulate are treated with Ganoderma. Of the thirteen species of Fomes reported from Louisiana, we have collected only two.

1. Pileus without crust; tubes not distinctly stratified in some specimens, but sporophore hard and woody when dry-----F. geotropus
1. Pileus with grayish crust, tubes distinctly stratified-----F. marmoratus

GANODERMA Karst. emend. Pat.

Annual or perennial, stipitate or sessile, leathery to woody. Pileus with a firm crust covering a brown to white contex. Characterized by brown, usually truncate spores which appear echinulate because of the minute spines borne by the endospore.

1. Sporophores usually stipitate-----2
1. Sporophores usually sessile-----3
2. Pileus surface bright red to mahogany or black; margin usually acute; in one collection with two layers of tubes-----G. lucidum
2. Pileus surface yellowish brown or olivaceous; margin usually thick and obtuse-----G. Curtisii
3. Surface varnished, light red to brownish red or darker-----G. sessile
3. Surface not varnished, crust grayish or dark; perennial with new pilei growing out below those of previous year; pores not stratified-----G. lobatum

HEXAGONA Pollini emend. Fr.

Pores resembling those of Favolus except not elongated or arranged in radiating rows. Sporophores are sessile in this genus and stipitate to substipitate in Favolus. H. variegata is the only Louisiana species.

LENZITES Fr.

Sporophores lamellate to somewhat daedaloid. Context usually white, but if hymenium daedaloid, then context brown. Three species of Lenzites have been reported from Louisiana. We have failed to find L. trabea, but add L. striata to the list.

Sporophore usually annual, stipitate, sessile, or effuso-reflexed; terrestrial or growing on wood; fleshy, tough, leathery, or woody. Context white, bright-colored, to dark brown. Hymenium typically poroid with circular to angular mouths, in old specimens somewhat hydnoid to daedaloid but poroid appearance generally present at margins of pileus. Spores white, brown, even, or roughened.

POLYPOROUS MICHELLI ex Fr.

1. Sporophore with well-developed, white, dimidiate pileus-----*M. incarnatus*
1. Sporophore resupinate or with inturned margins, but without well-developed pileus-----2
2. Sporophores fleshy-tremellose, pores large-----*M. tremellosus*
2. Sporophores not fleshy-tremellose-----3
3. Margins white, hymenial surface pink-----*M. pallens*
3. Margins golden-yellow, as is the hymenium-----*M. aureus*

Sporophore usually somewhat gelatinous when fresh, resupinate to pileate. Characterized by shallow folds or pores on the hymenial surface which are fertile over their edges.

MERULIUS Haller emend. Fr.

1. Context white to light wood color; pileus strongly pubescent -----*L. betulina*
2. Context umber to rusty brown-----2
2. Sporophore bright rusty brown or umber-----*L. saepiaria*
2. Sporophore umber or cinnamon; hymenium completely gilled-----*L. striata*

12. Pore surface flesh-colored; pileus hard and rigid, distinctly stipitate-----P. dealbatus
12. Pore surface yellowish, not flesh-colored; stipe not well-developed-----P. mutabilis
13. Pileus cinereous, gray, drab-----P. amygdalinus
13. Pileus brown, sometimes with lavender tints-----P. persicinus
14. Context yellowish-brown or darker-----15
14. Context white, bright-colored, or light wood brown-----16
15. Pileus covered on its upper surface with stiff, erect, brownish-black hairs-----P. hydroides
15. Pileus villose to glabrous but without hairs such as above-----P. gilvus
16. Pileus cinnabar-red-----17
16. Pileus variously colored but not cinnabar-red-----18
17. Context 4 mm or more thick-----P. cinnabarinus
17. Context 3 mm or less thick-----P. sanguineus
18. Pileus with cup-shaped sterile structure at the base of its upper side-----P. conchifer
18. Pileus lacking such a cup-shaped structure on the upper surface of the pileus-----19
19. Tubes of different color or consistency than context-----20
19. Tubes of same color and consistency as context-----24
20. Pores sulphur-yellow-----P. sulphureus
20. Pores flesh-colored, smoke-colored, reddish-purple, purplish-black to black-----21
21. Tubes waxy, easily separating from the context, flesh-colored through reddish-purple-----P. dichrous
21. Tubes not waxy, smoke-colored through black-----22
22. Tubes purplish, early breaking into teeth; pores 2-4 per mm.-----P. pargamensis
22. Tubes smoke-colored to black, not breaking into teeth-----23
23. Pores 3-4 per mm; tubes smoke-colored-----P. fumosus
23. Pores 6-8 per mm; tubes generally black-----P. adustus
24. Tubes breaking into teeth early, strongly resembling a hydroid fungus-----P. tulipiferae
24. Tubes may break into teeth after sporophore matures but then not with well-developed teeth-----25
25. Pores 1 mm or more wide; pileus azonate-----P. obtusus
25. Pores 2-9 per mm; pileus generally zoned but may be azonate-----26
26. Pileus azonate, drying soft and light, rigid but not hard-----P. amygdalinus
26. Pileus zonate, drying flexible or rigid but not soft and light-----27
27. Pileus nearly glabrous-----28
27. Pileus villose, pubescent, velvety to the touch-----29
28. Pores 4-7 per mm-----P. Drummondii
28. Pores 8-9 per mm-----P. zonalis
29. Zones on pileus multicolored-----P. versicolor
29. Zones, when present, nearly or quite concolorous or with marginal zone darker or lighter-----30
30. Pores 3-4 per mm, usually with marginal zone lighter or darker than rest of pileus-----P. hirsutus
30. Pores 5-6 per mm, usually with all zones more or less concolorous-----P. pavonius

TRAMETES Fr.

Sporophores leathery to corky, sessile to resupinate. Context white to brown. Pores seated at various depths in the context, thus not forming a continuous straight line at their bases. Only two of the five species reported from Louisiana by Overholts have been collected.

1. Pileus 0.5 cm or less thick, thin and coriaceous, sometimes resupinate, often effuso-reflexed with a narrow, free margin-----T. rigida
1. Pileus 2-5 mm thick, never resupinate and pileus well developed----T. malicola

The Genera of Hydnaceae in the North Central United States
(adapted from L. S. Miller, 1935)

- a. Trama pale; spores usually smooth, rarely spinulose;
hyaline or slightly colored- - - - - b
- a. Trama dark; spores rough, usually brown, varying
from subhyaline to dark- - - - - 1
 - b. Hymenophore lacking, teeth borne directly on
the substratum- - - - - Mucronella
 - b. Teeth borne on a distinct hymenophore- - - - - c
- c. Spines borne on tough branching processes partially sub-
merged in a brownish tomentum, resupinate or reflexed- - - - Gloidon
- c. Spines not borne on tough branching processes;
resupinate, reflexed or stipitate- - - - - d
 - d. Resupinate, thin, floccose, crustose;
ceraceous to subcoriaceous- - - - - e
 - d. Reflexed to stipitate, rarely resupinate; fleshy
to coriaceous- - - - - i
- e. Ceraceous; teeth usually thick, obtuse, often deformed
and irregularly scattered- - - - - Radulum
- e. Texture variable, teeth hemispherical, cylindrical or
subulate, varying from short warts to long spines- - - - - f
 - f. Cystidia and setae lacking- - - - - g
 - f. Cystidia or dendrophyses present- - - - - h
- g. Teeth in the form of short, hemispherical, cylindrical
or subulate warts- - - - - Grandinia
- g. Teeth in the form of long slender, terete spines- - Oxydontia (Mycoacia)
 - h. Dendrophyses present; trama dark, floccose;
spores smooth- - - - - Asterodon
 - h. Cystidia present; trama pale, variable in texture;
spores smooth or some times echinulate- - - - - Odontia
- i. Fleshy, fragile; terrestrial- - - - - Dentinum
- i. Fleshy or coriaceous; on wood- - - - - j

- j. Basidiocarp soft, fleshy, richly branched or pulvinate;
gloeocystidia usually present; spores spherical or
subspherical- - - - - Hericium
- j. Basidiocarp subfleshy and fibrous to coriaceous;
reflexed to laterally stipitate, rarely resupinate,
spores various- - - - - k
- k. Cap coriaceous; stipe long, laterally attached; spores
minutely roughened- - - - - Auriscalpium
- k. Subfleshy to coriaceous; reflexed to laterally
stipitate (rarely resupinate); spores smooth - - - - - Steccherinum
- l. Resupinate, soft, floccose; on wood- - - - - Caldesiella
- l. Stipitate and pileate, fleshy or coriaceous,
terrestrial- - - - - m
- m. Fleshy- - - - - Hydnum
- m. Fibrous, tough- - - - - Calodon

KEY TO THE GENERA OF THE AGARICACEAE OF MICHIGAN

Based on Kauffman.

- (a) Spores mostly white in mass (ochraceous in some species *Russula* and *Lactarius*) 1
- (a) Spores ochraceous, cinnamon or rusty-yellow in mass 21
- (a) Spores flesh-colored to roseate or salmon-color in mass 32
- (a) Spores purple-brown in mass 39
- (a) Spores black in mass 43

White-Spored Agarics

- 1. Gills of waxy consistency *Hygrophorus*
- 1. Gills not truly waxy. 2
 - 2. Fruit-body soft and flesh, decaying 3
 - 2. Fruit-body toughish, corky or woody; thin forms which shrivel on drying, revive when moistened 15
- 3. Gills thick on edge 4
- 3. Gills thin. 5
 - 4. Gills decurrent and forked dichotomously. *Cantherellus*
 - 4. Gills not decurrent; parasitic on other mushrooms *Nyctalis*
- 5. Trama of fruit-body of two kinds of tissue, i.e. of globular and filamentous cells; spores globose, echinulate. 6
- 5. Trama filamentous throughout. 7
 - 6. With milky juice. *Lactarius*
 - 6. Not with milky juice. *Russula*
- 7. Stem eccentric, lateral or wanting. *Pleurotus*
- 7. Stem central. 8
 - 8. Gills free. 9
 - 8. Gills adnexed 10
- 9. Volva and annulus present *Amanita*
- 9. Volva only present. *Amanitopsis*
- 9. Annulus only present. *Lepiota*
 - 10. With annulus only *Armillaria*
 - 10. Neither annulus nor volva present 11
- 11. Stem fleshy or fibrous, sometimes outer rind subcartilaginous. 12
- 11. Stem cartilaginous, mostly throughout. 13
 - 12. Gills decurrent or broadly adnate, not sinuate at stem. *Clitocybe*
 - 12. Gills at length sinuate or emarginate on a stem; mostly large mushrooms on the ground. *Tricholoma*
- 13. Gills decurrent, pileus umbilicate *Omphalia*
- 13. Gills not decurrent. 14
 - 14. Fruit-body small; pileus thin, tending to remain unexpanded and bell-shaped. *Mycena*
 - 14. Fruit-body small, medium or large; pileus usually expanded when mature, somewhat fleshy *Collybia*
- 15. Fruit-body usually small, toughish, thin, not woody. 16
- 15. Fruit-body larger; stem central, eccentric, lateral or wanting . . . 17
 - 16. Trama of pileus gelatinous. *Heliumyces*
 - 16. Trama fleshy-membranous; pileus usually small, not woody. *Marasmius*
- 17. Pileus woody or corky *Lenzites*
- 17. Pileus fleshy-leathery. 18

- 18. Gills of the usual kind 19
- 18. Gills longitudinally grooved or split on edge 20
- 19. Edge of gills serrate-torn Lentinus
- 19. Edge of gills entire Panus
- 20. Edge of gills split lengthwise Schizophyllum
- 20. Edge of gills obtuse, crisped Trogia

Ochre-Spored Agarics

- 21. Gills easily separable from the trama of the pileus; margin of pileus involute Paxillus
- 21. Gills not separating easily from the pileus. 22
- 22. Trama of pileus vesiculose; spores glabose and echinulate (See Russula and Lactarius)
- 22. Trama more or less filamentous 23
- 23. Inner veil cobweb-like (cortinate): gills at length dusted dark cinnamon or rusty; terrestrial. Cortinarius
- 23. Inner veil membranous, fibrous or floccose. 24
- 24. Annulus present. Pholiota
- 24. Annulus lacking. 25
- 25. Stem lateral or wanting Crepidotus
- 25. Stem central 26
- 26. Stem fleshy or fleshy-fibrous. 27
- 26. Stem cartilaginous or fragile. 29
- 27. Gills at length yellow, yellow-rusty, etc.; lignicolous Flammula
- 27. Gills alutaceous to sordid brown; terrestrial. 28
- 28. Pileus fibrillose, silky or innately scaly; spores often angular; cystidia often present Inocybe
- 28. Pileus more or less viscid when moist, smooth. Hebeloma
- 29. Gills decurrent. Tubaria
- 29. Gills not decurrent. 30
- 30. Pileus convex or plane, margin at first incurved; stem rather short Naucoria
- 30. Pileus bell-shaped or conical; stem slender 31
- 31. Pileus subviscid or viscid; very fragile Bolbitius and Pluteolus
- 31. Pileus not viscid. Galera

Pink-Spored Agarics

- 32. Stem lateral or lacking; on wood. Claudopus
- 32. Stem central. 33
- 33. Volva present only Volvaria
- 33. Annulus present only Chamaeota
- 33. Neither volva nor annulus present. 34
- 34. Gills free. Pluteus
- 34. Gills adnexed, adnate or decurrent. 35
- 35. Stem fleshy or fleshy-fibrous. 36
- 35. Stem cartilaginous, slender. 37
- 36. Gills at length sinuate Entoloma
- 36. Gills decurrent or broadly adnate Clitopilus
- 37. Gills decurrent; pileus umbilicate Eccilia
- 37. Gills not decurrent 38
- 38. Pileus convex, margin at first incurved Leptonia
- 38. Pileus bell-shaped to conical, margin at first straight Nolanos

Purple-Brown-Spored Agarics

- 39. Annulus present; veil distinct 40
- 39. Annulus and volva lacking 41
- 40. Gills free. Psalliota
- 40. Gills attached to stem Stropharia
- 41. Veil present, remaining attached to margin of pileus, rarely forming an annulus Hypnoloma
- 41. Veil, if at first present, quickly evanescent or none at all; slender-stemmed 42
- 42. Margin of pileus at first straight; hygrophanous Psathyra
- 42. Margin of pileus at first incurved; gills adnexed to adnate-subdecurrent. Psilocybe

Black-Spored Agarics

- 43. Gills delinquescent into a black mass when mature Coprinus
- 43. Gills not delinquescent 44
- 44. Spores elongate-fusiform; gills decurrent; soft-waxy; pileus viscid Gomphidius
- 44. Spores globose to elliptical 45
- 45. Pileus with striate or sulcate margin, fragile. Psathyrella
- 45. Pileus not striate, rather fleshy, exceeding the gills; gills variegated-dotted by the spores Panaeolus

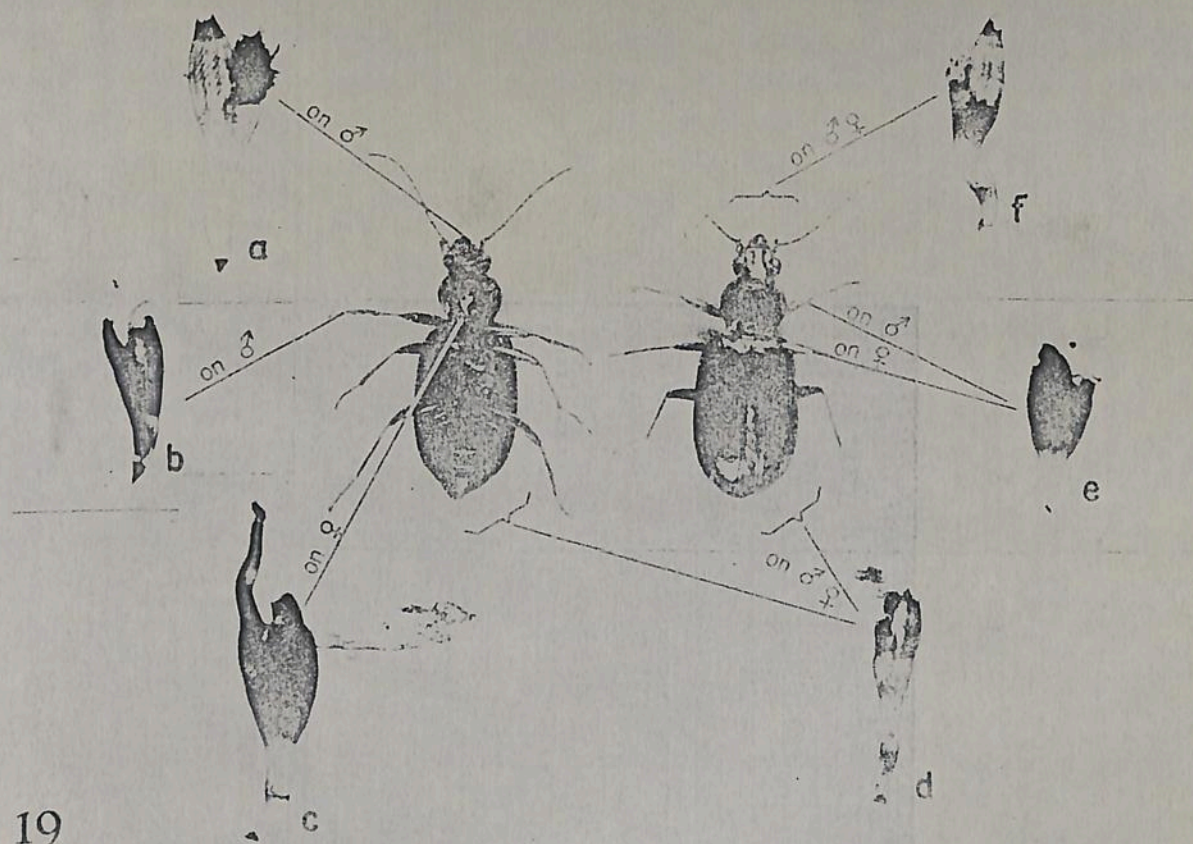


Fig. 19. Composite illustration showing the position upon the host, *Bembidion picipes* Kirby, of the 6 species of *Laboulbenia* encountered on the specimens collected in Brownfield Woods: a, *L. bembidio-palpi*, on mouth parts of the male; b, *L. truncata*, on the tarsi of the anterior legs of the male; c, *L. perpendicularis*, on the posterior surface of the prosternum of the female; d, *L. vulgaris*, on all parts of the integument of both male and female; e, *L. odobena*, on the humerus of the right elytron of the female, and on the inner distal surface of the femur of the right anterior leg of the male; f, *L. tapirina*, on all parts of the integument of the upper surface of both male and female. Host insect $\times 110$, parasites $\times 110$.

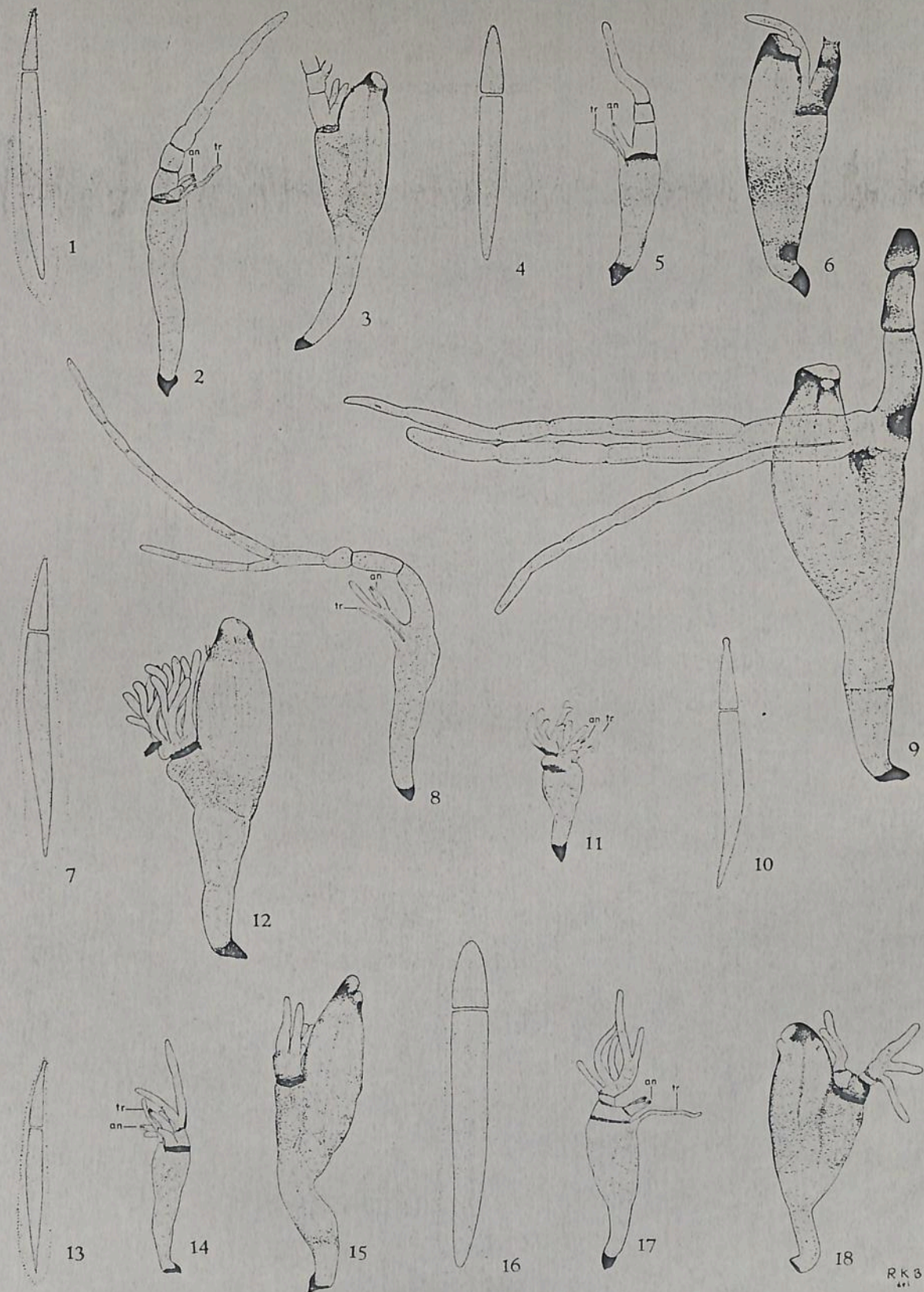
parasitized as follows: *Laboulbenia bembidio-palpi* on the mouth parts, and *L. odobena* on the inner, distal surface of the femur of the right and left anterior legs.

A series of specimens collected at Charleston, Coles County, Illinois, included 15 females and 11 males. Two of the former and six of the latter were parasitized by one or more of the species of *Laboulbenia* under consideration. *L. vulgaris* occurred on two individuals of each sex and showed the usual random distribution upon the host surface. One male bore *L. truncata* on the tarsi of the anterior legs. *Laboulbenia bembidio-palpi* infested the mouth parts of two males. Three beetles, two fe-

males and one male, were infected with *L. tapirina* which grew only upon the upper surface of the integument. Two beetles of each sex were infested with *L. odobena*, and here too this fungus was found on the humerus of the right elytron of the female and on the inner, distal surface of the femur of the right anterior leg of the male. A very interesting observation was made on one of the females bearing *L. odobena*. In addition to a very heavy infestation in its usual position on the right elytron, several specimens of the fungus were growing on the inner, distal surface of the femur of the right anterior leg!

A single male collected in Chicago, Cook County,

Fig. 1-18. Fig. 1-3, *Laboulbenia vulgaris*. Fig. 1, Spore. Fig. 2-3, Young and mature individuals, respectively. Fig. 4-6, *L. truncata*. Fig. 4, Spore. Fig. 5-6, Young and mature individuals, respectively. Fig. 7-9, *L. perpendicularis*. Fig. 7, Spore. Fig. 8-9, Young and mature individuals, respectively. Fig. 10-12, *L. bembidio-palpi*. Fig. 10, Spore. Fig. 11-12, Young and mature individuals, respectively. Fig. 13-15, *L. tapirina*. Fig. 13, Spore. Fig. 14-15, Young and mature individuals, respectively. Fig. 16-18, *L. odobena*. Fig. 16, Spore. Fig. 17-18, Young and mature individuals, respectively. Spores $\times 750$. All others $\times 210$. An, anthridium; tr, trichogone.



XXV. MYCOLOGICAL POETRY¹

The following was written by S. F. Blake, Bureau of Plant Industry, on the occasion of Prof. Roland Thaxter's 70th birthday, August 28, 1928.

There was a little beetle once no bigger than a flea;
Like other bugs, he had six legs, and used them constantly.
He travelled up, he travelled down, he travelled in between;
He sampled many things decayed, and many that were green.
He journeyed north, he journeyed south, he followed isotherms;
He gathered many kinds of food, and many kinds of germs.
His very latest day on earth he passed upon a wattle*;
A student saw him sitting there, and clapped him in a bottle.
(*Australian name for Acacia)

He gathered others, some of which a full three inches measure,
But of them all, both great and small, this beetle was the treasure.
(Now you must know a beetle's wing, just like his leg and tail, is
Created but to be a site for Laboulbeniales.)

And when this beetle studied was, upon him there were seen
Of good new species twenty-five, of genera sixteen.

I saw him lately where he sits, impaled upon a pin.
He sang a little song to me, and thus it did begin;

"Oh, I've Labouls on my tarsi, and Labouls on my toes,
On my antennae, in my tubes, and eke upon my nose.

"Upon my tail the Master found Tettigomyces varicus;
For T. pterophilus my wing is still the locus classicus.

"Eleven other Tettigo's from off my abdomen
Were scraped, and sorted into groups, and given names, and then

"The Master thought he had enough and let his needles fall,
But, inter nos, he missed the finest Laboulben of all.

"Within my third left spiracle a curious eye would see
This curious form which must, I think, form a new family.

"Its foot has toes with well-formed nails, its antherozoids can swim,
And the ascus holds a single spore, with a strongly chitinized rim."

Ed. note: This poem, one of my favorites, first was called to my attention by Dr. K. B. Raper some 14 years ago. The original is in a bound collection of letters and photographs presented to Dr. Thaxter by former students. This volume is in the Farlow Herbarium.

¹See also pages 5 and 13.

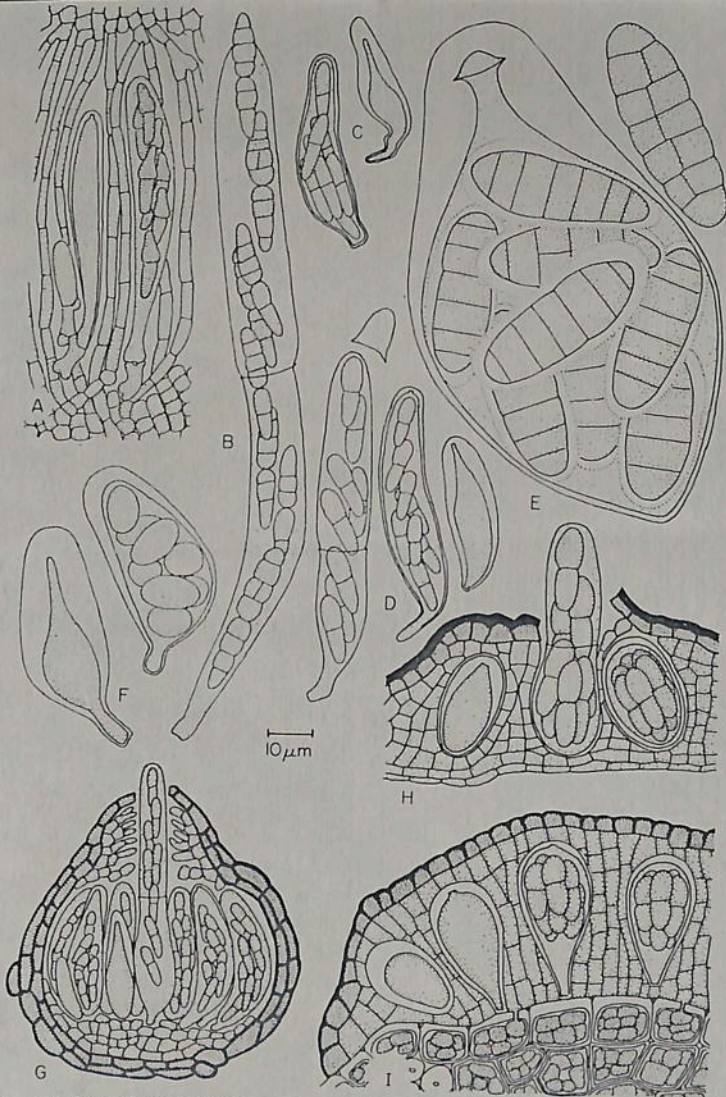


FIG. 1. (A) *Letendraea padouk*, young and mature asci among pseudoparaphyses. (B) *Dothiora schizospora*, ascus with expanded endoascus in process of spore discharge. (C) *Scirrha acicola*, young and mature asci. (D) *Stomiopeltis* sp., young and mature asci and ascus with tip of ectoascus thrown off as thimble-shaped cap by expanded endoascus. (E) *Leptosphaerulina americana*, ascus with maturing spores and mature ascospore. (F) *Ellisiodothis inquinans*, young and mature asci. [From *Amer. J. Bot.* 35:62, Fig. 34 (1948).] (G) *Mycosphaerella* sp., section of mature perithecioid pseudothecium with fascicle of paraphysate asci and periphysate ostiole. (H) *Schizothyrium pomi*, section of part of dimidiata-scutate ascocarp, one ascus with expanded endoascus emerging through split in the shield. (I) *Leptopeltopsis* sp., section of dimidiata-scutate ascocarp on surface of host leaf with asci individually distributed in the stromatic tissue of vertically arranged cells; internal mycelium massed in host cells, forming pseudostroma (hypostroma).

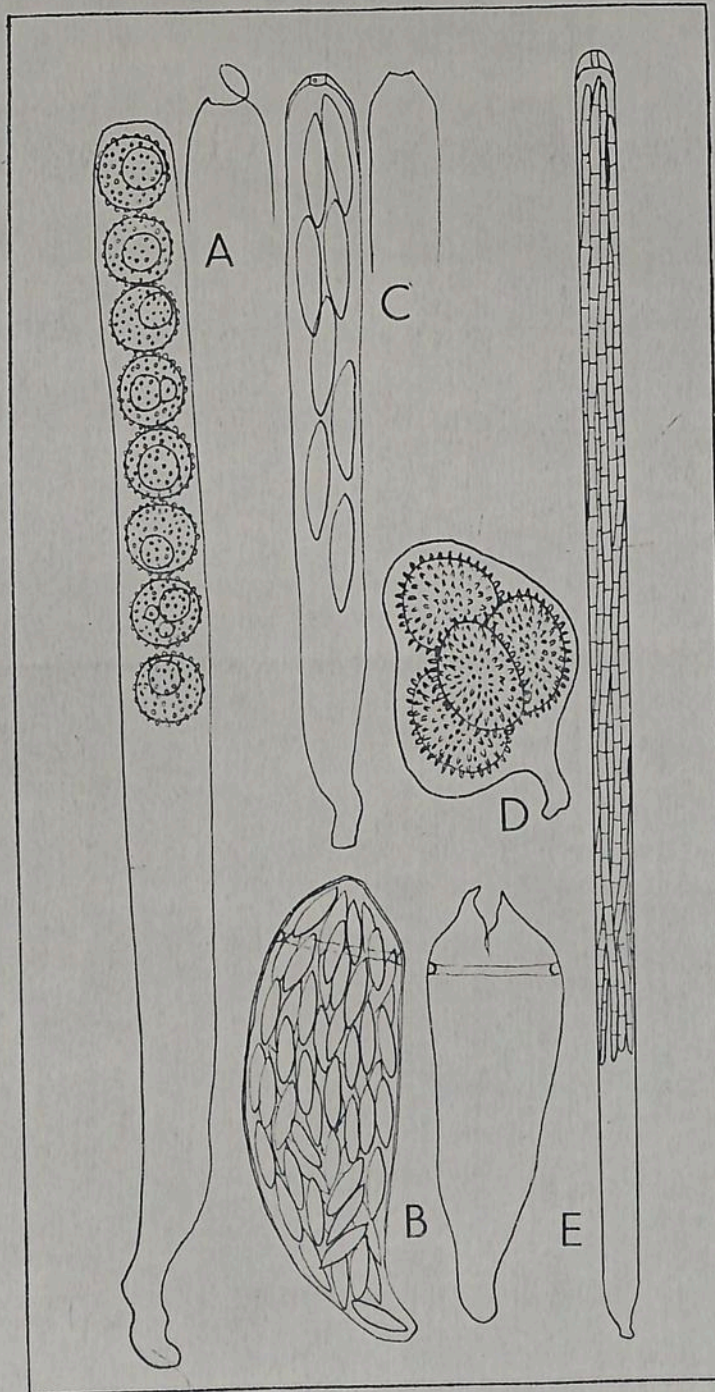


FIG. 1.—Some kinds of unitunicate asci. A. Operculate ascus of *Barlaicina amethystina*. B. Bilabiate ascus of *Ascozonus woolhopensis*. C. Inoperculate ascus of *Helotium aciculare*. D. Indehiscent ascus of *Tuber rufum*. E. Parallel-sided ascus of *Stictis stellata*. For bitunicate asci see individual species figured on the plates, e.g. Plate XXXVI.

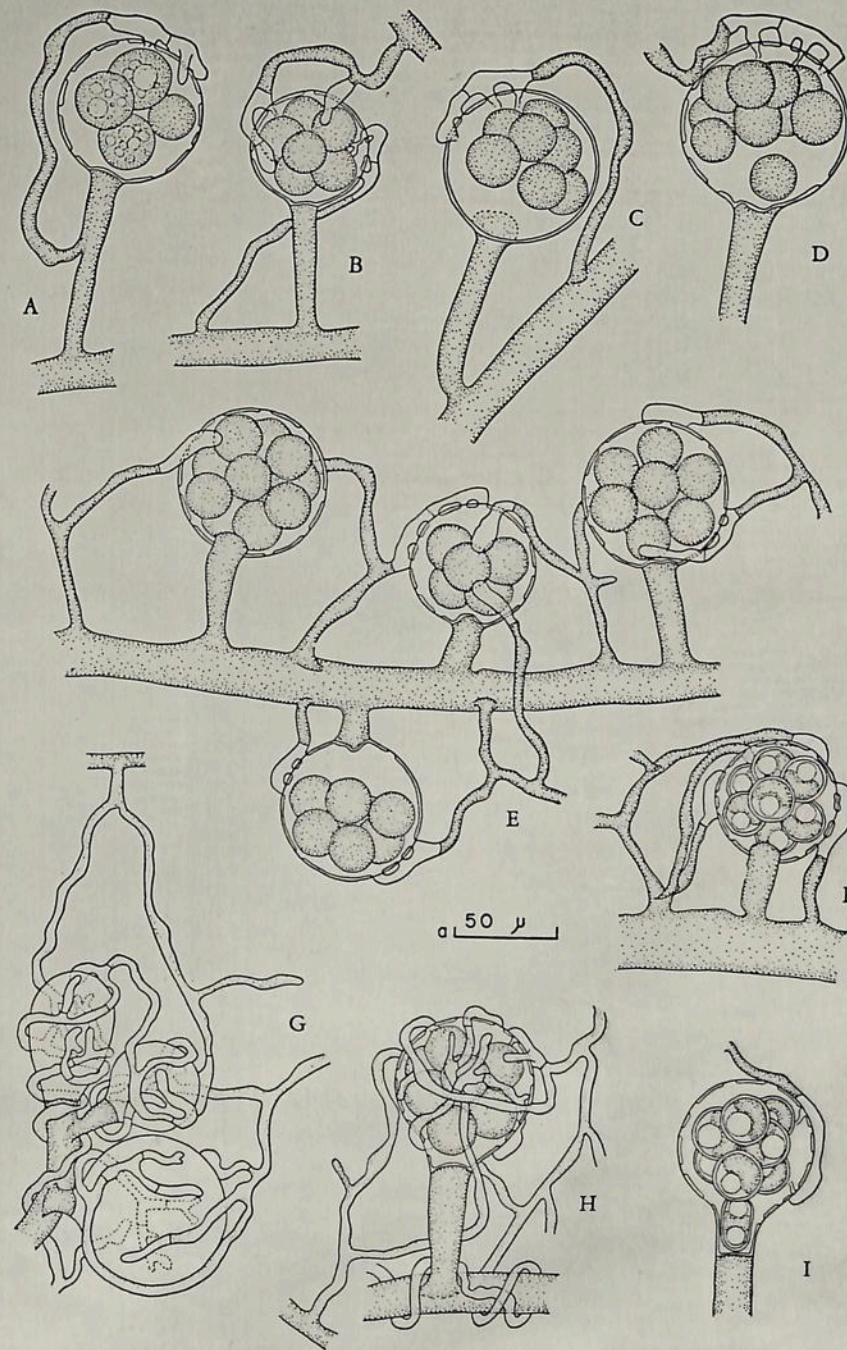
DENNIS, A.W.G. BRITISH CUP FUNGI. 1960.

EXPLANATION OF PLATE 19

FIGS. A–D. *Achlya conspicua* Coker: A, spherical oogonium containing nearly mature oöospheres; B, oogonium with a monoclinal and a diclinous antheridial branch; C, oogonium with wall pitted only under antheridial cells; D, pitted oogonium. In these figures note that the oöospheres do not fill the oogonial cavity and that intercalary antheridial cells are present. All figures, scale a.

FIGS. E, F. *Achlya americana* Humphrey: E, portion of hypha, showing the short-stalked, pitted oogonia and monoclinal antheridial branches; F, oogonium with eccentric oöspores. Both figures, scale a.

FIGS. G–I. *Achlya prolifera* C. G. Nees: G, apex of hypha with a terminal, obovate oogonium and two lateral, spherical ones; H, pyriform oogonium; I, pyriform oogonium with eccentric oöspores, pitted wall, and lateral appression of antheridial cell (antheridial branches not shown in their entirety). All figures, scale a.



reniform planont, but with the cyst wall left within the zoosporangium.

The arrangement of the fatty reserve, or oil globules, within the oöplasm of the mature "egg" is of much taxonomic significance. It is always the same in any given species (*Achlya oblongata* and *A. treleaseana* excepted), and is usually the same throughout a genus or in groups of closely related taxa within a genus. DeBary (1881) was the first to realize the significance of the mature oöspore, and described two types, centric and eccentric. Coker (1923) observed intergradations between these two extremes, and introduced the term subcentric to apply to a specific oil-globule arrangement. It is apparent now that there are five distinct types of oöspore structure within the genus. These may be defined as follows:

Centric: With one or two peripheral layers of small oil droplets completely surrounding the central oöplasm (Pl. 1, Fig. 6a).

Eccentric: With one large oil globule disposed on one side of the oöspore and not entirely enclosed by the oöplasm (Pl. 1, Fig. 6c).

Subcentric, Type I: With one layer of small oil droplets on

PLATE 1

Application of Descriptive Terminology

FIG. 1. Zoosporangial shape: *a*, clavate; *b*, filiform; *c*, naviculate; *d*, fusiform

FIG. 2. Method of zoospore discharge: *a*, achlyoid; *b*, aplanoid; *c*, dictyoid; *d*, thraustothecoid

FIG. 3. Method of zoosporangial renewal: *a*, cymose; *b*, basipetalous; *c*, sympodial

FIG. 4. Oögonial shape: *a*, spherical; *b*, *c*, pyriform; *d*, obovate; *e*, doliform; *f*, naviculate; *g*, subglobose; *h*, oval; *i*, fusiform; *j*, apiculate; *k*, filiform; *l*, angular

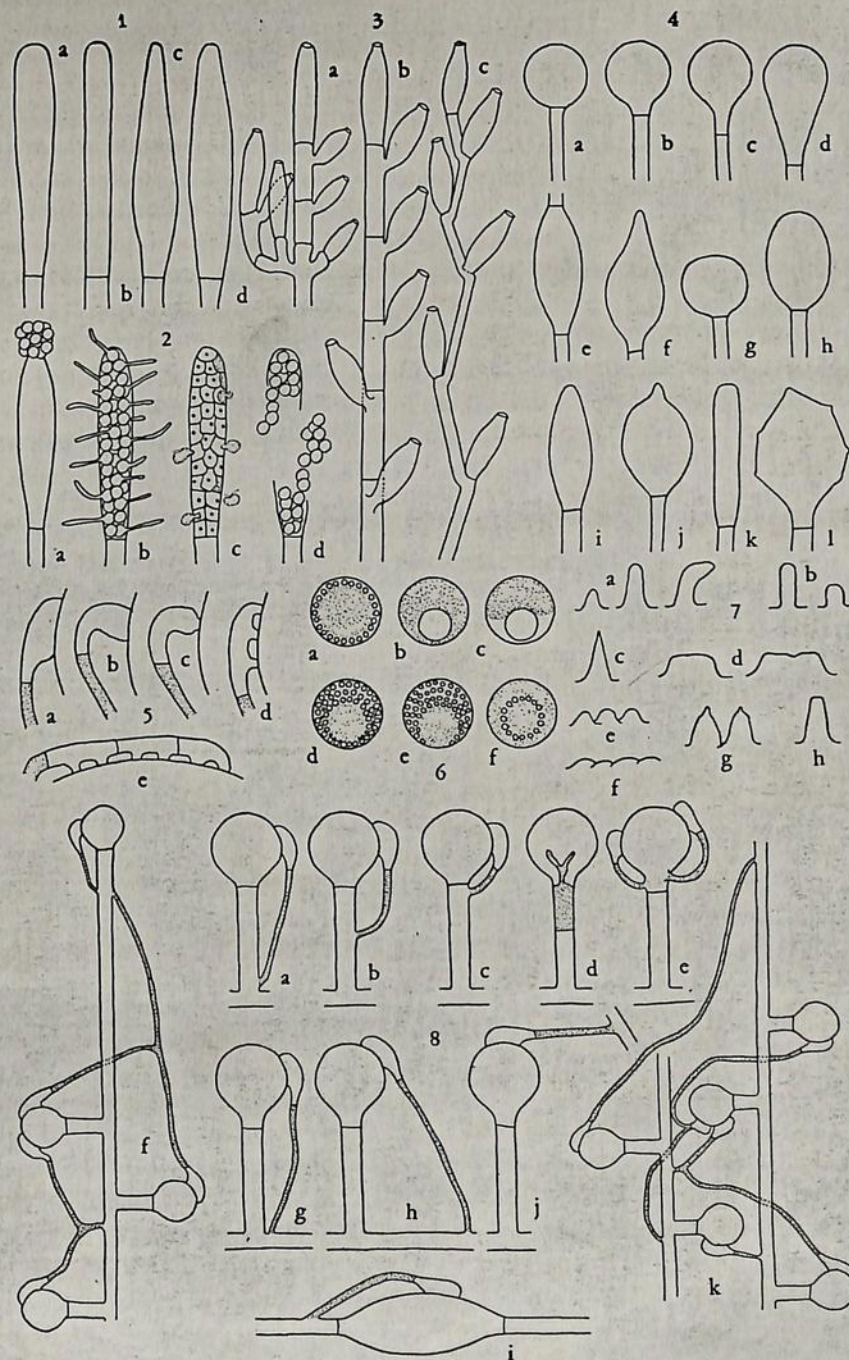
FIG. 5. Antheridial cell attachment: *a*, laterally appressed; *b*, *c*, apically appressed; *d*, projections; *e*, intercalary

FIG. 6. Mature oöspore types: *a*, centric; *b*, *c*, eccentric; *d*, subcentric, Type I; *e*, subcentric, Type II; *f*, subcentric, Type III

FIG. 7. Wall ornamentations: *a*, papillate; *b*, tuberculate; *c*, spiny; *d*, bululate; *e*, crenulate; *f*, wavy; *g*, mammiform; *h*, truncate

FIG. 8. Antheridial branch origin: *a*, *b*, *c*, androgynous; *d*, hypogynous; *e*, exigynous; *f*, *g*, *h*, *i*, monoclinal; *j*, *k*, dichinous

PLATE 1



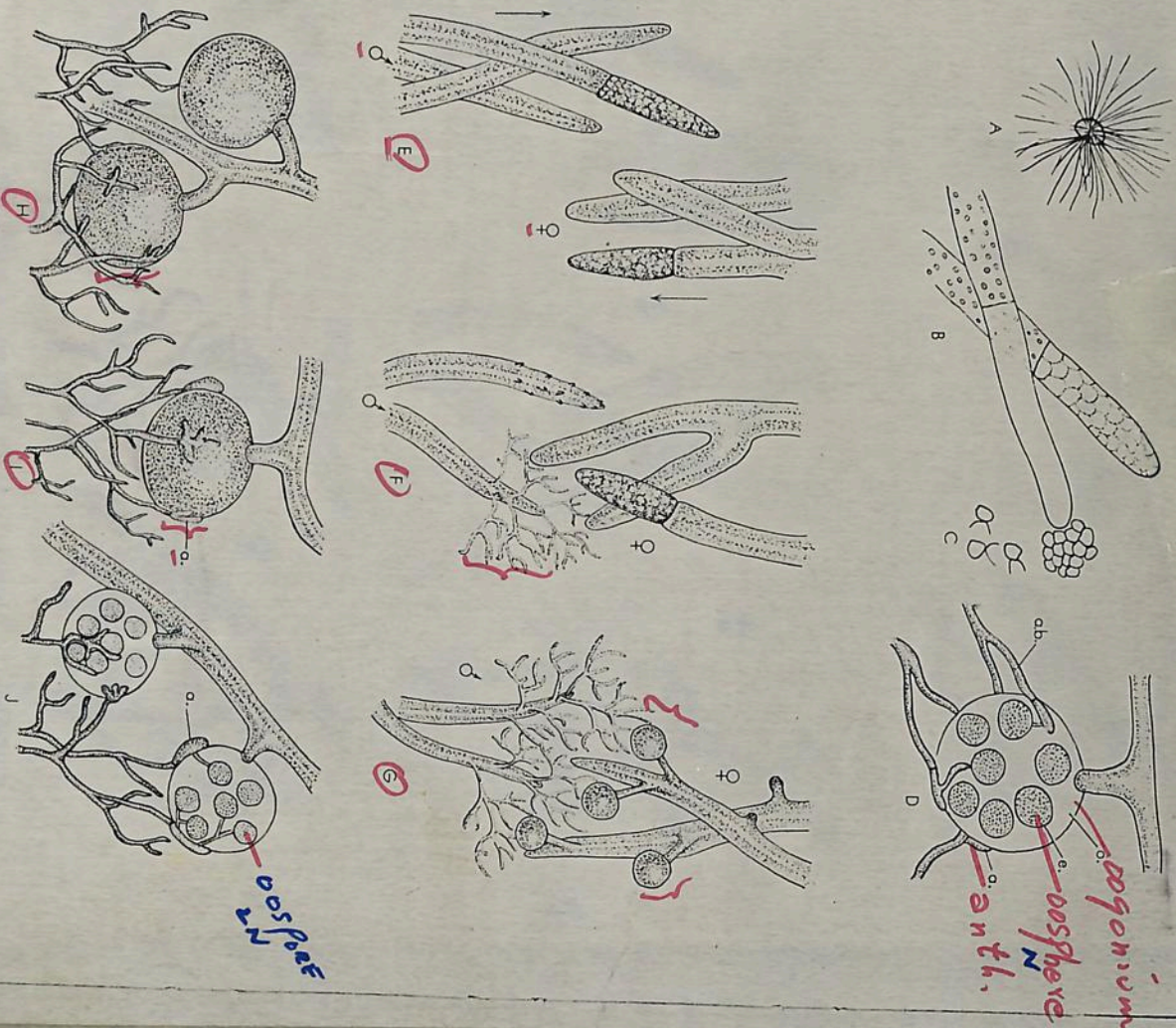


Fig. 18. *Achlya*, a water mold. (A) Habit of growth on a hemp seed; (B) Zoosporangia, with one shedding its spores; (C) Zoospores; (D) Sex organs: oogonium, o., containing eggs, e., appressed antheridial branches, an., and antheridia, a.; male nuclei from the antheridia are transported by tubes to the eggs; (E-J) Hormonal control of sexual maturation in *Achlya*: (E) Male and female branches growing in proximity; both have only to form slender antheridial hyphae; (F) Proximity causes proliferation or hyphae of δ hyphae stimulates the η mycelium to form oogonial branches; (G) Formation of antheridial hyphae stimulates the η mycelium to form oogonial branches; (H-I) Forward the oogonia: upon making contact, the antheridial hyphae directly and their tips are cut off as antheridia, a.; (J) Contact of the antheridial hyphae and antheridia with the oogonium stimulates cleavage of the latter into eggs and fertilization occurs. Each of the stages from E-J has been shown to be brought about by the secretion and diffusion of sexually active substances sometimes called sex hormones. (After J. Raper, courtesy American Scientist, January, 1951.)

J. RAPER

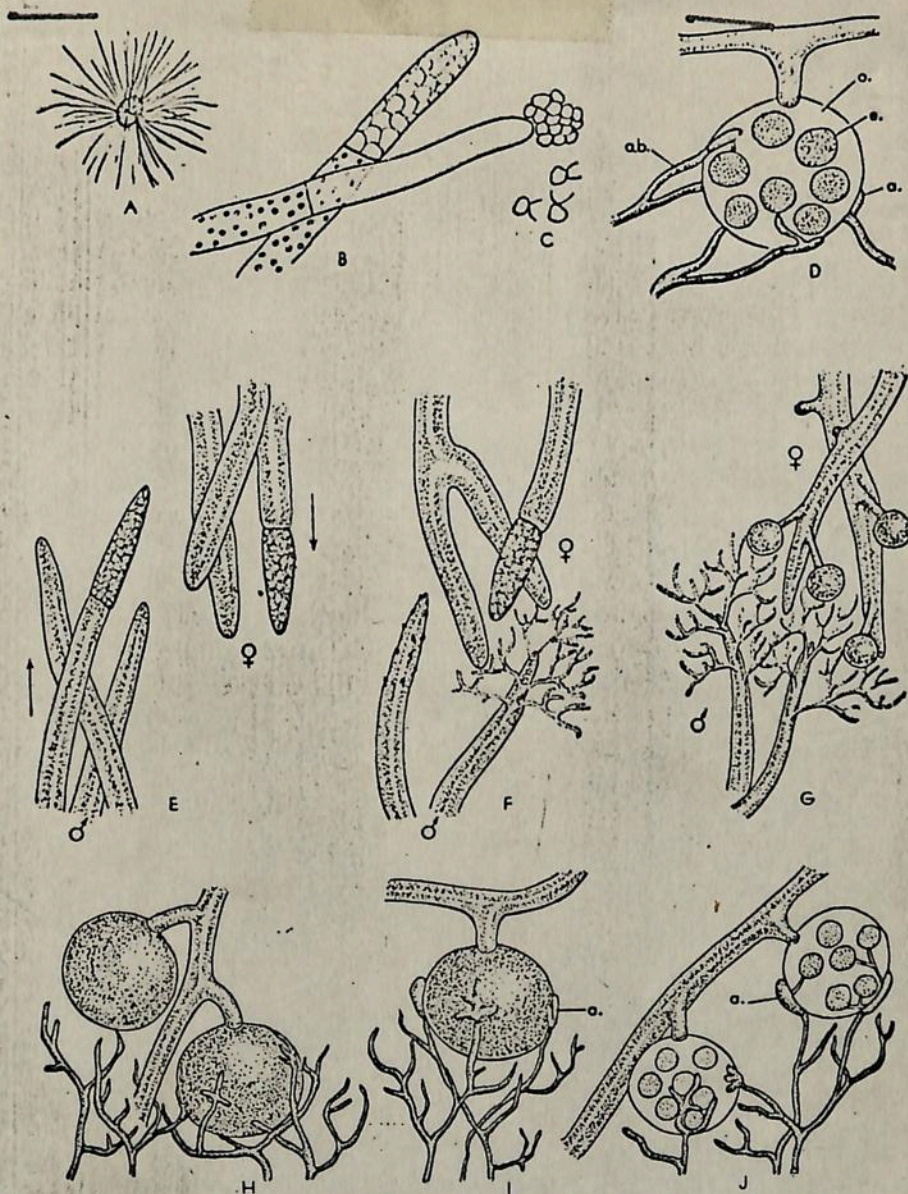


Fig. 18. *Achlya*, a water mold. (A) Habit of growth on a hemp seed; (B) Zoosporeangia, with one shedding its spores; (C) Zoospores; (D) Sex organs: oogonium, o., containing eggs, e., appressed antheridial branches, a.b., and antheridia, a.; male nuclei from the antheridia are transported by tubes to the eggs; (E-J) Hormonal control of sexual maturation in *Achlya*: (E) Male and female branches growing in proximity; both have only asexual zoosporeangia; (F) Proximity causes proliferation or hyphae of ♂ to form slender antheridial hyphae; (G) The formation of antheridial hyphae stimulates the ♀ mycelium to form oogonial branches; (H,I) Formation of oogonial branches causes growth of antheridial hyphae directly toward the oogonia; upon making contact, the antheridial hyphae branch, and their tips are cut off as antheridia, a.; (J) Contact of the antheridial hyphae and antheridia with the oogonium stimulates cleavage of the latter into eggs and fertilization occurs. Each of the stages from E-J has been shown to be brought about by the secretion and diffusion of sexually active substances sometimes called sex hormones. (After J. Raper, courtesy American Scientist, January, 1951.)

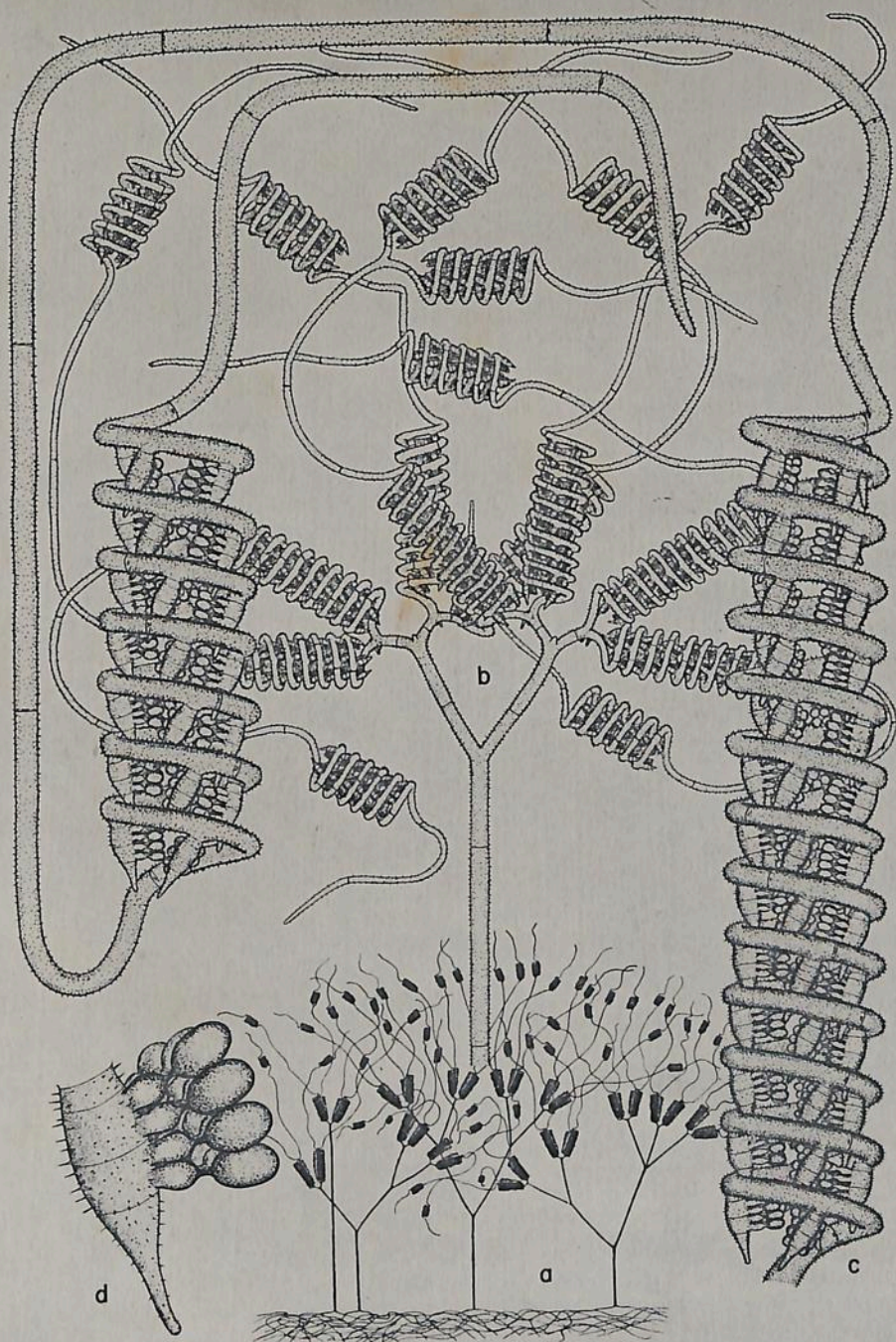


PLATE 32

Spirodictyon aurum Benjamin

Botanical Documentation

Table 7. *Primary mycological journals published up to 1950*

1879-1906	<i>Revue Mycologique</i>	Toulouse
*1885-	<i>Bulletin Trimestriel de la Société Mycologique de France</i>	Paris
1885-1908	<i>Journal of Mycology</i> (replaced by <i>Mycologia</i>)	Manhattan !
*1897-	<i>Transactions of the British Mycological Society</i>	London
1903-8	<i>Ohio Mycological Bulletin</i> (published by W. A. Kellerman)	Columbus, Ohio
1903-44	<i>Annales Mycologici</i> (continued as <i>Sydowia</i>)	Berlin
1908-24	<i>L'Amateur de Champignons</i>	Paris
*†1909-	<i>Mycologia</i>	New York
1912-15	<i>Mycologische Centralblatt</i>	Jena
*1914-36	<i>Bulletin de la Société Mycologique de Geneve</i>	Geneva
1915-22	<i>Pilz- und Krauterfreund</i> (continued as <i>Zeitschrift für Pilzkunde</i>)	Heilbronn
*1919-	<i>Mykologický Sborník</i>	Prague
*1922-	<i>Zeitschrift für Pilzkunde</i>	Heilbronn
*1923	<i>Schweizerische Zeitschrift für Pilzkunde</i>	Bern
1924-31	<i>Mykologia</i>	Prague
1925-	<i>Mycological Papers</i>	Kew
*1929-58	<i>Fungus</i>	Wageningen
*1931-	<i>Friesia</i>	Copenhagen
1936-	<i>Revue de Mycologie</i>	Paris
*1936-8	<i>Mitteilungen der Österreich Mykologisches Gesellschaft</i>	Vienna
1944-7	<i>Magyar Gombászati Lapok. Acta Mycologica Hungarica</i>	Budapest
*1947-	<i>Česka Mykologie</i>	Prague
1947-	<i>Sydowia</i>	Vienna
*1950-	<i>Karstenia</i>	Helsinki

* A society journal.

† Adopted as the journal of the American Mycological Society in 1931.

relatively easy to obtain financial support for scientific research, particularly from grant-giving bodies and indirectly from universities which, provided their staffs do a minimum of required teaching, have usually allowed considerable freedom in the matter of how the remainder of their employees' time is spent.

PROPOSALS FOR UPPER RANKS OF LIVING THINGS*

Hamilton P. Traub**

The discovery of the nucleus in plants (Brown, 1831), the promulgation of the cell theory for plants (Schleiden, 1838), and its extension to animals by Schwann (1839) together with the advent of modern virology with the work of Twort in 1915 and d'Hérelle in 1917, who demonstrated the particulate nature of viruses, and contributions of later workers, have laid the basis for the recognition of the primary lineagic groups of organisms - cellular and non-cellular. These groups are thus placed in the primary rank as superkingdoms - *Cellularae* and *Acellularae*.

When it was realized a decade ago that the procaryotic and eucaryotic cellular organization represented another profound structural and developmental discontinuity in biology - this time under Superkingdom *Cellularae* (Traub, 1963, 1964) - it was evident that this was *common ground* upon which all biologists might agree, and that the time had arrived for proposals to standardize the upper ranks for the linordination of organisms. Since then attempts have been made to establish the upper ranks, Superkingdom, Kingdom, Subkingdom, Infrakingdom, etc. (Traub, 1963, 1964, 1971, 1973), all in use, and thus to avoid the making of superfluous new names for the upper ranks.

Moore (1974) has recently proposed three groups in the primary rank - Dominion 1. *Virus*, Dominion 2. *Prokaryota* and Dominion 3. *Eukaryota*. However, allowing these three entities in the primary rank fails to take into consideration the fundamental differences between *cellular* (pro-, and eucaryotes) and *non-cellular* (virus) organization, and overlooks the fact that the choice is limited to one contrasting pair. Living things are either *cellular* or *non-cellular* on the primary level, Superkingdom 1. *Cellularae* vs. Superkingdom 2. *Acellularae*. The contrasting pair, procaryotes vs. eucaryotes belongs in the secondary rank of cellular organisms, Kingdom 1. *Procaryotae* vs. Kingdom 2. *Eucaryotae* (Traub, 1963, 1964, 1971, 1973). Thus, the upper ranks, Superkingdom, Kingdom, Subkingdom, Infrakingdom, etc., are sufficient for the needs as shown in Table 1, which places a roof over living things on the basis of fundamental differences in an evolutionary sequence.

TABLE 1. Four upper ranks used in grouping living things. Based on Traub (1963, 1964, 1971, 1973).

1a. Cellular organisms	Superkingdom 1. CELLULARAE
2a. Procaryotic organisms	Kingdom 1. PROCARYOTAE
3a. Autotrophic procaryotes: Blue	
-green Algae, and other procaryotic autotrophs	Subkingdom 1. AUTOBACAE
3b. Heterotrophic procaryotes (bacteria)	Subkingdom 2. HETEROBACAE
2b. Eucaryotic organisms	Kingdom 2. EUCARYOTAE
4a. Autotrophic eucaryotes; green plants plants, and added	
neoheterotrophs, <i>Cuscuta</i> , etc.	Subkingdom 2. PLANTAE
4b. Mesoheterotrophic eucaryotes (Fungi)	Subkingdom 2. HETEROPLANTAE (fungi)
4c. Archiheterotrophic eucaryotes, animals	Subkingdom 3. ANIMALIA

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** Editor, The American Plant Life Society, Box 150, La Jolla, Calif. 92037.

- 1-A. OUTLINE AND BRIEFLY DISCUSS WHITTAKER'S PHYLOGENETIC SCHEME.
- 1-B. WHAT JUSTIFICATION IS THERE FOR HIS PROPOSAL? ARE ANY HAZARDS TO BE OVERCOME IN MAKING SUCH GENERALIZATIONS FOR THE FUNGI?
- 2-A. DISCUSS: HOW DO FUNGI DIFFER FROM CONVENTIONAL PLANTS?
- 2-B. IN WHAT WAYS ARE THEY SIMILAR?
- 3-A. BRIEFLY DISCUSS PHYLOGENY IN THE MUCORALES.
- 3-B. WHAT PATTERNS OF SEXUAL REPRODUCTION OCCUR IN THE MASTIGOMYCOTINA? ILLUSTRATE.
- 4-A. OUTLINE THE LIFE HISTORY OF THE MYXOMYCETES USING LABELED SKETCHES ALONG WITH A BRIEF, APPROPRIATE NARRATIVE.
- 4-B. DISCUSS THE ARGUMENTS FOR REMOVING THE MYXOMYCETES FROM THE FUNGI.
5. DEFINE/IDENTIFY THE FOLLOWING WITH EXAMPLES.
DNA, NET PLASMODIUM, MONOECIOUS, HOMOTHALLISM, PSEUDOCAPILLITIUM, EUMYCOTA,
DIPLANETIC, OOSPHERE, 9:2 PATTERN, STICHONEMATIC FLAGELLUM, PROSORUS,
SPORANGIAL PROLIFERATION, APHANOPLASMODIUM, HOMOKONT, SPOROTHALLUS,
LOCULOASCOMYCETES, HYSTEROTHECIUM, MICRON, APLANOGAMETE, BISHOP USSHER.