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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.

Nihil est in homine quod non prius in amoeba erat.

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Journals

Mycologia .. bi-monthly

Phytopathology ;;; monthly

Amer. Jour. Bot. ... monthly except Aug. & Sept.

Lloydia .... quarterly (Mar., Ju., Sept., Dec.)

Bull. Torrey Bot. Club .... bi-monthly

FARLOWIA . DISCONTINUED.

FRIESIA — PERSOONIA — SACCARDOA — KARSTENIA — FUNGUS

Trans. Brit. Myc. Soc. ... quarterly

Rev. Applied Myc. .... monthly (Kew)

CESKA MYCOLOGIA

Sydowia Ann. Myc. ... bi-monthly (Wien)

Lilloa (Tucuman)

Rev. Myc. 5X yr. plus Supplement

Bull. Trimes. Soc. Myc. Fr. ... quarterly

Bio Abstracts
Agric. Index
Bibliog. Agric.
} monthly

Myc. Abst.

Texts

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C.W. Hesseltine No. 111

Contemporary Noted Mycologists. Focus p. 112. — Gallery of No. 109. C.W. Mates.

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Fungi

Introduction: Affinities (?) with bacteria & algae.

Numbers: 100,000.

Importance: N-cycle, pathogens, antibiotics, fermentations. (Billions of $ damage yearly in U.S., elsewhere)

General characetristics:
1) Mycelium
2) no chlorophyll
3) Spores (asexual, sexual)

Kinds with examples:

1) Phycomycetes. ("alga-like" fungi) aseptate mycelium
   1) Potato blight: Irish famine of 1845-46 (1 million dead. 1.5 million emigrated to U.S.)
   2) Grape mildew: 1880's France
   3) Black bread mold: food spoilage

Cheeses: Stilton, Roquefort, Camambert, Gorgonzola

2) Ascomycetes. Ascus, septate mycelium.
   1) Chestnut blight
   2) Ergot of rye
   3) Yeasts
   4) Antibiotics (Penicillium)
   5) Morels
   6) Truffles

3) Basidiomycetes. Basidium. septate mycelium.
   1) Rusts & Smuts
   2) Wood rotters (Dry rot)
   3) Mushrooms (edible vs poisonous)

4) Imperfecti. Without sexual reproduction.
   1) Dermatomycoses & others.
   2) Industrial fermentations (alcohols, citric acid etc.)

Penicillium notatum — Fleming 1929

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DEC 4 '67

MYCOTAXIA

Determination Handbooks of fungi.

Editors : Marcel **LOCQUIN** and Françoise **CLERET**

Handbag of IBM punched cards giving direct visual determination of genera and species.

Each set of **MYCOTAXIA** contains approximately one hundred punched and printed cards.

The first card gives the listing of genera or species, the others are the descriptive characters.

The combinatory analysis by hand superposition —without any accessory— of the listing-card and the character cards describing the species to be determined, gives directly the correct answer facing the clear holes, and the related species facing the holes partially darken.

The set of cards can be used for direct entry in a computer.

In twin languages : english and french.

Published sets are **underlined** (december 1967).

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I A	MYXOMYCETES — Genera mundi	$ 22
I B	MYXOMYCETES — World species	$ 50
II B M	AGARICALES — Genera mundi	$ 40
II C M	BOLETALES — Genera mundi	$ 30
III A M	CLAVARIALES — Genera mundi	$ 15
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II S M	AGARICALES — Coprinus, World species	$ 50
II O M	AGARICALES — Galerina, World species	$ 55
II G M	AGARICALES — Mycena, World species	$ 65
V A	PALYNOTAXIA — Spores and Pollens	

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II C	AGARICALES — Boletaceae Europe	$ 10
II D	AGARICALES — Cantharellaceae, Hygrophoraceae Europe	$ 10
II E	AGARICALES — Pleurotaceae, Europe	$ 10
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II G	AGARICALES — Mycena, Europe	
II H	AGARICALES — Clitocybe, Omphalia, Europe	
II I	AGARICALES — Tricholoma, Europe	
II J	AGARICALES — Lyophyllum, Clitopilus, Europe	
II K	AGARICALES — Rhodophyllus, Europe	$ 50
II L	AGARICALES — Inocybe, Europe	$ 40
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II N	AGARICALES — Cortinarius, Europe	$ 50
II O	AGARICALES — Galerina, Europe	$ 10
II P	AGARICALES — Dryophila, Geophila, Europe	
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II Z	AGARICALES — Russula-species, Europe	$ 50
III A	CLAVARIALES — Genera, Europe	$ 6
IV A	POLYPORALES — Genera, Europe	$ 15
V A	MYCOTAXIA — Mycosis	

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Associate Publisher : **Mondedition,** 10, rue Talma, Paris-16e (France).

Reprint

CHROMOTAXIA

Color Index
by Marcel LOCQUIN
$ 40

a set of 30 Kodak Color compensating filters mounted in six little fans. Combination of two or three of these filters gives a set of several thousand colors.
Color names are given in English, French, German and Latin.

References : Science Nov. 1967 - Scientific American Nov. 1967

Out of print : Marcel LOCQUIN : Petite Flore des Champignons de France. - Paris, 1963, France

Published elswhere :
LOCQUIN et CORTIN : Les champignons comestibles et vénéneux. - Nathan, Edit., Paris.
LOCQUIN : Les champignons - Que sais-je ? - Presses Universitaires, Edit., Paris.

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AINSWORTH & BISBY. 1971.

CLASSES OF FUNGI

Dictionary	*Bessey* (1950)	*Gäumann* (1964)	*Alexopoulos* (1962)	*Kreisel* (1969)
Kingdom **FUNGI**			Kingdom **PLANTAE** **Mycota**	Kingdom **PROTOBIONTA**
DIV. **Myxomycota**			**Myxomycotina**	
1. Acrasiomycetes				Excluded from fungi
2. Hydromyxomycetes				Excluded from fungi
3. Myxomycetes	Mycetozoa		Myxomycetes	
4. Plasmodiophoro-mycetes			**Eumycotina** Plasmodiophoromycetes	
		Archimycetes (4, 5 p.p.)		
DIV. SUBDIV. I **Eumycota**				**Eumycota**
Mastigomycotina	Class: Phycomyceteae (5–9)	Phycomycetes (5 p.p.–9)		
5. Chytridiomycetes			Chytridiomycetes	Chytridiomycetes
6. Hyphochytridio-mycetes			Hyphochytridiomycetes	Excluded from fungi
7. Oomycetes		Order: Oomycetes	Oomycetes	Excluded as a Class of Chrysophyta (Algae)
II **Zygomycotina**				
8. Zygomycetes		Order: Zygomycetes	Zygomycetes	Zygomycetes
9. Trichomycetes	Div. Carpomyceteae		Trichomycetes	Endomycetes (8 p.p., 9, 10 p.p., 16 p.p.)
III **Ascomycotina**	Class: Ascomyceteae	Ascomycetes	Ascomycetes	Ascomycetes
		Subclass: Prototunicatae (10 p.p., 11 p.p., 14)		
10. Hemiascomycetes			Hemiascomycetidae	
11. *Plectomycetes*		Subclass: Eutunicatae Group: Unitunicatae (10 p.p., 11 p.p., 12, 13)	Euascomycetidae series Plectomycetes	Euascomycetidae (10–13)
12. Pyrenomycetes	'The pyrenomycetes'		series Pyrenomycetes	
13. Discomycetes			series Discomycetes	
14. Laboulbenomycetes			series Laboulbeniomycetes	
15. Loculoascomycetes		Group: Bitunicatae	Loculoascomycetidae	Loculoascomycetidae
IV **Basidiomycotina**	Class: Basidiomyceteae	Basidiomycetes	Basidiomycetes	Basidiomycetes
		Subclass: Phragmobasidio-mycetes (16, 17a)	Heterobasidiomycetidae (16, 17a, 17b p.p.)	Phragmobasidiomycetidae (16 p.p., 17a)
16. Teliomycetes	Subclass: Teliosporeae			
17. Hymenomycetes				
(a) Phragmobasidio-mycetidae	Subclass: Heterobasidiae			
(b) Holobasidio-mycetidae	Subclass: Hymenomyceteae	Subclass: Holobasidio-mycetes (17b, 18)	Homobasidiomycetidae	Hymenobasidiomycetidae
18. Gasteromycetes	'Gasteromyceteae'		series Gasteromycetes	Gasteromycetidae
				Remaining Basidiomycetes (16 p.p., 17a p.p.)
IV a **Deuteromycotina**	The Imperfect Fungi	Fungi Imperfecti	Form class Deuteromycetes	
19. Blastomycetes				Endomycetes imperfecti
20. Hyphomycetes	Moniliales			Ascomycetes imperfecti
21. Coelomycetes	Sphaeropsidales, Melanconiales			Basidiomycetes imperfecti

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.

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flagellum, be transferred from the protists back to the fungi (where they have generally been classified by mycologists). These recommendations are incorporated into the revised classification of fungi and mycetozoans (with associated groups) that we propose below. A number of Whittaker's taxa are accepted at a reduced rank. In addition, we believe that the distribution of the two major pathways of lysine biosynthesis—α-ε-diaminopimelic acid (DAP) and α-aminoadipic acid (AAA) pathways—as determined by Vogel (1964) in the fungi should be taken into account in any current treatment of this group, and they are therefore indicated in the following classification of the fungi.

Kingdom Fungi

Phylum Pantonemomycota (planonts with anteriorly directed mastigonemate flagellum and posteriorly directed whiplash flagellum, or with anterior flagellum only; cellulose typically present in cell wall; DAP lysine pathway)
- Class Oomycetes (planonts with anteriorly and posteriorly directed flagella; mostly mycelial forms)
- Class Hyphochytridiomycetes (planonts with anteriorly directed mastigonemate flagellum only; typically chytrid-like; cellulose present or absent)

Phylum Eumycota (planonts with single posterior whiplash flagellum, or motile stages absent; cellulose generally absent from cell walls; AAA lysine pathway)
- Subphylum Opisthomastigomycota (planonts present; mostly aquatic forms)
  - Class Chytridiomycetes (chytridiaceous fungi)
- Subphylum Amastigomycota (planonts lacking; typically terrestrial and mycelial)
  - Class Zygomycetes (conjugation fungi)
  - Class Ascomycetes (sac fungi)
  - Class Basidiomycetes (club fungi)
  - Class Deuteromycetes (imperfect fungi)

Our proposed classification of the mycetozoans and their associates is as follows.

Kingdom Protista

Phylum Euprotista (most protozoans and simple algal forms)

Phylum Gymnomyxa (mycetozoans and associates). Trophic stage typically amoeboid and holozoic (but primarily absorptive in associated groups); multinucleate plasmodia or multicellular pseudoplasmodia present or absent; typically producing aerial fruiting bodies or, in associated groups, zoosporangia and/or sori of resting spores; syngamy present or absent
- Subphylum Mycetozoa (mycetozoans). Producing aerial fruiting bodies; flagella, when present, in an unequal, less often equal apical pair and nonmastigonemate
  - Class Eumycetozoa (true mycetozoans). Amoeboid stage producing filose pseudopodia; stalk tube typically present in fruiting bodies of the first two classes and in some myxomycetes

[2:9 FLAGELLA]

- Subclass Protostelia (the protostelids). Trophic stage varying from simple amoebae to plasmodia that lack shuttle movement of protoplasm; flagellate cells present or absent; fruiting bodies consisting of one to several spores on a narrow hollow stalk; sexual reproduction known in only one species.
- Subclass Dictyostelia (dictyostelid cellular slime molds). Nonflagellate; amoebae aggregating to form a multicellular pseudoplasmodium that gives rise to a multispored fruiting body; stalk tube present; occurrence of sexual reproduction indicated in some species
- Subclass Myxogastria (myxomycetes or true slime molds). Flagellate cells present; major trophic stage a multinucleate coenocytic plasmodium that typically shows shuttle movement of protoplasm; fruiting bodies multispored; syngamy and meiosis present in life cycle
  - Class Acrasea (acrasid cellular slime molds). Trophic stage comprised of amoeboid cells with lobose pseudopodia; flagellate cells known in only one species; amoeboid cells aggregating to form a pseudoplasmodium that gives rise to a fruiting body lacking a stalk tube; sexual reproduction unknown

Subphylum Plasmodiophorina. Obligate intracellular parasites with minute plasmodia; zoospores produced in zoosporangia and bearing an anterior pair of unequal, nonmastigonemate flagella; resting spores formed in compact sori or loose clusters within the host cells; sexual reproduction reported in some
- Class Plasmodiophorea (the plasmodiophorids). With characteristics of the subphylum

Subphylum Labyrinthulina. Trophic stage producing an ectoplasmic net that functions in absorptive nutrition and in *Labyrinthula* provides channels for cell movement; aquatic forms with zoosporangia that produce planonts with anteriorly directed mastigonemate flagellum and posteriorly directed nonmastigonemate flagellum; evidence of sexual reproduction found in only one isolate of *Labyrinthula*.
- Class Labyrinthulea (labyrinthulas and thraustochytrids). With characteristics of the subphylum

Whittaker's taxon Gymnomycota has been replaced by the much earlier one, Gymnomyxa, of Lankester (1885), modified to exclude the relatively simple forms that lack specialized fruiting structures such as sorocarps, cystosori, and zoosporangia (a heterogeneous group classified by Lankester among the proteomyxans). Because we do not consider the Gymnomyxa to be fungi, substitutions for the *-mycota* suffixes of other Whittaker taxa have been made. The concept of the subphylum Mycetozoa adopted here is essentially that of De Bary, who considered the group to be comprised of organisms with amoeboid, holozoic trophic stage and aerial fruiting bodies. Subphyla Plasmodiophorina and Labyrinthulina are included primarily as a matter of convenience, because they have frequently been classified or tentatively allied with the mycetozoans and their actual relationships are obscure. We consider neither subphylum to be related to the Mycetozoa. Ainsworth (1973) divides the Fungi into Myxomycota and Eumycota. His key to the Myxomycota contains four "classes": Acrasiomycetes, Labyrinthulales, Myxomycetes,

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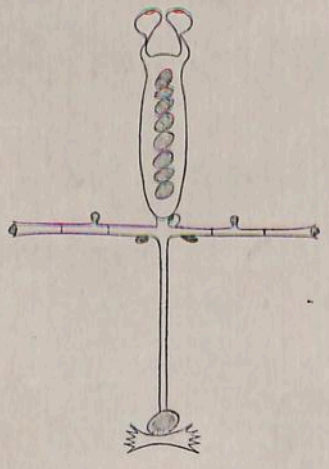
OLIVE 1975 - MYCETOZOA

MYCOTA

SYSTEMA CLASSIUM



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MYCOTA

SUBDIVISIONES:

Plasmathalle: plasmode initial développé, puis sporanges ..... **MYXOMYCOTINA**
Microthalle réduit, endoparasite ..... **premycotina**
Phragmothalle initial à éléments grégaires ..... **ACTINOMYCOTINA**
Phragmothalle à éléments désarticulés ..... **eubacteria**
Phragmothalle initial à simblospores ..... **ZOOMYCOTINA**
Siphothalle mycelien, conidiophore érigé ..... **PHOROMYCOTINA**
Septothalle à perforation simple ..... **UTEROMYCOTINA**
Septothalle à perforation épaissie ..... **ACROMYCOTINA**
Septothalle à perforation fruste et pseudobaside collapse ..... **EPIMYCOTINA**
Septothalle à propagules ..... **PERIMYCOTINA**
Cladothalle exoparasite ..... **CLADOMYCOTINA**

CLASSES ET SUBCLASSES

MYXOMYCOTINA

Plasmode laiteux ou coloré, endospores .....MYXOGASTROMYCETES

Protoplasmode, spores pâles..... *MYXOGASTROMYCETIDAE*
Aphaneroplasmode, spores foncées, acalcarés
STEMONOMYCETIDAE
Phaneroplasmode, spores foncées, calcaire
PHYSAROMYCETIDAE

Plasmode aqueux incolore, exospores sur un stipe-sterigmate plein .....EXOSPOROMYCETES
Plasmode réduit, exospores sur un stipe creux ou filamenteux .....POIKILOSPOROMYCETES

ACTINOMYCOTINA

Phages ou Bactéries à tête et stipe différenciés..... BACTERIOPHAGOMYCETES
Myxamibes grégaires ..... ACRASIOMYCETES
Promycelium .....ACTINOMYCETES

ZOOMYCOTINA

Callothalle, simblospores à deux fouets .....PERONOSPOROMYCETES
Opisthomastigiés .....CHYTRIDIOMYCETES
Prosomastigiés ..... HYPHOCHYTRIDIOMYCETES
Plasmodiés ..... MYXOCHYTRIDIOMYCETES

PHOROMYCOTINA

Deuteroforme à conidies exogènes .....PHOROMYCETES
Conidies et zygospores .....ZYGOMYCETES

Les Premycotina ou Rickettsies et les Eubacteria ou Bactéries au sens restreint sont classiquement quoique artificiellement exclus des MYCOTA

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UTEROMYCOTINA

Mycelium conidiogène, spores diachroniques ..... CLINOMYCETES
Mycelium ascogène, spores synchroniques.....ASCOMYCETES
Homotunasqués anellascés ou frustascés ..
SORDARIOMYCETIDAE
Opertunasqués .....*PEZIZOMYCETIDAE*
Bitunasqués archéascés ou nassascés
ASCOMYCETIDAE
Prototunasqués, souvent un mazaedium
MAZAEDIOMYCETIDAE
Chlamydospores supères, conidies basidiosporoides infères
ASTEROPHOROMYCETES

ACROMYCOTINA

Septum hyphal à rebord épaissi .....ENDOMYCETES
Zygote sporangifère .....*ENDOMYCETIDAE*
Zygote dikariotique puis
probaside ..... *USTILAGOMYCETIDAE*
Stade imparfait seul .....*CACUMISPOROMYCETIDAE*
Basides à répétition .....*REPETOBASIDIOMYCETIDAE*
Septum à dolipore.....BASIDIOMYCETES
Spore simple .....*BASIDIOMYCETIDAE*
Spore cloisonnée .....*MERISTEMOBASIDIOMYCETIDAE*
Conidiospore basidiosporoïde....*LYCOPERDELLOMYCETIDAE*

EPIMYCOTINA

Carpe simple ..... ANGIOMYCETES
Stipités .....*TULOSTOMOMYCETIDAE*
Sessiles .....*MELANOGASTROMYCETIDAE*
Carpe complexe ou composé .....NIDULARIOMYCETES

PERIMYCOTINA

Pas de spores, des propagules.....PROPAGOMYCETES

CLADOMYCOTINA

Pseudothèque coenocytique, pleuridies à oïdies terminales
RHYNCHOPHOROMYCETES
Pseudothèque paucinucléée, phialides de conidies-spermaties
LABOULBENIOMYCETES
Pseudothèque à spores appariées de sexe opposé, non
septées, naissant diachroniquement, phialides de zoospores
FUTUROMYCETES

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PRIORITE DES TAXA

MYXOMYCOTINA Lindquist, ACTINOMYCOTINA Locquin, ZOOMYCOTINA Locquin, PHOROMYCOTINA Locquin, UTEROMYCOTINA Locquin, ACROMYCOTINA Locquin, EPIMYCOTINA Locquin, PERIMYCOTINA, Locquin, CLADOMYCOTINA Locquin, MYXOGASTROMYCETES (Fr.) Schr., MYXOGASTROMYCETIDAE G.W. Martin, STEMONOMYCETIDAE Locq., PHYSAROMYCETIDAE Locq., EXOSPOROMYCETES (Hintikka) Locq., POIKILOSPOROMYCETES Locq., BACTERIOPHAGOMYCETES Locq., ACRASIOMYCETES Cejp, ACTINOMYCETES (Buchanan)Langeron, PERONOSPOROMYCETES Locq., CHYTRIDIOMYCETES Cejp, HYPHOCHYTRIDIOMYCETES Alexopoulos, MYXOCHYTRIDIOMYCETES (Kreisel) Locq., PHOROMYCETES Locq., ZYGOMYCETES.Sachs ex Winter, CLINOMYCETES Locq., ASCOMYCETES Sachs ex Winter, SORDARIOMYCETIDAE Locq., PEZIZOMYCETIDAE Locq., ASCOMYCETIDAE Locq., MAZAEDIOMYCETIDAE Locq., ASTEROPHOROMYCETES Locq., ENDOMYCETES von Arx, ENDOMYCETIDAE Locq., USTILAGOMYCETIDAE Locq., CACUMISPOROMYCETIDAE Locq., REPETOBASIDIOMYCETIDAE Locq., BASIDIOMYCETES Sachs ex Winter, BASIDIOMYCETIDAE Locq., MERISTEMOBASIDIOMYCETIDAE Locq., LYCOPERDELLOMYCETIDAE Locq., ANGIOMYCETES Locq., TULOSTOMOMYCETIDAE Locq., MELANOGASTROMYCETIDAE Locq., NIDULARIOMYCETES Locq., PROPAGOMYCETES Locq., RHYNCHOPHOROMYCETES Locq., LABOULBENIOMYCETES G.W. Martin FUTUROMYCETES Locq.

GLOSSAIRE

Anellascé: asque unituniqué dont l'appareil apical a un manubrium et un anneau sans nasse.
Aphaneroplasmode. plasmode opaque sans palmettes.
Archéascé: avec asques dont l'appareil apical a un anneau apical et une nasse.
Basidiosporoide: en forme de basidiospore supportée par un stérigmate.
Bitunasqué: avec asques bituniqués.
Callothalle: thalle à parois callosiques.
Carpe: fructification sporifère.
Chlamydospore: spore volumineuse enkystée à paroi épaisse et contenu dense.
Cladothalle: thalle en forme de bourgeon avec un axe et issu de deux cellules initiales superposées.
Coenocytique: dont le protoplasme sans paroi et sans cloisons contient de nombreux noyaux.
Conidie-spermatie: microconidie dont on a parfois supposé une fonction de gamète mâle.
Deuteroforme: forme imparfaite asexuée.
Diachronique: naissant successivement.
Dolipore: dome perforé au niveau de la perforation du septum des hyphes des Acromycotina
Frustascé: avec asque fruste simplifié par évolution.
Homotunasqué: avec asques à paroi simple homogène.
Mazaedium: masse compacte gélatineuse puis pulvérulente de spores, de débris d'hyphes, d'asques, de capillites.
Microthalle: thalle rédui à une seule cellule.
Nassascé: asque bituniqué dont l'appareil apical a une nasse.
Oïdie: conidies détachables en bout d'hyphe.
Opertunasqués: avec asques dont l'appareil apical s'ouvre par un opercule.
Opisthomastigié: muni d'un flagelle lisse.
Paucinucléé: ayant peu de noyaux.
Phaneroplasmode: plasmode à palmettes en éventail.
Phialide: cellule en bouteille dont le goulot laisse échapper les conidiospores:
Phragmothalle: thalle à cellules accolées.
Plasmathalle: thalle en plasmode, sans parois.
Pleuridies: conidies allongées, latérales.
Promycelium: file courte de cellules.
Propagule: massif de cellules reproducteur détachable.
Protoplasmode: constitué de veines peu opaques.
Prototunasqué: avec asques unituniqués.
Prosomastigiés: à flagelles antérieurs pleuronématés ou plumeux.
Pseudothèque: cavité reproductrice parfois en forme d'asque des Laboulbeniomycetes.
Pseudobaside: fausse baside vite collapse.
Septothalle: thalle à hyphes cloisonnées.
Simblospore: spore mobile par flagelles.
Siphothalle: thalle à hyphes non cloisonnées.
Synchronique: naissant simultanément.
Zoospore: spore mobile.
Zygospore: zygote à paroi épaisse.

ORDRES FAMILLES & GENRES

Pour continuer la détermination on se reportera directement dans les pages qui suivent à la Classe ou à la Sous-classe du SYSTEMA ORDINES FUNGORUM qui contient le tableau des ordres puis à l'Ordre qui contient le tableau des Familles puis à la Famille qui contient le Tableau des Genres.

L'ensemble au niveau des Familles est récapitulé et ordonné dans le SYNOPSIS GENERALIS FUNGORUM.

A chacun des Taxa on trouvera les voies documentaires spécifiques, un glossaire ainsi qu'une matrice descriptive normalisée, qui guideront le mycologue dans les ouvrages à consulter et préciseront les caractères à observer.

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Mushere, obs. form of Mouse-ear.

Musherom, -on, -oom, etc.: see Mushroom.

‖**Mushla** (mʊ·ʃlə). Also 7 **mushelaw**, 7–9 **mishlaw**. [Mosquito *mushla* (A. Henderson).] A fermented liquor from plantain, cassava, maize, etc.

1697 Dampier *Voy.* xi. 314 The Moskito Indians will take a ripe Plantain and roast it; then take a pint and half of Water in a Calabash, and squeeze the Plantain in pieces with their hands, mixing it with the Water; then they drink it all off together: this they call Mishlaw. *c* 1699 M. W. *Mosqueto Indians* in *Collect. Voy.* (Churchill 1732) VI. 293 Their plantain drink they call Mushelaw. 1827 O. W. Roberts *Voy. Centr. Amer.* 128 Preparations were making for a grand feast and mishlaw drink. 1842 T. Young *Narr. Resid. Mosquito Shore* iii. 33 It is a custom to let their quarrels rest until they get inflamed by their filthy mushla.

Mush-melon, -millian, obs. ff. Musk-melon.

Mushroom (mʊ·ʃrum), *sb.* Forms: α. 5 **musseroun**, 5–7 **muscheron**, 6 **mus(s)heron**, **mousheroun**, 7 **mucheron (muceron)**, 8 **mushroon**; β. 6 **musherom**, **mousherom**, **mushrum(m)e**, **-romme**, **(mushorme)**, 6–7 **mushrum**, **-rom**, 7 **muschrom(be**, **(mes-**, **musrume**, **mustrome)**, 7 **musheroom**, **mushroome**, 6– **mushroom**; γ. 6 **moshrump**, **(mushrumpt)**, **moushrimpe**, 6–7 **mus(c)hrump(e**, **mushrompe**, **(mustrump)**; δ. 6 **mushrubbe**, 7 **mushrub**. See also Mousseron. [a. F. *mousseron* (OF. *moisseron*, 1389 in Hatz.-Darm.), usually held to be a derivative of *mousse* moss.]

1. In early use, a fungus of any of the larger 'umbrella-shaped' species, to which the names *toad's hat* and *toadstool* were also applied indiscriminately. Now commonly restricted to the common edible mushroom, *Agaricus campestris*, or to this and species that closely resemble it in general appearance. Some apply *mushroom* to any fungus supposed to be edible, and *toadstool* to any that is believed to be deleterious. Certain botanical writers have used the word as equivalent to Fungus. The mushroom is a proverbial type of rapid growth.

14.. *Voc.* in Wr.-Wülcker 597/13 *Mussetum*, musserouns. *c* 1440 *Promp. Parv.* 349/1 Muscheron, toodys hatte, *boletus, fungus*. 1533 Elyot *Cast. Helthe* (1539) 89 Beware of musherons,..and al other thinges, whiche wyll sone putrifie. 1563 Hyll *Art Garden.* (1593) 30 The Toad stooles or Mushrooms, which grow out of the Walnut tree, and bee stiffe and hard. 1595 Southwell *Poems* (Grosart) 69 He that high growth on cedars did bestowe, Gave also lowly mushrumpes [*v.r.* mushrumpts] leave to growe. 1612 W. Parkes *Curtaine-Dr.* 20 That Cædar..Vnder whose girdle, nay beneath whose knee, The little Mesrumes louingly agree. 1656 Marnette *Perf. Cook* I. 312 With Sparagus, with Hartichokes, with Muscherons, with Cream [etc.]. 1732 Arbuthnot *Rules of Diet* in *Aliments*, etc. I. 258 Mushrooms contain an Oil of a volatile Salt. 1818 Keats *Endym.* IV. 234 For wine we left our heath, and yellow brooms, And cold mushrooms. 1846 Lindley *Veg. Kingd.* 37 In Paris none [*i.e.* no fungi] are permitted to appear in the markets except the common Truffle, Morel, and Mushroom. 1887 Bentley *Bot.* (ed. 5) 378 Fungi or Mushrooms.

2. *fig.* **a.** A person or family that has suddenly sprung into notice; an upstart. Also applied to a city, an institution, etc., that is of sudden growth.

a 1593 Marlowe *Edw. II* (1598) C 1 b, A night growne mushrump, Such a one as my Lord of Cornewall is. 1622 *Interpreter* A 3 b, He may not..seeme to shrinke, withdraw, giue way, whilst other mushrumpes doe the state betray. 1651 Howell *Venice* 204 Which Commonwealths may be sayed to have bin but Mushrumps in point of duration. 1721 Amherst *Terræ Fil.* No. 13 (1754) 66, I hear them scornfully call a rising great man an upstart, a mushroom, and a thing of yesterday. 1787 Bentham *Def. Usury* xiii. 179 Sheffield is an old oak; Birmingham is a mushroom. 1864 Burton *Scot Abr.* I. ii. 96 The Stewarts..were mere mushrooms beside the descendants of the Guelphs.

†**b.** A contemptible person. *Obs.*

1594 ? Greene *Selimus* Wks. (Grosart) XIV. 282 Summon a parley sirs, that we may know Whether these Mushroms here will yeeld or no. 1676 D'Urfey *Mad. Fickle* II. i, Come Ladies, I'le be your Gaurdian; Let these Musrumes stand if they dare. 1680 D. Granville in *Life* (1902) 224, I will make a filthy bustle before I dye among the Clergy of the nation, as contemptible a mushrump and silly ignoramus as some do make me. 1769 *Public Advertiser* 4 Oct. 2/2 A gouty Mushroom of an Earl from the West.

†**c.** An excrescence. *Obs. rare.*

1648 Prynne *Plea for Lords* 2 They are..the Exorbitances and Mushromes of Prerogative, the Wenns of just Government.

†**d.** A spontaneous growth. *Obs.*

1670 C. Gataker in *Gataker's Antid. Errour* Ep. Ded. A ij b, Who endeavour to forget that they are Gods offspring, and would fain be taken for the Mushrooms of Chance.

3. *transf.* Something shaped like a mushroom.

†**a.** In ornamental waterworks (see quot.). *Obs.*

1712 J. James tr. *Le Blond's Gardening* 214 Mushrooms are a sort of inverted Bowl-dishes, cut with Scales on the upper Part, over which the Water falls into the Bason below.

b. = *mushroom anchor* (see 6 c).

1890 *Nature* 10 Apr. 539 A temporary light-vessel is substituted,..but probably before her mushroom bites the ground it has dragged somewhat.

4. a. *slang.* An umbrella.

1856 [see Mush *sb.*[3] 1]. 1871 'M. Legrand' *Cambr. Freshm.* 87 Mr. Pokyr said he would take care of my umbrella—'mushroom' was the term he used.

b. *colloq.* A low-crowned circular hat, esp. a lady's straw hat with down-curving brim.

1865 *Hotten's Slang Dict.*, *Mushroom*, an inelegant round hat worn by demure ladies. 1896 Georgiana M. Stisted *Capt. Sir R. F. Burton* xi. 265 Many a pretty face..surmounted by the 'mushroom' or 'pork-pie'. 1898 *Westm. Gaz.* 21 Apr. 3/2 The mushroom..is a quite round straw with a low crown. 1902 *Ibid.* 31 May 2/1 Mimi's costume consisted of a short holland overall and a brown straw mushroom.

5. = *mushroom-colour* (see 6 c).

1884 *West. Daily Press* 25 Apr. 7/6 The fanciful shade of mushroom. 1903 *Westm. Gaz.* 10 Sept. 4/2 A shade called mushroom..a fascinating sober and unusual tone.

6. *attrib.* and *Comb.* **a.** simple attrib., as *mushroom-juice*, *-ketchup* (*-catchup*), *-sauce*; parasynthetic and similative *mushroom-coloured*, *-like*, *-shaped* adjs.

1748 *Mushroom juice [see Ketchup]. 1808 Mrs. Rundell *Dom. Cookery* (1824) 168 *Mushroom Ketchup. 1839 T. C. Hofland *Brit. Angler's Man.* viii. (1841) 147 Mushroom catchup. 1753 Chambers *Cycl. Supp.* s.v. *Heath-moss*, The brown *mushroom-like *Coralloides*. 1771 Mrs. Haywood *New Present* 46 *Mushroom Sauce. 1845 Eliza Acton *Mod. Cookery* 118 White Mushroom Sauce. 1835-6 *Todd's Cycl. Anat.* I. 39/2 The principal organ of motion in the pulmograda is the large..*mushroom-shaped disc.

b. *attrib.* quasi-*adj.* with the sense: Resembling a mushroom in rapidity of development or growth or in brief duration of existence; upstart; ephemeral.

1599 B. Jonson *Ev. Man out of Hum.* I. ii, These mushrompe gentlemen, That shoot vp in a night to place and worship. 1647 Clarendon *Hist. Reb.* VI. § 293 This was the end of that mushrump-army, which grew up and perished so soon that [etc.]. 1703 Savage *Lett. Antients* lxviii. 207 A Mushrome Love sprung from a transitory View. 1707 E. Filmer *Defence Plays* 130 A new, upstart, Mushroom Sect, sprung from their own filthy Dunghill. 1818–60 Whately *Comm.-pl. Bk.* (1864) 145 He outlived his own mushroom-reputation. 1887 *Westm. Rev.* June 269 Radical millionaires, and mushroom aristocrats.

c. Special combinations: **mushroom anchor**, a mooring anchor having a saucer-shaped head upon a central shaft; **mushroom-bed**, a bed of horse-dung and fine earth specially prepared for mushroom growing; **mushroom colour**, a pale pinkish colour resembling that of a mushroom; so **mushroom-coloured** *a.*; †**mushroom-coral** = Fungite; **mushroom earth**, earth containing mushroom spawn; **mushroom-faker** *slang*, an itinerant umbrella-mender; †**mushroom gall** (see quot.); **mushroom-grown** *a.*, sprung up spontaneously like mushrooms; **mushroom hall** *dial.*, a house or hut erected by stealth (see quot.); **mushroom hat** = sense 4 b; **mushroom head**, (*a*) a kind of 'head' for a church bell; (*b*) the nose-plate on the inner part of the breech-plug of a breech-loading cannon (*Cent. Dict.* 1890); **mushroom-headed** *a.* (see quot.); **mushroom house**, a house specially constructed for growing mushrooms; **mushroom loaf** (see Loaf *sb.*[1] 2 d); **mushroom-man** (see quot.); **mushroom powder**, dried mushrooms powdered to serve as a flavouring; **mushroom-ring** = Fairy-ring; **mushroom spawn**, the vegetative mycelium of mushrooms, usually embedded in an earthy matrix; **mushroom-stone** = Fungite; **mushroom sugar**, mannite derived from fungi.

1845 *Encycl. Metrop.* XIV. 548/1 An anchor of a very peculiar kind is employed to secure the vessels..; it is technically called the *mushroom anchor. 1763 Mills *Syst. Pract. Husb.* IV. 186 The spawn of mushrooms may be procured at almost any time, by those who have not already had *mushroom-beds in their gardens. 1900 *Westm. Gaz.* 16 Aug. 3/1 It is as near as you can get to it unless you say *mushroom-colour. 1904 *Daily Chron.* 13 Feb. 8/5 A..skirt of delicate *mushroom-coloured face cloth. 1681 Grew *Musæum* III. I. iii. 280 *Mushroom-Coral. *Fungites*. So called from a little likeness it hath to a Toad-Stool. 1731 Miller *Gard. Dict.* s.v. *Mushrooms*, You should put in some of the Knobs of *Mushroom Earth, about six Inches asunder. 1851 Mayhew *Lond. Labour* II. 127/2 The *mushroom-fakers will repair any umbrella on the owner's premises. 1753 Chambers *Cycl. Suppl.*, *Mushroom Galls ..a name given by authors to a small species of galls very common on the leaves of the oak in September and October. 1827 G. Higgins *Celtic Druids* 86, I have no experience of *mushroom-grown men. 1872 R. Heath *Eng. Peasant* (1893) 145 It was a notion held among the peasantry in olden times, that he who could in one night erect a '*Mushroom Hall'..without hindrance from the officials of the manor, had obtained a copyhold right to the land. 1897 *Westm. Gaz.* 17 June 3/2, 'The *mushroom hat', the peculiar genius of which shape dwells in that coy droop of the brim. 1872 Ellacombe *Bells of Ch.* in *Ch. Bells Devon* viii. 393 The bell being turned a quarter round by the button or *mushroom head by which it is hung. 1899 *Westm. Gaz.* 30 Nov. 4/2 Over this is placed a block of steel called the mushroom head. 1839 Lindley *Introd. Bot.* III. (ed. 3) 454 *Mushroom-headed; cylindrical, having a rounded, convex, overhanging extremity. 1817 Neill in *Edin. Encycl.* XI. 238/2 A *mushroom-house, constructed on Oldacre's plan. 1892 *Labour Commission* Gloss., *Mushroom-men*, men, having very little or no capital, who hire looms and start to compete in the cotton industry, on the principle that they have all to gain and nothing to lose. 1747 Mrs. Glasse *Cookery* xi. 122 To make *Mushroom Powder. 1807 Wollaston in *Phil. Trans.* XCVII. 138, I cut a groove..along the diameter of a *mushroom-ring. 1753 Chambers *Cycl. Supp.* s.v. *Mushroom*, Into this [trench]..should be put in the knobs of *Mushroom spawn. 1850 Pereira *Elem. Mat. Med. & Therap.* (ed. 3) II. I. 952 Mushroom spawn is the name given by gardeners to the white branching cottony fibres (*mycelia*) which form the so-called root of the mushroom. 1668 Charleton *Onomasticon* 267 *Fungites*..*Mushrum-stone. 1840 Pereira *Elem. Mat. Med.* II. 572 *Mushroom sugar has been found identical with mannite.

Mushroom (mʊ·ʃrum), *v.* [f. Mushroom *sb.*]

1. *trans.* To elevate (a person) in social position with great suddenness. *nonce-use.*

1747 Richardson *Clarissa* (1749) I. xl. 270 None but the prosperous upstart mushroom'd into rank (another of his peculiars) was arrogantly proud of it.

2. a. *intr.* Of rifle-bullets: To expand and flatten. Occas. with *out*. **b.** *trans.* To cause (a bullet) to 'mushroom'.

1893 Selous *Trav. S. E. Africa* 431 Such a bullet will mushroom on striking an animal. 1896 *Westm. Gaz.* 16 Dec. 6/3 The bullet was either mushroomed or the nickel shell and lead had parted company. 1900 *Brit. Med. Jrnl.* No. 2054. 1158 The result is that the lead mushrooms out.

3. *intr.* To gather mushrooms. Chiefly in pr. pple. or gerund.

1894 *Westm. Gaz.* 2 Jan. 7/2 While walking across a field mushrooming. 1901 *Essex Weekly News* 25 Oct. 3/3 He had been 'mushrooming'.

Mu·shroomed, *ppl. a.* [f. Mushroom *sb.* and *v.* + -ed.]

†**1.** *Cookery.* ? Dressed with mushrooms. *Obs.*

1821 Combe *Wife* III. 390 Broil'd ham and a nice mushroom'd chicken.

2. Overgrown with mushrooms.

1885 Mrs. Caddy *Footsteps Jeanne D'Arc* (1886) 9 The path turns downwards..across the mushroomed meadows.

3. Of rifle-bullets: Expanded and flattened.

1901 *Wide World Mag.* VIII. 160/1 The 'mushroomed' bullet was dug out of the earth.

Mu·shroomer. [f. Mushroom *v.* + -er [1].] One who gathers mushrooms.

1885 *Illustr. Lond. News* 26 Sept. 331 One of the provincial advertisers calls such persons 'mushroomers'. 1898 Cadman *H. Druidale* 175 I'll teach those mushroomers to keep out of my meadow.

Mushroo·mic, *a.* *nonce-wd.* [f. Mushroom *sb.* + -ic.] 'Upstart'. (Cf. Mushroom *sb.* 6 b.)

1859 G. Meredith *R. Feverel* xvi, There were names historic and names mushroomic.

Mu·shrooming, *vbl. sb.* [f. Mushroom *v.* + -ing [1].] **a.** The gathering of mushrooms. **b.** The flattening and expansion (of bullets).

1900 *Daily News* 14 May 3/6 Soft-nosed bullets..appear to have been freely used by the Boers, as 10 per cent. of the wounds were caused by the 'mushrooming' of the core of the bullet. 1900 *Westm. Gaz.* 16 Aug. 3/1 Mushrooming. The mushrooming is the event of our day.

Mu·shroomy, *a.* [f. Mushroom *sb.* + -y.] Like a mushroom.

1860 O. W. Holmes *Elsie V.* vii, A large house of some pretensions to architectural display, namely, unnecessarily projecting eaves, giving it a mushroomy aspect. 1895 *Outing* (U.S.) XXVI. 42/2 These portable roof trees, though in shape mushroomy, have nothing else of the *parvenu* about them.

Mushrub(be, -rum(pe, etc.: see Mushroom.

Mushy (mʊ·ʃi), *a. colloq.* [f. Mush *sb.*[1] + -y.] Soft, pulpy; also *fig.* Hence **Mu·shiness**, the condition of being soft or pulpy.

1876 Geo. Eliot *Dan. Der.* xlvi, She's not mushy, but her heart is tender. 1883 *Pall Mall G.* 18 Sept. 12/1 It is poured into a machine in a thick, mushy state. 1890 Sarah J. Duncan *Soc. Departure* 221 The unutterable mushiness of the 'bullock's heart' [fruit].

Music (miū·zik), *sb.* Forms: 3–5 **musik**, 3–6 **musike**, 4 **musyce**, **musiqe**, 4–6 **musyk(e**, 4–7 **musique**, 5 **musy(c)que**, **-icque**, 6 **musyck**, *Sc.* **mwseik**, 6–7 **musick(e**, 7 **musiq**, 5– **music**. [a. F. *musique* (12th c. in Hatz.-Darm.), ad. L. *mūsica*, ad. Gr. μουσική (*sc.* τέχνη) lit. 'the art of the Muse' (fem. of μουσικός pertaining to the Muse or Muses, f. μοῦσα Muse *sb.*[1]), applied *gen.* to artistic culture, poetry, etc., but also *spec.* to music. Cf. Pr. *muzica*, Sp. *música*, Pg., It. *musica*; also G. *musik* (MHG. *museke*, OHG. *musica*), Du. *muziek*, Da., Sw. *musik*.]

1. That one of the fine arts which is concerned with the combination of sounds with a view to beauty of form and the expression of emotion; also, the science of the laws or principles (of melody, harmony, rhythm, etc.) by which this art is regulated.

Considered as an art, music has two distinct branches, the art of the composer and that of the executant. The word is often used with special reference to the executive branch, and to instrumental execution rather than vocal; thus, the designation of 'a teacher of music' is usually apprehended to mean one who teaches the art of playing on some instrument.

c 1250 *Gen. & Ex.* 460 Wit of musike, wel he knew. 1390 Gower *Conf.* III. 90 The science of Musique, That techeth upon Armonie A man to make melodie. 1481 Caxton *Myrr.* I. xii. 37 Of this science of musyque cometh alle attemperaunce. 1570 Dee *Math. Pref.* d iij, An Architect (sayth he [*sc.* Vitruvius]) ought to..haue heard Philosophers, haue skill of Musike, not ignorant of Physike [etc.]. 1638 *Burgh Rec. Glasgow* (1876) I. 388 That na maner of persone sould be permittit to teitch musik within this burgh..except [etc.]. 1711 Addison *Spect.* No. 29 ¶ 13 Musick, Architecture, and Painting..are to deduce their Laws and Rules from the general Sense and Taste of Mankind. 1827 Whately *Logic* I. (ed. 2) 18 There must have been..musical compositions previous to the science of Music. 1884 Mac-

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THE COLLECTION OF PLASMODIAL SLIME MOLDS AS A WINTER HOBBY

Karl Leo Braun[1]
and
Harold W. Keller[2]

INTRODUCTION

This article describes a technique for culturing Myxomycetes in the home or school laboratory and has been written primarily for the amateur mycologist. During the winter months, the study of slime molds growing on tree bark in a moist-chamber can provide the amateur mycologist with a pleasant pastime until weather permits the more traditional field collections of the fleshy fungi. Teachers of mycology should consider organizing their courses to cover the Myxomycetes in mid-winter, and the Ascomycetes and Basidiomycetes in early fall or late spring when field collecting is more productive.

The moist-chamber technique, as it applies to the plasmodial slime molds, was first used by Gilbert and Martin (1933), who wanted to show their botany classes the algae that grew on the bark of living trees. Much to their surprise, a number of tiny fructifications of two different undescribed Myxomycetes developed on the bark along with the algae. Many forms of life may develop on bark in a moist-chamber in addition to the plasmodial slime molds, such as algae, lichens, mosses, leafy liverworts, filamentous fungi, nematodes, tardigrades and insects - to mention just a few. Although their original technique was limited to the use of tree bark, the technique has been modified to include the use of leaf-litter, manure, and other types of substrata. Davis and Butterfield (1967) used the peel of banana fruit and obtained Myxomycetes representing five genera.

Gilbert and Martin (1933) mentioned that "...fruiting structures [of Myxomycetes] are usually in better condition, there are fewer abnormal or imperfectly matured sporangia, and the average size is usually slightly larger [than field collections]." Many Myxomycetes are now believed to grow primarily, if not exclusively, on the bark of living trees (Keller and Brooks, 1973) and are referred to as corticolous Myxomycetes.

PROCEDURE FOR PREPARING MOIST-CHAMBERS

This technique is simple. Petri dishes (or other suitable containers) can be fitted with filter paper discs or absorbent paper toweling. Plastic Petri dishes work well and have the added advantage of being disposable. The bark sample is placed on the filter paper in such a way as to cover the bottom of the dish without overlapping. Enough distilled water (10 to 15 ml) is added to wet the bark thoroughly. The plates are then set aside to soak overnight. The next morning any excess water should be carefully poured off, or, if necessary, more water added. Too much water often interferes with the development of the Echinostelia, which may appear in the first 24

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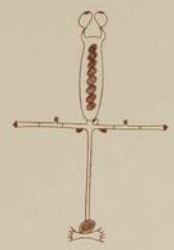
Marcel V. LOCQUIN

SYNOPSIS GENERALIS FUNGORUM

excerpta ex libro
DE TAXIA FUNGORUM

Subdivisiones, Classes, Ordines et Familiae ita dispositi ut tempus cochleatum processum aperit

Genus typicum et familia typica ordinis typici similem radicem habent



Règles suivies
Priorité des caractères

Signa (descripteurs)	subdivisiones	classes	ordines	familiae
Thallus	+			
Sporophora	+	+		
Spora		+		
Carpus			+	
alia			+	+

I. MYXOMYCOTINA
1. MYXOGASTROMYCETES

MYXOGASTROMYCETIDAE

1 Liceales	Liceaceae, Tubiferaceae, Myxomamilliferaceae, Reticulariaceae, Enteridiaceae, Alwisiaceae, Cribrariaceae, Lindbladiaceae.
2 Trichiales	Listerellaceae, Prototrichiaceae, Dianemaceae, Perichaenaceae, Trichiaceae, Arcyriaceae, Eleomyxaceae.
3 Echinosteliales	Echinosteliaceae.

STEMONOMYCETIDAE

4 Myxopouchetiales	Myxopouchetiaceae.
5 Stemonitales	Schenellaceae, Clastodermaceae, Comatrichaceae, Stemonitaceae, Enerthenemaceae, Symphytocarpaceae, Amaurochaetaceae, Colladermaceae.
6 Diachaealles	Lamprodermaceae, Macbrideolaceae, Diachaeaceae.

PHYSAROMYCETIDAE

7 Physarales	Fuligaceae, Badhamiaceae, Heterobadhamiaceae, Diperidiaceae, Triperidiaceae, Myxorostafinskiaceae, Physaraceae, Trichamphora ceae, Crateromyceaceae.
8 Crateriales	Crateriaceae, Cienkowskiaceae, Leocarpaceae.
9 Didymales	Didymiaceae, Lepidodermaceae, Didermaceae.

2 EXOSPOROMYCETES

1 Echinosteliopsiales	Echinosteliopsiaceae, Prosteliopsiaceae.
2 Ceratiomyxales	Ceratiomyxaceae.
3 Protosteliales	Schizoplasmodiaceae, Protosteliaceae.

3 POIKILOSPOROMYCETES

1 Asterococcales	Tetrapilaceae, Asterococcaceae, Bartonellaceae.
2 Krassilnikoviales	Krassilnikoviaceae.
3 Pasteuriales	Pasteuriaceae.
4 Cavosteliales	Cavosteliaceae.
5 Endemosarcales	Endemosarcaceae.
6 Acytosteliales	Acytosteliaceae.
1b (Premycotina) Rickettsiales	

II. ACTINOMYCOTINA
4. BACTERIOPHAGOMYCETES

1 Caulobacteriales	Gallionellaceae, Caulobacteriaceae.
2 Bacteriophagales	Bacteriophagaceae.
3 Phytobacteriophagales	Phytobacteriophagaceae.
4 Enzymophagales	Enzymophagaceae.
5 Micramonosporales	Micromonosporaceae.
6 Hyphomicrobiales	Hyphomicrobiaceae.
7 Sphaerophorales	Sphaerophoraceae.
8 Actinophagales	Actinophagaceae.
9 Clostridiophagales	Clostridiophagaceae.
10 Mycobacteriophagales	Mycobacteriophagaceae.

5 ACRASIOMYCETES

1 Plasmodiophorales	Plasmodiophoraceae.
2 Sorosphaerales	Sorosphaeraceae.
3 Woroninales	Woroninaceae, Phagamyxaceae.
4 Labyrinthulales	Labyrinthulaceae.
5 Labyrinthomyxales	Labyrinthomyxaceae, Gymnococcaceae.
6 Pyrrhosorales	Pyrrhosoraceae.
7 Acrasiales	Guttulinaceae, Acrasiaceae.
8 Sappiniales	Sappiniaceae.
9 Dictyosteliales	Dictyosteliaceae, Hartemanellaceae.

6 ACTINOMYCETES

1 Myxobacteriales	Myxococcaceae, Archangiaceae, Cytophagaceae.
2 Cyclobacteriales	Cyclobacteriaceae, Listeriaceae, Vitreoscillaceae.
3 Mycobacteriales	Mycobacteriaceae, Myxococcaceae, Siferiaceae, Nevskiaceae.
4 Actinomycetales	Actinobacteriaceae, Erisipelatrichaceae, Actinomycetaceae.
5 Streptomycetales	Streptomycetaceae, Phytomycetaceae,
6 Actinoplanales	Actinoplanaceae, Streptosporangiaceae.
7 Amoebidiales	Amoebidiaceae, Paramoebidiaceae.

IIb (EuBacteria)

III. ZOOMYCOTINA
7. PERONOSPOROMYCETES

1 Leptomitales	Leptomitaceae, Rhipidiaceae.
2 Saprolegniales	Saprolegniaceae. Thraustochytriaceae, Ectrogellaceae
3 Lagenidiales	Pythiaceae, Lagenidiaceae, Olpidiopsiaceae.
4 Peronosporales	Peronosporaceae, Zoophagaceae.

8 CHYTRIDIOMYCETES

1 Blastocladiales	Catenariaceae, Blastocladiaceae, Coelomomycetaceae
2 Monoblepharidales	Monoblepharidaceae, Gonapodyaceae.
3 Chytridiales	Chytridiaceae, Rhyzidiaceae, Phlyctidaceae, Physodermataceae, Cladochytridiaceae, Megachytriace.

9 HYPHOCHITRIDIOMYCETES

1 Hyphochytridiales	Hyphochytridiaceae.

10 MYXOCHYTRIDIOMYCETES

1 Olpidiales	Olpidiaceae, Synchytriaceae, Achlyogetonaceae.

IV. PHOROMYCOTINA
11. PHOROMYCETES

1 Septonemales	Septonemaceae & de nombreuses autres familles de forme.
2 Phomales	Phomaceae & autres familles de forme.
3 Mucedinales	Mucedinaceae & autres familles de forme

12 ZYGOMYCETES

1 Mucorales	Mortierellaceae, Mucoraceae.
2 Syncephalastrales	Syncephalastraceae, Thamnidiaceae.
3 Endogonales	Endogonaceae.
4 Entomophthorales	Entomophthoraceae, Pilobolaceae, Basidiobolaceae.
5 Zoopagales	Piptocephalidaceae, Zoopagaceae.
6 Choanephorales	Choanephoraceae

V. UTEROMYCOTINA
13. CLINOMYCETES

1 Oidiodendrales	Oidiodendraceae & autres familles de forme.
2 Hysteriales	Hysteriaceae & autres familles de formes.
3 Phialophorales	Phialophoraceae & autres familles de formes.
4 Ascoideales	Ascoideaceae

14 ASCOMYCETES

SORDARIOMYCETIDAE

1 Trypetheliales	Trypetheliaceae
2 Coronophorales	Coronophoraceae
3 Sordariales	Sordariaceae, Roselliniaceae.
4 Diaporthales	Valsaceae, Diaporthaceae, Halosphaeriaceae, Lasiosphaeriaceae.
5 Hypocreales	Nectriaceae, Hypocreaceae, Ophionectriaceae, Xenonectriellaceae.
6 Hypodermales	Hypodermaceae, Geoglossaceae.
7 Hyponectriales	Hyponectriaceae.
8 Diatrypales	Diatrypaceae, Anthostomaceae, Loramycetaceae, Amphispheriaceae. Staurotheleaceae, Vialaeasceae.
9 Xylariales	Neurosporaceae, Xylariaceae, Sarcostromellaceae, Fassariaceae.
10 Coniochaetales	Coniochaetaceae.
11 Helotiales	Ascocorticiaceae, Helotiaceae, Hyaloscyphaceae, Dermataceae, Hemiphacidiaceae, Orbiliaceae, Cyttariaceae, Sclerotiniaceae, Bulgoriaceae, Vibrissaceae, Thelebolaceae.
12 Phacidiales	Phacidiaceae, Cryptomycetaceae, Hypodermataceae.
13 Tympanidales	Tympanidaceae.
14 Ostropales	Ostropaceae
15 Leotiales	Leotiaceae, Baeomycetaceae.
16 Polystigmales	Polystigmaceae.
17 Gibbellinales	Gibbellinaceae.
18 Clavicipitales	Clavicipitaceae.
19 Reichengeriellales	Reichengeriellaceae.
20 Microtheciales	Microtheciaceae, Dexteriaceae.
21 Erisiphales	Erisiphaceae, Lanomycetaceae, Paradiellaceae, Paradiopsidaceae, Phaeosaccardinulaceae.
22 Sphaerothecales	Sphaerothecaceae.

PEZIZOMYCETIDAE

23 Pezizales	Ascobolaceae, Pyronemaceae, Pezizaceae, Sarcoscyphaceae, Helvellaceae, Morchellaceae.
24 Morchellales	Sarcoscyphaceae.
25 Sarcoscyphales	Hydnotryaceae, Geneaceae, Tuberaceae.
26 Tuberales	

ASCOMYCETIDAE

27 Leconorales	Lecanoraceae, Acaroporaceae, Pertusariaceae, Umbilicariaceae, Lecideaceae, Cladoniaceae, Telaschistaceae, Buelliaceae, Gyalectaceae, Collemaceae, Lichinaceae, Peltigeraceae, Coloplaceae, Patellariaceae.
28 Graphidales	Thelotremaceae, Graphidaceae.
29 Verrucariales	Verrucariaceae, Dermatocarpaceae, Pyrenulaceae, Strigulaceae.
30 Arthopyrenales	Arthopyrenaceae.
31 Melanogrammales	Melanogrammaceae.
32 Pleosporales	Pleosporaceae, Letendreaceae, Wettsteiniaceae, Sporormiaceae, Phaeotrichaceae, Venturiaceae Mycosphaerellaceae, Trypetheliaceae, Dermatinaceae, Hysteriaceae, Arthoniaceae, Roccellaceae.
33 Hysteriales	Botryosphaeriaceae, Dothioraceae, Parmulariaceae.
34 Dothiorales	Uleomycetaceae, Atichiaceae, Piedrioiaceae.
35 Uleomycetales	Hemisphaeriaceae, Polystomellaceae, Stigmateaceae, Chaetothyriaceae, Capnodiaceae, Schizothyriaceae, Micropeltaceae, Trichothyriaceae, Microthyriaceae, Eoceramiaceae, Trichopeltinaceae, Leptopeltaceae, Entopeltaceae, Dictyopeltinaceae, Perisporiopsidaceae, Englerulaceae, Asterinaceae.
36 Capnodiales	

MAZAEDIOMYCETIDAE

37 Caliciales	Cypheliaceae, Sphaerophoraceae, Coliciaceae, Coryneliaceae, Protocaliciaceae.
38 Orbiculales	Orbiculaceae.
39 Chaetomidiales	Chaetomidiaceae.
40 Cyanocephalales	Cyanocephalaceae.
41 Meliolales	Meliolaceae.
42 Microascales	Microascaceae, Ceratocystaceae, Melanosporaceae, Viennotidiaceae, Microeurotiaceae.
43 Chaetomiales	Achaetomiaceae, Chaetomiaceae.
44 Eurotiales	Phaeotrichoceae, Zopfiaceae, Hemicarpenteliaceae, Thielaviellaceae, Aniziaceae, Coniochaetidiaceae, Thermoascaceae, Thielaviascaceae, Eurotiaceae, Cephalothecaceae, Amorphothecaceae, Melanosporaceae, Backusiaceae, Eremomycetaceae, Eoterfeziaceae, Xeromycetaceae, Xylogonaceae, Hexagonellaceae, Preussiaceae.
45 Elaphomycetales	Terfeziaceae, Elaphomycetaceae.
46 Mesophellilales	Mesophelliaceae.
47 Penicilliopsiales	Penicilliopsiaceae.
48 Trichocomales	Trichocomaceae, Chadefaudiellaceae.
49 Onygenales	Onygenaceae.
49 Gymnoascales	Gymnoascaceae. Arthrodermaceae, Rollandiniaceae, Lophophytomaceae.
51 Ascosphaerales	Ascosphaeraceae
52 Monascales	Saturnopichiaceae, Waldemeriaceae, Trichomonascaceae, Monascaceae, Myriogonaceae.

15 ASTEROPHOROMYCETES

53 Asterophorales	Asterophoraceae.

VI. ACROMYCOTINA
16. ENDOMYCETES

ENDOMYCETIDAE

1 Spermophthorales	Spermophthoraceae.
2 Endomycetales	Endomycetaceae, Dipodascaceae, Fabosporaceae, Saccharomycetaceae, Lipomycetaceae, Schizosaccharomycetaceae, Nematosporaceae.
3 Taphrinales	Protomycetaceae, Taphrinaceae, Conidiascaceae.
4 Eccrinales	Eccrinaceae, Caryophanaceae, Asellariaceae.
5 Harpellales	Harpellaceae, Genistellaceae.
6 Kickxellales	Kickxellaceae, Dimargaritaceae, Spinaliaceae.
7 Palavasciales	Palavasciaceae, Paratoenelliaceae.
8 Torulopsidales	Torulopsidaceae

USTILAGOMYCETIDAE

9 Ustilaginales	Ustilaginaceae, Graphiolaceae.
10 Tilletiales	Tilletiaceae.
11 Brachybasidiales	Brachybasidiaceae
12 Exobasidiales	Exobasidiaceae, Cryptobasidiaceae.
13 Digitatosporales	Digitatosporaceae.
14 Sporobolomycetales	Sporobolomycetaceae.

CACUMISPOROMYCETIDAE

15 Cladosporiales	Cladosporiaceae. & autres familles de formes.
16 Helminthosporiales	Helminthosporiaceae. & autres familles de formes.
17 Papulariales	Papulariaceae. & autres familles de formes.
18 Cocumisporiales	Cacumisporiaceae. & autres familles de formes.
19 Anellophorales	Anellophoraceae & autresfamilles de formes.

REPETOBASIDIOMYCETIDAE

20 Repetobasidiales	Repetobasidiaceae.
21 Dacrymycetales	Dacrymycetaceae.
22 Auriculariales	Auriculariaceae, Pleogenaceae.
23 Tremellales	Tremellaceae, Sirobasidiaceae, Hyaloriaceae.
24 Tulasnellales	Tulasnellaceae, Ceratobasidiaceae.
25 Septobasidiales	Septobasidiaceae.
26 Pucciniales	Pucciniastraceae, Chrysomyxaceae, Cronartiaceae, Coleosporiaceae, Melampsoraceae, Phragmidiaceae, Pucciniaceae.

17 BASIDIOMYCETES

BASIDIOMYCETIDAE

1 Cantharellales	Hydnaceae, Cantharellaceae, Clavulinaceae, Gomphoceae, Clavariaceae, Pterulaceae, Sparassidaceae
2 Poriales	Bondarzewiaceae, Hybogasteraceae, Hericiaceae, Auriscalpioceae, Bankeraceae, Telephoraceae, Scutigeraceae, Laetiporiaceae, Meruliaceae, Lachnocladiaceae, Poriaceae, Coniophoraceae, Stereaceae, Podoscyphaceae, Coriolaceae, Corticiaceae.
3 Polyporales	Cyphellaceae, Fistulinaceae, Schizophyllaceae, Polyporaceae, Ganodermaceae, Hymenochaetaceae.
4 Boletales	Strobilomycetaceae, Chamonixiaceae, Xerocomaceae, Suillaceae, Boletaceae, Gyrodontaceae, Gastroboletaceae, Neopaxillaceae, Paxillaceae, Austrogastraceae,
5 Gautierales	Gamphidiaceae, Baunelliulaceae.
6 Agaricales	Gautieraceae, Rhizopogonaceae. Hygrophoraceae, Lentinellaceae, Lentinaceae, Tricholomaceae, Lyophyllaceae, Marasmiellaceae, Mycenaceae, Pleurotellaceae, Panellaceae, Phaeomarasmiaceae, Conocybaceae, Lachneliaceae, Pleurotaceae, Inocybaceae, Melanophyllaceae, Cystodermaceae, Lepiotophyllaceae, Entolomaceae, Laccariaceae, Leucopaxillaceae, Leucocortinariaceae, Cortinariaceae, Crepidotaceae, Lacrimariaceae, Rhodogasteraceae, Thaxtergasteraceae, Corrugariaceae, Agaricaceae, Secotiaceae, Strophariaceae, Weraroaceae, Agrocybaceae, Bolbitiaceae, Setchelliogasteraceae, Psathyrellaceae, Panaeolinaceae, Coprinaceae, Montagneaceae, Podaxaceae,
8 Amanitales	Amanitaceae, Amidellaceae, Brauniellaceae, Pluteaceae, Volvariaceae,
9 Russulales	Archerussulaceae, Russulaceae, Lactariaceae, Elasmomycetaceae.
10 Hymenogastrales	Protogastraceae, Hymenogastraceae, Hydnangiaceae, Maccagnaceae,

MERISTEMOBASIDIOMYCETIDAE

11 Meristemobasidiales	Meristemobasidiaceae.

LYCOPERDELLOMYCETIDAE

12 Lycoperdellales	Lycoperdellaceae.

VII. EPIMYCOTINA
18. ANGIOMYCETES

TULOSTOMOMYCETIDAE

1 Tulostomales	Tulostomaceae, Phelloriniaceae.

MELANOGASTROMYCETIDAE

2 Melanogastrales	Melanogastraceae, Torrendiaceae.
3 Lycoperdales	Mycenastraceae, Lycoperdaceae, Battoreaceae, Broomeiaceae, Arachniaceae.
4 Calostomales	Astraeaceae, Calostomaceae.

19 NIDULARIOMYCETES

1 Phallales	Hysterangiaceae, Protophallaceae, Gelopellaceae, Clathraceae, Phallaceae,
2 Nidulariales	Nidulariaceae, Sphaerobolaceae.
3 Sclerodermatales	Sclerodermataceae.
4 Geastrales	Geastraceae.
5 Gastrosporiales	Gastrosporiaceae.

VIII. PERIMYCOTINA
20. PROPAGOMYCETES

1 Rhacophyllales	Rhacophyllaceae.

IX. CLADOMYCOTINA
21 RHYNCHOPHOROMYCETES

1 Rhynchophoromycetales	Rhynchophoromycetaceae.

22 LABOULBENIOMYCETES

1 Ceratomycetales	Ceratomycetaceae, Zodiomycetaceae, Coreomycetaceae,
2 Peyritschiellomycetales	Dimorphomycetaceae, Rickiaceae, Peyritschiellaceae, Enarthromycetaceae, Monaicomycetaceae, Haplomycetaceae.
3 Laboulbeniomycetales	Herpomycetaceae, Stigmatomycetaceae, Idiomycetaceae, Teratomycetaceae, Gorgothamycetaceae, Laboulbeniaceae, Rhachomycetaceae, Clematomycetaceae, Compromycetaceae, Chaetomycetaceae, Ecteinomycetaceae, Misgomycetaceae.

13. FUTUROMYCETES
Amorphomycetales — Amorphomycetaceae.

Principe de l'idoneité la meilleure. F. GONSETH.
Ontogénèse récapitulant la phylogénèse. CUVIER.
Evolution helicocyclique. GAUSSEN, MANGENOT, LOCQUIN.
Onde transsociée. L. de BROGLIE, comm. LOCQUIN.
Probabilité de vie. LOCQUIN.
Parasite postérieur au parasite. LOCQUIN.

Ce tableau mural: **SYNOPSIS GENERALIS FUNGORUM**, condense la systématique adoptée dans **DE TAXIA FUNGORUM**, 1972, arrêtée aux familles.

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IX Subordines, INA, 23 Classes: MYCETES,
Subclasses: MYCETIDAE,
166 Ordines: ales, 660 Familiae: aceae,
circa 3000 Genera, circa 300.000 species

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Excerpts from significant portions of

Buffaloe & Throneberry's Principles of Biology

2nd edition, 1967

Published by **Prentice-Hall, Inc.**

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A Science includes 4 kinds of knowledge
① Empirical –
② Anticipated –
③ Explained –
④ Inferred – ie Atomic Theory

Mycology

Historical Outline

(A)

Theophrastus - 380-287 Bc

Cesalpini .. 1583. 16 vols. on plants

Brunfels (1530), Fuchs (1542), deLobel Herbalists.

C. 1 R. Clusius .. 1601. Codex. 1st illustrated prints of fungi.

Gaspar Bauhin .. 1623. Pinax.

John Ray .. 1704. Historia Plantarum. Fungi in distinct group.

Tournefort .. 1694. LINNAEUS - 1753.

Dillenius .. 1718. 170 spp. fungi described.

3 P. Bulliard .. (1752-93) 1780-93. Herbier de la France.
1791-92. Histoire de Champignons de la France.

* 4 C.H.Persoon .. (1761-1836) 1801. Synopsis Methodica Fungorum.
Gymnocarps (hymenium) vs Angiocarps (Gasteros)
Starting point : Rusts, Smuts, Gasteros.

* 5 E.M.Fries .. (1794-1878) 1821-32 (Elenchus 1828) Starting point.
Systema Mycologicum

2 A. Micheli .. (1679-1737) 1729. Nova Plantarum Genera. (isolation trchnique)

Nees von Esenbeck .. 1816. Life cycle of Rhizopus on bread.

6 J.H. Léveillé .. (1796-1870) 1837. Resherches sur l'hymenium de champignons.
term "basides" = basidium (with Guillemin)
Thecosporew(=Ascos), Basidiospores(=Basidio)
Cystospores(=Mucorineae), Clinospores(=Imp.)

L.R.(C.)

* 7 1 Tulasne .. (1815-1885) 1853. Basidia of Tremellales (Exidia, Dacrymyces, Tremella)
1861-65. Selecta Fungorum Carpologia. (Erysiphales etc)

8 N. Patouillard .. (1854-1926) 1877. Heterobasidios vs Homobasidios
1900. Essai Taxonomique.

10 E. Boudier .. (1828-1905) 1885-1907. Operculate Discos.

P. Vuillemin .. 1910-11. Imperfects (Hyphomycetes)

* 9 H.A. deBary .. (1831-1888) 1863-65. Pure cultures of fungi.
1884. Morphologie und Biologie der Pilze.

Blakeslee (1904, Heterothallism); Kneip (1915, clamps);
Brefeld(1872-1912, Untersuchen); Buller (1909-1934,
Researches on Fungi, 7 vols.)

10 Bourdot et Galzin .. (1861-1937) 1927. Hymenomycètes de France.
Heteros & Homos

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for class

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Myxos

Class Review
2-X-67

Eumycetes vs Myxogastres

8 swarm cells
Sporophore w. external spores

1-2 swarm cells
Sporangia w. internal spores

INDOSPORAE

PROTOPLASMODIUM

Licea

Spore dust

Trichia

Arcyria
Capill. warts, cups
Perdiu fugaciens.

Trichia
Capill. w. spirals distinct
Short threads

Oligonema
Capill. w. indistinct spirals
Short threads

CALYCULUS

Hemitrichia
METATRICHIA
Capill. a network w. distinct spirals.

Pseudocapillitium ± Cap. +

Tubifera (Liaceae)
no capillitium
pseudoaethalium

Lycogala (Reticulariaceae)
pseudocapillitium
aethalium

Spore dust

Stemonitis

ECHINOSTELIALES

Proto plasmodium

Dictydium (Cribrariaceae)
Dictydine granules on net
+ spores

PHYSAROPLASMODIUM

Net calcareous in Fendium
or/capill.

[Both columella may be - or stipe -
(Diachea)]

Stemonitis
Cap. a simple net

Comatricha
Cap. open-ended

Diachea
Columella + stalk calcareous

PHAEODERMOPLASMODIUM

Physarales

Cap. + frids calcareous

Badhamia
Cap. with circumparietal nodes

Physarum
Cap. with large calcareous nods

Fuligo — aethalium (+ soot)

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Some aspects of fungal activities

I Position of fuhgi: not "conventional" plants or animals.

a) achlorophyllous saprobic parasitic

b) no chemosynthetic or photosynthetic (as among bacteria)

c) morphology: hyphae mycelium (assimilative)vs reproductive

d) taxonomy: Myxomycota Fumycota (Art. 16 Rec. 16A Code 1956)
Myxomycetes Phycomycetes etc.

* II Beneficial activities of fungi

A Destruction of organic wastes — ENDLESS ACCUMULATION OTHERWISE.

a) Humus formation { MIXTURE OF ORGANIC COMPOUNDS. ACTION OF SOIL MICROORGANISMS

2) Degredation of cellulose, lignin

3) restore CO_2 to atmosphere BY RESPIRATION — C CYCLE

B Mycorrhizal Fungi — NATURE OF RELATIONSHIP — COMMON & WIDELY DISTRIBUTED.
FRANK 1885

1) generally beneficial to higher plant (Fricaceae Orchidaceae Indian pipe)

C Industrial fermentations + FOOD YEASTS (TORULOPSIS UTILIS) SUPPLIMENT TO DIET. { Gymnospermae PINE SEEDLINGS; ANGIOSPERMS

CHEESE { P. ROQUEFORTI, P. CAMEMBERTI
BREAD ✓ PAUL IN CORINTH. 1 5:6: "KNOW YE NOT THAT A LITTLE LEAVEN LEAVENETH THE WHOLE LUMP?" SACCHAROMYCES { COMPRESSED YEAST SINCE 1840.

1) alcohol synthesis (respiration)

2) acid syntheses (citric, gallic, gluconic, kojic)

BREWER'S / BAKER'S } YEAST — SOFT DRINKS - DYES - FLAVORING - PHOTOGRAPHIC - MEDICINE — A. NIGER — P. CHRYSOGENUM — A. STR. — STREPTOMYCIN —

D Fungi in medicine — PENICILLIN, AUREOMYCIN, TERRAMYCIN, ECHINOMYCETIN, 1929 (P. NOTATUM) — EPIDERMIPHYTON, TRICHOPHYTON

1) antibiotics 2) medical mycology — SUPERFICIAL { MYCOSES — DEEP { COCCIDIOMYCOSIS, HISTOPLASMOSIS, BLASTO—

VITAMIN SYNTHESES
RIBOFLAVIN B-COMPLEX BY ASHBYA GOSSYPII

E Growth-promoting substances + BIOLOGICAL ASSAYS 1) PABA WITH NEUROSPORA CRASSA (MYCELIAL ADVANCE) 2) THIAMIN WITH YEAST (AMOUNT CO_2 IN GIVEN TIME) 3) AMINO ACIDS WITH NEUROSPORA (GROWTH PROPORTIONAL TO AMOUNT OF ACID)

1) gibberellin (A FAD) FUSARIUM MONILIFORME JAPAN 1939 RICE + FUNGI AS GENETIC TOOLS (NEUROSPORA, GLOMERELLA

** III Harmful activities — LOSS?

A Plant & animal diseases zb Chestnut blight, Dutch elm, Rust, Smut, Mildews, Leaf spots etc.

ABOVE { Coccidiomycosis, Blastomycosis, Candidiasis, Chromoblastomycosis etc.

B Destruction of timber & timber products
1)pulpwoods decay

C Tropical deterioration
paper, glass, leather, textiles etc. — erect metals

D Food spoilage
Dairy products, bread, fruit, vegetables, meat

E Poisonous fungi
Amanita phalloides etc.

A. MUSCARIA ± M.L.D. DOGS: ± 0.1 mg / Kg. BODY WT. } ATROPINE ANTIDOTE

LUMINESCENCE C. ILLUDENS A. MELLEA etc.

HALLUCINOGENIC : PSILOCYBE SPP. MEDICAL APPLICATION.

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MYXOMYCETES

Link, Handb. Gew. 3: 405. 1833 (as suborder) °
Mycetozoa de Bary, Bot. Zeitung 16: 369. 1858 (as Mycetozoen).

Assimilative phase a multinucleate, free-living, acellular mass of protoplasm, the plasmodium, naked, amoeboid, varying from very small and giving rise to a single fructification, to an extensive system of branching and anastomosing veins in which the active protoplasm is enclosed in an amorphous gelatinous sheath with the anterior advancing portion naked; usually immersed within the interstices of wood, bark, leaves, dung, soil, or litter and emerging to the surface before or at the time of fructification and capable of movement within or on the substratum, less commonly superficial from the first. Reproductive phase characterized by spores or spore-like cysts, in the first subclass borne on individual stalks, in the second in the interior of spore cases, these seated on a horny, spongy, or calcareous base, the hypothallus. Spores, on germination, giving rise to one or more naked myxamoebae or flagellated swarm-cells. Under the influence of unfavorable conditions, the plasmodium sometimes fragments into a large number of disconnected cysts or becomes transformed into a horny mass, the sclerotium, consisting of multinucleate cell-like units capable of resuming plasmodial characters under favorable circumstances.

In the following treatment, the genera in each family are arranged in the order in which they appear in the keys. Within each genus, the recognized species are in alphabetical order.

KEY TO SUBCLASSES

Spores borne externally on individual stalks, each producing on germination a naked protoplast which develops into a cluster of eight swarm-cells; hypothallus always well developed, giving rise to erect, often branched, and sometimes anastomosing extensions, the sporophores. Subclass **CERATIOMYXOMYCETIDAE**

Spores borne internally in fructifications of characteristic form, each producing on germination one or two, rarely more, swarm-cells or myxamoebae; hypothallus occasionally prominent, usually inconspicuous, sometimes imperceptible. Subclass **MYXOGASTROMYCETIDAE**

° Myxomycetes Wallroth, Fl. Crypt. Germ. 2: 333. 1833 (as order), appeared earlier in 1833 than Link's Handbuch, but Wallroth included gasteromycete genera in it. While Link did include a few genera not now regarded as Myxomycetes, none of them are gasteromycetes, and his grouping is therefore more in accordance with present opinion than is that of Wallroth. Myxogastres Fries, Syst. Myc. 3: 67. 1829 was published as the second suborder of his order Gasteromycetes genuini, the first suborder, Trichogastres, included mainly gasteromycetes, nearly all puffballs, and his name suggests relationships with that group. All of these names included only the endosporous forms. Since Link was the first to treat them as a distinctive group, the class name is credited to him, and Fries's name is used as the base for the subclass embracing the endogenous species only.

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MARTIN & ALEX.

MARTIN, G.W. 1958. THE CONTRIBUTION OF DEBARY TO OUR KNOWLEDGE OF MYXOMYCETES. PROC. IOWA ACAD. SCI. 65: 122-127.

ALEXOPOULOS, C.J. 1959. THE LABORATORY CULTIVATION OF STEMONITIS. AMER J. BOT. 46(2): 140-142.

COLLINS, O.R. 1961. HETEROTHALLISM & HOMOTHALLISM IN 2 MYXOS. AMER. J. BOT. 48(3): 674-683.

HETERO DIDYMIUM IRIDIS
HOMO FULIGO CINEREA

MYXO-
Div. MYCOTA (FUNGI)
SUBDIV. MYXOMYCOTINA
CL. MYXOMYCETES
SBCL. CERATIOMYXOMYCETIDAE
ORD. CERATIOMYXALES
SBCL. MYXOGASTROMYCETIDAE
ORD. LICIALES
TRICHIALES
ECHINOSTELIALES
STEMONITALES
PHYSARALES

Wilson, C.M. & Ian K. Ross. Meiosos in the Myxomycetes. Amer. Jour. Bot. 42(8):743-749. 1955. (OCT.)

In Exosporeae, meiosis occurs in spores (confirming earlier workm, of Olive 1907, & Gilbert 1935). In Endosporeae (those studied meiosis and capillitium formation take place simultaneously.
Smear preparations of spores with aceto-orcein (stain-fixative).
Ceratiomyxa fruticulosa with 8 haploid chrom.

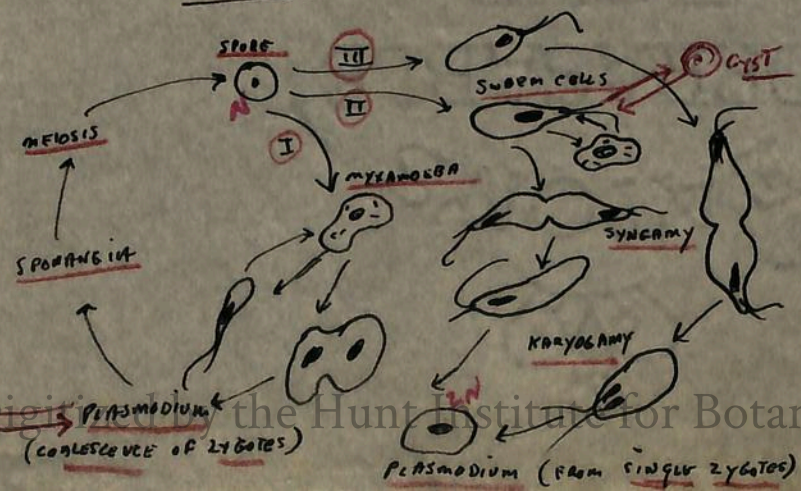
Species investigated by Wilson & Ross:

Ceratiomyxa fruticulosa
Lycogala epidendrum
Trichia persimilis
Hemitrichia Vesparium
Stemonitis axifera
S. pallida
Comatricha typhoides
Lamproderma arcyrioides

(all collections made at Mt. Royal, Montreal)

DIV. EUMYCOTA
SUBDIV. EUMYCOTINA
CL. PHYCO
ASCO.
BASIDIO
DEUTERO

ROSS, I.K. SYNGAMY & PLASMODIUM FORMATION IN THE MYXOGASTRES. AMER. JOUR. BOT. 44(10): 893-850. 1957.



3 BASIC PATTERNS

TYPE III MOST COMMON IN SPP. STUDIED

TYPE I: BRIEFLY FLAGELLATE; AMOEBOID STATE DOMINANT
II: FLAGELLATE! TEMPORARY AMOEBOID STATE
III: COMPLETELY FLAGELLATE: NO AMOEBOID STATE

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MONDAY — 17th

NOT IN KUDO. ← OLIVE, E.W. 1902. MONOGRAPH OF THE ACRASIAE. PROC. BOSTON SOC. NAT. HIST. 30: 451-513.

ACRASIALES vs MYXOMYCETES (9 gen; 25 sp.)

Similarities: 1) Myxamoebae move in same way.

2) Feeding similar too. (bacteria etc.)

Differences: 1) No flagellated swarm cells. MYXAMOEBAE ONLY.

2) PSEUDOPLASMODIUM (amoebae distinct, no union)

3) Each amoeba forms SOROCARP of distinct morph.

EXCLUDED FROM FUNGI BY G.W.M.

DICTYOSTELIUM

IN SARCODINA OR KUDO.

(3 gen., 6 sp.)

LABYRINTHULALES (Dangeard. 1932. Le Botaniste 24.)

(Raper. 1943. Amer. J. Bot. 30(8): 586-593.)

Parasitic on algae.

= ZOPF {1885 1892

Characteristics: NET*PLASMODIUM formed prior to reproduction.

(Lorus, J & Milne, M.J. 1951. Sci. Amer. Jan. 52-55.) Zostera

Spindle-shaped cells mass together; peripherally located ones send out slender processes which join to form the net. This is also a pseudoplasmodium

(Najadaceae. also zb. Potamogeton)

Labyrinthula macrocystis and the Zostera disease.

JAN. 1951. Sci. Amer.

Summer 1931 Zostera began dying off in vicinity of Portsmith, N.H. Set off a chain of events resulting in great diminution of wild life in that area.

Sept. Sci. Amer. 52-55.

Within 3 yrs., only about 20% of Brant (ducks) survived; Cod, shellfish (oysters, clams) died in enormous numbers. Raw sewage from neighboring towns accumulated in rivers which previously had supported game fish, wild life etc. (geese, halibut, cr This cycle has lasted about 20 years; now the Zostera (Eelgrass) is beginning to come back; also the fish, wildlife etc.

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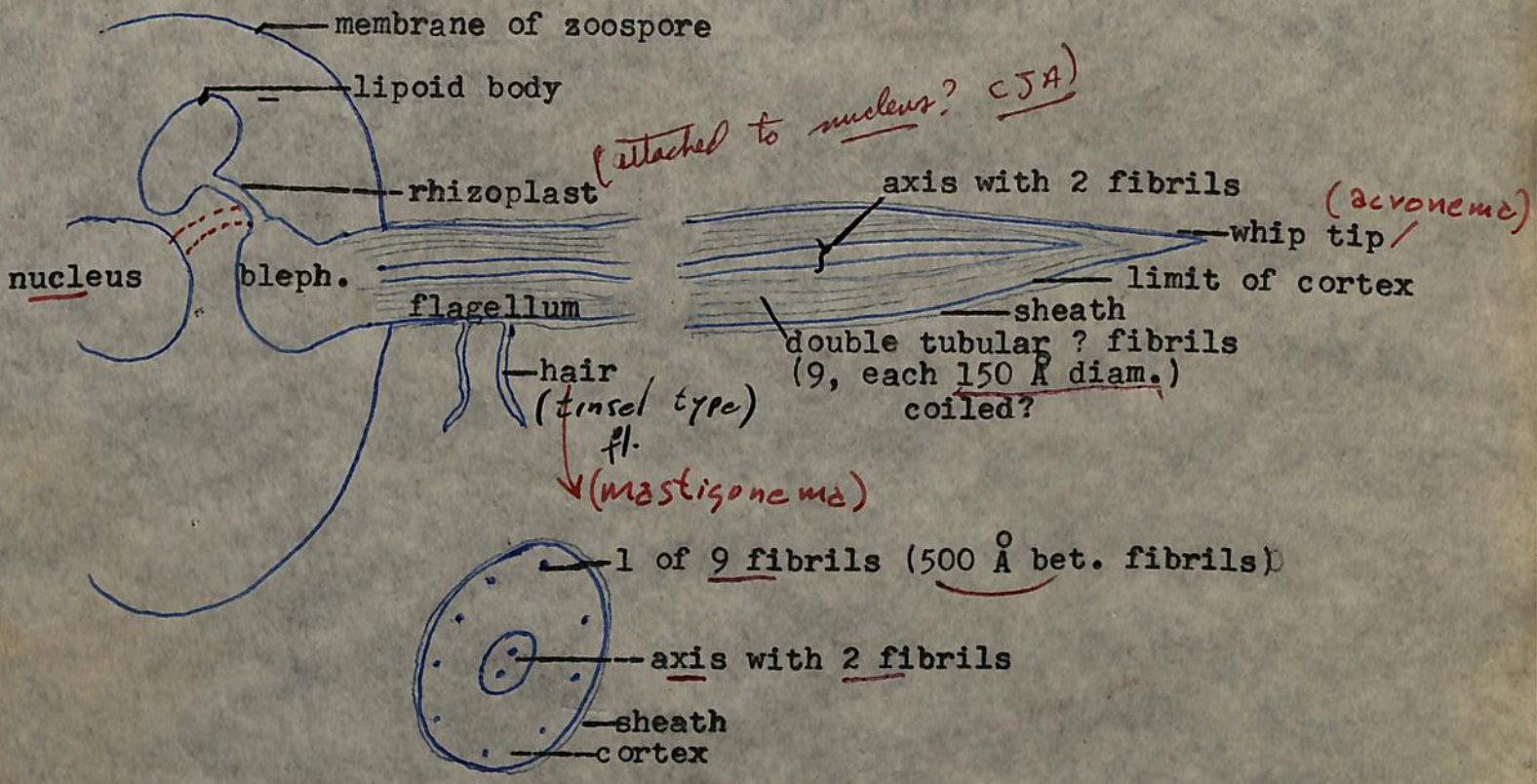
Waterhouse, G.M. 1962. The zoospore. Presidential address. TBMS 45: 1-20.



see also: Manton, I. The fine structure of plant cells. Symp. Soc. Exp. Biol. 6: 306-319.

[Pleuronematic = side (stichonematic = row)]

Flagella Types

Eq
1) 1-sided tinsel — 1 row of hairs (mastigonemata) 1-4 μ long along entire length — Zb Euglenoid
(Pantonematic = all)
2) 2-sided tinsel — 2 rows of hairs along entire length — (Anterior flagellum: Saprolegniale, Lagenidiale, Peronosporales, Brown algae, Yell-green "; Chrysoflagellates, Diatoms)

Eq
3) whip-tinsel — 2 rows or more, but thin tip devoid of hairs
(acronematic = tip)
4) whiplash 1 — No hairs, tip thin } Posterior flagellum of Chytridiales
5) whiplash 2 — No hair, no thin end } Green algae

rhizoplast

Tinsel = shimmer

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WATERHOUSE

THE ZOOSPORE

In all groups the zoospore is a uninucleate, flagellate body with a very thin limiting membrane; but the shape, flagellation, movement, and cytoplasmic inclusions vary from group to group.

Flagellum

There has been a flood of most interesting work on the structure of the flagellum (Manton, 1952) in the last 10 years—too much for me to recapitulate here; I can only offer a summary (Text-fig. 1). The basic pattern throughout—indeed throughout the plant and animal kingdoms of both cilia and flagella—is the same. There is an axial strand composed

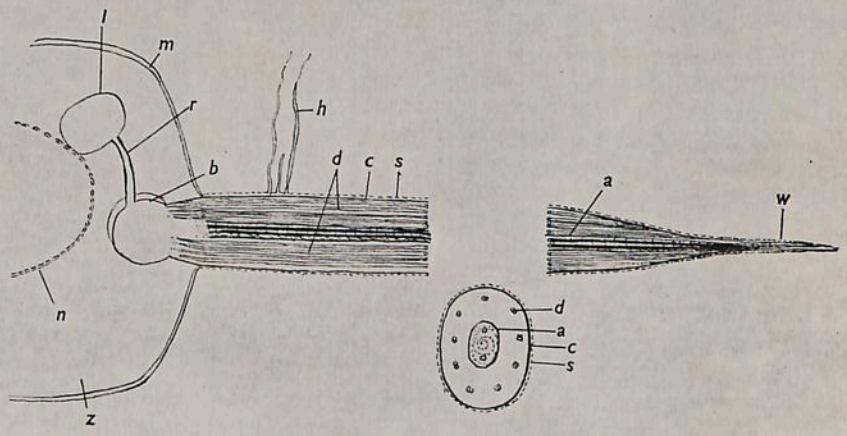

Fig. 1. Diagrammatic representation of the known and presumed structure of the zoospore flagellum. *a*, Axis with two fibrils (150 Å. diam.) in ? helical matrix; *b*, blepharoplast (double); *c*, limit of cortex (? gelled matrix); *d*, double tubular ? fibrillar fibrils (9 in all, 150 Å. diam.); *h*, hairs (mastigonemata); *l*, lipoid body; *m*, membrane of zoospore; *n*, nucleus; *r*, rhizoplast; *s*, sheath; *w*, whip tip; *z*, zoospore body. 500 Å. between each fibril, 250 Å. between the fibril and the limit of the cortex.

of two fibrils or filaments which may be double, tubular or fibrillar. Some preparations have suggested that the two filaments are spirally twined but other workers have found no evidence of coiling. The two lie in some sort of matrix; again, the suggestion is that there is some helical arrangement in this matrix. Equidistant from the central filaments and from each other are disposed nine filaments which also may be double, tubular or fibrillar. They appear to be denser and more resistant to enzymes than the central ones. They, too, are embedded in some sort of matrix within a boundary layer, which keeps the filaments together. Beyond this there is a suggestion of a sheath. Again, opinions differ about the sheath. Some workers have found no evidence of a sheath in the species they have studied. Others give quite convincing pictures of a sheath—for example, one has been shown in the flagellate Protozoa, in the Saprolegniales, in *Allomyces*, and one is possibly present in *Phytophthora*.

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for Jan

(Table 2) suggests that flagellum ...

Flagellum versus cilium

Before I go on to the other parts of the zoospore I should like to digress here for a moment on the subject flagellum *v.* cilium. Earlier on, both terms were used for the motile organ of zoospores before it was realized that the cilia of the ciliated protozoa and of the ciliated epithelium in the metazoa were different in form and function from the zoospore organ. Then flagellum came to be more or less universally adopted for the latter. Since the electron microscope has shown the same basic 9+2 structure throughout, the two terms have again been used indiscriminately.

There are, however, certain basic differences.

(1) Whether there be 1, 2, 4, or 8 flagella, they are single, independent units. Cilia are in serried co-ordinated ranks.

(2) The flagellum is connected to the nucleus or to a body near the nucleus via the rhizoplast. The cilium is not connected to the nucleus by a special structure.

(3) Flagella have a spiral undulating or screw motion. Cilia lash to and fro in the same plane.

(4) Cilia beat all together in metachronal rhythm, whereas each flagellum beats independently.

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Zoospores and flagella

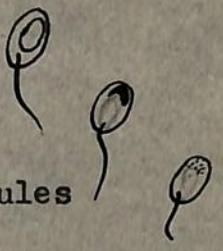
5 major types:

1) Posteriorly uniflagellate

Chytridiales ..... with oil globule

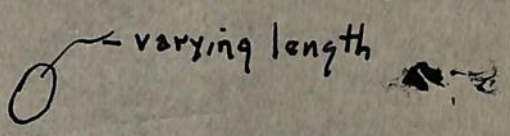
Blastocladiales .... nuclear cap

Monoblepharidales .... anterior granules



2) Anteriorly uniflagellate

Hyphochytriales



3) Heterokont (Ant.) RIx

Plasmodiophorales .... apically attached and oppositely directed.

Myxomycetes (both subapical)

4) Anteriorly biflagellate

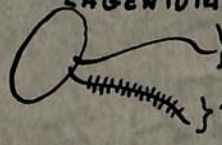
Saprolegniales .. "primary zoospore" pyriform.

5) Posteriorly biflagellate
Laterally "

monoplanetic [Pythiopsis]
di- [Saprolegnia]
poly- [Dictyuchus]
(all 2° type)

Saprolegniales ... "secondary zoospore"; bean shaped or kidney-shaped.

LEPTOMITALES
LAGENIDIALES



" flagellum of whip lash type
" " tinsel (Flimmer) "

Flagellar insertion may be lateral or subapical, with flagella oppositely directed.

Electron micrographs { Flagellum of Allomyces made up of 11 longitudinal strands, including a central pair. With translucent sheath surrounds central axis.

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LIFE CYCLES

PROTISTA (OLIVE)

MYXOMYCOTA [MYCETOZOA]

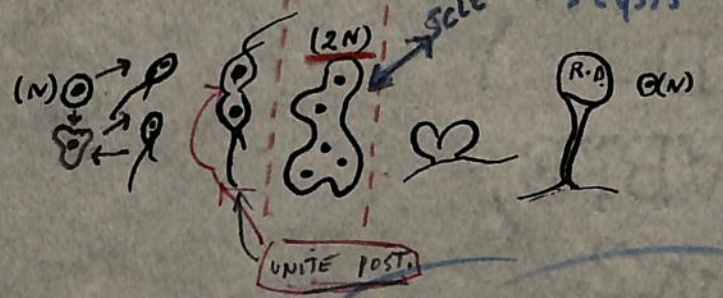
1) MYXOMYCETALES = MYXOGASTRALES } PLASMODIAL SLIME MOLDS
2) PLASMODIOPHORALES
3) LABYRINTHULALES
4) ACRASIALES } CELLULAR SLIME MOLDS (PSEUDOPLASMODIAL)

The Cellular Slime Molds. J.T. BONNER. 1959. PRINCETON. 150 pp.

PROTOZOA

5) PROTOSTELIDA OLIVE
NO AGGREGATION!

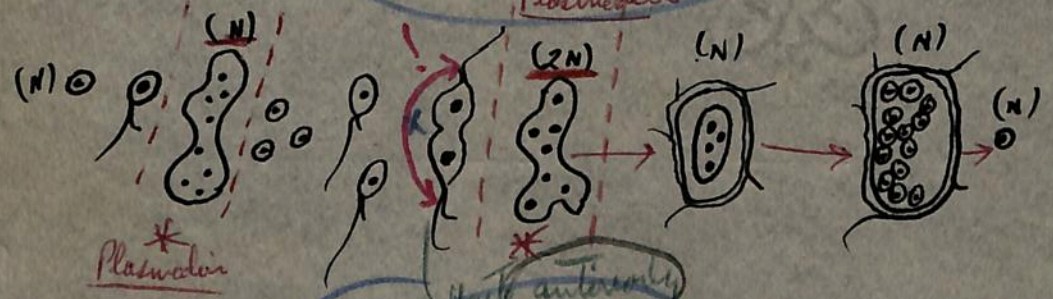
① HEMITRICHIA



SAPROBIC
2N PLASMODIUM
FLAGELLA BOTH WHIPLASH TYPE
i.e. NON MASTIGONEME

② PLASMODIOPHORA (PLASMODIOPHORALES)

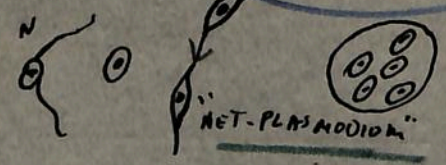
9:2 MORPHOLOGY (EM) also in



PARASITIC
2N & N PLASMODIA
FRUITING BODY ABSENT
not as in Myxos

③ LABYRINTHULA (LABYRINTHULALES)

CELLULAR SLIME MOLDS

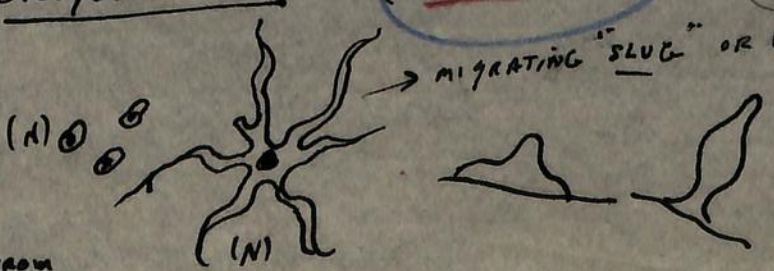


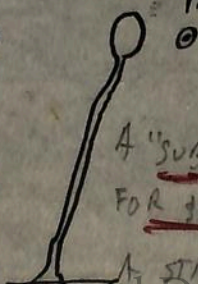
ANT. (MASTIGONEMATE) i.e. FLIMMER } = FLIMMERN G. TO TWINKLE or FLASH
2 FLAGELLA
(N)
POST. (NON MASTIGONEMATE) (SMOOTH)

ASEXUAL CYCLE ONLY
"NET" = PSEUDOPLASMODIUM
NO TRUE AGGREGATION
PARASITIC

④ DICTYOSTELIUM

CELLULAR SL.M. (ACRASIALES) — ACRASIN — J.T. BONNER (PRINCETON)





ASEXUAL CYCLE ONLY
AGGREGATION OF CELLS
PSEUDOPLASMODIUM
NO FLAGELLATED CELLS.
FREE LIVING IN SOIL

ORIGIN FROM "FREE-LIVING AMOEBAE OF SOIL"?

PSEUDOPLASMODIUM

PROTOSTELIDA OLIVE 1966.

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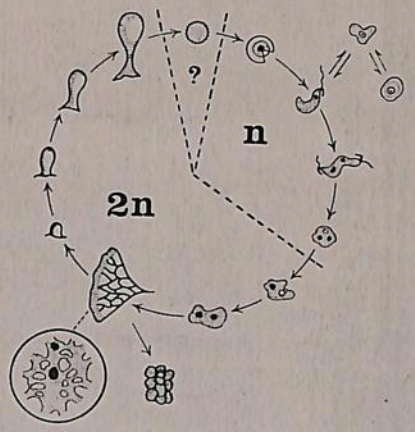

4

The Nuclear Cycle

Except under unusual circumstances, the myxamoebae or swarm cells that issue from germinating spores are uninucleate and are regarded as haploid. A general belief among students of Myxomycetes is that coalescence of amoeboid or flagellated protoplasts is a prerequisite for plasmodial formation in most species that have been investigated, and that only rarely, under unusual circumstances, may a plasmodium develop from single protoplasts that issue from the spores (Kerr, 1967; Henney, 1967). There is considerable disagreement, however, as to the behavior of the nuclei after coalescence has taken place.

In the discussion that follows, any fusion of haploid cells known to result in the formation of a diploid zygote will be regarded as sexual regardless of the morphology of the fusing cells and will be termed *syngamy*. The fusion of cells preceding nuclear fusion will be termed *plasmogamy*, and fusion of the nuclei will be termed *karyogamy*. Fusion of protoplasts without reference to subsequent fate of the nuclei will be termed *coalescence*.

PLASMOGAMY

That syngamy occurs in many species of Myxomycetes has been well established by actual observation in some and by genetic experiments in others. That sexual fusions occur in heterothallic species cannot be denied. Whether so-called homothallic species are actually so, as some

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Alexopoulos. Mycologia 52(1):1-20. 1960.

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MYKOS

Plasmodial Types.

Plasmodium: 1 cell. multinucleate mass of protoplasm which engulfs solid particles of food; has amoeboid movement.

3 Types recognized: I Protoplasmodium (Limacia, Echiostelium, Licea)

a) Young Plasmodium has appearance of & large myxamoebae. (20-30 μ diam.) ←
b) Colorless
c) No differentiated fan- ~~like~~ shaped region
d) No veins
e) No reticulation
f) No reversible streaming

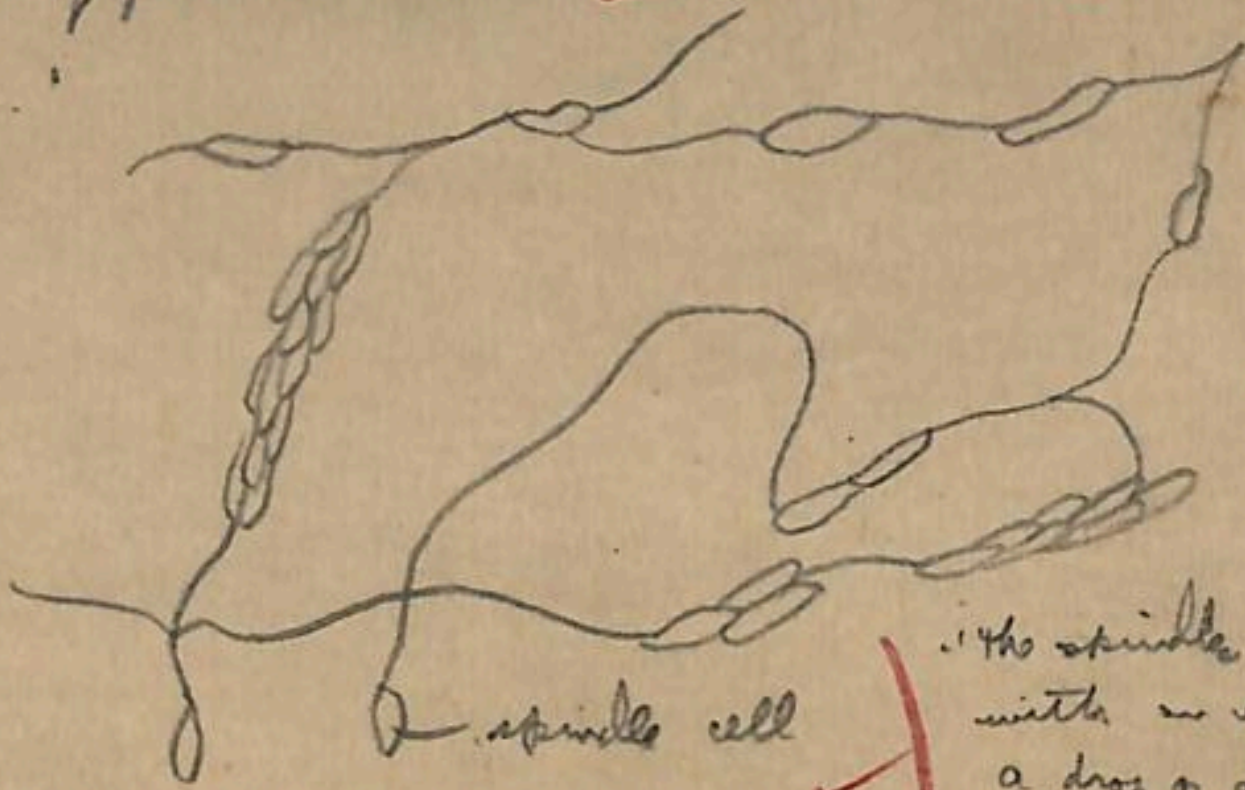
II Aphanoplasmodium (Stemonitales, Stemonitis + Comatricha)

a) Young plasmodium flattened & very transparent ("invisible")
b) Anastomoses form early — strands hyphae-like
c) Rhythmical streaming of protoplasm visible

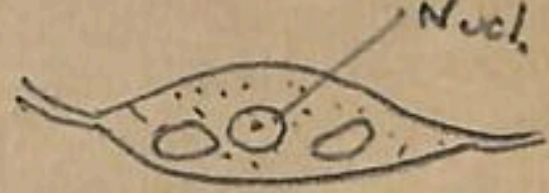
III Phanoroplasmodium (Trichiales, Physarales)

a) Young Plasmodium becomes fan-shaped at anterior end
b) Anastomoses large & irregular
c) 3-dimensional appearance at early stage
d-e) reversible streaming — reticulation.

Young, E.L. Amer. J. Bot. 30: 586-593. 1943. Studies on Lycopersicum.



net "plasmodium"



spindle cell

"the spindle glides along the tract with an effortless motion like a drop of glycerin rolling down a taut silk thread." (p. 587)

No negation of tracts seen.

Cienkowski, L. 1863. Das Plasmodium.

Dangeard, P. 1932.

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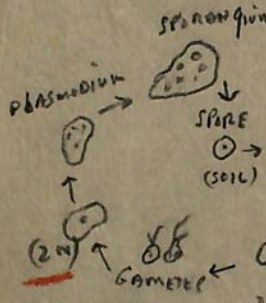
NOTE: ○ ○ ○ } zoosphere Types
CON- EX- SUB-

[FORMS OF UNCERTAIN RELATIONSHIPS]

Myxomycetes & Plasmodiophorales



P. brassicae

Close relationship bet. groups suggested on basis of foll evidence:

a. Plasmodial nutrition similar.
b. multi-nucleated plasmodia.
c. isogametes.
d. homo & heterothallic.
* e. anteriorly biflagellate & heterokont (Elliot '49)
* f. 2 blepharoplasts in zoospore

Myxos formerly considered uniflagellate, with exceptions; now the reverse . (Stemonitis is "weakly heterokont").

BUT cheif differences are: → CRUCIFORM DIVISION → AKARYOTE PHASE } ALEX P. 177

a. parasitic vs non-parasitic habit.
b. myxos: spore produces 1-many zoospores.
plasm: " " 1 zoospore
c. myxos: gametes fuse posteriorly
plasm: " " anteriorly
d. NO FRUITING BODY FORMED (AS IN MYXOS)

Similarity bet Synchytrium spp. and Plasmodiophorales: infected cell stimulated to divide. (ie S. endobioticum, S. australe)

Plasmodiophorales placed in Sarcodina by some zoologists (amoeboid nature of plasmodium);

Genera of most economic importance:
Plasmodiophora brassicae
Sorosphaera veronicae
Spongospora subterranea

See: Leidy. Fresh Water Rhizopods.

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ENCYCLOPAEDIA CINEMATOGRAPHICA

Editor: G. WOLF

E 2000/1974

Stemonitis flavogenita (Myxomycetes) Plasmodial Phase (Aphanoplasmodium)

5 Illustrations

GÖTTINGEN 1974

INSTITUT FÜR DEN WISSENSCHAFTLICHEN FILM

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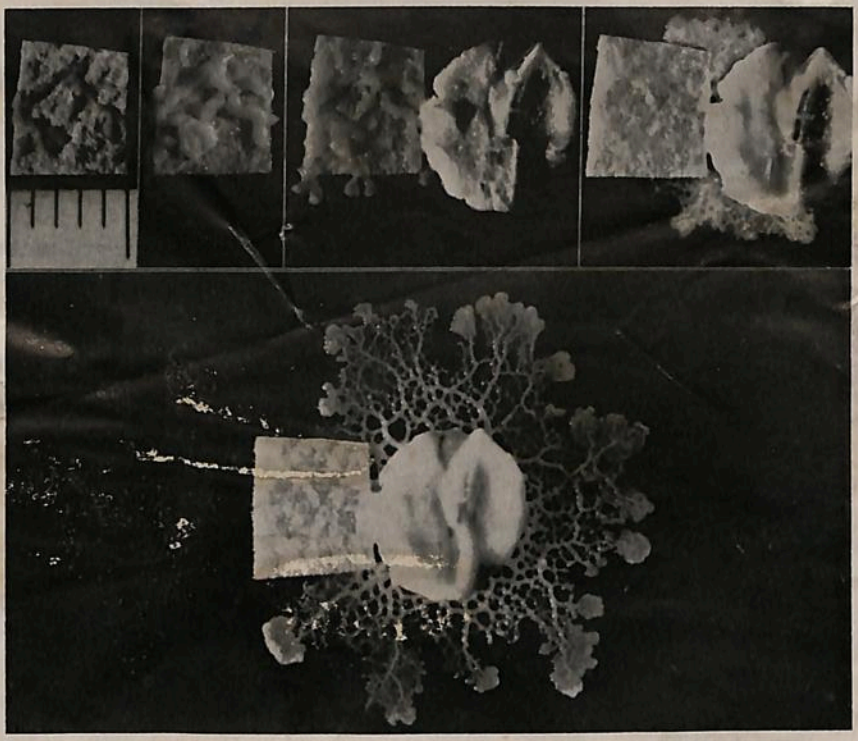

Development of plasmodium from the sclerotial stage of Physarum polycephalum over a period of 15 hours. Magnified 3X.

Culturing Physarum Polycephalum from the Sclerotial Stage

The myxomycete, *Physarum polycephalum*, is becoming an increasingly popular subject for the biology classroom, because it offers up so readily the secrets of slime mold growth and reproduction and permits easy observation of naked protoplasm in action.

In order to simplify culturing of *Physarum polycephalum* and insure certain success, the Turtox Laboratories have developed a method of producing an extremely resistant resting stage which can survive extremes in temperature and months of storage. Yet, when introduced into a favorable environment of moisture and food, the apparently lifeless orange-colored incrustation (the sclerotium) quickly transforms into an active, bright-yellow plasmodium.

The accompanying photomacrographs illustrate this remarkable transformation. First row, left to right: 1) a dry sclerotium on a piece of filter paper is shown with a millimeter scale; 2) at 1 PM, an hour after placing the sclerotium on 1.5% plain agar, considerable enlargement occurred because of moisture absorption (a grain of oats was placed directly in touch with the swelling, knotted mass after taking this picture); 3) at 2 PM, the plasmodium had broken forth, flowing onto the oat grain and spilling from the paper; 4) at 8 PM, the plasmodium had covered the grain of oats completely and commenced to flow away from the area. Second row: 5) fifteen hours after placing the piece of sclerotium on the agar (3 AM), the ravenous plasmodium had increased enormously in mass—striking out in all directions in its quest for food.

The agar culture technique (agar-oats or oatmeal agar) carried out in a petri

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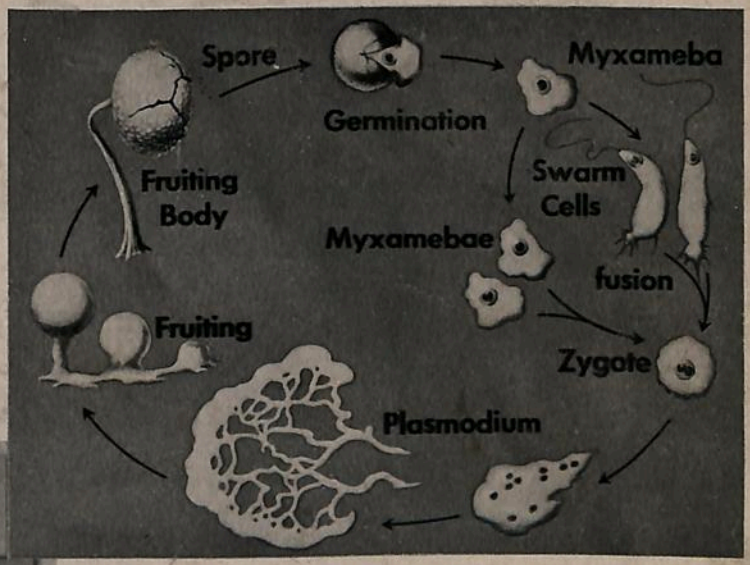
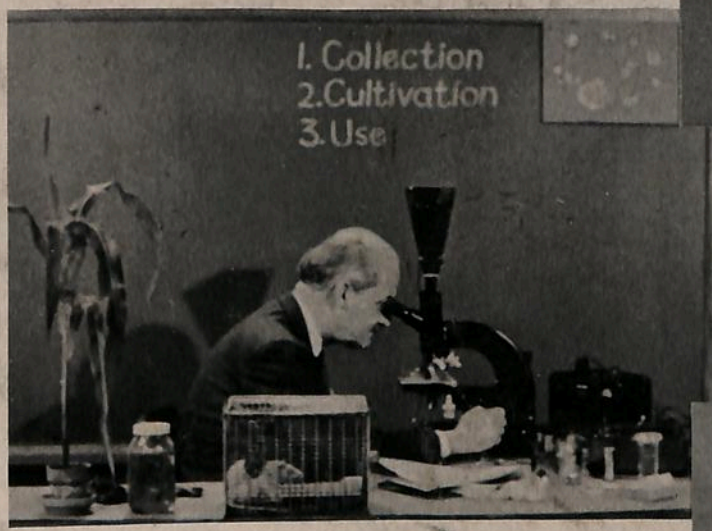
Slime Molds

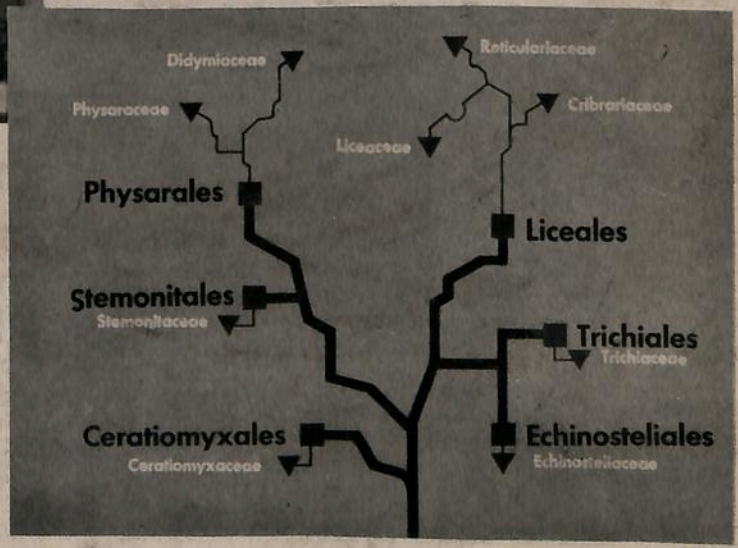


SLIME MOLDS I: LIFE CYCLE, U-5518, 30 min sd color or b&w. The fascinating and complex life cycle of one Myxomycete is revealed in detail by a combination of high and low magnification, phase contrast, dark field, bright field, normal speed, and time-lapse cinephotomicrography. Form is related to function. Unsolved problems are pointed out. The uniqueness of Myxomycetes is stressed. Animation is used to point out details, such as mitosis. Similarities and differences in the life cycle of different species are indicated.



SLIME MOLDS II: COLLECTION, CULTIVATION AND USE, U-5519, 19 min sd color. The techniques involved in collection, cultivation and use of the Myxomycetes are presented by taking the viewer into the field and laboratory. A few selected studies on slime molds are reviewed thru animation. Some projects are suggested. Several classroom demonstrations are shown.

SLIME MOLDS III: IDENTIFICATION, U-5520, 24 min sd color. The use of a key is illustrated by comparing a modified portion of Prof. G. W. Martin's key to a road map. Each road is followed until the main families of Myxomycetes are identified. Representative genera and species are shown thru a variety of photographic techniques. The reasons for identification, keys, terminology, and scientific names are given. Animation is used to show the parts of fruiting bodies used in identification of the slime molds.



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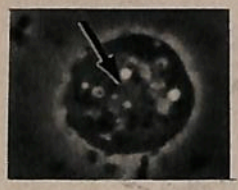
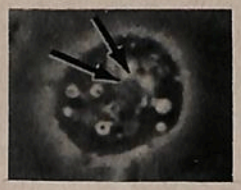
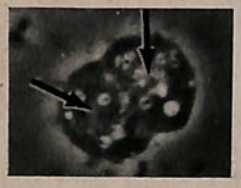
1 - 5. The life cycle begins with the germination of the spores. The protoplast swells, the spore wall splits or develops a pore, and the protoplast crawls out. Following germination the protoplast usually develops flagella and swims away. 1200X



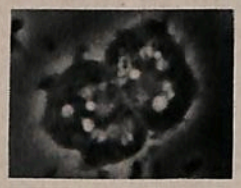
6. Metaphase



7. Anaphase

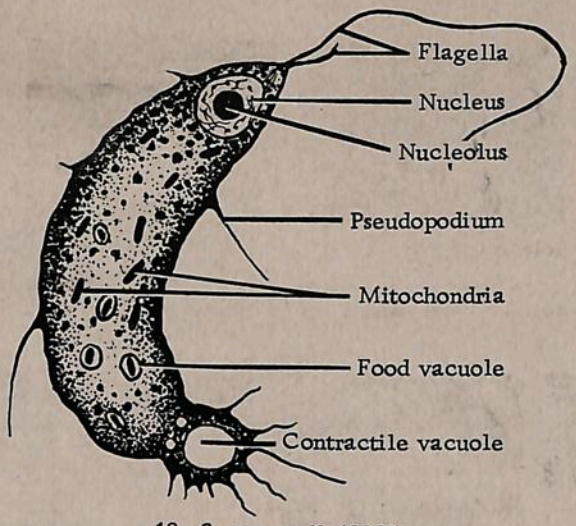


8. Telophase



9. Cleavage 2000X

Cell division occurs in the myxameba stage. The cell rounds up. The small nucleus undergoes a typical mitotic division similar to that found in higher organisms. The numerous minute chromosomes become visible during prophase. The nuclear membrane and nucleolus disappear. The spindle is formed. The chromosomes line up on the equatorial plane during metaphase and move to the poles during anaphase. During telophase the cell puts out numerous pseudopodia at the pole regions, constricts thru the equatorial plane, and divides. The nuclear membranes and nucleoli become visible as the daughter cells separate.



10. Swarm cell 4000X

The swarm cell (Fig. 10) has one or two flagella. It swims in a rotating spiral with the long flagellum directed anteriorly. When a swarm cell comes into contact with a surface it usually crawls over that surface with the flagellum moving back and forth like an antenna. This crawling movement is the result of surface undulations and fine pseudopodia which may be mistaken for additional flagella. Both swarm cells and Myxamebae feed by engulfing particles. They may also take in nutrients in solution. Both types of cells are haploid. Fusion may occur between two swarm cells or between two myxamebae. Fusion consists of two stages: plasmogamy, or the fusion of protoplasts, and karyogamy, or the fusion of nuclei. Karyogamy restores the diploid number of chromosomes.

11, 12. Plasmogamy

1200X

Although the three films were designed to be used as a series they may be used independently. Each film has a different approach. Their use depends entirely upon the situation at hand. All of the films present information about a group of organisms which are usually overlooked. The viewer cannot be expected to assimilate all of the material presented and certainly should not be held responsible for it. The main purpose of these films is not to "stuff facts", but to introduce the viewer to the fascinating world of slime molds, stimulate student investigation and research, present certain biological principles, and help students form desirable attitudes toward scientists and the ways in which they work.

The effectiveness of these films depends in part on how they are used. If the students are not prepared before viewing the films, or if they are told they will be tested over the films, they will probably be overwhelmed by new words, facts, etc.

The teacher should stress the areas which he feels are the most important. One example might be the use of a key. Film III: IDENTIFICATION, might be shown. Before seeing the film, the class might be given a problem of identifying some unknown specimens of different organisms, including a few slime molds. The problem of terminology and scientific names is certain to arise. The teacher might point out that some of the specimens are slime molds and have the students find information about them before seeing the film. Following a presentation of the film, the class should consider

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TURTOX SERVICE

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B61V13 - B61V13S

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Instructions For Culturing Physarum Polycephalum

FROM DRIED SCLEROTIUM (61V13S): The minute amount of orange-colored incrustations on the slips of filter paper (or the free fragments in the vial) represents a more than ample quantity of sclerotium to start several cultures of Physarum polycephalum. Store unused portions of sclerotium in the original container under refrigeration. To secure the active plasmodium, prepare a culture chamber by placing a dish that will serve as a small platform (petri dish, saucer, etc.) in an inverted position on the floor of a larger, covered container (casserole, opposing Pyrex pie plates, etc.). Cover the bottom of the dish and platform with a sheet of filter paper or paper toweling and wet the paper thoroughly with distilled water (AVOID CHLORINATED TAP WATER), pouring off the excess.

Place one of the dry fragments (keeping the other in reserve) on the platform, and wet the sclerotium with a drop of water (for a more rapid transformation, crumble the sclerotium). The plasmodium will have emerged and begun to seek food within 4 hours at room temperature, but allow it to roam about for several hours more before placing a flake of uncooked, rolled oats ("Old Fashioned," not the "Quick" variety) in contact with the spreading growth. Cover the dish and keep at room temperature in an area that does not receive direct sunlight. As the plasmodium increases in size, place more individual oat flakes along the growth front and cover each flake with a drop of water.

Plasmodia exhibit different degrees of vitality and should be fed and watered accordingly. If a plasmodium is sluggish and tends to remain in one spot, cut down moisture and food until activity has been restored. On the other hand, a repidly-moving plasmodium will accept a larger number of oat flakes and increase more quickly in volume; but, even then, the feeding organism will show a decided preference for fresh oat flakes and abandon only partially consumed flakes.

The appearance of adventitious molds is usually an indication that the plasmodium has been pampered. Since molds also constitute a natural food for Physarum, it is only necessary to remove excess food and reduce moisture for a day to have Physarum focus its attention on them. The simplest way to reduce moisture quickly if the filter paper happens to be sopping wet, is to superimpose it over a dry sheet for as long as it takes to clean and dry the culture chamber. Afterward, normal moisture may be restored and judicious feeding resumed.

Occupied oat flakes (these appear yellowish in color) or sections of paper bearing plasmodium from the original culture may be transferred to clean sheets of paper to keep the culture going for longer periods of time. FOR OBSERVATION OF PROTOPLASMIC STREAMING, transfer occupied oat flakes to petri dish cultures of non-sterile, non-

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nutrient 1.5% agar. The agar culture is maintained in the same way as the paper culture -- except for the addition of water.

If the culture is started on agar, add a drop of distilled water to the dry sclerotium and, for greater vigor, allow the plasmodium to develop and range about until the following day before adding oat flakes.

Wash and dry the culture chamber between transfers. A neglected culture will sometimes transform spontaneously into the sporangial stage.

FROM PLASMODIAL AGAR CULTURES (61V13): Set up a culture chamber like that indicated above. Remove a portion of plasmodium from the agar slant (or a flake of oats bearing plasmodium) and place it on the paper in the center of the platform. Wait for the plasmodium to become really active before adding a few oat flakes to the edge of the plasmodium.

Note: Physarum cultures supplied by us are pure only in the sense that THERE ARE NO OTHER SLIME MOLDS PRESENT. However, Physarum lives on bacteria and molds. When an agar culture of Physarum occasionally allows mold to develop, it usually means that the plasmodium has become sluggish while in transit and lost appetite for one of its natural food forms. Restoration to normal activity is accomplished in a filter paper culture by the method suggested above.

We recommend use of the sclerotial form of Physarum rather than the more costly plasmodial agar culture, but for those interested in purchasing and maintaining transfers of the latter on agar, proceed as follows: Make up 1.5% agar (non-nutrient), dispense into test tubes, plug with cotton, sterilize and slant. Seal the tubes that will be stored with sterile, paraffin-dipped corks (after pushing the cotton a sufficient distance into the tube) or with sterile rubber stoppers. Just prior to making the transfer, add three non-sterile oat flakes to each tube. Sterilization of the agar is necessary only if the unused slants are to be stored for some time.

Test tube cultures should be transferred weekly if kept at room temperature or every three months if they are stored in the refrigerator after growth has been established.

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Turtox News

JANUARY, 1953 • volume 31 • number 1

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STEMONITIS
(See page 6.)

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Turtox News

April 1951 • volume 29 • number 4

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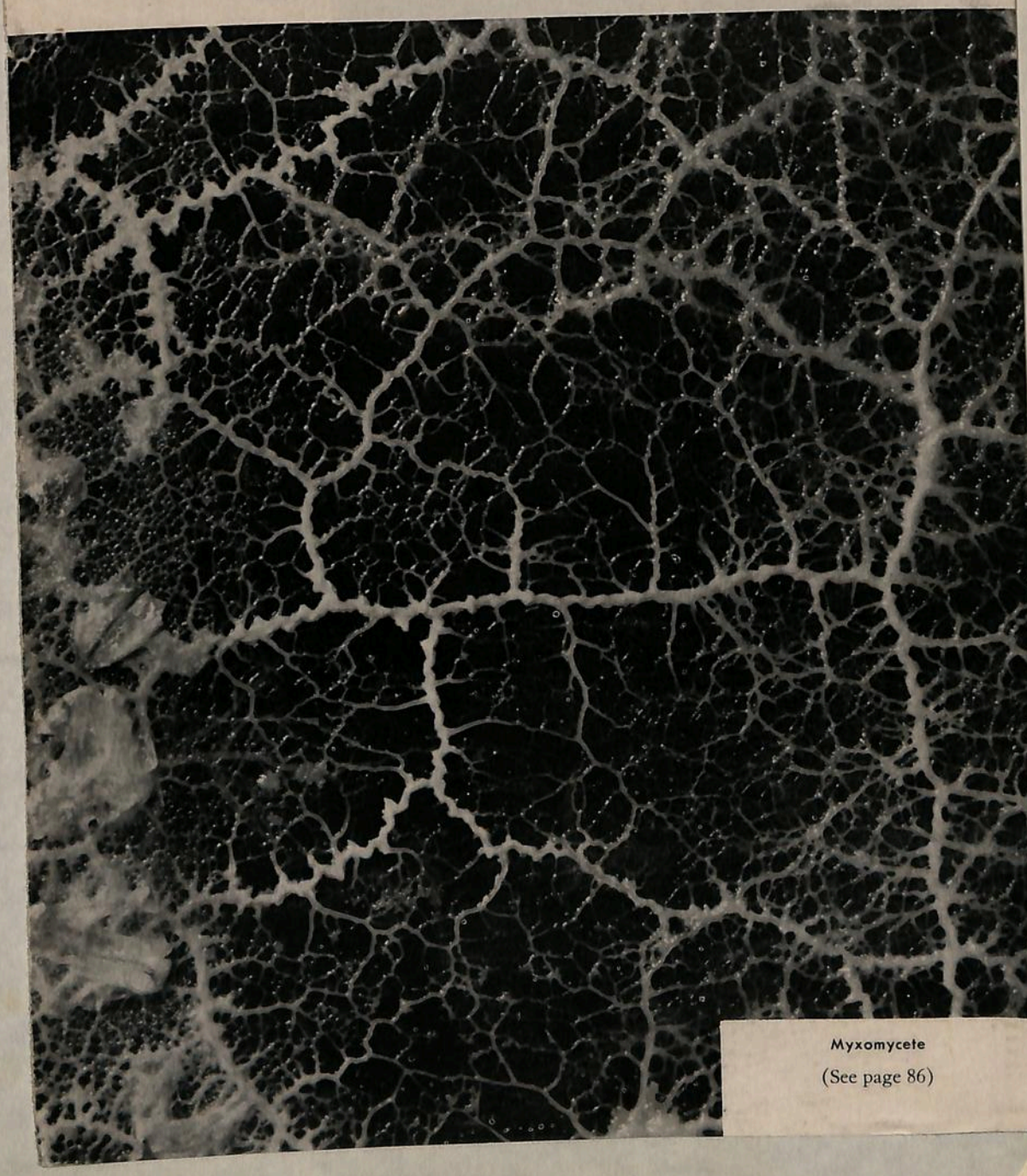

Myxomycete

(See page 86)

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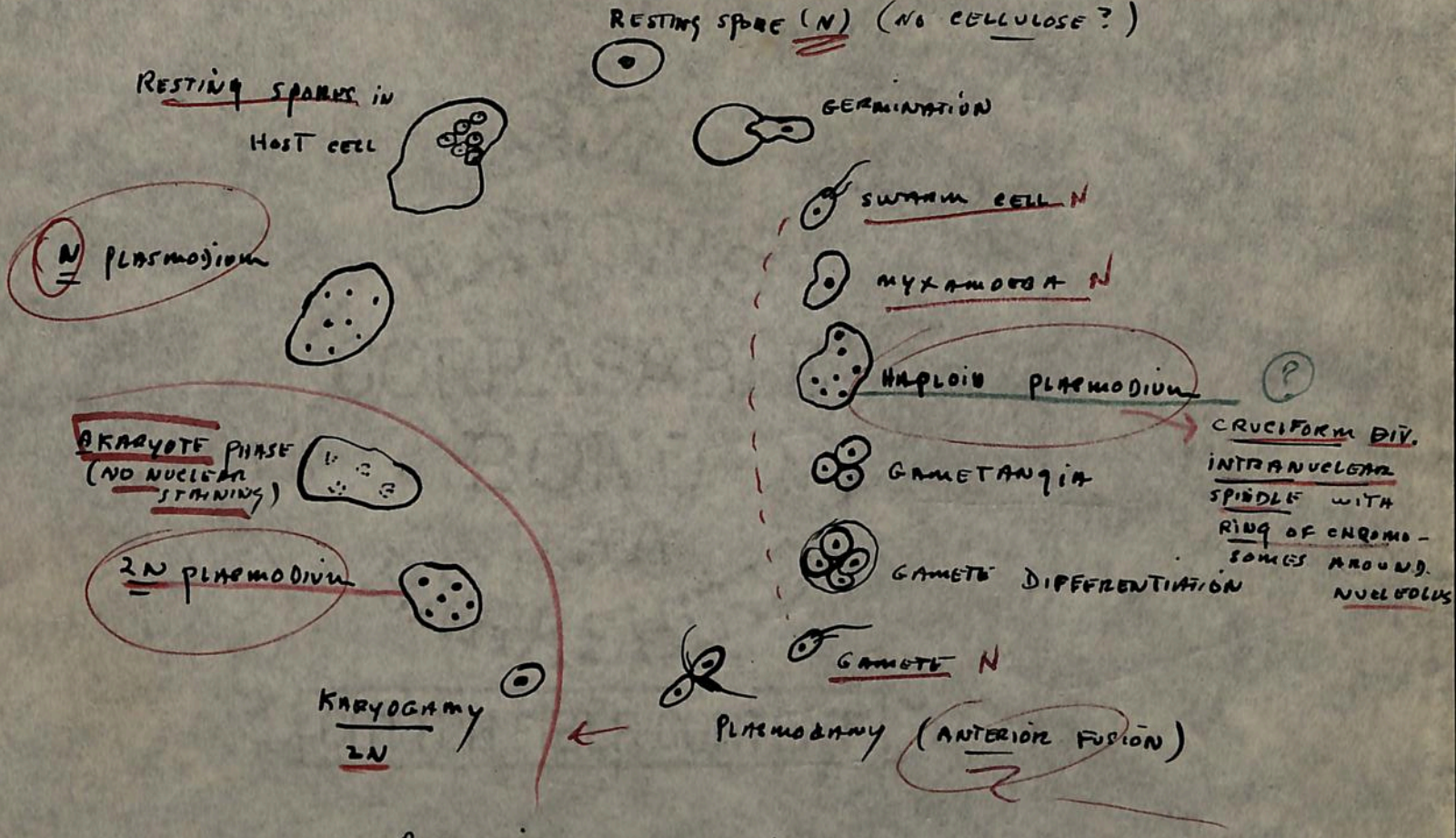
PLASMODIOPHOROMYCETES (SPARROW 1959)



PLASMODIOPHORA BRASSICAE

DIFFERENCES BET. PLASMODIOPHORALES & MYXOS:

1	PARASITIC (INTRAC.)	SAPROBIC - FREE LIVING
2	ANT. FUSION ZOOSPORES	POST. FUSION
3	N & 2N PLASMODIA	2N PLASMODIA ONLY
4	NO SPORANGIAL BODY	+

SIMILARITIES

1. HETEROKONT ZOOSPORES
2. PLASMODIUM & MULTINUCLEATE

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Phycos cont'd. (deBary)

Phylogeny: Phycomycetes means algal fungi; from certain morphological resemblance of these fungi to certain green algae.

2 views:

1) funus groups evolved from various algae through loss of chlorophyll and assuming parasitic or saprobic (saprophytic) life; therefore no separation made between algae and fungi, but latter included within the algal group from which it was supposed to have descended. (Pringsheim 1858) (Cohn 1872, Sachs 1874)

Polyphyletic (including origin from Red algae)

2). algae and fungi arose as separate groups and have developed along more or less parallel lines; algae arose from unicellular chlorophyllous forms, fungi from achlorophyllous unicellular ones. ie from Protozoa, and constitute a separate phylum. (MYCOPHYTA) (deBary 1881. GWM)

(or PROTOZOA-LIKE ANCESTORS)

I MYXOMYCOTA

II EUMYCOTA
EUMYCOTINA

Taxonomy of Martin to be followed in this course.

2 series of Oomycetes: Uniflagellate zoospores produced in foll.

CHYTRIDIOMYCETES

Orders: Chytridiales (300 SPP) Blastocladiales (90 SPP) Monoblepharidales (10 SPP) Hyphochytriales } ANTERIORLY 1 FLAG. (TINSEL) POSTERIORLY UNI-FLAGELLATE.

- Isogamy
- Anisogamy
- Oogamy

{BLASTO = A SHOOT CLAD = BRANCH Cellulose + / - → SEXUAL??

Eccrinales

Bi-flagellate: Plasmodiophorales (15 SPP) (zoospores heterokont; as in Myxos)

OOMYCETES

Saprolegniales (90 SPP)

Leptomitales .. zoospores isokont

Lagenidiales

Peronosporales (50 SPP.)

{LEPTO = THIN MITUS = THREAD ENGLEHART BLACK

20 SPP. → MINDENIELLA ARAIOSPORA

(235 SPP.) PHYTOPHTHORA PYTHIUM ALBUGINACEAE ALBUGO

OBLIGATE PAR.

CHYTRIDIALES

SUB-CLASS 2

ZYGOMYCETES
MUCORALES (250 SPP)
ENTOMOPHTHORALES (100 SPP)
ZOOPHAGALES (CONIDIA NOT EXPLODED)

Structurally the simplest fungi; Mycelium lacking or rudimentary; (Rhizomycelium)

Many parasites of algae, fungi or higher plants;

Cellulose in cell wall; zoospores with large oil drop, POSTERIORLY UNI-FLAGELLATE.

Holocarpic or Eucarpic

ENTIRE THALLUS → FRUITING BODY

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HETEROTHALLISM

BLAKESLEE. 1902 — + (♀) + (♂) "STRAINS"
RHIZOPUS STOL.

BENSAUDE. 1908. } BASIDIOS
KNIEP — 1920. }

EDGERTON. 1912 — GLOM.

COUCH — 1926. [SAPROLEGNIACEAE]

SHEAR & DODGE. 1927. NEUROSPORA

CRAGIE. 1927 — UREDINALES [BULLER]

WINGE & LAUSTSEN. 1939 — } ENTS
HARDER & SÖRGEL. BLASTOCLADIALES. 1938
DEE (1960) COLLINS (1961) — MYXOS.

2 TYPES OF INCOMPATIBILITY in Fungi.

1) HOMOGENIC: SEXUAL INTERACTION PREVENTED BY LIKE ALLELES.

2) HETEROGENIC: SEXUAL INTERACTION PREVENTED BY UNLIKE ALLELES.

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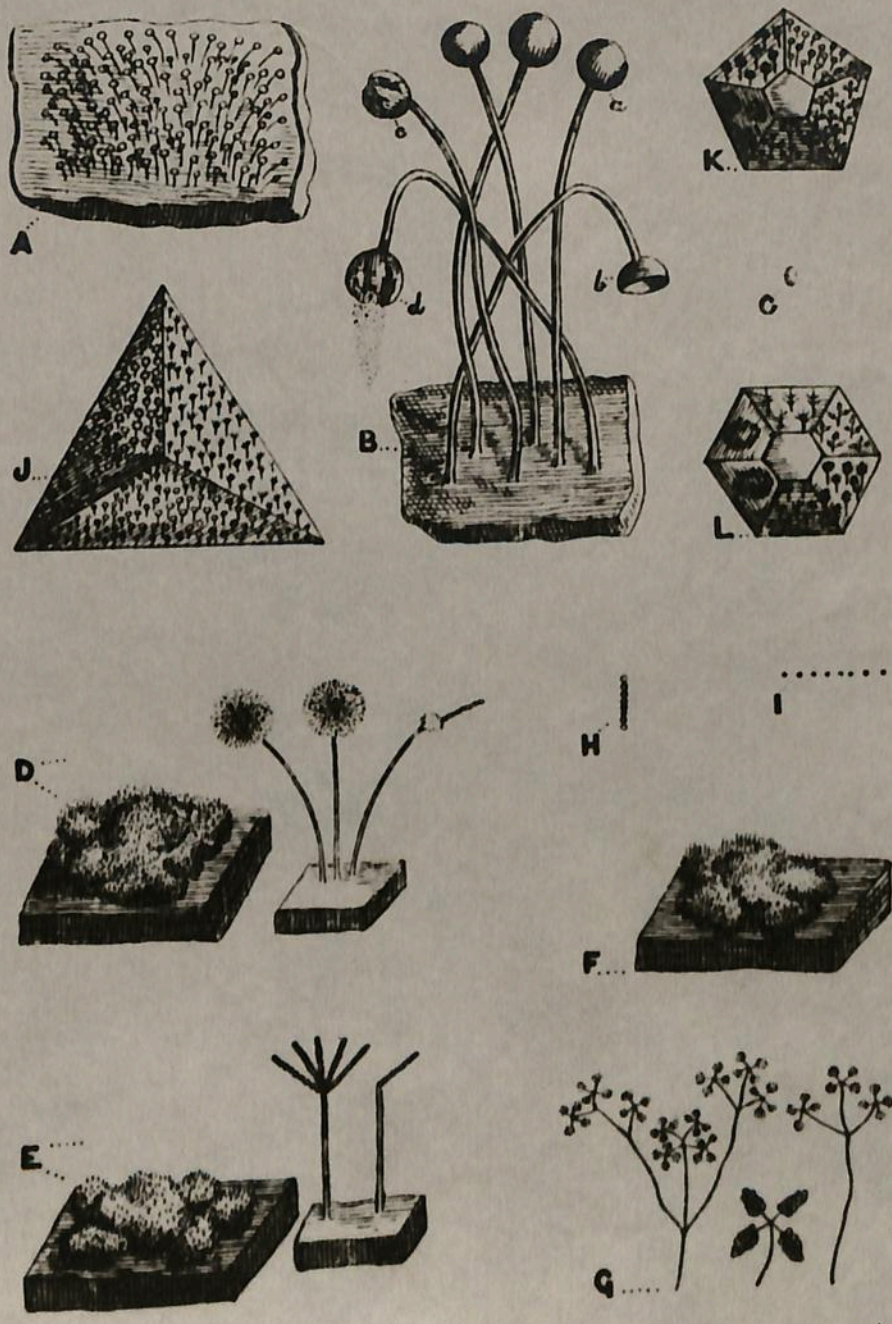

P.A.Micheli Nova Plantarum Genera 1729.

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1960. 2ND ED. REV. (1187 PP.)

See: Sparrow, F.K. Aquatic Phycomycetes. 1943. (Excluding Saprolegniaceae & Pythium
Coker, W.C. Saprolegniaceae. 1923.
Fitzpatrick, H.M. The Lower Fungi. 1930.
JOHNSON, T.W. THE GENUS ACHLYA. Phycomycetes 1956. 180 PP.
HESSELTINE, C.W. 1955. GENERA OF MUCORALES. MYCOLOGIA 47(3): 344-363.
SCOTT, W.W. A MONOGRAPH OF THE GENUS APHANOMYCES. 1961. 95 PP.

Typically tubular coenocytes; older mycelium may become septate; septa also present separating reproductive organs from "vegatative" assimilative mycelium. PLASMODESMATA

(CHYTRIDIOMYCETES) 1) Two large classes: Oomycetes & Zygomycetes.

Oomycetes characterized by producing oospores in sexual reproduction; asexual spores frequently motile zoospores; as in all aquatic phycos; gametangia are unlike (antheridium, oogonium)

2) Zygomycetes produce zygospores sexually; asexual spores are (never motile, but produced in sporangia or on conidiophores; gametangia alike. (gametangia unite, contiguous walls are absorbed, protoplasts unite and zygospore produced.)

Sexual reproduction in Oomycetes:

Antheridium & Oogonium easily distinguished: Oogonium, when mature contains variable number of Oospheres. Fertilization occurs by Antheridium coming into contact with Oogonium, contiguous walls absorbed, male gamete (aplanogamete ie non-motile) enters oosphere which is then known as an Oospore (2N). This is the usual process in such forms as: Achlya, Saprolegnia, Dictyuchus, Pythium, Pythiogeton etc. BUT in Monoblepharidaceae, male gamete is uni-~~ciliate~~ flagellate (produced in small multi-nucleate gametangium); female gametangium is uninucleate & produces a single egg, larger than male gamete. (ie in Monoblepharis & Allomyces)

GONOTODYA

Sexual reproduction in Zygomycetes:

Ends of hyphae come in contact (plus and minus straind of Blakeslee); enlargement occurs at contact point, these being forerunners of the gametangia ie Progametangia; Swelling continues & septa cut of progametangia from rest of hypha; these structures

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See: Biol. Rev. 24: 411-447. 1949. Heterothallism & Sex in Fungi.

Incompatibility in Fungi: Symposium (1968) K. Esser & J.R. Raper. 1965. 124 pp. Springer Verl.

Blakeslee, A.F. 1904. Proc. Amer. Acad. Arts & Sci. 40: 203-320.

Sexual Reproduction in the Mucorineae.

General Summary:

1) Based upon method of zygospore formation, HOMOTHALLIC & HETEROTHALLIC species differentiated.

2) In Homothallic sp.: zygospores obtained from single spore cultures. Minority of sp. in this group.

3) In heterothallic sp : (the majority), two distinct mycelial strains necessary to produce zygospores; never from a single spore.

4) Differentiation in vegatative luxuriance between the strains; more luxuriant termed plus, less, minus.

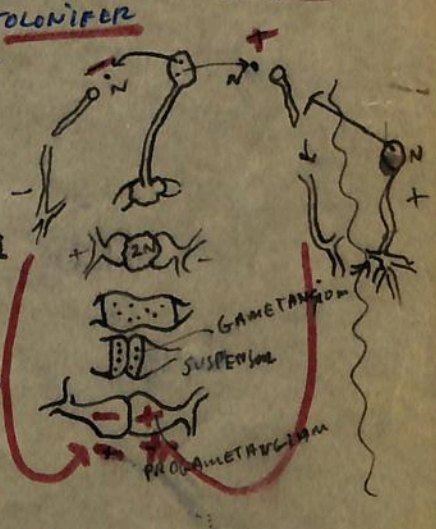
5) Progametangia (called progametes by B.) arise from stimulus of contact between physiologically differentiated hyphae (called zygophores).

6) Zygospore formation is a sexual process. (TETRIPOTENT) (SELF FERTILE)
Mycelium of homothallic sp. is bisexual (monoecious .. hermaphrod).
" heterothallic " sp. " unisexual (dioecious). (SELF STERILE)

Some heterothallic species:
Rhizopus nigricans = STOLONIFER
Mucor mucedo hiemalis
Phycomyces nitens
Absidia caerulea
Mucor sp.

Some homothallic species:
Sporodinia grandis
Zygorrhynchus Moelleri
Mucor sp. hiemalis

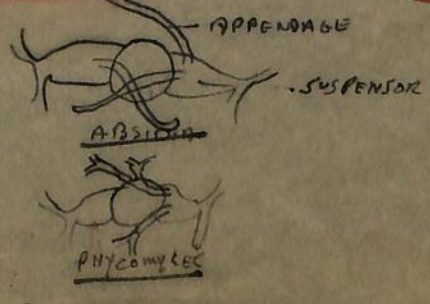
Blakeslea Cunninghamella Syncephalastrum racemosum Piptocephalis Thamnidium



High humidity encourages zygospore formation.

Single spore cultures → zygospores

HETEROKARYOSIS = "FUNGAL MONOPOLY"



INCOMPATIBILITY FACTORS

1 locus, 2 alleles (multiple)

in genetic determination of mating types in absence of morphological differentiation

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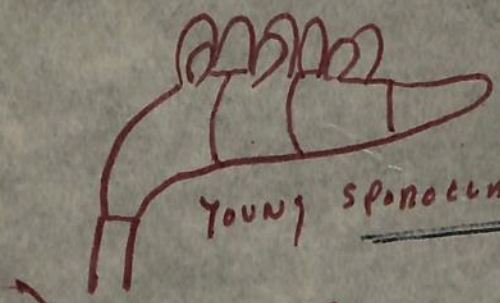
PRIMITIVE: MYCELIUM NON-SEPTATE AT FIRST.
SPORANGIA LARGE, ∝ SPORED, COLUMELLATE.
ZYGOSPORES THICK-WALLED, ROUGH, PIGMENTED.
ON AERIAL HYPHAE

ADVANCED: MYCELIUM SEPTATE AT FIRST.
SPORANGIA FEW-SPORED
ZYGOSPORES THIN-WALLED, HYALINE, SMOOTH
± ON SUBSTRATE

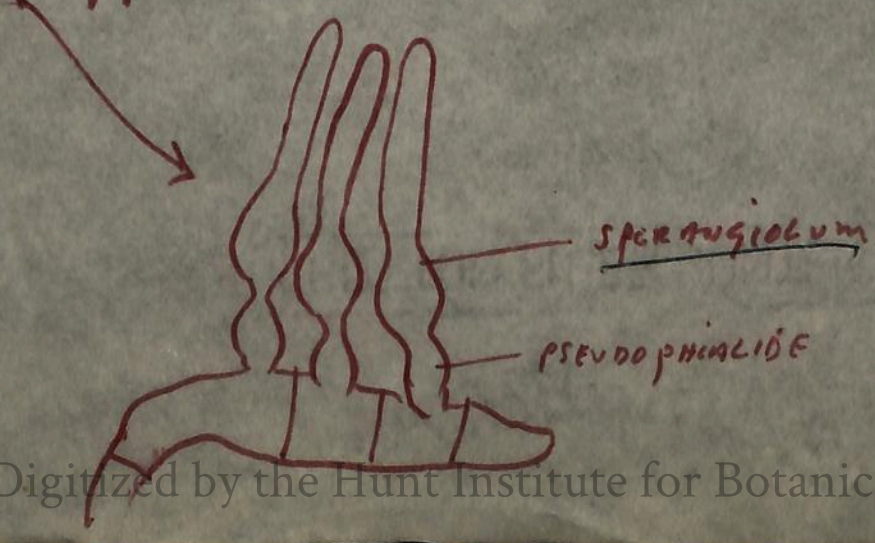
BENJAMIN R.K. 1959. THE MEROSPORANGIFEROUS MUCORALES. ALISO 4(2): 321-433.

KICKXELLACEAE

∝ SAPROBIC, COPROPHILIC



YOUNG SPOROCLADIUM OF MARTENSIOMYCES



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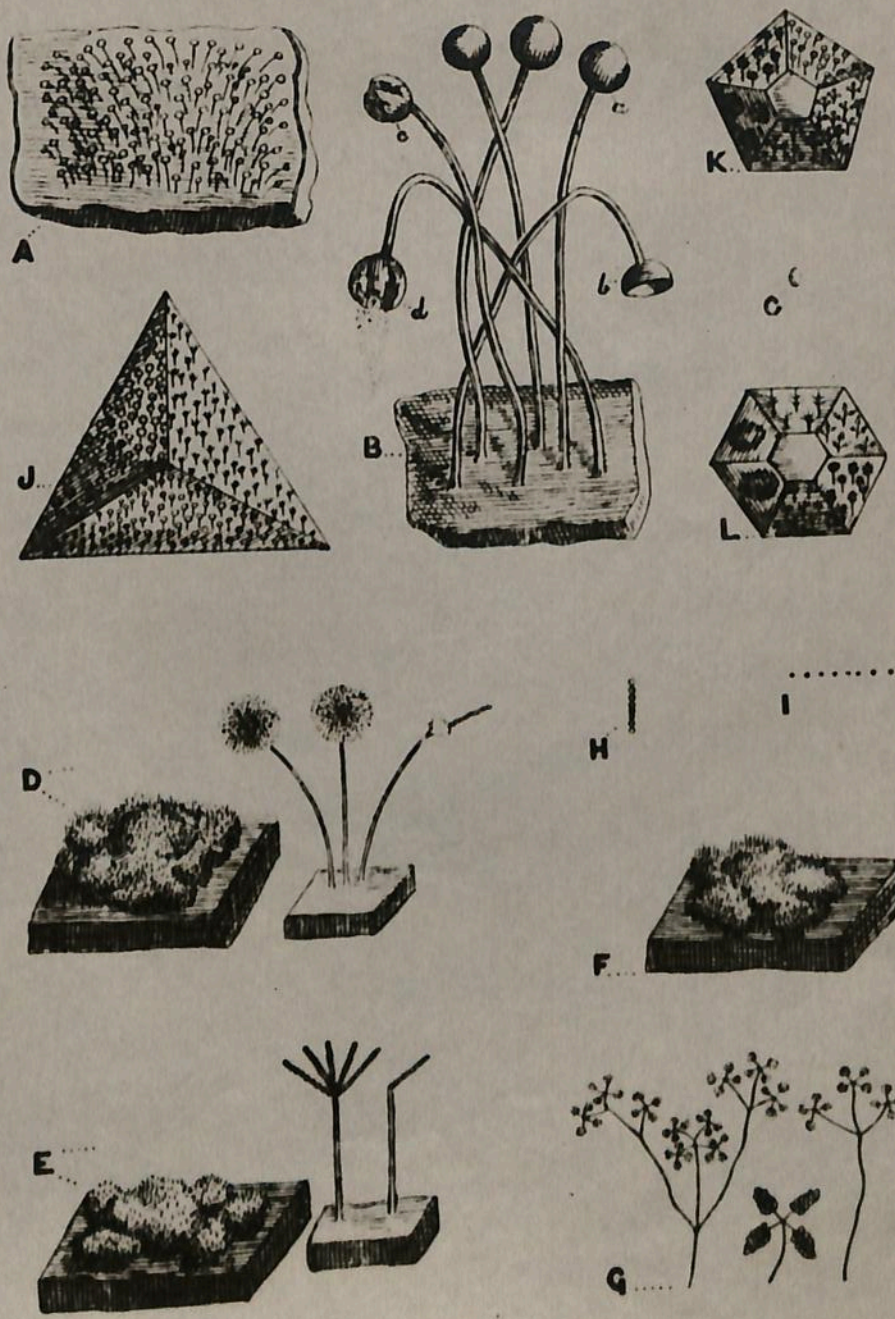

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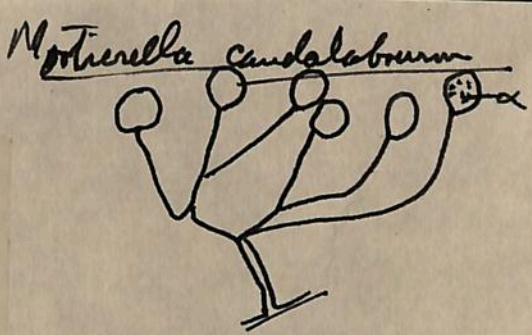
Mucor
Rhizopus
Pilobolus
Thamnidium
Syzygites
(SPORANGIA
Blakeslea
Sporobolus
Syncephalis
(Sporangiophore not branched)
Piptocephalis
Blakeslea
(Choanephora)
Cunninghamella
Their wall
carbonized
ves.
ENDO-
SPORE
Mero-
sporangia
not divided
V.
V.
V.
no vesicle
acid



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Mucor: Sporangiophores arise singly, not fascicles. (no rhizoids)

Mucoraceae:

Circinate appendages

Absidia: Zygospore:

Sporangia pyriform

Sporangia + Pyriform. 4 Absidia

~~No Rhizoids~~ rhizoids

Sporangiophores arise at internodes.

Rhizopus: on stolons, opposite rhizoids

Sporangia as in Mucor.

Zygorhynchus: Unequal gametangia all homothallic

suspensor

* Sporodinia = SYZYGITES = Dichotomous branching

sporangiophores

SPOROCLADIUM

Thamnidium: terminal 1-spored sporangium + columella

few-spored sporangiolum no columella

sporangium

COEMANSIA

Phycomyces: appendages branched:

sporangiophore over 80 mm. high. (long)

metallic luster.

Blakeslea: Sporangiola:

close to Choanephora (without sporangiola)

Sporangiolum:

3 spores

2-6 spores

EXOGENOUS

Cunninghamella: Spore, VESICLE

Piptocephalis

Syncephalastrum (ENDOGENOUS)

merosporangia few spores

Lichtheimia: ~~entire~~ Umbrella entire sporangium discharged.

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MUCORALES

1) Coenocytic at first → septate.
2) aerial mycelium prominent.
3) asexual sporangiospores — always non-motile
4) conidia (when present) on swellings on conidiophores; never catenate
5) zygospores from = or ± ≠ gametangia
6) terrestrial — ± saprobic

I Mucoraceae — Sporangial wall membranous, thin, fugaceous; spores liberated by wall breaking; zygospores rough, suspensors usually not long-tube.

II Pilobolaceae — Sporangial wall heavily cutinized above; violently discharged; zygospores smooth; suspensors long-tube.

III Thamnidiaceae — Terminal columellate & sympodial sporangia; sporangiola or none sporangiophore

IV Piptocephalidaceae — Merosporangia on swollen vesicle, cylindrical; few spores in columns

V Kickxellaceae — Conidia on phialides borne on sporodochia; no sporangia.

VI Cunninghamellaceae — Conidia only; zygospores as in Mucor no sporangia? (ex others)

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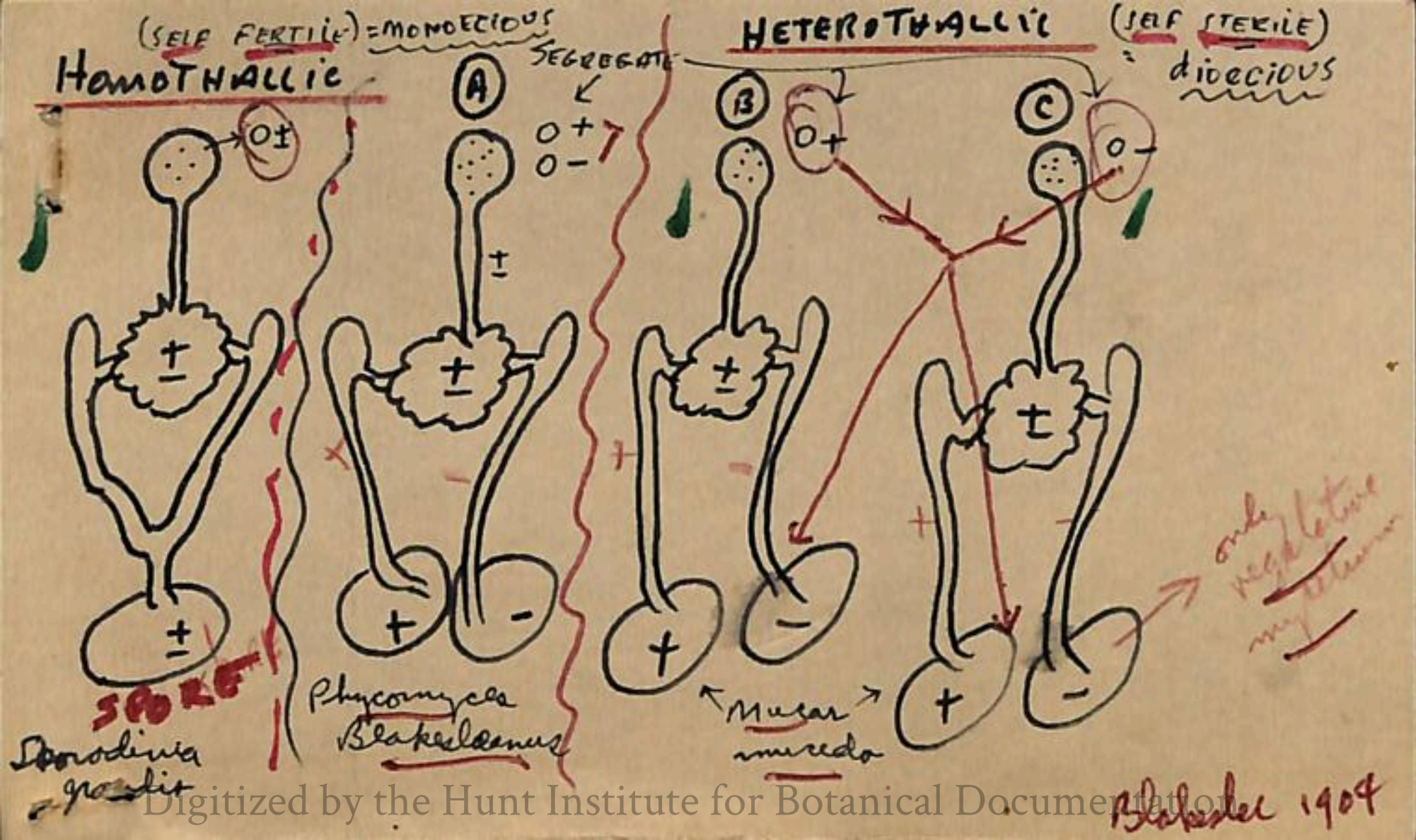

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are now the Gametangia. These fuse, the resulting cell, becoming thick-walled and rounded; ie the Zygospore. Old gametangium wall may develop characteristic processes (Absidia etc.)

Asexual spores are non-motile, produced in globose Sporangia borne on aerial hyphae, the Sporangiophores..

HETEROTHALLISM: (Blakeslee, A.F. 1904. Sexual reproduction in the Mucorineae. Proc. Amer. Arts & Sci. 40: 205-319.
also: Sci. 51: 375-382, 403-409. 1920.

Some (Mucorales) phycos never known to produce zygospores, others did; Blakeslee, working with Mucor, showed there were two kinds of spores produced in sporangia; these gave rise to differently reacting mycelium (plus & minus) each strain, alone, (in heterothallic forms) incapable of producing zygospores, but giving rise to them when both strains "mixed". ie single spore cultures of heterothallic species never produced zygospores; but homothallic species did.

This phenomenon not limited to Mucorales, but also known in Ascos and Basidios.

General remarks: Oomycetes - zygomycetes:

Oomycetes show cellulose reaction; zygos have fungus chitin, also Ascos & Basidios.

Fruiting bodies of Phycos usually quite inconspicuous; but mycelium extensive.

NOTE: HETEROTHALLISM in ASCOS FIRST VERIFIED BY B.O. DODGE - NEUROSPORA 1920.
BOT: C.G. EDGERTON - GLOMERELLA - 1918
.. .. BASIDIOS .. .. BENSAUDE. 1918.
.. .. Basidios .. .. STARR - 1954 (Amer. J. Bot. 41(8): 601.

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The key to the known genera of the family presented in an earlier paper (Benjamin, 1959: p. 399) may be revised as follows:

A. Sporocladia globoid, nonseptate ..... *Linderina*
AA. Sporocladia elongate, usually attenuated distally, septate ..... B.
B. Spores ellipsoidal, only slightly longer than broad; fertile region of the sporophore coiled ..... *Spirodactylon*
BB. Spores elongated, more than twice as long as broad; fertile region of the sporophore not coiled ..... C.
C. Sporocladia verticillate or umbellate ..... D.
CC. Sporocladia pleurogenous ..... E.
D. Sporocladia verticillate, formed simultaneously ..... *Kickxella*
DD. Sporocladia umbellate, formed successively ..... *Martensiomyces*
E. Sporocladia not formed acrogenously ..... *Dipsacomyces*
EE. Sporocladia formed acrogenously ..... F.
F. Sporangiola borne on the upper surfaces of the sporocladia ..... *Martensella*
FF. Sporangiola borne on the lower surfaces of the sporocladia ..... *Coemansia*

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A. *Primitive.*
1. Vegetative and fruiting hyphae generalized, initially nonseptate; simple imperforate septa formed to delimit reproductive structures or laid down adventitiously in aging hyphae.
2. Sporangia relatively large, multispored, columellate.
3. Progametangia opposed, highly differentiated morphologically; zygospores usually formed on aerial hyphae; zygosporangium thick-walled, rough, often highly pigmented.

B. *Intermediate.*
1. Vegetative and fruiting hyphae essentially as in A; perforate septa sometimes formed in fruiting structures.
2. Sporangiola containing relatively small numbers of spores; columellae absent or rudimentary.
3. Progametangia apposed, more or less differentiated; zygospores often as in A, sometimes formed in or at the surface of the substrate; zygosporangium sometimes thin-walled, hyaline, nearly smooth.

C. *Advanced.*
1. Vegetative and fruiting hyphae septate from the beginning; septa highly modified.
2. Sporangiola containing only one or two spores.
3. Sexual hyphae relatively undifferentiated; zygospores usually formed in or near the surface of the substrate; zygosporangium thin-walled, hyaline, nearly smooth.

PIPTOCEPHALIDACEAE Brefeld.

Botan. Untersuch. über Schimmelpilze I: 53. 1872.

Vegetative hyphae hyaline, delicate, branched nonseptate or septate; sporangiophores simple or branched, septate or nonseptate, bearing merosporangia on terminal deciduous or nondeciduous enlargements; sporangiospores usually uniseriate; merosporangial wall evanescent at maturity or persistent and separating along with the spores by circumscissile rupture; zygospores formed from the union of gametangia produced terminally by apposed or coiled progametangia; species typically obligate parasites of other fungi—mostly other Mucorales.

Type genus: *Piptocephalis* de Bary (1865, p. 356).

A KEY TO THE GENERA

A. Sporangiophores branched; merosporangiferous vesicles usually deciduous ..... *Piptocephalis* (p. 334)
AA. Sporangiophores not branched; merosporangiferous vesicles not deciduous ..... *Syncephalis* (p. 352)

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what the fertile heads of *Spinalia*. However, merosporangial development in *Linderina* is exactly like that in the other genera of the family. Morphologically and cytologically, early stages of merosporangial formation in the Dimargaritaceae are very similar to those encountered in the development of the unisporous sporangiola and pseudophialides in the Kickxellaceae, and the writer believes that the sporangiola and pseudophialides of the latter family have evolved directly from a bisporous merosporangium like that found at present in *Piptocephalis lepidula* and most members of the Dimargaritaceae. Thus the sterile, nondeciduous pseudophialide in the Kickxellaceae is thought to be derived from the fertile, deciduous, basal portion of a presumably more primitive merosporangium of the type found in the above forms. Linder (1943) suggested that the sporocladium of members of the Kickxellaceae has evolved from fertile heads of fungi like those characterizing certain species of *Syncephalis*. The writer believes, however, that the genus *Syncephalis*, with its unique type merosporangium, represents an isolated group within the merosporangiferous Mucorales that, along with *Piptocephalis*, diverged from the line of evolution leading to the Dimargaritaceae and Kickxellaceae. Spore germination in the Kickxellaceae and Dimargaritaceae is lateral—reflecting a type of spore formation more nearly like that in the genus *Piptocephalis*. Acropetal development of the merosporangium has been evolved in *Piptocephalis* and is characteristic of all known species of Dimargaritaceae except *Dimargaris bacillispora*, where the merosporangium develops as in most species of *Piptocephalis*. The writer, however, believes that the latter genus represents a separate phyletic line within modern groups of merosporangiferous forms, but that the characteristics of the Dimargaritaceae and Kickxellaceae reflect closer affinity of the members of these families to the genus *Piptocephalis* than to *Syncephalis*.

In the diagram presented in Plate 34, the areas, A, B, and C, bounded by dotted lines, are intended to represent levels of advancement of morphological characters which may be summarized, in general, as follows:

A. *Primitive.*
   1. Vegetative and fruiting hyphae generalized, initially nonseptate; simple imperforate septa formed to delimit reproductive structures or laid down adventitiously in aging hyphae.
   2. Sporangia relatively large, multispored, columellate.
   3. Progametangia opposed, highly differentiated morphologically; zygospores usually formed on aerial hyphae; zygosporangium thick-walled, rough, often highly pigmented.

B. *Intermediate.*
   1. Vegetative and fruiting hyphae essentially as in A; perforate septa sometimes formed in fruiting structures.
   2. Sporangiola containing relatively small numbers of spores; columellae absent or rudimentary.
   3. Progametangia apposed, more or less differentiated; zygospores often as in A, sometimes formed in or at the surface of the substrate; zygosporangium sometimes thin-walled, hyaline, nearly smooth.

C. *Advanced.*
   1. Vegetative and fruiting hyphae septate from the beginning; septa highly modified.
   2. Sporangiola containing only one or two spores.
   3. Sexual hyphae relatively undifferentiated; zygospores usually formed in or near the surface of the substrate; zygosporangium thin-walled, hyaline, nearly smooth.

Because the rate of evolution of given morphological characters has varied greatly in the different families or even in various representatives of a given family, this scheme is intended only to indicate the range of primitiveness or advancement ex-

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Pythium: swarmspores discharged from sporangium in immature condition, into thin-walled vesicle which later breaks, releasing mature zoospores.

Phytophthora: swarmspores discharged fully formed into vesicle. IRISH POTATO FAMINE

P. infestans.

ZYGOMYCETES: 2 Orders: Mucorales, Entomophthorales. mostly Parasitic: Conidiobolus (on Tremellales) Basidiobolus Entomophthora

Mucorales: walls of gametangia modified to form part of zygospore in sexual reproduction.

Asexual reprod. typically by sporangiospores.

Contrast method of spore formation in Ascos (Free cell formation). ie here, an indefinite number of spores asexually produced.

A transition in this group from endogenous to exogenous spores; zb from Mucor & Rhizopus to Blakeskea[1] & Cunninghamella (sporangiola).

PLUS & MINUS STRAINS (BLAKESLEE).

Upon germinaton of a zygospore, usually a single GERM SPORANGIUM is formed. The physiological condition of the nuclei differ according to the species:

a) All spores may develop HOMOTHALLIC MYCELIA; (Sporodinia grandis
b) All spores may be EITHER PLUS or MINUS. (Mucor mucedo)
c. Spores are BOTH plus & minus. (Phycomyces nitens).

Question as to WHEN NUCLEAR FUSION occurs still debatable.

In Homothallic strains, gametangia may differ in size, but not so in Heterothallic ones. (The larger gametangium considered the homologue of the Oogonium, the smaller, the antheridium.

LAGENIDIALES } ALL PARASITIC ON ALGAE

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Hesseltine, C.W. 1954. The section Genevensis of the Genus Mucor. Mycologia 46(3):358-366. (9 Sections of Mucor recognized)

Mycologia 47: 344-363. 1955
Genera of Mucorales

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Mucorales

APLANATE

Recall reproduction in Rhizopus. { Heterothallic vs Homothallic

Contrast free cell formation in Aecos
and
that formation in sporangia by cleavage

in Cleavage plane originate at columella,
grow in all directions
&
cut out uninucleate bits of protoplasm.
these invested with walls → spore.

Transition from Endogenous → Exogenous spores (higher forms)

{ Mucor, Rhizopus, Absidia, Phycomyces } { Blakeslea, Cunninghamella, Thamnidium } ?

6-7 Families recognized in Mucorales.

Character of Sporangium basis for separation:

is thin, no sporangia — Mucoraceae { Absidia — circinate appendages

Cuticized sporangia — Pilobolaceae

Merosporangia — Pilobolidaceae

No columella
No swollen tips → Mortierellaceae

etc.

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Morphogenesis in Myxos

I Spore germination

a) Breaking of spore wall → escape of protoplast : Physarales
b) Pore in spore wall → Stemonitales
c) Dissolution of spore wall → Ceratiomyxa

Speed of germination varies from a few minutes (Fuligo septica, Reticularia lycoperdon) to several weeks (Cribraria, Trichia spp.)

- Wetting spore essential — bile salts by Elliot;
- Enzymatic action ? Imbibition ? Mechanism doubtful.
- Age of spores (up to 61 yrs); pH, temp.

II Myxamoebae & Swarm Cells

1–4 liberated by spore (-8). Ceratiomyxa

Heterokont, anteriorly flagellated The rule.

Apogamy vs syngamy

Union of amoebal vs swarm cells : → karyogamy → meiosis

Evidence for syngamy : Heterothallism demonstrated in: Physarum group, P. flavicomum, Didymium iridis, Fuligo septica, Comatricha laxa

see Ross

Multiple fusion in syngamy ?? (in 3 or 7 cells)

DNA measurements of plasmodial nuclei in Didymium migripes = 2X
" " myxamoebae - " " = X

III Plasmodium formation

1) By mitotic ÷ of 2N nucleus, without fusion of the zygotes
2) By fusion of zygotes
   - Proto- (Echinostelium)
   - Aphano- (Stemonitales)
   - Phaneo- (Physarales)

Nutritional requirements?

Sclerotium formation : streaming stops (P. polycephalum)
= gelation
= macrocyst formation (up to 14 nuclei)
= shuttering of nuclei

Viable for ± 3 yrs. in P. polycephalum.
(10°C)

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IV | Spore formation

c) Light required for sporulation of segmented filaments. Why?? cytochrome oxidase?

Capillitium ??

(A) – Physarales: (deposition) excretion of $CaCO_3$ + into vesicular network, connected to invaginations of peridial wall.

Trichiales: deposition of material from cytoplasm, not walls.

Stemonitales: In Stemonitis 2 capillitial systems:
1) from sporangium wall
2) " columella

Spore formation

in Ceratiomyxa meiosis in spore during germination.

in endosporous spp.: some may be like Ceratiomyxa
: in most, meiosis in cytoplasm of sporangium.

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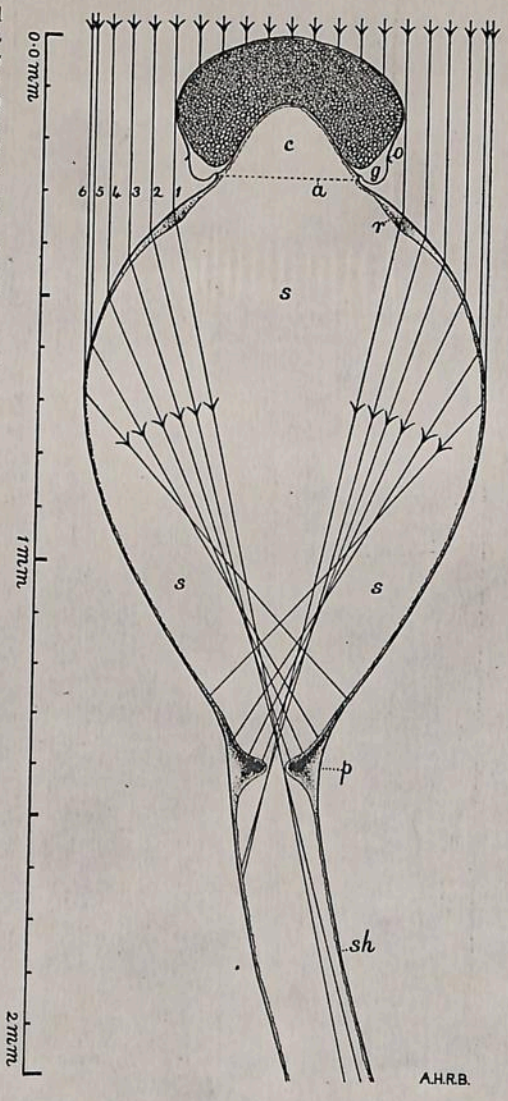

FIG. 46.—A median longitudinal section through the upper part of a fruit-body of *Pilobolus Kleinii*, just before the discharge of the projectile. The gun is shown directed toward the source of the brightest light, in which position it is, heliotropically (or photochemically), in a condition of physiological equilibrium.

The sporangium is filled with spores and covered with an outer intensely black wall *o* which is now broken below, thus allowing a thick gelatinous inner ring, *g*, which is only present around the base of the sporangium, to bulge outwards. The subsporangial swelling, which is pear-shaped, has a thin elastic wall lined by a layer of protoplasm which is very thin everywhere except at *r*, where it is slightly thickened, and at *p*, where it bulges inwards so as to form a large biconcave septum which is perforated in the centre. The protoplasm at *r* is reddish and at *p*, as indicated by the shading, very red, especially on its upper side where it receives the light rays. The subsporangial swelling is continued above into a conical columella *c*, and below into the upper part of the cylindrical stipe or shaft *sh*. The protoplasm of the stipe, swelling, and columella contains one large continuous vacuole filled with clear cell-sap. The broken line *a* passes through the plane of abscission and indicates where the Pilobolus projectile, consisting of the sporangium and the columella, separates from its attachment when the Pilobolus gun is discharged.

Twenty-one parallel rays of light are shown diagrammatically, by means of arrows, striking the fruit-body head-on in a direction parallel to the longitudinal axis of the subsporangial swelling. Nine of these rays strike the black cell-wall of the sporangium, which they cannot penetrate. The other twelve rays strike the upper surface of the subsporangial swelling and are there refracted through the wall into the interior of the swelling and, as shown by the arrows, converge upon the red perforated protoplasmic septum. The septum, like the retina of an ocellus, comes to be lit up with a spot of light, in consequence of which it gives out a red glow which in living fruit-bodies can be seen with the naked eye. *s*, *s*, *s* are parts of the subsporangial swelling which are not pierced by any direct rays of light and are therefore in the shade. Some of the light of all of the rays Nos. 1–6 is reflected at the surface of the wall of the subsporangial swelling; and, in passing in succession from ray No. 1 to No. 6, more and more light is reflected and less and less refracted. The size of every part is shown by the scale. Magnification, 69.

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BULLER, A.H.R. RESEARCHES ON FUNGI. V. 1934.

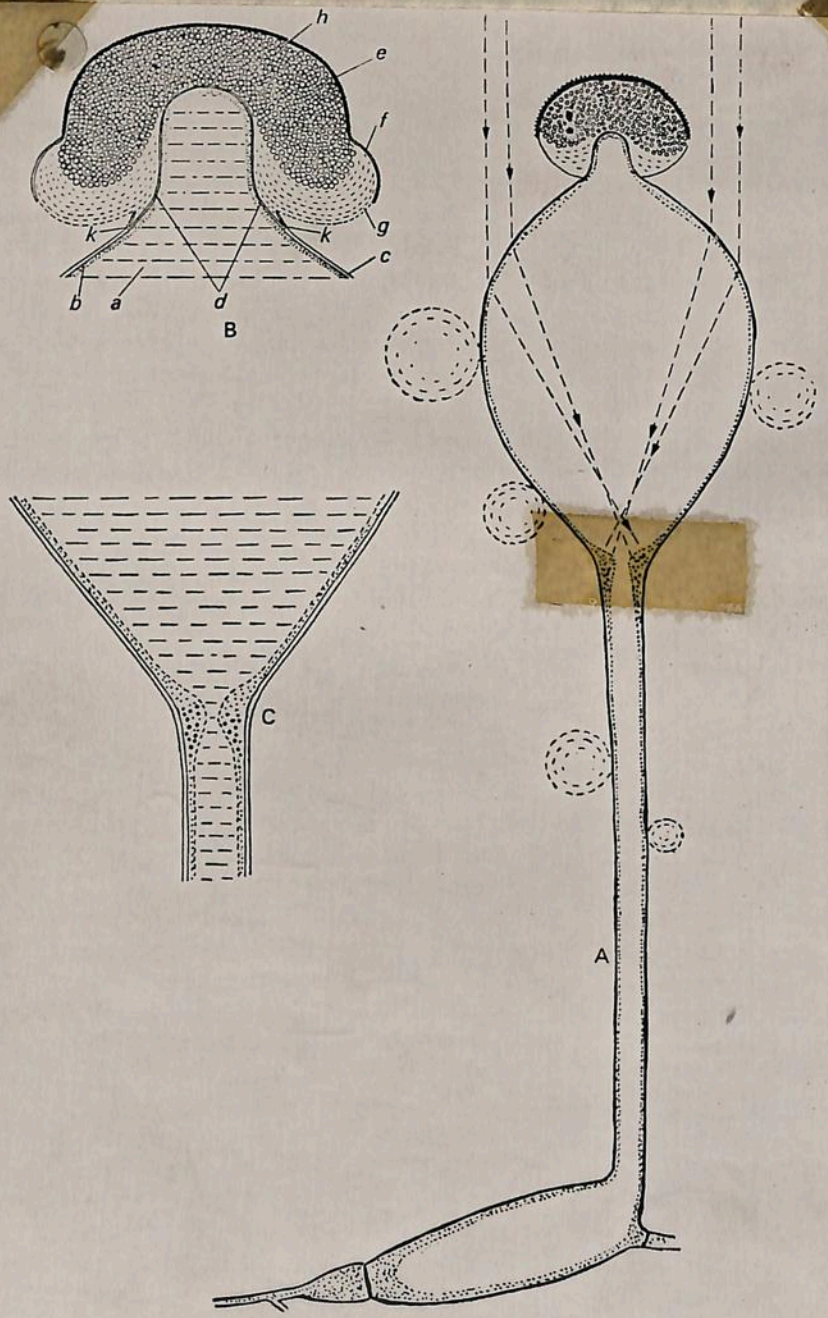

FIG. 3.9. *Pilobolus longipes*. (A) L.S. sporangiophore at a stage when the sporangium has not yet dehisced. Liquid droplets are exuded from the sporangiophore. Dotted lines show how incident light is focused on the 'retina'. (B) L.S. sporangium just before discharge: (*a*) sporangiophore sap; (*b*) layer of protoplasm; (*c*) sporangiophore wall; (*d*) columella; (*e*) opaque black sporangial wall; (*f*) semi-transparent part of wall; (*g*) mucilage; (*h*) spores; (*k*) region where sporangiophore ruptures. (C) base of subsporangial bulb, note thickened, carotene-rich protoplasm forming 'retina'.

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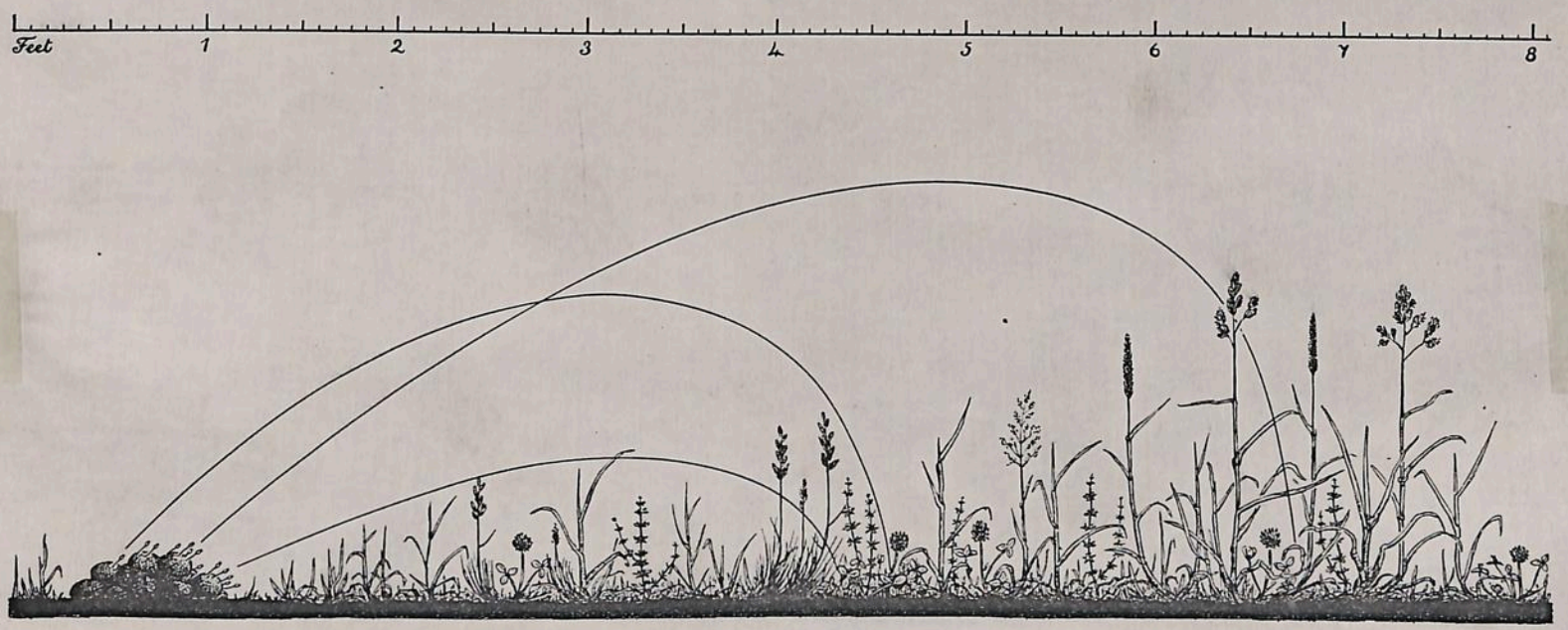

FIG. 79.—*Pilobolus longipes*. Diagrammatic representation of the discharge of sporangia in a meadow. To the left is a horse-dung plat, deposited about five days ago and now bearing fruit-bodies. It is noontide and the fruit-bodies are beginning to discharge their sporangia. The trajectories of three discharged sporangia are indicated. Owing to the resistance of the air, the sporangia, like spent bullets, have descended more steeply than they rose. As may be seen by reference to the scale of feet, the sporangium shot farthest travelled horizontally about six feet.

BULLER, A.H.R. RESEARCHES ON FUNGI VI. 1934.
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MUCORS

Speed of Realignment of Pilobolus

An interesting experiment with *Pilobolus* is to study the speed with which the phototropic spore-guns, aligned by light from one direction, can be realigned by illumination from a new direction. Under natural conditions of lighting, discharge is strictly periodic, beginning in the late forenoon and ending by early afternoon.

The arrangement shown in Figure 20 is suitable. An approximately cubical cardboard box (about 20-25 cm) is painted black inside to give a nonreflective surface. Two small square holes 2-3 cm across are cut in the lid, as far apart as possible, on either side of the central point, and covered on the inside by small glass sheets each about 10 cm^2. These are secured in position by adhesive tape. Thus two small windows are provided, either of which can be obscured at will. A duplicate lid similarly equipped should also be prepared.

A few dung balls that have been under natural conditions of illumination, with good crops of yellow developing sporangiophores, are placed in the evening in the box together with a few beakers of water to maintain humidity. Early next morning the sporangiophores are illuminated through one of the windows, the other remaining blacked out. Discharge should start around 10-11 am. When perhaps 20-50 of discharged sporangia have accumulated on the glass of the exposed window, the lid of the box should be removed, replaced by the duplicate one and now illuminated from the second direction.

Examination of the glass plates from the first lid should indicate that sporangia are to be found only on the plate through which illumination had occurred. During the next few hours the newly-illuminated window should be kept under observation. When discharged sporangia appear on it, there is clear evidence that the spore guns have become realigned. In this way the time necessary for realignment can be determined.

Distance of Discharge in Pilobolus

A set-up essentially similar to that proposed for *Sphaerobolus* can be used. It is interesting to compare the respective distances in these two fungi in relation to the sizes of their projectiles.

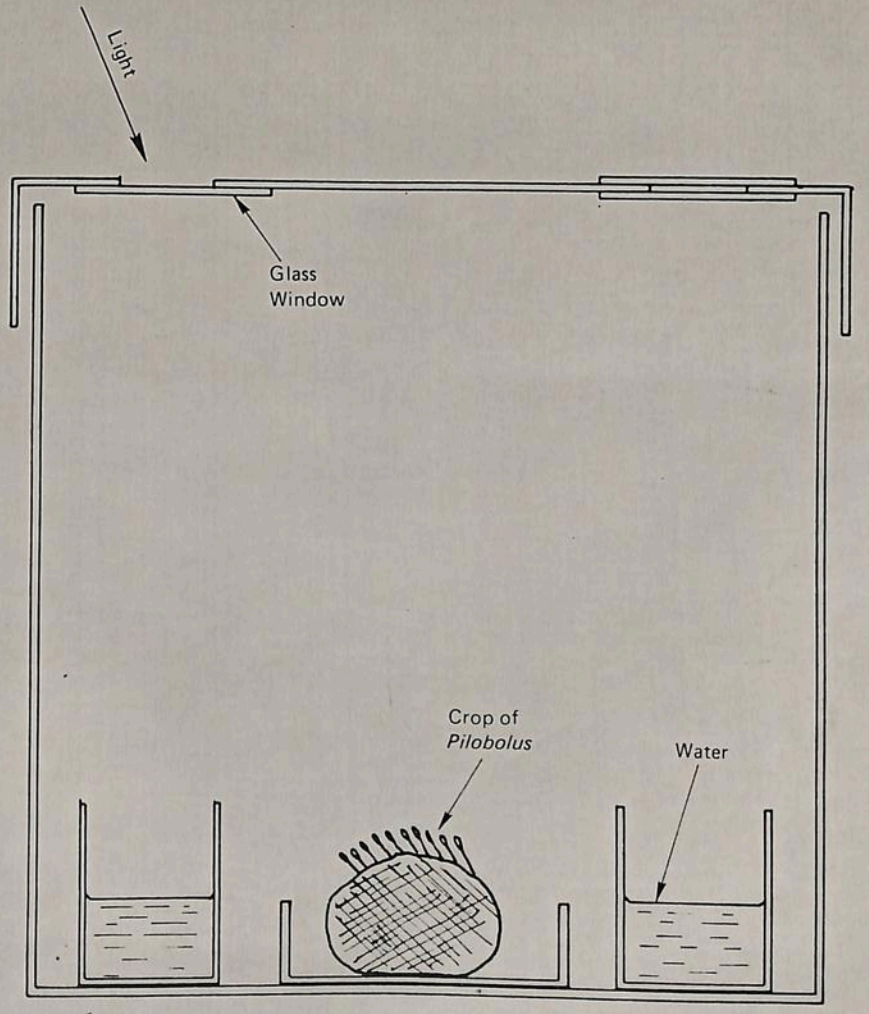

FIGURE 20 *Arrangement for studying readjustment of Pilobolus to light.*

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Buller, A.J.H. Researches on Fungi 6. 1934.

(P.93.)

Explanation of movement in Pilobolus.

" The concentration of the rays of light ... gives a photochemical stimulus to the protoplasm, which stimulus is conducted to ... the motor region of the stipe."

" The stipe grows faster on(one side) than on the other, with the result that the subsporangial swelling and sporangium are turned ..until their axis becomes parallel to the direction of the incident rays of light."

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See: Buller 6: 91, 124 etc.

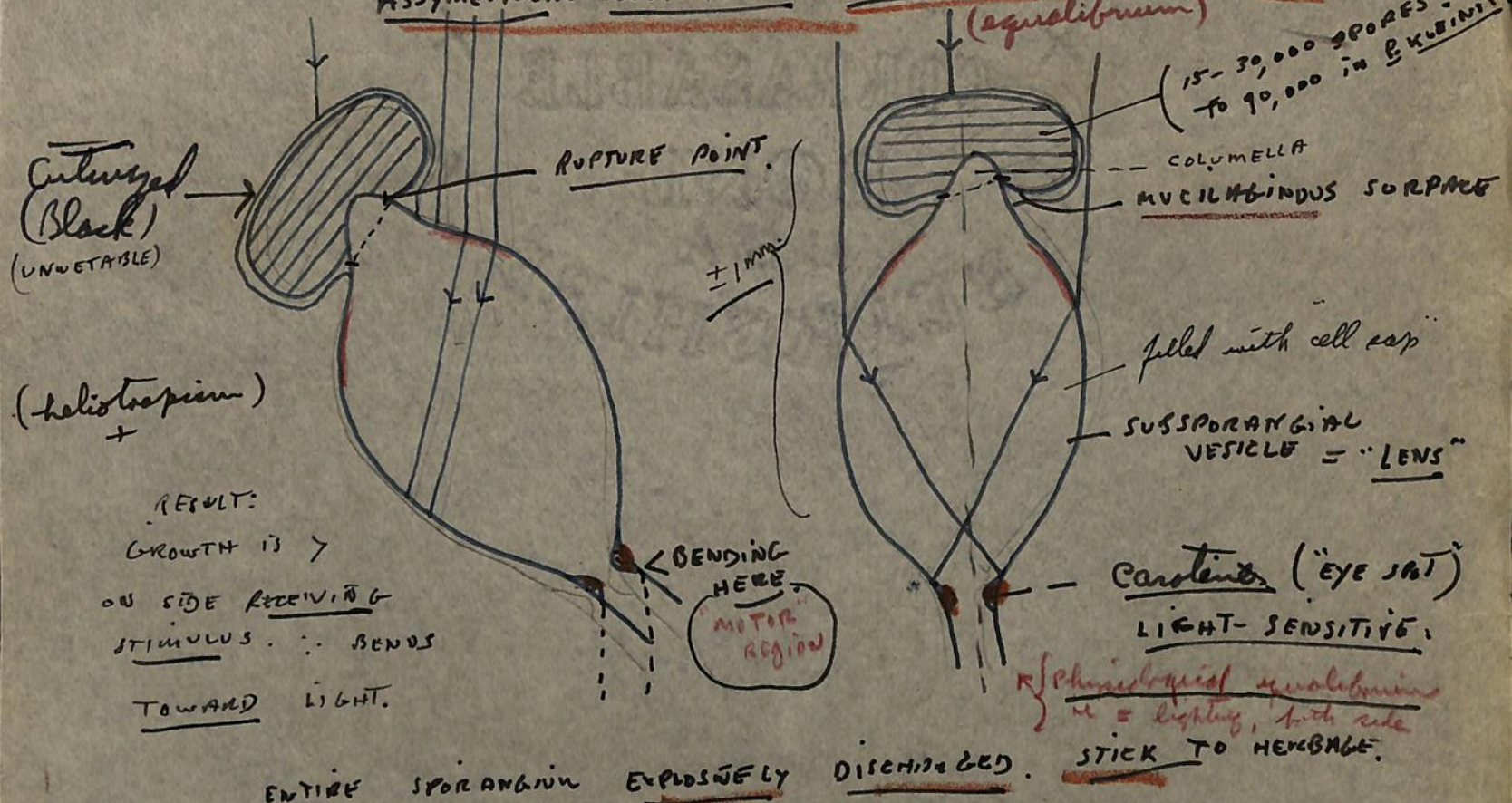
1688 J. Ray in Historia Plantarum.

PHOTOTROPISM

Pilobolus (Coprophilous)

ASSYMETRICAL ILLUMINATION

SYMMETRICAL ILLUMINATION (equilibrium)



ENTIRE SPORANGIUM EXPLOSIVELY DISCHARGED. STICK TO HERBAGE.

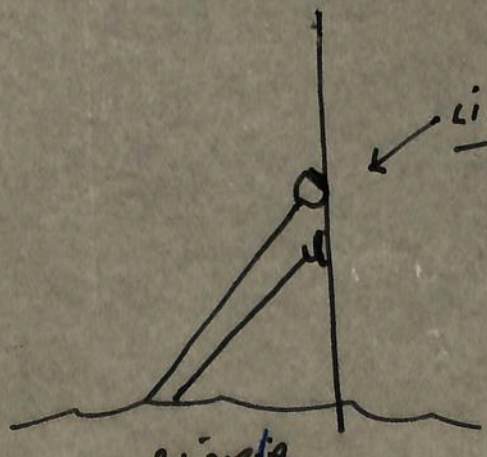
SPORANGIUM EATEN WITH GRASS ETC. GERMINATE IN DUNG. etc.

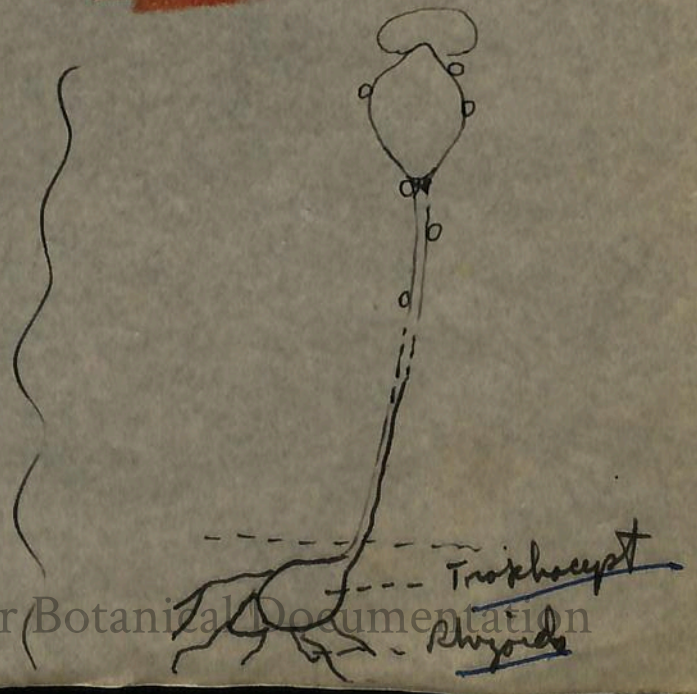
~~DISCHARGE~~

- Initial velocity of projectile: ± 20 ft/sec.
- Pilobolus gun: horizontal trajectory 8'. Vertical: ± 6'
- Sporangia retain vitality in field (on foliage) for ± 9 months.

PILOBOLUS NOT EXPLOSIVE - BUT DISCHARGED BY CONTACT.

No subsporangial vesicle.





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CAROLINA TIPS

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SAPROLEGNIA LIFE CYCLE

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Carolina Biological Supply Company, Burlington, North Carolina 27215

Saprolegnia (Fig. 1) is the best known organism of a group of fungi called water molds. It depends on water for asexual dissemination, but does not require an aquatic environment for sexual reproduction. As *Saprolegnia* is easily cultured and the reproductive stages are readily induced, it should be more widely used in teaching.

Saprolegnia is of economic importance as a parasite on fish, fish eggs, and frog eggs; infections can reach epidemic proportions.

HYPHAE

Saprolegnia is coenocytic; that is, the plant body (mycelium) consists of hyphae which are hollow, tubular cells without cross walls. The cytoplasm forms a thin layer just inside the cell wall and surrounds large vacuoles in the middle of the cell. Each cell has several nuclei embedded in the cytoplasm. Cross walls (septa) appear only when reproductive structures are formed or when hyphae have been injured.

ASEXUAL REPRODUCTION

Zoosporangium

The zoosporangium is found on the tip of a hypha. It is produced by the collection of cytoplasm and nuclei in the hyphal tip and the formation of a separating wall (septum) at the base of this tip.

The vacuole in the middle of the young zoosporangium extends toward the zoosporangial wall in a number of fingerlike projections dividing the cytoplasm. Each portion of cytoplasm thus separated contains one nucleus and its surrounding cytoplasm (zoospore initial). Zoospore initials are easily seen, but the zoospores are later obscured by swelling during maturation (Fig. 2). After the swelling, the zoospores (asexual, motile reproductive cells) become visible as round bodies (Fig. 3).

Shortly before release, the zoospores move with a slight rocking motion within the zoosporangium. On close observation, one can see that the zoospores near the tip of the zoosporangium have flagella moving in the limited space available. Also, before release, an apical papilla (exit tube) is formed, usually at the tip of the zoosporangium (Fig. 3).

Just prior to zoospore discharge, the apical papilla seems to dissolve. The active zoospores, tightly packed in the zoosporangium, burst from the zoosporangium as if under pressure (Fig. 4). After the initial surge, a steady stream of zoospores in decreasing numbers emerges. The remaining zoospores swim out of the zoosporangium (Fig. 5). Occasionally a few of the zoospores will remain in the zoosporangium.

After the discharge of the zoospores, the wall at the base of the old zoosporangium may grow through it. This process is known as internal proliferation and is peculiar to many higher Phycomycetes (alga-like fungi). Frequently this extension of the hypha will form a new zoosporangium. This may be repeated several times.

Zoospores

The zoospores of *Saprolegnia* are said to be diplantic (dimorphic); that is, they are of two types, primary and secondary. The primary zoospores are formed in the zoosporangium. Secondary zoospores are derived from primary zoospores. Primary zoospores have two flagella apparent when released from the zoosporangium. The flagella are subapically attached to the tear-drop shaped body (Fig. 6). After swimming awhile, the primary zoospores settle down,

FIGURE 1 *Saprolegnia* is called a water mold because it is frequently found on submerged or floating debris, in this case hemp seed. X 11.

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further standards for judging relationships which are already well-founded on morphological grounds. Furthermore, in instances where morphological evidence is insufficient, it may be possible to use nutritional and metabolic data to shift the emphasis in one direction or another. Thus a more satisfactory explanation of phylogeny might be achieved. Finally, it is of interest to consider nutrition and metabolism per se as a separate entity. Although the biological activities of any organism are the result of many interrelated factors, the progressive losses in synthetic abilities and the fundamental changes which may have occurred in their metabolic processes are in themselves worthy of investigation. It may logically be objected that the production of many single-

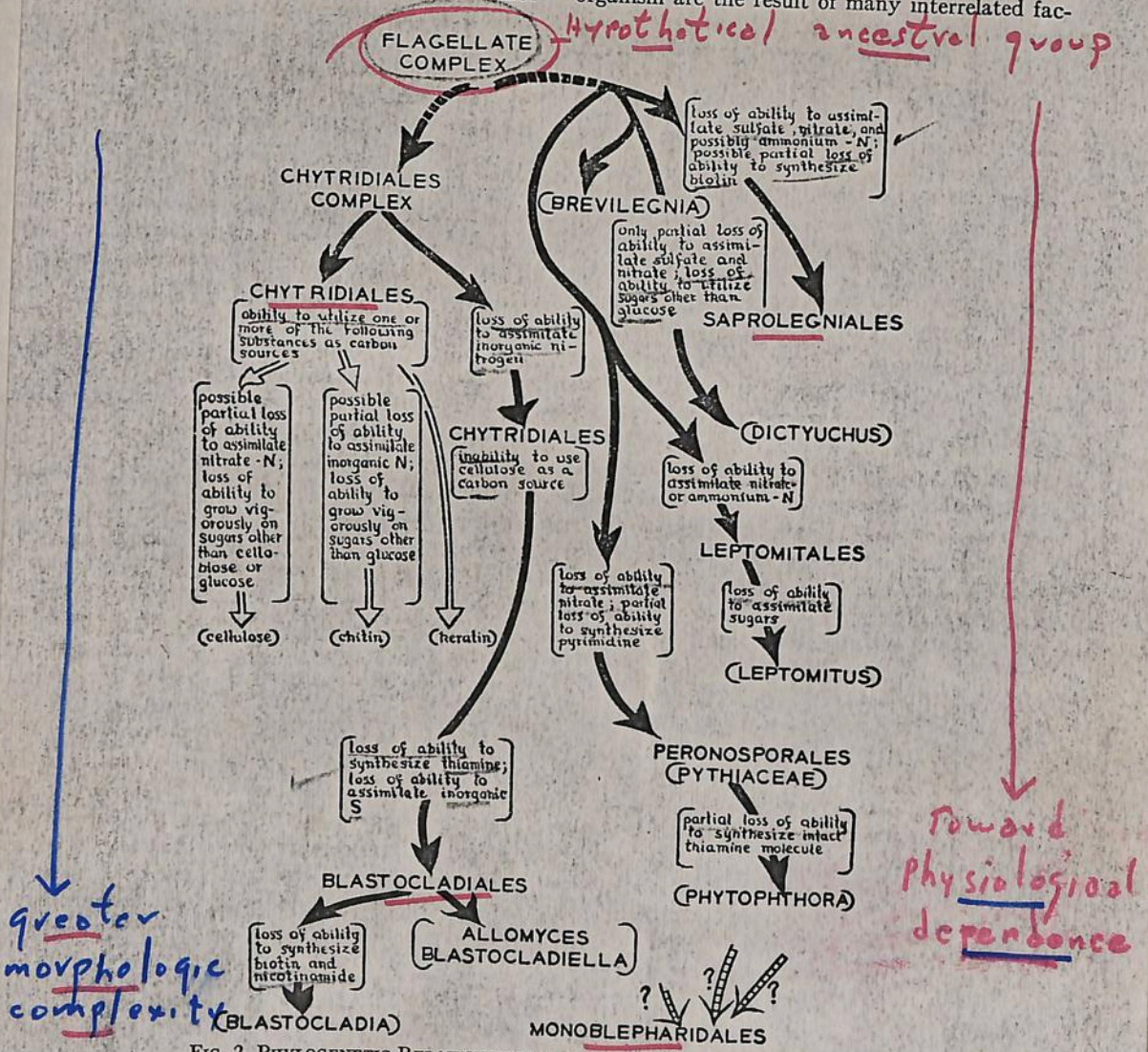

FIG. 2. PHYLOGENETIC RELATIONSHIPS AMONG THE WATER MOLDS, BASED UPON NUTRITIONAL CHARACTERISTICS.

The term "loss of ability" is restricted in meaning. Most investigations of nitrogen nutrition in the fungi have attempted to show that a given organism can or cannot use, let us say, nitrate as the sole source of this element. However, in those instances where amino acids are required for growth, it has seldom if ever been shown by analysis whether or not nitrate- or ammonium-N is actually assimilated simultaneously. Therefore, for example, "loss of ability to assimilate nitrate" implies that this substance, *when used as the sole source of nitrogen*, will not support growth.

Cantino, E.C. 1950. Quart. Rev. Biol. 25: 269-277.

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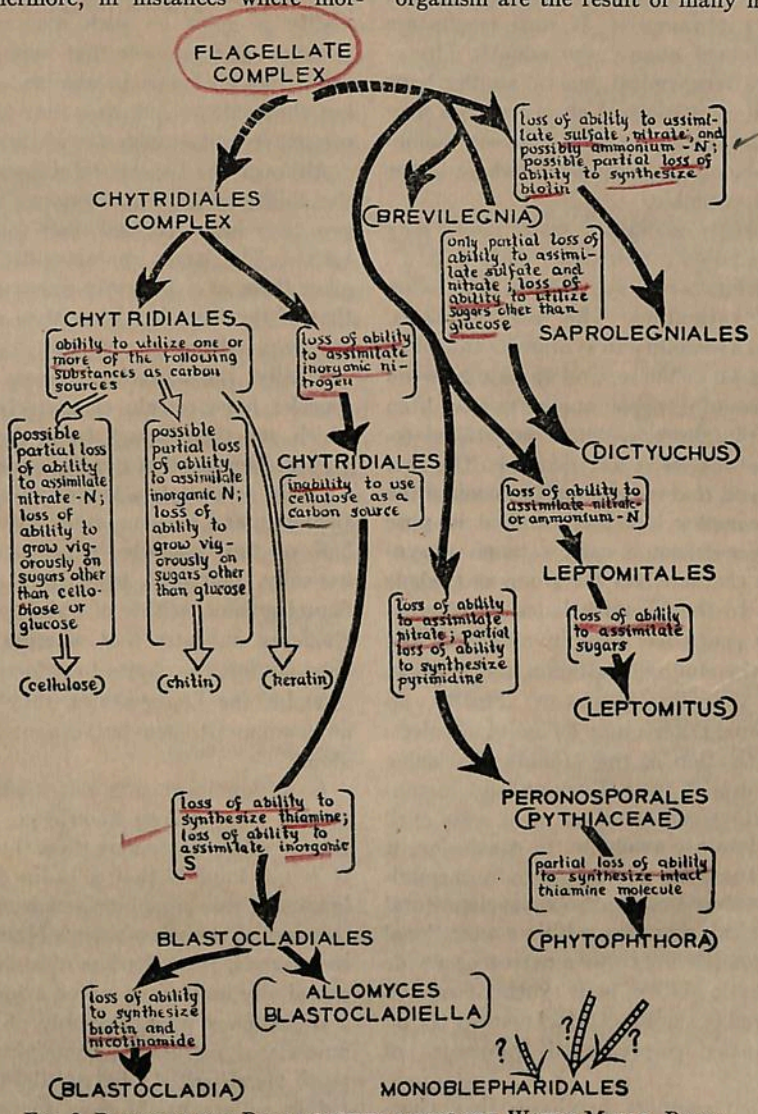

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Cantino, E.C. 1950. Quart. Rev. Biol. 25: 269-277.

Coker.

SAPROLEGNIACEAE

Key to the Genera

1. Sporangia rare or absent; oogonia with very thick pitted walls, the antheridia arising from immediately below them and running up their sides. ..... *Aplanes* (p. 76)
1. Not as above 2
2. Spores normally leaving the sporangium by a common mouth 3
2. Spores not leaving the sporangium by a common mouth (see also *Achlya dubia*) 8
3. Spores all (normally) swarming separately on escaping from the sporangium 4
3. Spores all collecting in a hollow sphere or an irregular group at the mouth of the sporangium on escaping 7
3. Part of the spores on emerging swimming away or sluggishly jerking away and encysting separately from the remainder, which stop at the sporangium mouth. Sporangia rounded at the tip and not tapering, in great part proliferating cymosely as in *Achlya*, but at times threads may grow through empty sporangia as in *Saprolegnia*. Eggs centric ..... *Protoachlya* (p. 90)
4. Sporangia not thicker than the vegetative hyphae; zoospores in a single row *Leptolegnia* (p. 157)
4. Sporangia usually thicker than the hyphae; zoospores not in a single row 5
5. New sporangia formed within the empty ones ..... *Saprolegnia* (p. 22)
5. New sporangia formed in greater part by cymose branching 6
6. Antheridia on every oogonium, androgynous ..... *Pythiopsis* (p. 17)
6. Antheridia absent, or on less than half the oogonia, diclinous ..... *Isoachlya* (p. 81)
7. Sporangia usually thicker than the vegetative hyphae; zoospores not in a single row *Achlya* (p. 95)
7. Sporangia not thicker than the vegetative hyphae; zoospores in a single row *Aphanomyces* (p. 160)
8. Spores encysting within the sporangium, then emerging separately through the sporangium wall and swarming ..... *Dictyuchus* (p. 150)
8. Spores set free by the breaking up of the sporangial wall ..... *Thraustotheca* (p. 148)

PYTHIOPSIS de Bary, 1888, p. 609.

Hyphae slender, much or little branched. Sporangia typically short and plump, spherical, oval, pyriform with a distinct apical papilla, or varying to elongated and irregular, primarily borne at the tips of the hyphae and multiplied from lateral stalks below the old ones to form more or less dense clusters. Spores emerging and swimming as in *Saprolegnia*, pip-shaped with two apical cilia, sprouting after the first encystment (monoplanetic). Gemmae resembling the sporangia or oogonia, formed plentifully, often in chains, producing zoospores after a rest. Oogonia borne like the sporangia and gemmae and resembling them in youth, typically spherical, oval or pyriform with unpitted walls.

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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*, dolioform; *f*, naviculate; *g*, subglobose; *h*, oval; *i*, fusiform; *j*, apiculate; *k*, filiform; *l*, angular

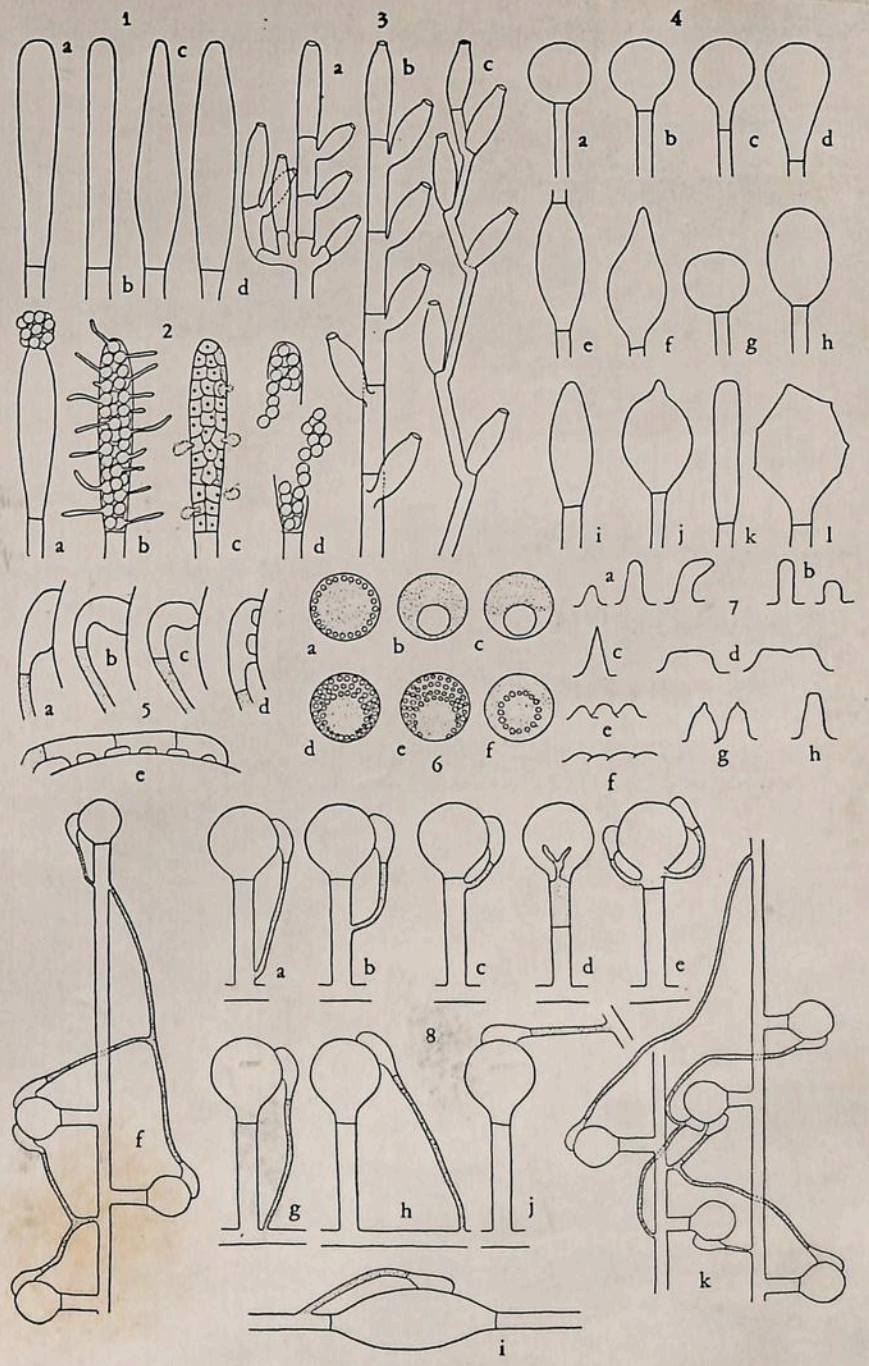
FIG. 5. Antheridial cell attachment: *a*, laterally appressed; *b*, *c*, apically appressed; *d*, projections; *e*, intercalary

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*, bullate; *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*, monoclinous; *j*, *k*, diclinous

PLATE 1



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COKER, W.C. THE SAPROLEGNIACEAE. 1923.

JOHNSON, T.W. THE GENUS ACHLYA. 1956. UNIV. MICH. (180 pp.)

BIFLAGELLATAE

Saprolegniales — Fitzpatrick erects 2 Families:
Saprolegniaceae
Leptomitaceae (separate Order by GWM)

Mycelium abundant. (Coenocytic)

Hyphal walls give cellulose reaction.

ANDROGENOUS — ♂, ♀ on same hyphae
DICLINOUS — ♂, ♀ on diff. hyphae

Asexual spores produced in sporangia (zoospores), are isokont and biflagellate. POST.

Sexual reproduction by antheridia (clavate) & oogonia (globose).
↓ OOSPHERES
OOSPORES

~~No ciliated sex cells.~~

Saprolegniaceae:

Monopodial branching (dichotomous rarely).

Septa delimit reproductive cells only.

Asexual reproduction:

Sporangial protoplasm denser than elsewhere; cleavage planes cut out protoplasm into polyhedral masses, each with 1 nucleus; these become the individual spores.

GEMMAE

Manner odf spore discharge diagnosti c for genus.

zb. in Achlya, Aphanomyces, : spores mass outside exit papilla & encyst;

Phenomenon of 2 swarming periods, ovoid, reniform (with spores of different kinds,) with rest period between, called DIPLANETISM; (contrast monoplanetic, aplanetic).

following rest period, reniform, bi-ciliate zoospores escape & encyst again (may repeat); ovoid diplanetic
eventually, spores germinate by a germ tube to produce a mycelium

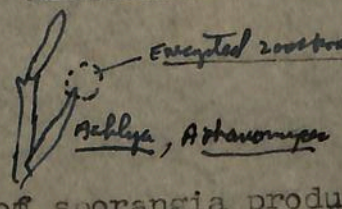
POLYPLANETISM

PYTHIOPSIS

in Saprolegnia, Leptolegnia, Isoachlya : zoospores escape separately then encyst;

swarm & encyst a 2nd time;

finally germinate by tube to produce mycelium.



Method off sporangia production diagnostic in some species:

ie : Saprolegnia, Leptolegnia, PROLIFERATION the rule; ie new sporangia formed within old ones.

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ZOOSPORANGIAL SHAPE

CLAVATE

FILIFORM

FUSIFORM

NAVICULATE

OOGONIAL SHAPE

SPHAGRIFAL

PYRIFORM

SUBGLOBOSE

ANGULAR

DOLIFORM

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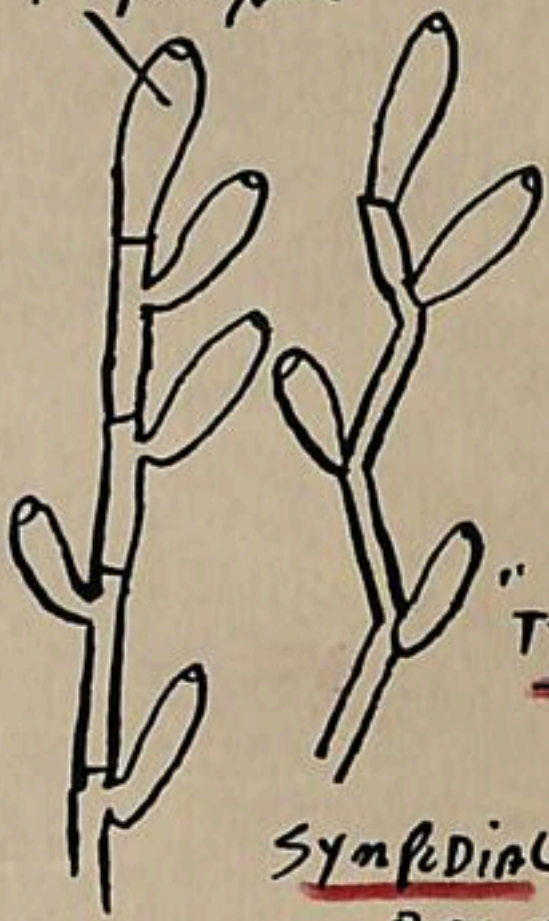
FORMATION OF SPORANGIA

1° SPORANGIUM

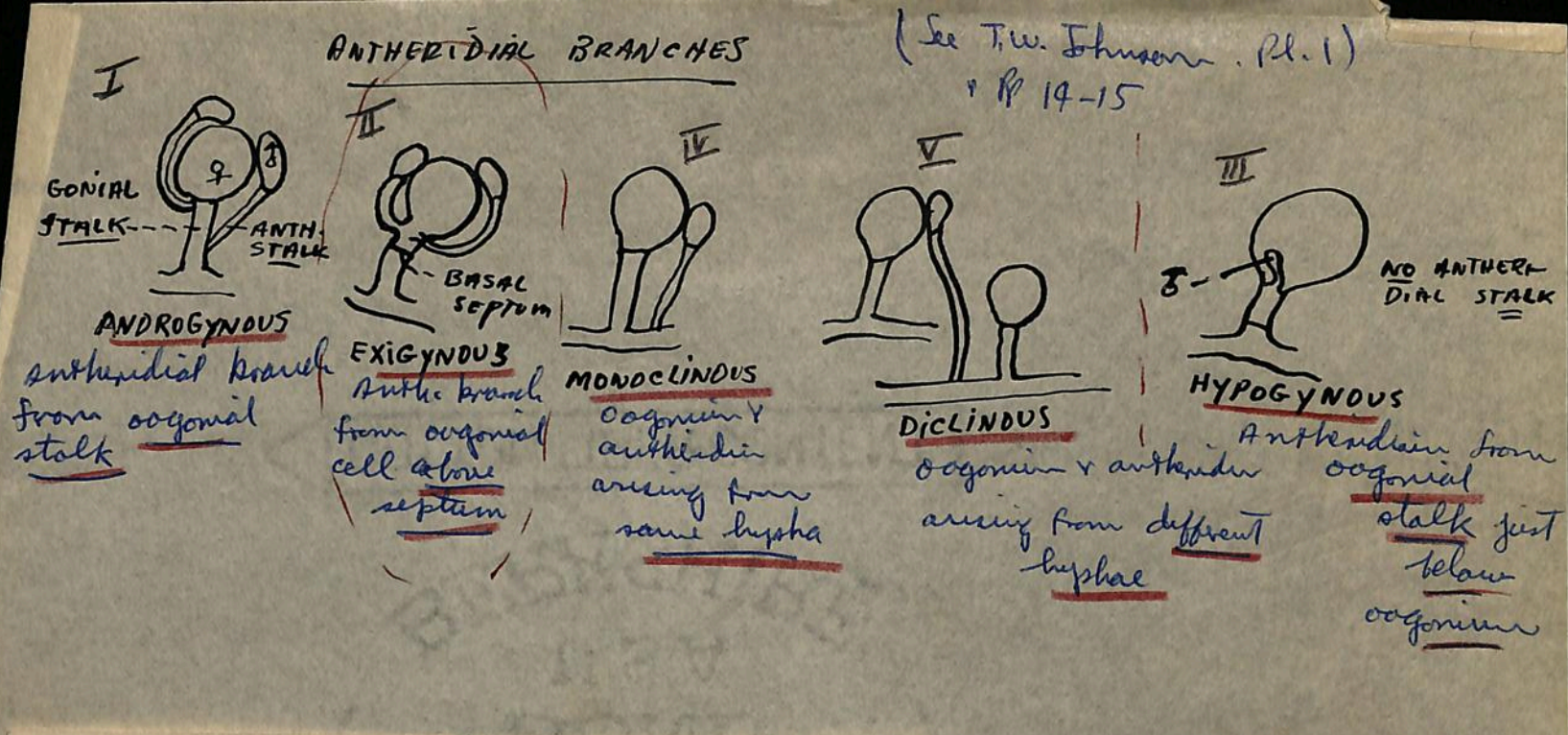


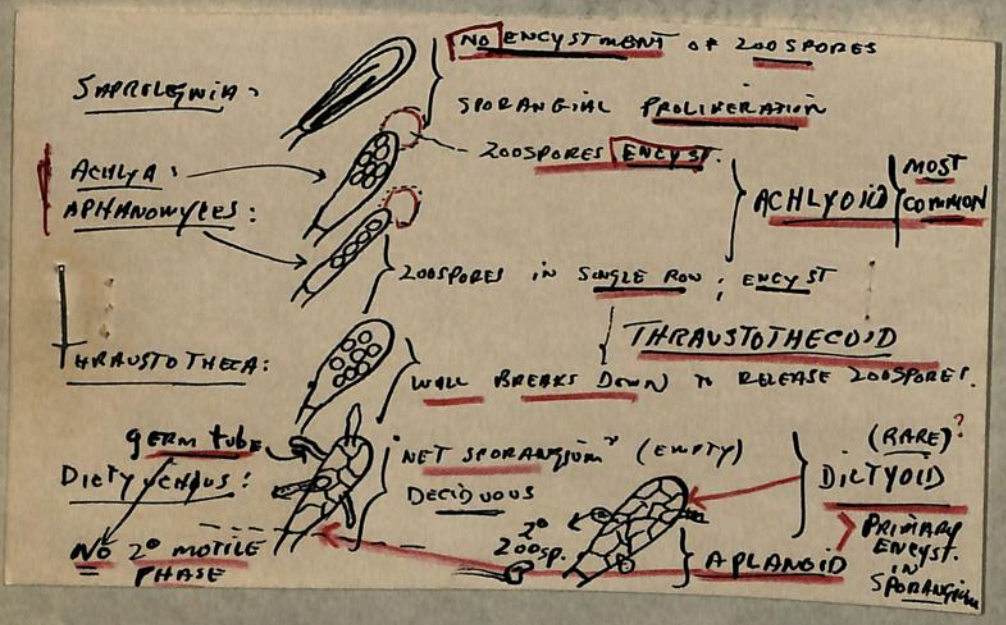
"TYPICAL"

SYMPODIAL — HYPHA BRANCHES LATERALLY BELOW BASAL SEPTUM

BASIPETALOUS

CYMOSE BRANCHING — A MODIFICATION OF SYMPODIAL, IN WHICH HYPHAL TIP BRANCHES REPEATEDLY





10.00 Syngamy and Alternation of Generations in Allomyces, a Water Mold (Produced by Phase Films), black and white, 20 minutes.

All the major features of reproduction are revealed in considerable detail with exceptional clarity in this film of the aquatic phycomycete Allomyces.

10.30 Growth and Asexual Reproduction of Saprolegnia Ferax (Produced by A.D. Greenwood), black and white, 30 minutes.

Time-lapse studies of the growth of the mycelium of Saprolegnia ferax and the development of zoosporangia.

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IX Int. Bot. Congr. Aug. '59

- Emerson & Cantino. 1948. The isolation, growth and metabolism of Blastocladia in pure cultur

Amer. J. Bot. 35: 157-~~188~~ 171. X

(Glucose-yeast agar)

Blastocladia : pH 5.8 - 6.5 (Prune agar)

Allomyces &
Blastocladiella : pH 6.0 - 8.0

R. E.M. Emerson & Wilson. 1954. Interspecific hybrids. . . Mycologia 46: 393-434.

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EUALLOMYCES

(EPIGYNY vs HYPOGYNY) genetically controlled

1. ARBUSCULES
A. JAVANICA

HYPOGYNOUS
EPIGYNOUS

RESTING

THICK-WALLED SPORANGIUM
PIGMENTED (MELANIN)
→ MEIOSPORES (SMALLER) = HAPLOID (N) → GAMETOTHALLUS

SIRENIN

THIN-WALLED SPORANGIUM
COLORLESS
→ MITOSPORES = DIPLOID (2N) → cardiosporic

HYPOGYNOUS

A. ARBUS

2N

2N

ANISOGAMOUS
PLANOGAMETES

SPOROTHALLUS

2N

2N

(diffuse mostly

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9 Families (MGWM): Inoperculate (7)
Operculate (2)
part of
Thallus Eucarpic (~~entire~~ thallus converted into fructification)
Holocarpic: entire " " "

Monocnetric: developing from a single center.
Polycentric: " " several " .

See: Farlow, W.G. 1885. Bot. Gaz. 10: 235-245. Synchytria of U.S.
Cook, M.T. on Synchytrium.

SPARROW, F. AQUATIC PHYCOMYCETES.
HASKINS, J.S. MYCOLOGIA 45(3): 293-313. 1954.
——— * AMER. J. BOT. 41(8): 651-662. 1954.

SEE: EMERSON, R. & C.M. WILSON. 1954. MYCOL. BLASTOCLADIALES } AUTOGAMY FRESH H2O; ON ROSACEOUS FRUITS, DERMOCHER.

Thallus always Eucarpic; no cellulose reaction; (fungus chitin).
Aquatic saprobes ; more extensive assimilative phase (vegatative) than in chitrids
Zoospores with nuclear cap attached to anterior surface of nucleus.
(N) THICK-WALLED SPORANGIA ALWAYS PRESENT.

Asexual reproduction: thin & thick-walled sporangia, giving rise to zoospores; sporangia often pitted.

Sexual reproduction: known only in some sp. Union of iso or aniso-
Planogametes (motile). (Biflagellate) zygote germinates → SPOROPHYTE

3 Families: Catenariaceae .. parasitic in worms or fungi.
Coelomomycetaceae .. " in insect larvae. (mosquito) esp.
Blastocladiaceae .. saprobic; Blastocladia
Allomyces

Ref. : Cantino, E.C. 1950. Quart. Rev. Biol. 25(3): 269-277. Nutrition & Phylogeny in the Water Molds.

Kanouse, B.B. 1927. Amer. Jour. Bot. 14. Monographic Study of Special Groups of Water Molds. (Blastocladiaceae Leptomitaceae)

——— . 1955. Physiology & Phylogeny in the water molds, a re-evaluation. Quart. Rev. Biol.

A. arbuscula (♂ hypogynous) × A. macrogynus (♂ epigynous) → A. javanica

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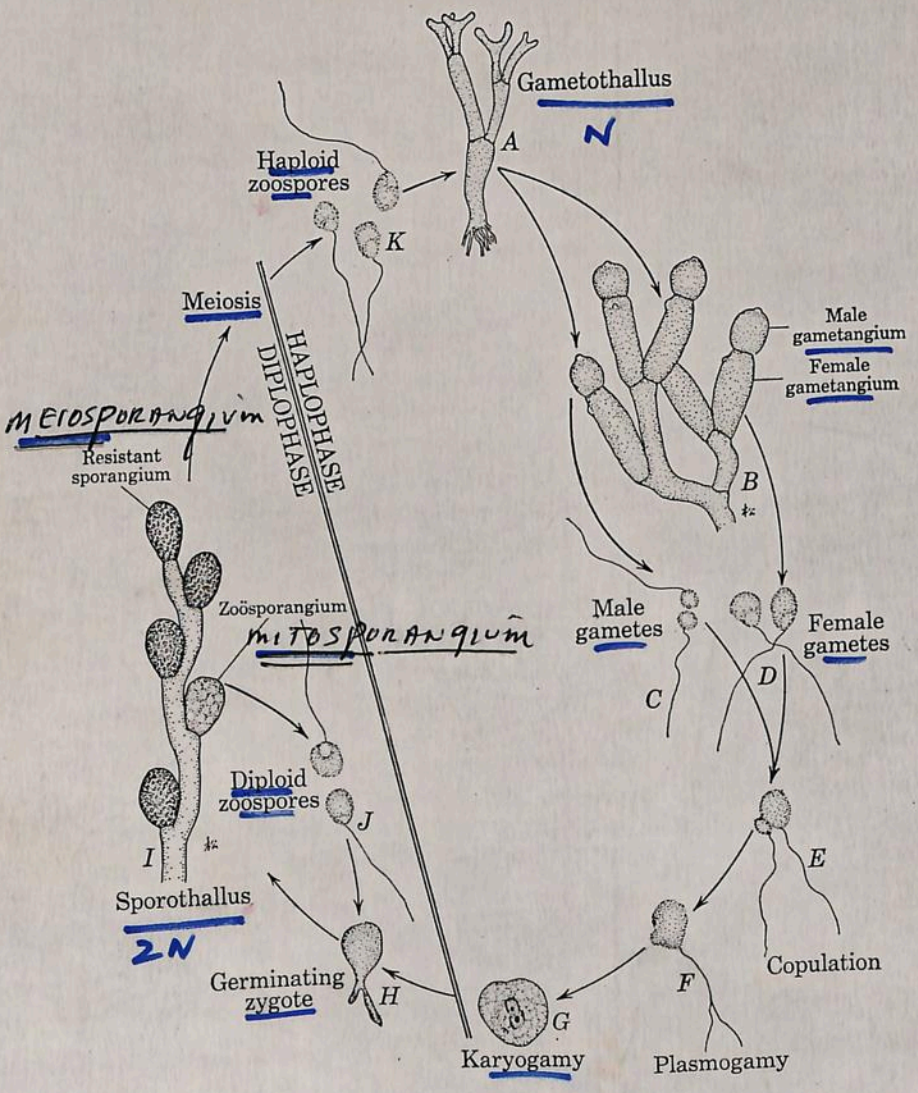

Figure 45. Life cycle of *Allomyces macrogynus*. *A*, *H*, redrawn from Emerson, 1941, *Lloydia*, 4:77–144; *E*, *F*, constructed; *G*, redrawn from Hatch, 1938, *Ann. Bot.*, n.s., 2:586–614.

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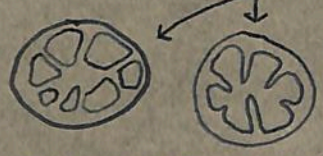
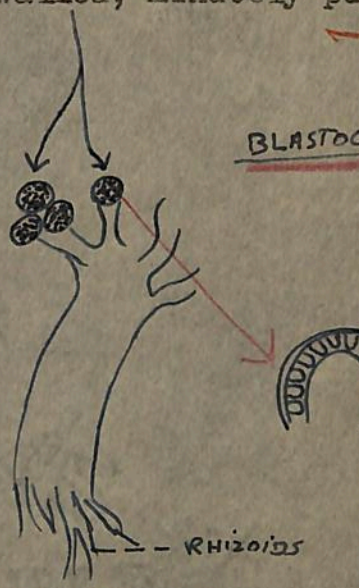
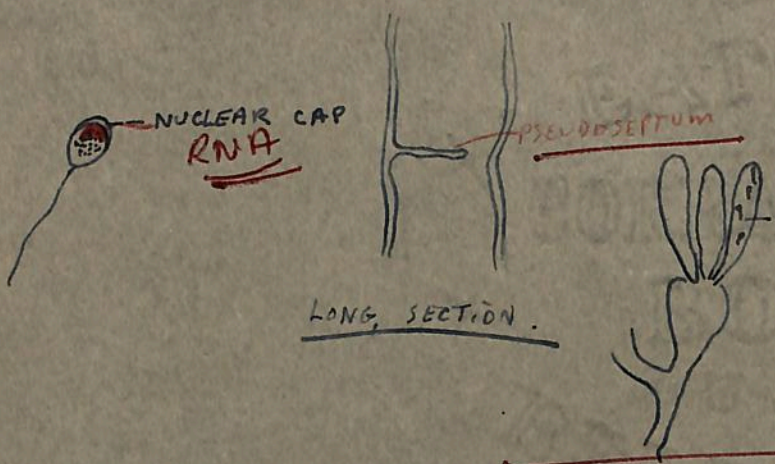
COELOMOMYCETACEAE — MOSQUITO LARVAE — PARASITIC — ASEXUAL PHASE ONLY KNOWN
(MYCELIUM PLASMODIUM-LIKE)

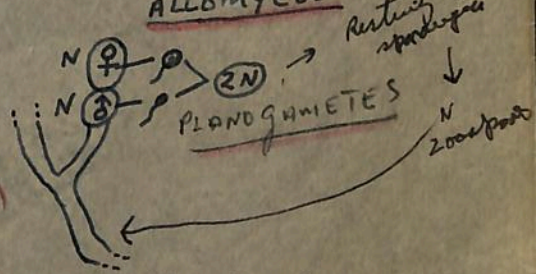
sporangia
Resting ~~spores~~ dark colored, thick-walled, minutely punctate;
Extensive holdfasts (rhizoids).
Perforated pseudosepta.


TRANSVERSE SECTIONS.



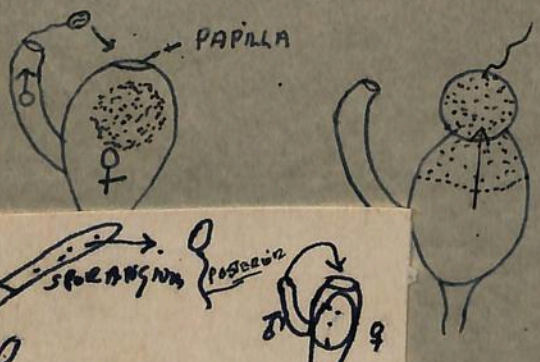
UNIQUE AMONG FUNGI.
?
see: Amauroderma



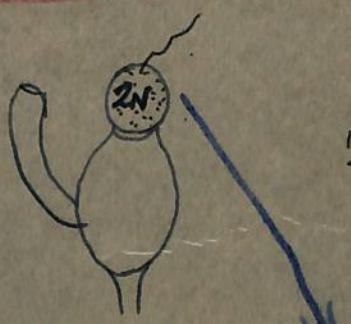


Monoblepharidales (Gamy)

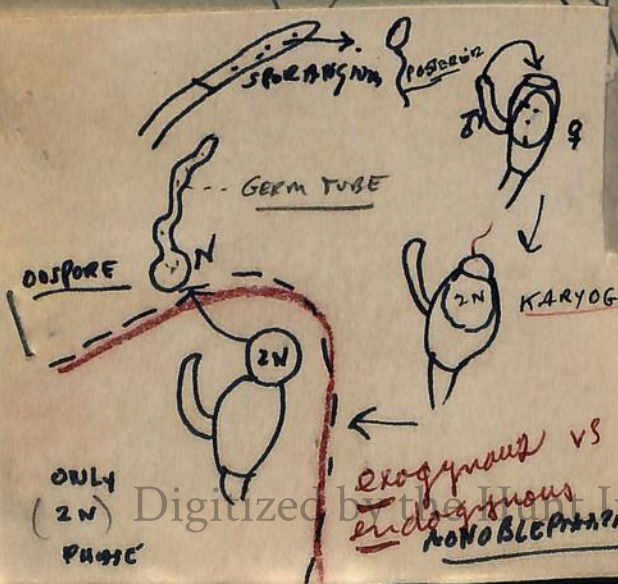
Characetrized by unique type of reproduction in the fungi;
Motle sperm fertilizes large, non-motile oosphere (egg).
Cell walls non-cellulose. NO THICK-WALLED SPORANGIA.



MONOBLEPHARIS



MONOBLEPHARELLA SPARROW 1940
oospore emerges with flagellum of spore still functional.



exogynous vs endogynous
MONOBLEPHARIS

Perrott, P.Elizabeth Thomas. The Genus Monoblepharis. Trans.Brit.Myc.Soc. 38(3): 247-282. 1955.
7 spp., 6 var. are described (world-wide).

CORNU

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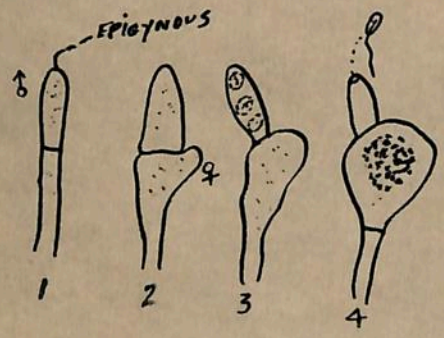
Emerson, R. & C.M.Wilson. 1954. Interspecific hybrids and the cytogenetics and cytotaxonomy of Euallomyces. Mycologia 46(4):393-434.
(SUMMARY OF 17 YRS. WORK) CHROMOSOME NUMBER HYBRIDIZATION

Johns, R.M. & R.K.Benjamin. 1954. Sexual reproduction in Gonapodya. Mycologia 46(2):201-208.
(differs from Blastocladia : incomplete fusion of gametes followed by motile stage of egg...flagellum of sperm propells fused gametes...comes to rest; spherical oospore produced). Close to Monoblepharella.

MONOBLEPHARIDALES

Monoblepharis sexual reproduction. Sparrow, F.K. Aquatic Phycomycetes. 1943. p.450.



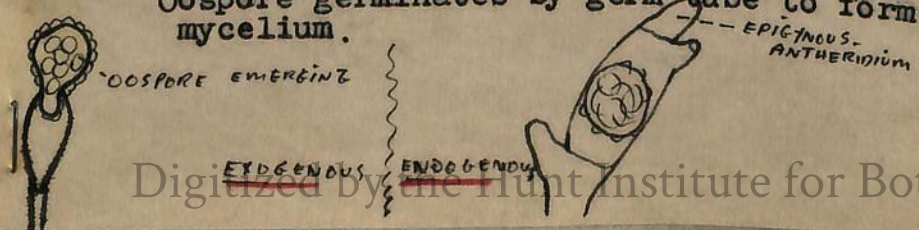
1) Terminal antheridium
2) Oogonial rudiment
3) Mature antheridium
4) Maturing oogonium

M. POLYMORPHA

Monoblepharis bullata
M. fasciculata
M. insignis
M. sphaerica
} Endogenous spp. ie Oospore does not migrate foll. fertilization

M. hypogyna
M. macandra
M. polymorpha
} Exogynous spp; ie Oospore leaves oogone foll. fertilisation. (3-5 min.)

Oospore germinates by germ tube to form mycelium.



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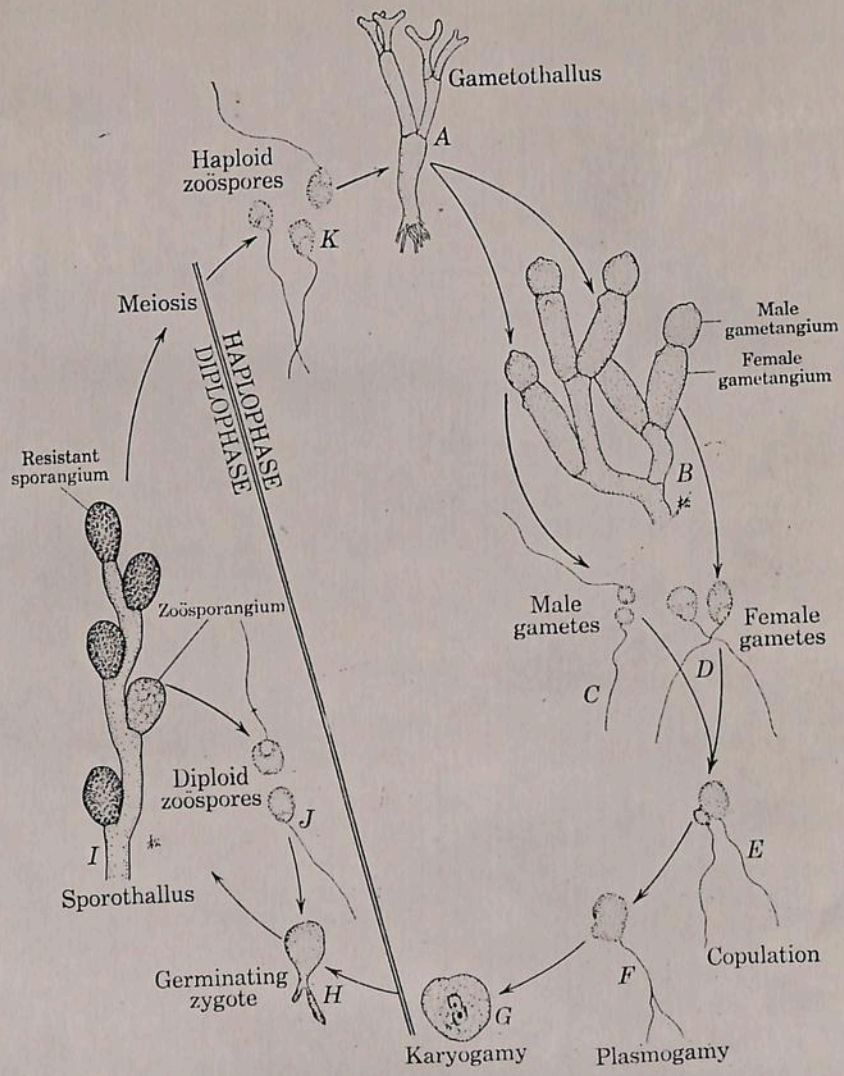

Figure 45. Life cycle of *Allomyces macrogynus*. A, *H*, redrawn from Emerson, 1941, *Lloydia*, 4:77–144; *E*, *F*, constructed; *G*, redrawn from Hatch, 1938, *Ann. Bot.*, n.s., 2:586–614.

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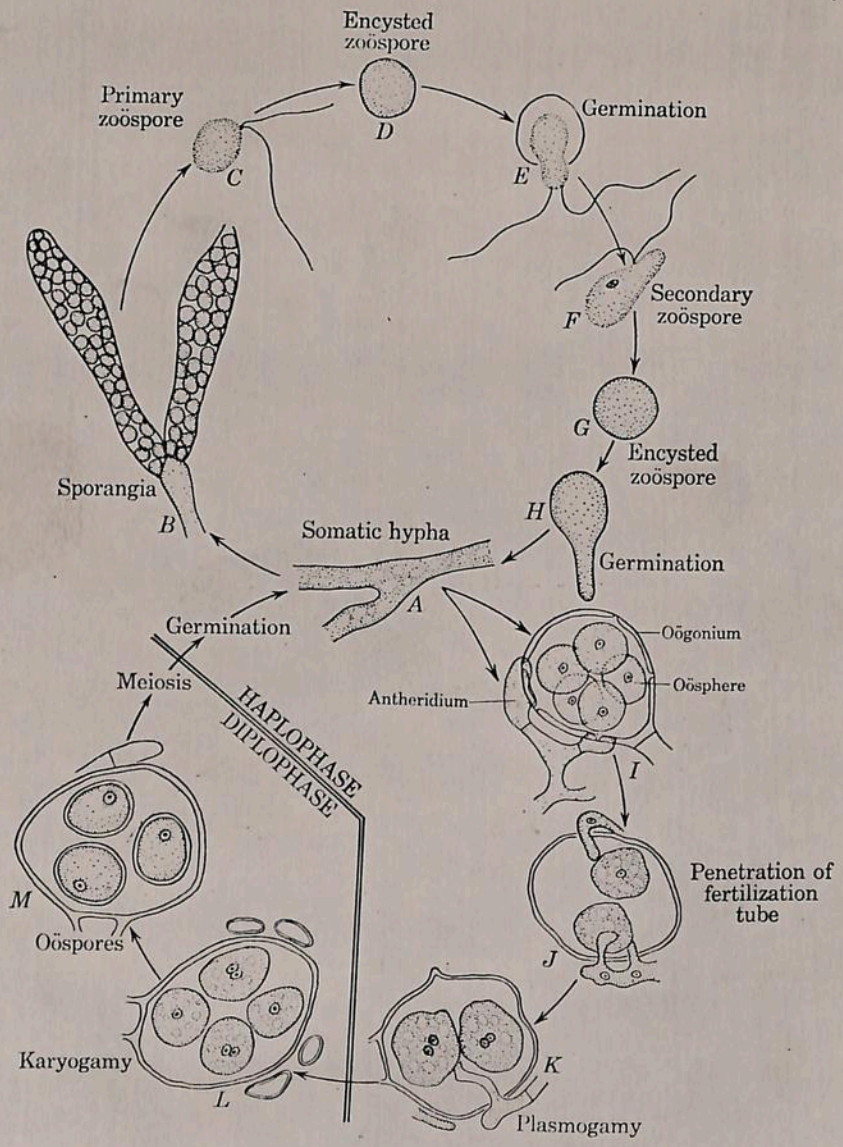

Figure 54. Life cycle of *Saprolegnia* sp. *C*, *E*, *F*, constructed; *J–L*, redrawn by permission from *Cryptogamic botany*, Vol. I, by G. M. Smith, 1938, McGraw-Hill Book Co., New York.

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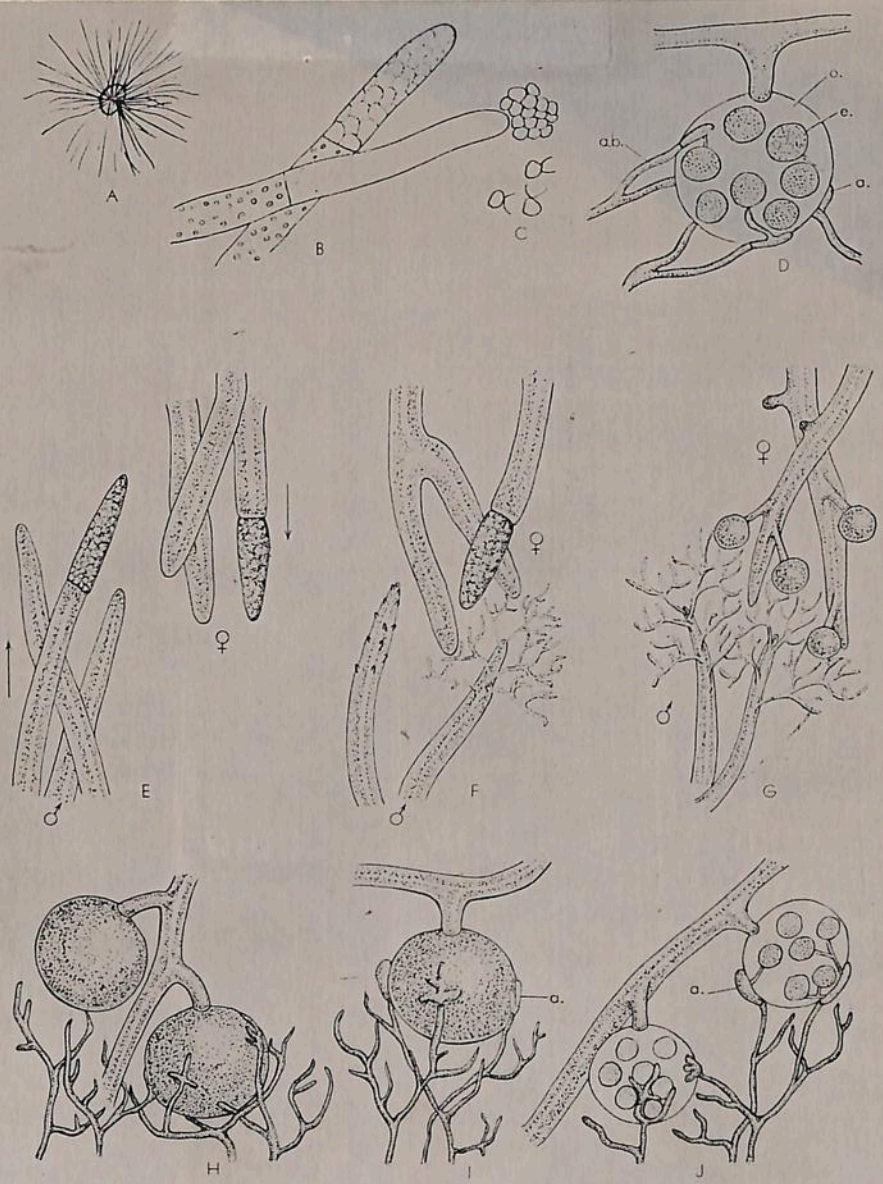

Fig. 18. *Achlya*, a water mold. (A) Habit of growth on a hemp seed; (B) Zoosporangia, with one shedding its spores; (C) Zoospores; (D) Sex organs: oogonium, o., containing eggs, e., appressed antheridial branches, a.b., and antheridia, a.; male nuclei from the antheridia are transported by tubes to the eggs; (E–J) Hormonal control of sexual maturation in *Achlya*; (E) Male and female branches growing in proximity; both have only asexual zoosporangia; (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.)

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J. R. Raper. Amer. Sci. 39: 110-120. 1951.

Julius Sachs 1880 – Hypothesis that development & differentiation in plants dependent on specific chemical substances.

E.g. Auxins of higher plants well known.

Some spp. of Achlya homothallic: ie ♂, ♀ gametangia borne on same individual. ∴ self-fertile. (most spp.: ie hermaphroditic)

Other heterothallic: ie ♂, ♀ gametangia on different individuals. ∴ self-sterile.

Now, 1) Numerous, branched hyphae develop at tips of ♂ hyphal; These are antheridial initials.

2) Following dev. of antheridial branches, lateral swellings occur ♀ hyphae; These become oogonial initials.

3) Antheridial hyphae grow toward oogonial branches

4) Antheridial " contact " " and antheridia cut off by septa. ∝ antheridia may be present.

5) Septum cuts off oogonium with ∝ nuclei

6) Oospheres delimited in oogonia.

7) Tubules from antheridia contact oospheres & nuclei of ♂ nucleus is discharged

8) Fusion of antheridial nucleus & oosphere nucleus follows: ie fertilization.

9) Zygote (oospore) secretes thick wall & becomes dormant.

Normal sequence of events. Each step controlled by specific hormone(s)

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Each of above events (except transfer of ♂ nuclei) is initiated by 1 or more specific, diffusible, hormones

Sequence of events is invariable. ∴ each stage must be dependent upon preceding stage.

Maturation of gametangia can be induced without physical contact between compatible strains. ∴ a diffusible chemical reagent postulated.

♂ x ♀ strains separated by a cellophane membrane show following activity:

1) Antheridial hyphae, upon making contact with membrane, → antheridia. ∴ 2 requirements needed for this
   a) contact with surface
   b) secretions of oogonial initials
2) Oogonial hyphae → oogonial initials, but if antheridial branches do not make contact, they proliferate secondary oogonial branches.

Filtrate Studies (Feed of spores + hyphae) = "activated"

1) Oogonial initials induced by filtrate from antheridial colonies. ∴ Filtrate from strictly vegetative hyphae bearing no antheridial branches → no oogonial initials

∴ 1) Induction of sexual activity dependent on secretion by ♀ of substance(s) inducing antheridial formation

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2) Oogonial initials dependent on secretions by ♂, following its own activation by ♀

3) Attraction of antheridial hyphae depends on substance(s) secreted by ♀, after oogonial initials appear

Summary

1) Antheridial hyphae initiated & regulated by 4 hormones, collectively called the "A-Complex", consisting of:

Hormones A & A_2 } secreted by ♀ vegetative stage

A_1 & A_2 } " " ♂ " "

Hormones separated by solubility in H_2O or acetone

{ ie A & A_3 acetone-soluble
  A_1 & A_2 H_2O "

2) Antheridial hyphae secrete Hormone B, which induces oogonial initials on ♀.

3) Oogonial initials secrete Hormone C during growth.

a) cause + tropic growth toward oogonial initials

b) cause delimitation of antheridium after contact with oogonium.

4) Antheridia secrete (Hormone ?) ⟶ oospore formation

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a) nucleus oosphere formation
b) delimitation of oogonium (septum formed)

All above activities normally follow each other in sequence; reaction may be experimentally interrupted at any stage.

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Lagenidiales (few saprobic)
Parasites of algae and aquatic Phycomycetes. (Olpidiopsis).

Zoospores with oppositely directed flagella (2)

Walls with cellulose reaction. (GENERALLY)

Sexual cycle: unequal gametangia; (as in Saprolegnia). ie heterogamy

Ex. Myzocytium vermicola parasitic in Nematodes
Lagenidium spp. parasites in aquatic fungi.

Leptomitales } PEDICELLATE REPRODUCTIVE ORGANS. SINGLE EGG IN OOGONIUM. (APODACHLYELLA EXCEPTED)
Saprobic; hyphae constricted & with pseudosepta; (cellulose present).

Chief Genera: Leptomitus (no sex organs formed) IMPERFECT GENUS.
Apodachlya (single oospore formed)
Apodachlyella (several oospores)

MENDENIELLA

Entomogenous fungi:

1) No motile spores.
2) Mycelium with more frequent septation than found in Mucorales.
3) Mycelium smaller in diameter (less abundnt
4) Hyphae with greater diameter and with fatty contents.
5) Conidia (or sporangia) violently discharg
6) Mycelium fragments into hyphal bodies.

HYPHAL BODIES → CONIDIOPHORE
↘ CONIDIUM OR SPORANGIUM
↘ GERM TUBE
↓ UNITE TO FORM
↓ ZYGOSPORES

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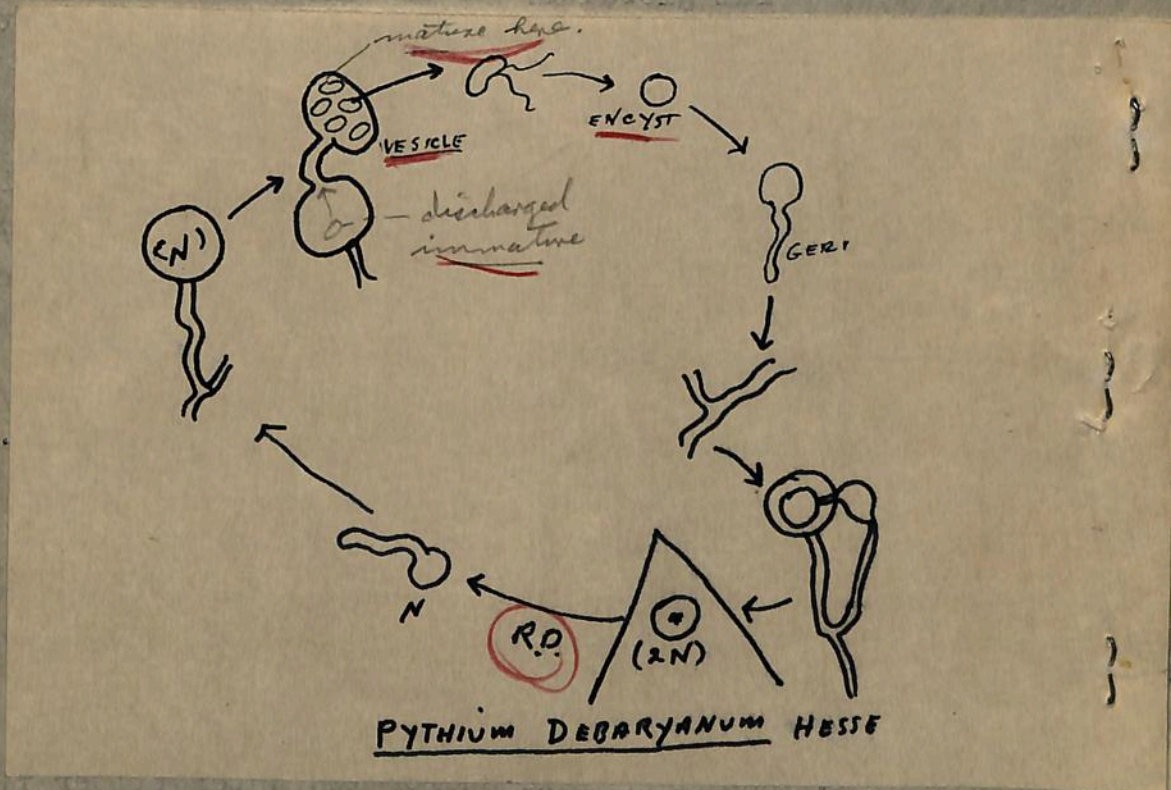

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Sexual reproduction:

Oogonia & antheridia usually terminal;

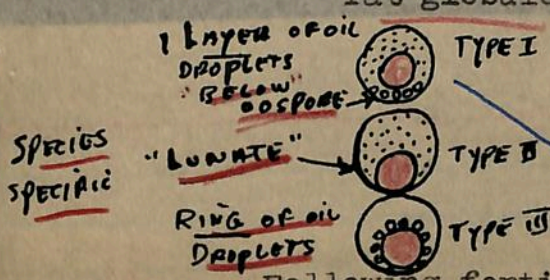
(rather than intercalary).

if a hyphal branch gives rise to both antheridia & oogonia,

the species is called : ANDROGENOUS.

if either one OR the other are produced, species is DICLINOUS.

OOGONIUM produces OOSPHERES (multinucleate bodies at first, become uninucleate when mature). Oospheres have characteristic appearance when mature because of disposition of stored fat globules:



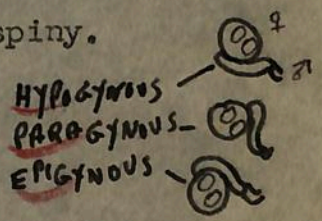
a) CONETRIC: small droplets at periphery of protoplasm.

b) ECCENTRIC: ~~few~~ ONE large drops at 1 side.

c) SUBCENTRIC: intermediate in position.

3 TYPES (See Johnson P. 16)

Following fertilization, oosphere secretes cellulose wall and gives rise to OOSPORE, which may be smooth or spiny.



Single oospore produced in Leptolegnia, Aphanomyces.

Several " " " Saprolegnia, Achlya.

Oospore germinates by GERM TUBE, rhizoids, new phase of life cycle.
^ VEGETATIVE

Methods of collection & study ("water molds")

1. Sterilize lake and/or tap water (liter flasks).
2. Collect soil samples.
3. Add 10cc sterile water to sterile petri dish.
4. Add soil sample (small)
5. Add boiled, split hemp seed.

Leave at rm. temp. in diffuse light for 24-48 hrs. fungi aggregate around hemp seed. Study for reproductive organs etc. in situ, on stage of scope. Mounts made in Hoyer(s medium.

PYTHIUM (OVER)

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Saprolegniales

Generic distinctions based on:

1) Method of zoospore production (MONO - DI-PLANETIC)
2) Type of zoosporangium
3) OIL DROPLETS AROUND OOSPORE

Saprolegnia proliferation; no encystment at apex.

Achlya encystment

Aphanomyces zoospores in single row; no encystment.

Dictyuchus "net sporangium"; deciduous

Thraustotheca zoosporangium wall breaks, releasing spores.

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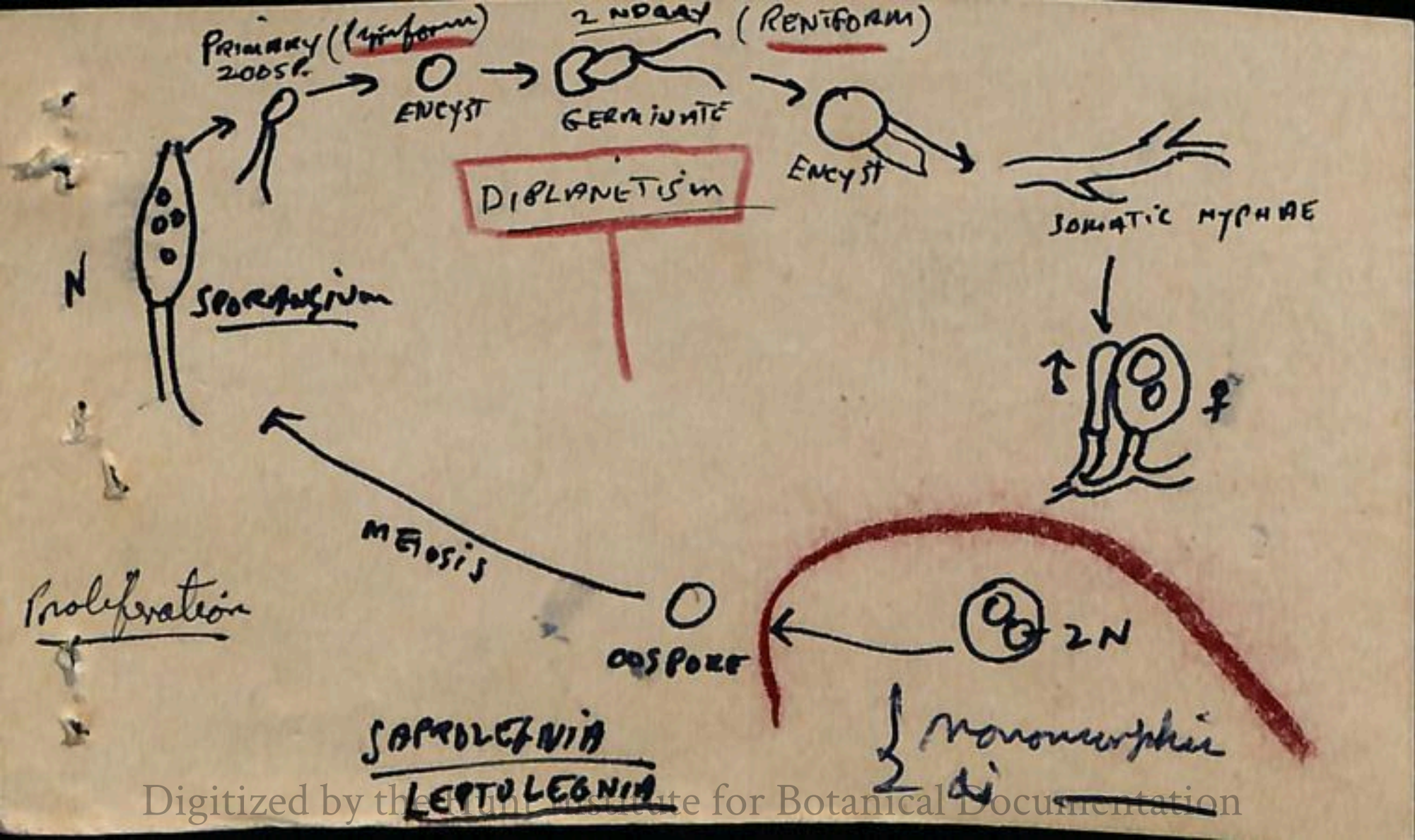

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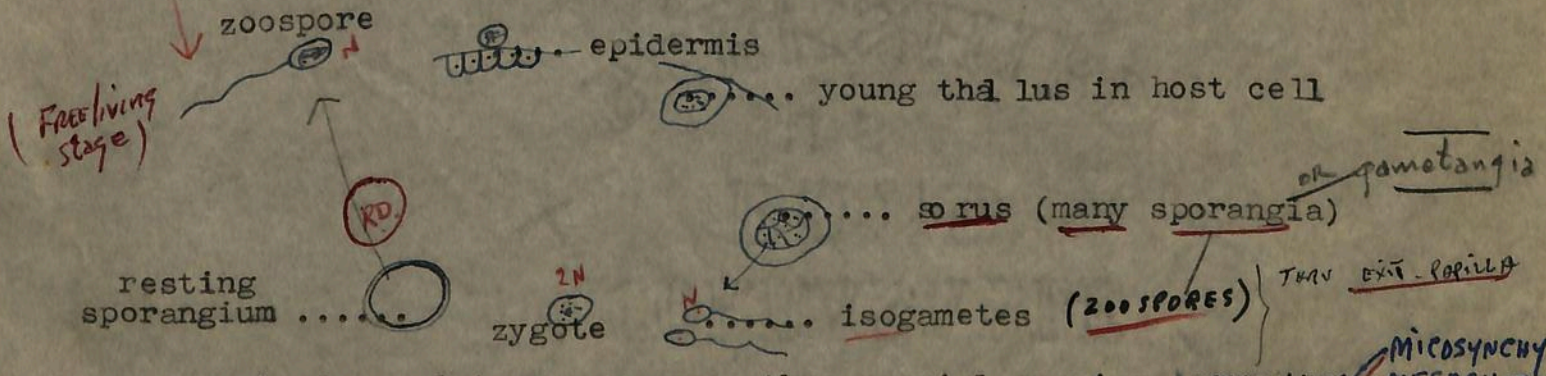
Thallus may be limited to a single host cell; ie Monophagus;
If branches occur in several host cells then Polyphagus.
Thallus may give rise to: sporangium, sorus (group of sporangia),
resting spore, group of resting spores.
Two thalli may conjugate, one acting as "male", other as "female" cell.
Asexual reproduction: thallus begins as zoospore which enlarges;
zoospore may be amoeboid; if flagellate,
then called swarmspores.

Thin-walled Summer sporangia contain many zoospores; under unfavorable conditions, these may become thick-walled and termed Resting sporangia or Resting spores.

In parasitic sp., resting spores produced inside host cells are called Endobiotic; Epibiotic, if confined to surface of host; (but hyphae may penetrate cells). Saprophytic sp. are termed Intramatrical or Extramatrical, depending upon their position with relation to the substratum.

Life Cycle: zoospore in contact with host cell;
" rounds up & effects entrance into host
exists in host cell as naked protoplast.
enlargement within host cell parasitized. (now called Thallus
matures & surrounded by membrane;
produces zoospores which leave host thru Exit Tube.

SYNCHYTRIUM given



in Operculates: zoospores thru special opening — OPERCULUM
Inoperculates: " " Exit Papilla (deliquesces).

SUBGENERA
MICROSYNCHYTRIUM
MESOCHYTRIUM
EUSYNCHYTRIUM
EXOSYNCHYTRIUM
PYCNOCHYTRIUM
WORONINELLA

SEE: KARLING, J.S. SYNCHYTRIUM. Academic Press, N.Y. 1964. 470 pp.
REVIEW IN ECONOMIC BOT. JULY-SEPT. 1966. 332-333.

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Micromyces Dangeard 1888

Synchytrium deBary & Woronin ~~1865~~ 1863

Genera fundamentally similar morphologically & functionally (life cycles, as far as known). Micromyces therefore merged with Synchytrium. (over ± 150 spp.)

7 subgenera established(provisionally) based on "presence or absence of summer sporangial sori.

2) type of resting spore germination

3) dev. of veg. thallus into sorus or functioning as prosorus.

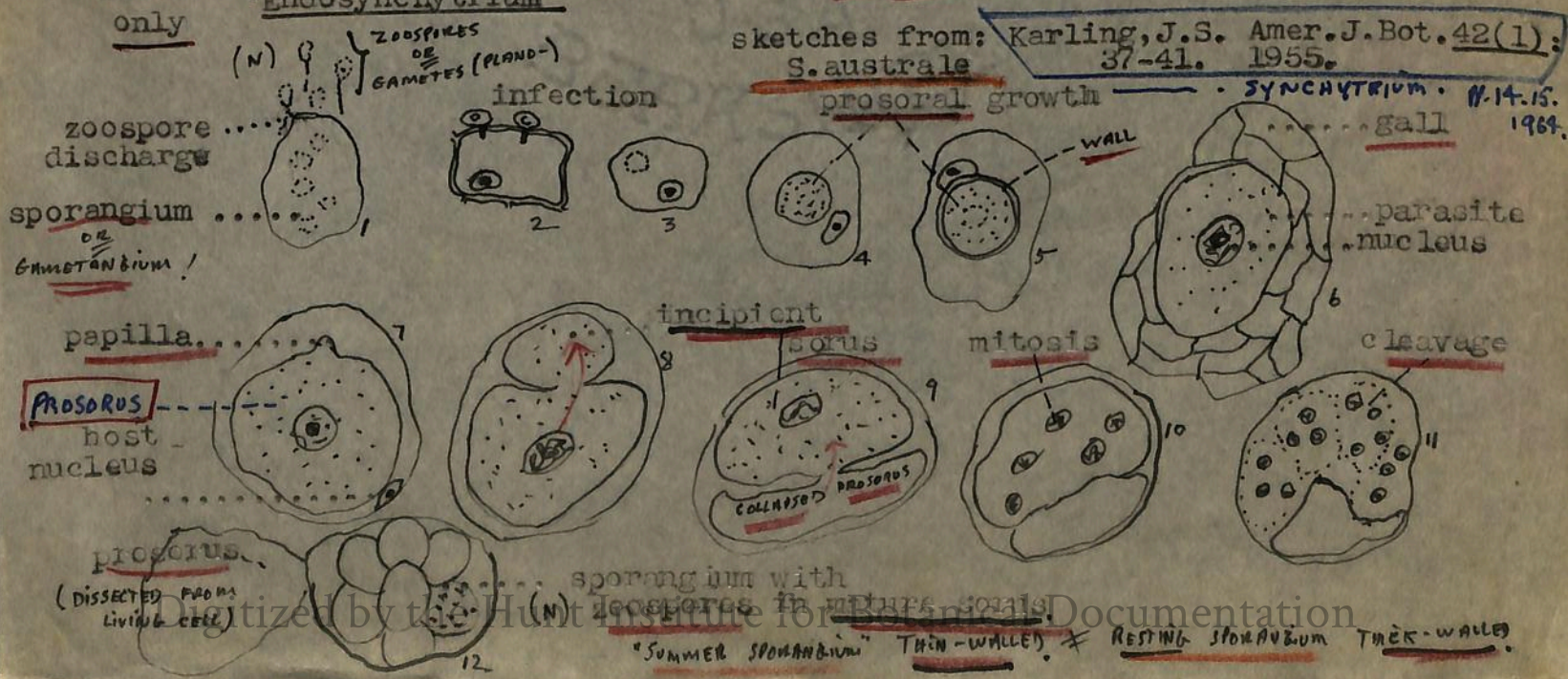
"..no distinction is made between sporangia and gametangia or between zoospores and gametes because they are morphologically and structurally alike so far as is known at present." KARLING.

no resting spores { Woroninella
resting spores & summer sporangial sori { Eusynchytrium, Exosynchytrium, Mesochytrium (+ S. endobioticum), Microsynchytrium } resting spore functions as sporangium in germination, giving rise directly to zoospores. only 2 subgenera to produce prosori.

resting spore known only { Pycnochytrium, Endosynchytrium

S. australe Sparg. = [S. modiolensis Cook] SYNONYM

sketches from: Karling, J.S. Amer. J. Bot. 42(1): S. australe 37-41. 1955.



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Entomophthorales = Zoopagales

Zoopagaceae – Conidia single or catenate; not forcibly discharged. Parasitic on nematodes & amoebae

Basidiobolaceae – Sporangium modified as single conidium; forcibly discharged. Saprobic on dung. Gametangia ±.

Entomophthoraceae – Gametangia = Parasitic on insects

Eccrinales [Mycol. 46:569] Lichtwardt

Commensals in digestive tract of arthropods. (2k millipedes), Coleoptera & Crustacea Trinidad

not cultured. ? sexual repro? Alex 211-213

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MEM, BOSTON SOC. NAT. HIST. 4(6): 133-201. (21 PLATES)

Zoosporic + Parasitic on soil-inhabiting & H_2O organisms.
Eccrinales } Parasitic in alimentary canal of Arthropods. (C, O, M. & A.)
Mycol. 46: 564.

Thaxter, R. 1888. Entomophthoraceae of the U.S.

MOSTLY OBLIGATE PARASITES Entomophthorales } Reduced mycelium; Hyphae large diam., fatty contents; Thick-walled zygospores by union of "hyphal bodies"

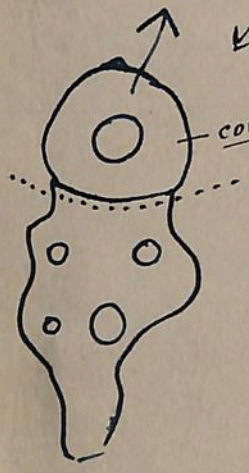
Entomogenous fungi in 4 groups:

PHYCOS 1) Entomophthoraceae (mostly parasitic on insects, but not all.)

ASCOS 2) Laboulbeniaceae (on insects and arachnids)

3) Hypocreaceae (Cordyceps) (on insects)

1-2 cm. DISTINCTIVE CONIDIA. (4) SEPTOBASIDIUM (WITH SCALE INSECTS) [COUCH]



Empusa (Entomophthora) (common on flies)

a. hyphae of large diam. & fatty contents emerge from host in white mass;

b. conidia produces, which are violently discharged;

c. resting spores when germinated, produce conidia, discharged as above & infect new hosts; PENETRATE HOST AT JOINTS (?) RAPID VEG. GROWTH IN HOST.

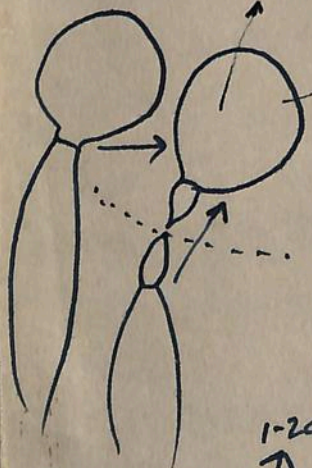
A.

Completoria Lohde (on fern prothalli) [Entomophthorales]

short, thich hyphae (hyphal bodies) produce conidiophores which become swollen at tips; produce ovoid conidia, discharged into air.

Sexual reproductuon ?

1-2 cm.

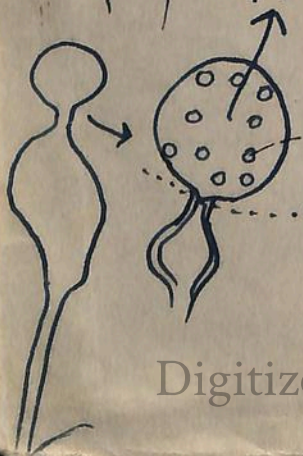


Conidiobolus Brefeld (parasitic on Tremellales)

mass of branched, rarely septate hyphae; large, ovoid conidia at tips; violently discharged.

Zygospores from unequal gametangia.

1-2 cm.



Basidiobolus Eidam (all saprobic; on frog & lizard dung)

spores dormant in digestive tract; germinate on feces to produce large, co,orless hyohae; erect conidiophores produce large conidium, violently discharged at maturity.

Zygospores from fusion of adjacent cells of same hypha.

SPORES FIRST EATE BY BEETLES, BEETLES BY FROGS; → SPORES GERM.

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Peonosporales } Pythiaceae, Peronosporaceae, Albuginaceae

Most highly develpped of the Oomyctes; mostly terrestrial & parasitic on higher plants;

Asexual reproduction:

Sporangia are DECIDUOUS & germinate by germ tubes, commonly. (rather than zoospores). These disseminated by wind. Term CONIDIUM sometimes used synonomyously with SPORANGIUM in this group; no uniformity . Sporangium preferable, conidium reserved for asexual spore.

Profuse mycelium usually present & in parasitic sp., is intercellular, penetration effected by HAUSTORIA: sometimes, intracellular also.(esp. obligate parasites)

Sexual reproduction:

Oogonia & antheridia as in Saprolegniales. Oospore always lies free in oogonium. Germination is by zoospores or germ tubes.

3 Families:
* Pythiaceae: sporangiophores hardly differentiated from assimilative hypha no haustoria.
Pythium
Phytophthora

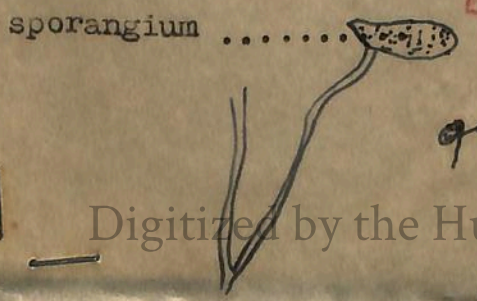
* Peronosporaceae: sporangiophores different haustoria various
Plasmopara, Bremia.
Peronospora,

* Albuginaceae: sporangia catenulate, in sori, beneath epidermis of host (white Blisters).
Albugo.

Pythiaceae:?

Most primitive of the Order because of aquatic habit, sporangia remain attached and zoospores produced in asexual reproduction. Parasitism never obligate.

Pythiogeton: assymetrical sporangium, with long axis perpendicular to sporangiophore.



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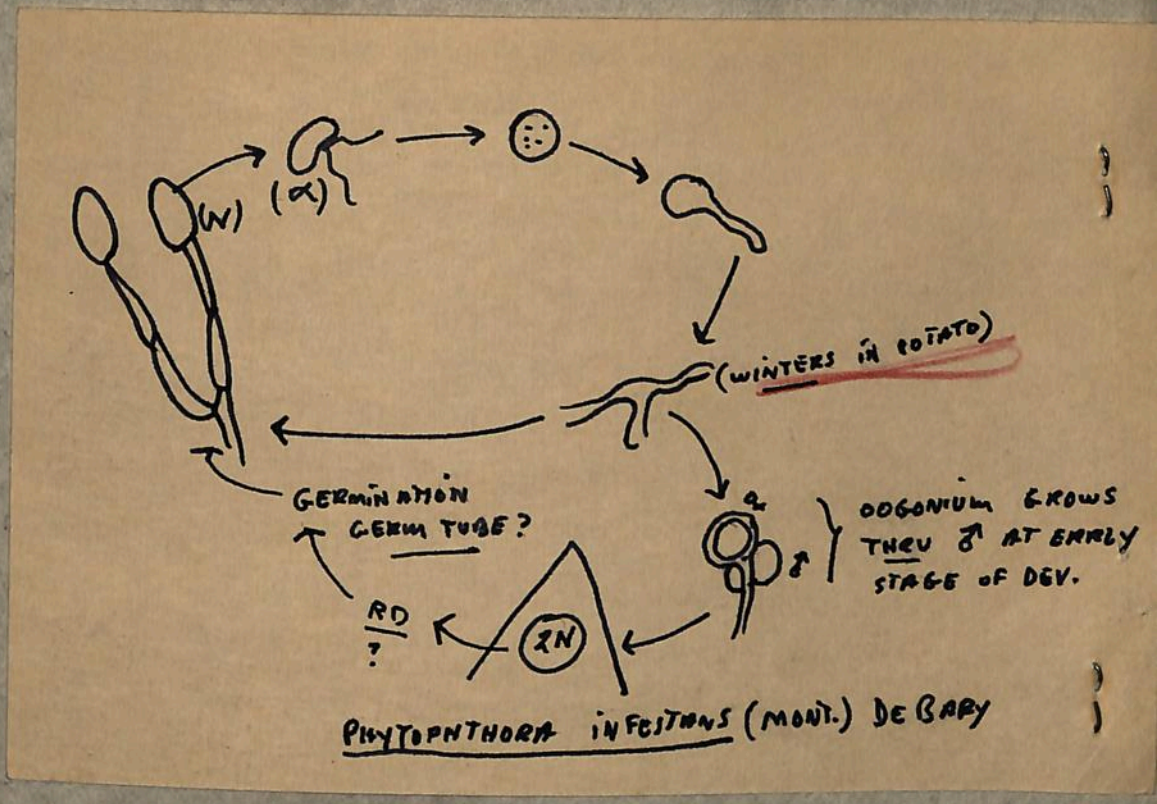

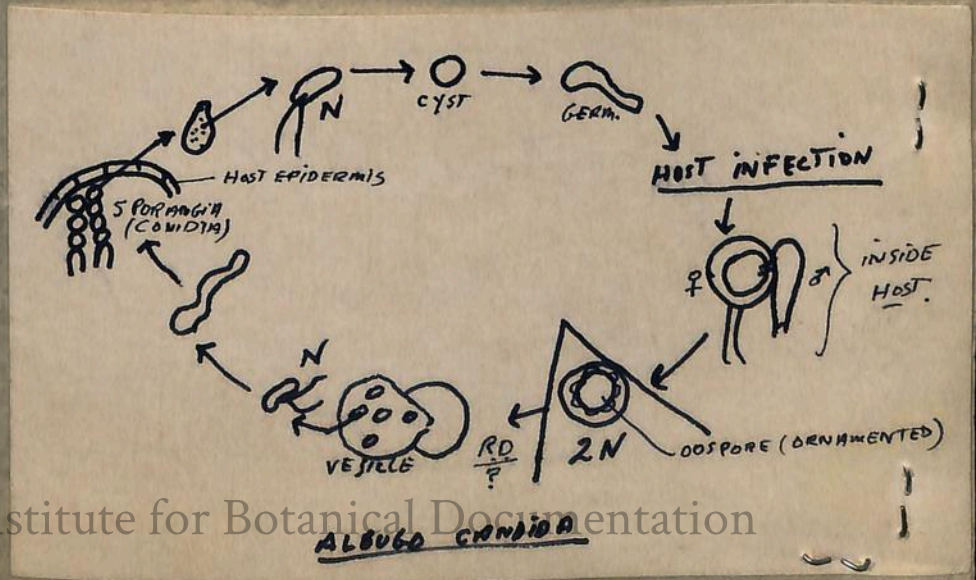

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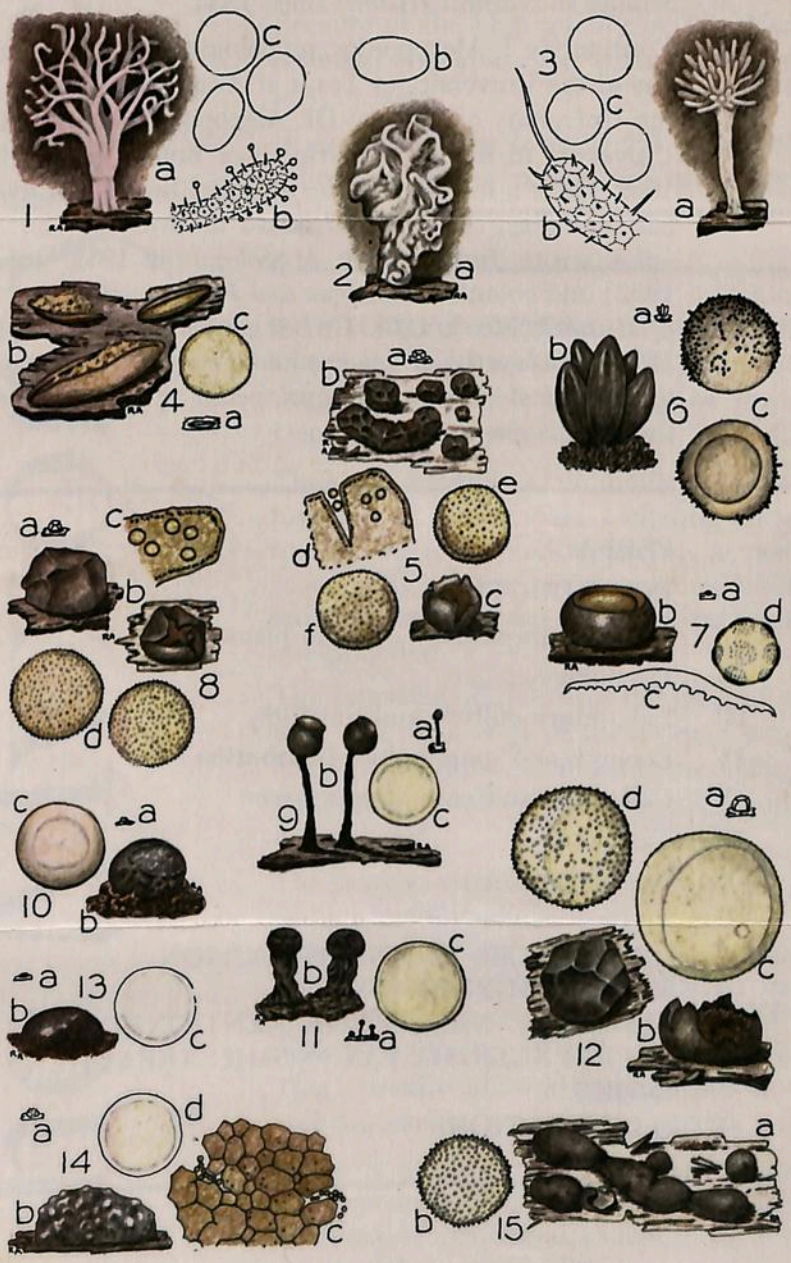
Plate I



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The Authors

George W. Martin, professor emeritus of botany at The University of Iowa, holds a Litt. B., M.S. and honorary D.Sc. from Rutgers University, and a Ph.D. from the University of Chicago. A student of the myxomycetes for more than 35 years, Dr. Martin, with T. H. Macbride, set standards in the botanical field in 1934 with *The Myxomycetes.* In 1949, his *Myxomycetes of North America* was written for the New York Botanical Garden's *North American Flora.* Dr. Martin served as editor-in-chief of *Mycologia* from 1951 until 1957, and as head of The University of Iowa's Department of Botany from 1953 until 1955. He has edited that University's *Studies in Natural History* since 1934.

Constantine J. Alexopoulos, mycologist and professor of botany at the University of Texas at Austin, holds a Ph.D. from the University of Illinois. Dr. Alexopoulos was head of The University of Iowa's Department of Botany from 1956 until 1962. He is a member of the editorial board of *Lloydia* and has served on the editorial board of *Brittonia.* Dr. Alexopoulos wrote *Introductory Mycology* in 1952 (revised in 1962) and co-authored *Algae and Fungi* in 1967 and *Biology of Myxomycetes* in 1968. He has contributed to the McGraw-Hill *Encyclopedia of Science and Technology, Encyclopedia of Biological Sciences, Encyclopedia of Biochemistry,* and the *Encyclopedia Britannica.*

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THE UNIVERSITY OF IOWA, IOWA CITY, IOWA 52240

The Myxomycetes

The University of Iowa Press announces the publication of a book we feel will be of interest to you.

The Myxomycetes is a treatment, world-wide in scope, of all species of slime molds reported up to 1967. The book is the first world-wide treatment of the group since 1925.

Because of the high quality of *The Myxomycetes,* we have included a sample color plate and legend as it will appear in your copy.

If you decide the book would be a useful addition to your collection, please return the order form in the enclosed postage-paid envelope and your order will be filled promptly.

THE MYXOMYCETES. G. W. Martin and C. J. Alexopoulos. Illustrated by Ruth McVaugh Allen. 41 color plates illustrating 364 species. University of Iowa Press, Iowa City. December 31, 1969. 576 pages. 7x10. Cloth. $30.00.

The study presents a comprehensive treatment of the Myxomycetes, or slime molds, including all species described up to 1967. As complete a synonymy as possible is given for all recognized species, and numerous additional names which have appeared in the literature are cited in the text and in an appendix.

The introduction discusses the general morphology, life history, and physiology of these organisms, with directions for laboratory culture. Comments on ecology and geographical distribution, and on the collection and care of specimens are included.

The book's systematic portion attempts to follow a natural system for all taxa down to genera. Within the genera, the recognized species are arranged in alphabetical sequence. Each formal description is followed by indication of type locality, habitat and distribution, a list of selected illustrations, and citation of exsiccati which have been examined. This is usually followed by comments on the species involved, and comparison with related species.

There is a bibliography for the introduction, and one for the taxonomic portion. The monograph has a complete index to all names mentioned, except those in the appendix, which are in alphabetical order.

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Plate I

1 *Ceratiomyxa fruticulosa* (Müll.) Macbr.
- a Stalked sporophore, from large group, × 20
- b Tip of branch, × 100
- c Spore, × 1000

2 *Ceratiomyxa morchella* Welden
- a Fructification, × 15
- b Spore, × 1000

3 *Ceratiomyxa sphaerosperma* Boedijn
- a Fructification, × 15
- b Tip of branch, after Boedijn, × 100
- c Spore, × 1000

4 *Licea biforis* Morgan
- a Sporangium, × 5
- b Cluster of three sporangia, × 50
- c Spore, × 1000

5 *Licea castanea* G. Lister
- a Sporangium, × 5
- b Cluster of sporangia, × 20
- c Open sporangium, × 40
- d Sporangial lobes, × 100
- e/f Spores, × 1000

6 *Licea fimicola* Dearn. & Bisby
- a Cluster of sporangia, × 5
- b Cluster of sporangia, × 50
- c Spores, × 1000

7 *Licea kleistobolus* Martin
- a Sporangium, × 5
- b Sporangium, × 100
- c Diagram of lid in section, × 300
- d Spore, × 1000

8 *Licea minima* Fries
- a Sporangium, × 5
- b Two sporangia, × 40
- c Spores, × 1000

9 *Licea operculata* (Wingate) Martin
- a Sporangium, × 10
- b Two sporangia, × 25
- c Spore, × 1000

10 *Licea parasitica* (Zukal) Martin
- a Sporangium, × 5
- b Sporangium, × 50
- c Spore, × 1000

11 *Licea pedicellata* (H. C. Gilbert) H. C. Gilbert
- a Sporangium, × 5
- b Two sporangia, × 50
- c Spore, × 1000

12 *Licea pusilla* Schrad.
- a Sporangium, × 5
- b Two sporangia, × 25
- c Spore in optical section, × 1000
- d Spore from different fruiting, surface view, × 1000

13 *Licea tenera* Jahn
- a Sporangium, × 5
- b Sporangium, × 50
- c Spore, × 1000

14 *Licea tuberculata* Martin
- a Sporangium, × 5
- b Sporangium, × 50
- c Portion of wall, by transmitted light, flattened and showing plates, × 250
- d Spore, × 1000

15 *Licea variabilis* Schrad.
- a Sporangia and plasmodiocarp formed by union of sporangia, × 5
- b Spore, × 1000

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CAROLINA TIPS

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BURLINGTON, NORTH CAROLINA 27215 GLADSTONE, OREGON 97027

SLIME MOLD LIFE CYCLE

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The slime molds serve very nicely to introduce the Protista as they have both plant and animal characteristics and the life cycle (Fig. 1) can be easily demonstrated in the laboratory.

PLASMODIUM

The plasmodium is the "slime" stage of the life cycle. It can be found on moist logs in woods or on the grass in your yard, as well as many other moist spots. It has even been found growing on a basement wall. Plasmodia may be of several different colors—red, orange, black, white—but the most common color is probably yellow as in *Physarum polycephalum*.

When the plasmodium is found in the field it may be carefully transferred to a moist chamber and cultured in the laboratory. A large transparent moist chamber is ideal for student observation of a large mass of plasmodium over a period of time. When not being viewed, the chamber should be darkened to discourage fruiting.

Each student or group of students should be given a small portion of the plasmodium to examine under the stereomicroscope and to carry out experiments concerning plasmodial response to various environmental factors. Small plastic petri dishes work nicely for individual experimentation.

Place filter paper in the bottom of the dish and saturate with water. Lift a small portion (about 2 mm²) of the large demonstration plasmodium onto the moist paper in the dish. In a few hours the plasmodium will become active and can be fed by placing one or two oat flakes (old fashioned oatmeal) onto the plasmodial fan. When working with *P. polycephalum*, do not expose to bright light as fruiting may take place. Plasmodia not containing yellow pigments may not be as sensitive to the light (Gray, 1938).

When fruiting occurs in *P. polycephalum*, the fruiting bodies are stipitate sporangia and can be easily studied using a 10X stereomicroscope or a hand lens if no scope is available. Students should be encouraged to ask questions and find their own answers experimentally, if practical.

SCLEROTIUM

After the plasmodium has grown in the moist chamber for a while, it is possible to sclerotize a portion of it by drying slowly. The dried sclerotium can be stored for a year or longer in the refrigerator and can be reactivated by placing it in a moist chamber and by feeding.

FRUITING BODIES

The plasmodium will, under certain poorly defined conditions, clump-up and form one of several types of fruiting bodies. The stipitate

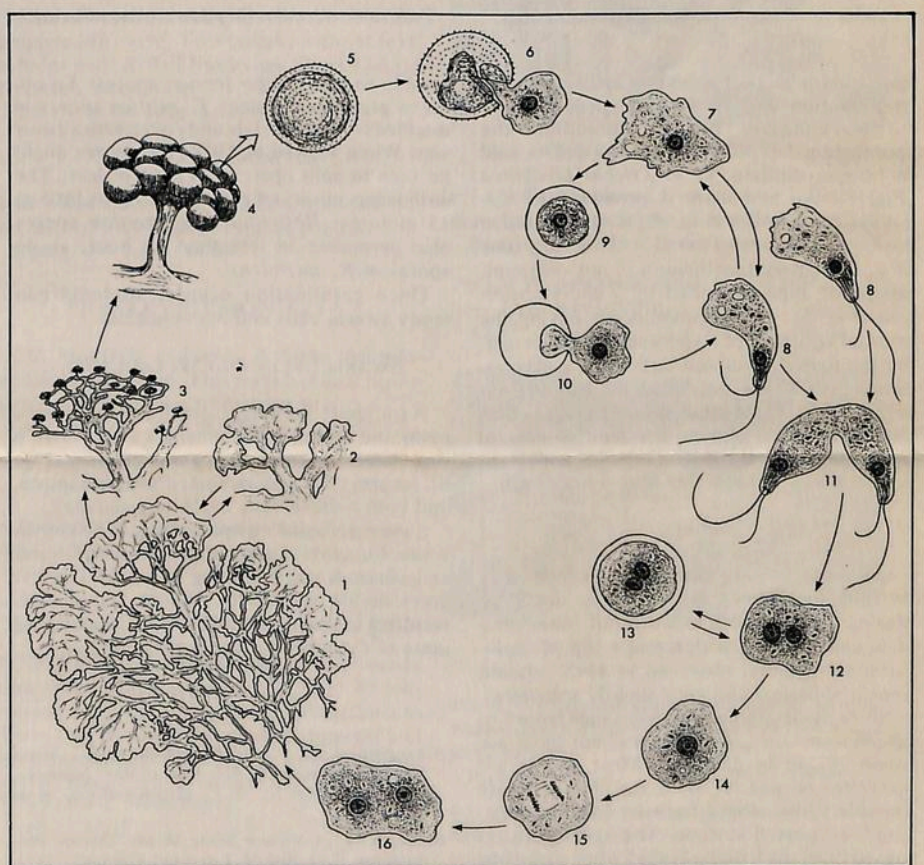

FIGURE 1 Physarum life cycle. 1. Plasmodium. 2. Sclerotium. 3. Sporangia. 4. Sporangium. 5. Spore. 6. Germination. 7. Amoeboid swarm cell. 8. Rotating, flagellated swarm cell. 9. Microcyst. 10. Emergence. 11. Posterior fusion of gametes. 12. Plasmogamy. 13. Binucleate microcyst. 14. Nuclear fusion. 15. Division. 16. Young plasmodium. Reproduced from Bioreview® Sheet 42-8314 Physarum Life Cycle.

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(51 GENERA)
[197 GENERA IN SINGER 1962]

KEY TO THE GENERA OF THE AGARICACEAE OF MICHIGAN

Based on Kauffman. 1918 (2 vols.) (16 FAM.)
(a la Fries)

(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 Agaries

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. . . . . .Heliomyces
16. Trama fleshy-membranous; pileus usually small, not woody. . . . . .Marasmius
17. Pileus woody or corky . . . . . Lenzites
17. Pileus fleshy-leathery. 18

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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 globose 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 . . . . . Crepidotue
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 alutaceus 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 . . .Nolanea

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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 delinquescing into a black mass when mature . . . . . .Coprinus
43. Gills not delinquescing 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

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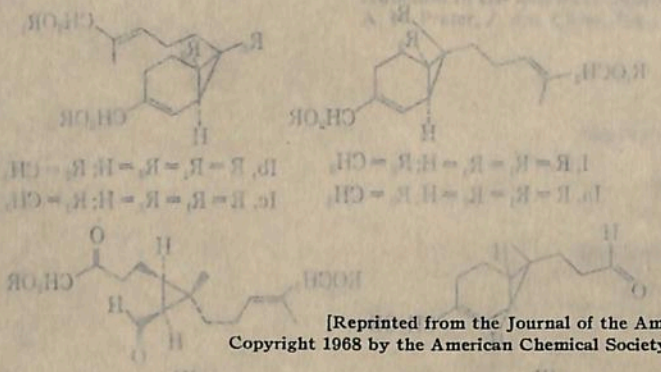

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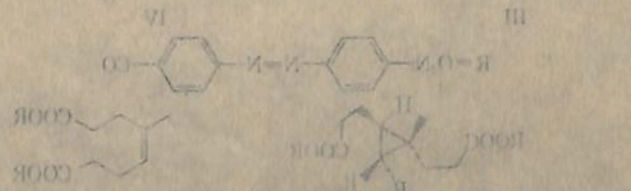

The Structure of Sirenin[1]

Sir:

Sirenin is a sperm attractant, active at concentrations of 10^{-10} *M*, produced by the female gametes of the water mold *Allomyces*. The production, isolation, and characterization of sirenin and its 4-(4-nitrophenylazo)-benzoate (NABS) esters have been described.[2] We now present the complete structure of sirenin (I) which becomes the first structurally characterized plant sex hormone.

Bis-NABS-sirenin (II) had nmr signals[3] at 0.95 (3 H, s, tertiary CH_3), 1.78 (3 H, broadened s, C=CCH_3), 4.75 (4 H, s, two NABS-OCH_2C(C)=C), 5.59 (1 H, t, J = 7 Hz, C=$CHCH_2$). Partial ozonolysis at −60° gave three products, purified by tlc on silica gel. One was the NABS ester of hydroxyacetone, identical with an authentic sample.

A second product (III), mol wt 447 (mass spectroscopy), retained nmr signals attributed to the tertiary methyl, one NABS-OCH_2C(C)=C, and the vinyl proton at 5.98. New signals appeared at 9.79 (1 H, t, J = 1.45 Hz) and 2.55 (2 H, "t"). The 2.55 "triplet" was composed of two overlapping doublets, J = 6.90 and 7.85 Hz. Each peak of the "triplet" was further split into a doublet with coupling constant corresponding to the 9.79 peak which collapsed to a singlet upon irradiating the signal at 9.79. This product thus results from loss of hydroxyacetone-NABS ester from bis-NABS-sirenin with concomitant formation of an aldehyde, ir[4] peak at 2736 and enhanced absorption at 1722. A propionaldehyde residue attached to an asymmetric center would make the adjacent methylene protons nonequivalent[5] and result in unequal coupling to the methylene group α to the carbonyl. A 5-hydroxy-4-methyl-3-pentenyl moiety in sirenin accounts for these observations.

The third product (IV) retained nmr absorptions characteristic of the pentenyl double bond in II. New signals at 2.53 (2 H, t, J = 6.35 and 6.60 Hz for low- and high-field portions) and 4.95 (2 H, s, identical in chemical shift with NABS-hydroxyacetone) reflected the

(1) Financial support in part by the National Science Foundation is gratefully acknowledged.

(2) L. Machlis, W. H. Nutting, M. W. Williams, and H. Rapoport, *Biochemistry*, 5, 2147 (1966).

(3) All nmr data are δ values, recorded at 60 and 100 MHz in $CDCl_3$ with internal TMS (δ 0) unless otherwise stated.

(4) All ir spectra were taken in $CHCl_3$ unless otherwise stated and are given in reciprocal centimeters, cm^{-1}.

(5) See M. L. Martin and G. J. Martin, *Bull. Soc. Chim. France*, 2117 (1966). Dimethyl (+)-*trans*-homocaronate exhibits a multiplet for its methylene group: L. R. Subramanian and G. S. K. Rao, *Tetrahedron*, 23, 4167 (1967).

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A RE-EXAMINATION OF THE FLORIDEAN THEORY: ANNOTATED BIBLIOGRAPHY*

William C. Denison
29 August 1961

I. OCCURRENCE OF MITOCHONDRIA IN LOWER PLANTS*

Major Group	Genus	Mitochondria?	Reference
BACTERIA	Spirillum	absent	Chapman + Kroll 1957
ACTINOMYCETES	Streptomyces	absent	Glauert + Hopwood 1959
BLUE GREEN ALGAE		absent	Ris * Singh 1961
RED ALGAE	Porphyridium	absent	Brody + Vatter 1959
	Griffithsia	absent	Meyers + Preston 1956
FUNGI			
Phycomycetes	Allomyces	present	Blondel + Turian 1960
Ascomycetes	Aspergillus	present	Tsuda 1955
	Penicillium	present	Tsuda 1956
	Neurospora	present	Shatkin 1959, Zalokar 1961
	Saccharomyces	present	Hashimoto, Conti, +Naylor 1959, Vitols, North, + Linnane 1961
	Coccidioides	present	Breslau, Hensley, + Erikson 1961
Basidiomycetes	Polystictus	present	Girbardt 1958
YELLOW GREEN ALGAE	Vaucheria	present	Greenwood, Manton, * Clarke 1957
BROWN ALGAE	Scytosiphon	present	Manton 1957
SLIME MOLDS	Badhamia	probably present	Niklowitz 1957

II. RECENT STUDIES OF SEPTAL PORES OR PIT CONNECTIONS

Major Group	Genus	Reference
FUNGI		
Ascomycetes	Neurospora	Shatkin 1959
Basidiomycetes	Polystictus	Girbardt 1958
RED ALGAE	Laurencia	Meyers, Preston, + Ripley 1959
	Rhodymenia	" " " "
	Compsopogon	Fan 1959
		Dawes, Scott, + Bowler 1960

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*For a general discussion of mitochondria in plants see Sun 1960.

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CELL WALL MATERIALS IN LOWER PLANTS

Major Group	Genus	Cellulose?	Chitin?	Reference
FUNGI				
Phycomycetes	Achlya	present	none	Frey 1950
	Saprolegnia	present	none	Frey 1950
	Pythium	present	none	Frey 1950
	Phytophthora	present	none	Frey 1950
	Lagenidium	present	none	Frey 1950
	Allomyces	absent	present	Frey 1950, Aronson & Preston 1960
	Blastocladiella	none	present	Frey 1950
	Monoblepharella	none	present	Aronson & Preston 1960
	Gonopodya	none	present	"
	Chytridium	none	present	"
	Rhizophydium	none	present	"
	Mucor	none	present	Frey 1950
	Phycomyces	none	present	Frey 1950, Middlebrook & Preston 1952
	Rhizopus	none	present	Frey 1950
Ascomycetes	Aspergillus	none	present	Frey 1950
	Nectria	none	present	Frey 1950
	Sclerotinia	none	present	Frey 1950
	Neurospora	none	present	Shatkin 1959
Basidiomycetes	Coprinus	none	present	Frey 1950
	Hypholoma	none	present	Frey 1950
RED ALGAE	Ptilota	present	none	Cronshaw, Meyers & Preston 1958
	Griffithsia	present	none	"
	Rhodymenia	present	none	"
	Porphyra	present	none	"
GREEN ALGAE	Cladophora	present	none	"
	Ulva	present	none	"
BROWN ALGAE	Fucus	present	none	"
	Laminaria	present	none	"
ACTINOMYCETES	Streptomyces	none	none	Cummins & Harris 1958
	Actinomyces	none	none	"
BACTERIA	Propionibacterium	none	none	"

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III. CELL WALL MATERIALS IN LOWER PLANTS

Major Group	Genus	Cellulose?	Chitin?	Reference
FUNGI				
Phycomycetes	Achlya	present	none	Frey 1950
	Saprolegnia	present	none	Frey 1950
	Pythium	present	none	Frey 1950
	Phytophthora	present	none	Frey 1950
	Lagenidium	present	none	Frey 1950
	Allomyces	absent	present	Frey 1950, Aronson + Preston 1960
	Blastocladiella	none	present	Frey 1950
	Monoblepharella	none	present	Aronson + Preston 1960
	Gonopodya	none	present	" "
	Chytridium	none	present	" "
	Rhizophydium	none	present	" "
	Mucor	none	present	Frey 1950
	Phycomyces	none	present	Frey 1950, Middlebrook + Preston 1952
	Rhizopus	none	present	Frey 1950
Ascomycetes	Aspergillus	none	present	Frey 1950
	Nectria	none	present	Frey 1950
	Sclerotinia	none	present	Frey 1950
	Neurospora	none	present	Shatkin 1959
Basidiomycetes	Coprinus	none	present	Frey 1950
	Hypholoma	none	present	Frey 1950
RED ALGAE	Ptilota	present	none	Cronshaw, Meyers, + Preston 1958
	Griffithsia	present	none	" "
	Rhodymenia	present	none	" "
	Porphyra	present	none	" "
GREEN ALGAE	Cladophora	present	none	" "
	Ulva	present	none	" "
BROWN ALGAE	Fucus	present	none	" "
	Laminaria	present	none	" "
ACTINOMYCETES	Streptomyces	none	none	Cummins + Harris 1958
	Actinomyces	none	none	" "
BACTERIA	Propionibacterium	none	none	" "

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INDUCING SCLEROTIZATION IN PHYSARUM POLYCEPHALUM

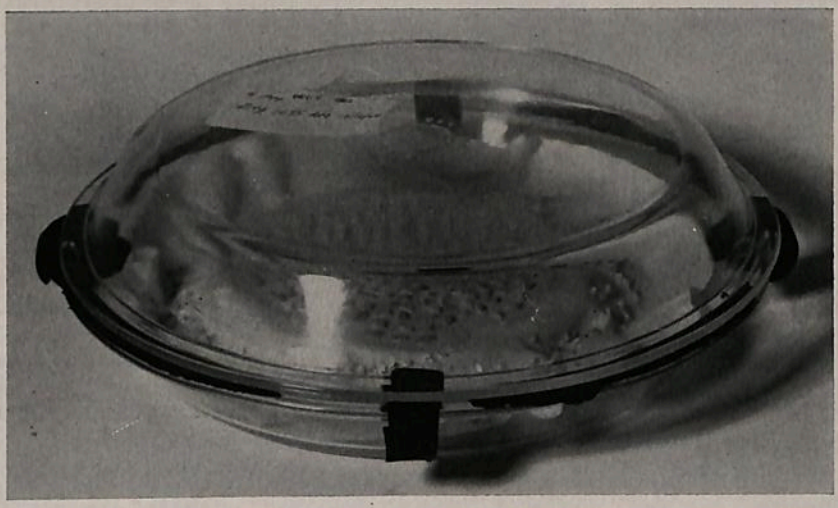

Fig. 1. Culture chamber prepared for gradual drying of *Physarum polycephalum* plasmodium with rubber separators in place.

A high-yield method for producing sclerotia with rapid transforming capability (within 1½ to 4 hours at 80°F.) has been developed, which represents a valuable contribution to scientific know-how. In line with Turtox policy of publishing useful information and methods developed by its own staff members, we are happy to share the details of this technique with the many biologists and biology teachers who refer to *Turtox Service Leaflets*. Those who may wish to develop their own sclerotia will find the procedure quite simple; our results are easily reproducible with Turtox strain of *Physarum polycephalum*.

The method described below is based entirely on original work by a member of our staff. Available literature dealing with the subject failed to supply any new information that could be used in developing this procedure. When tried out in our laboratory, it was found that most of the methods discussed in the rather scant literature had two things in common: the forming of the sclerotium in the absence of food and a low yield of viable sclerotia (usually less than 30%) with poor emergence capability (by our standards). In this method, the sclerotium is formed in the presence of excess food.

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SPORE WALL FORMATION IN THE MYXOMYCETE PHYSARELLA OBLONGA[1]

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ABSTRACT

The spore wall of the myxomycete, *Physarella oblonga*, requires only 1 hr to develop. The spore wall surface ornamentations, the warts, are secreted first, followed by an outer electron-dense layer and an inner electron-lucent layer. A measurement analysis was conducted to determine if vesicles were involved in wall elaboration. By comparing spore plasmalemma length to the number of fused vesicles, a semi-quantitative analysis can be obtained. The determination reveals that very few vesicles are associated with wart and outer wall development. The greatest number of vesicles are associated with inner wall secretion. Plasmalemmasomes are most numerous during outer wall formation and Golgi bodies are observed only during inner wall elaboration. Other organelles do not seem directly involved in wall secretion.

ULTRASTRUCTURAL INVESTIGATIONS of myxomycete sporogenesis are numerous, but few have dealt with spore wall formation. The mature wall is composed of two layers, an outer electron-dense wall and an inner electron-lucent wall. The surface ornamentations are formed first (Aldrich, 1974; Mims, 1972; Schuster, 1964). Mims (1972) noted two types of surface structures in *Arcyria cinerea*, projections and warts. Aldrich (1974) concluded that the spines of *Physarum flavicomum* and *Didymium iridis* formed on plasmalemma evaginations and were secreted into cleavage furrows by vesicles containing polysaccharides.

To my knowledge outer wall formation has not previously been reported. The secretion of the inner wall has been described only by Mims (1972), who showed that the inner wall formed after the outer wall and who thought it was secreted by vesicles. The vesicles were associated with short cisternal elements prior to wall secretion, were numerous during inner wall development, and decreased in number as the wall was produced.

I will describe spore wall formation in the myxomycete *Physarella oblonga* and describe a technique to determine if vesicles were involved in the process. Evidence is also presented for the involvement of plasmalemmasomes in secretion of the outer wall.

MATERIALS AND METHODS—*Physarella oblonga* (Berk. and Curt.) Morgan was cultured and prepared for microscopy as described by Bechtel (1974) and Bechtel and Horner (1975). Vegetative plasmodia were maintained in the dark on sterile 2% water agar and rolled oats. Plasmodia were induced to fruit by transferring 1-cm squares of a plasmodium to 2% plain agar and allowed to starve for several days. The cultures were then illuminated and sporangia formed 2–4 days later.

Sporangia were fixed in a combination of 1.5% paraformaldehyde and 1.5% glutaraldehyde in 0.05 M phosphate buffer at 22 C for 2 hr, washed in buffer for 1 hr and post-fixed in buffered 1% osmium tetroxide for 1–2 hr at 22 C. Sporangia were washed in water and stained in 0.5% aqueous uranyl acetate overnight. Following dehydration in a graded acetone series, samples were embedded in Epon 812 (Luft, 1961). Thin sections were stained in 2% aqueous uranyl acetate (Watson, 1958) and lead citrate (Reynolds, 1963), and examined on either a Hitachi HS-8, HU-11C, or Philips EM 201 electron microscope. Plasmalemma length was measured on electron micrographs with a map distance measurer and converted into micrometers. Organelle terminology was based on the descriptions of Rhodin (1974) while plasmalemmasomes were based on the definition by Marchant and Robards (1968).

RESULTS—Sporogenesis in *P. oblonga*, from inception to completion of the spore wall, required about 11 hr. The entire process was divided into 16 stages (A–P) based on the time elapsed, sporangial color and shape, the timing of calcium excretion and various other processes occurring within a developing sporangium (Bechtel, 1974; Bechtel and Horner, 1975). A summary of sporulation is shown in Table 1. Secretion of the spore wall occurred during stages K–N,

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Portions of this paper were conducted at Iowa State University, Ames.

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