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

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

## CLASSES OF FUNGI

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

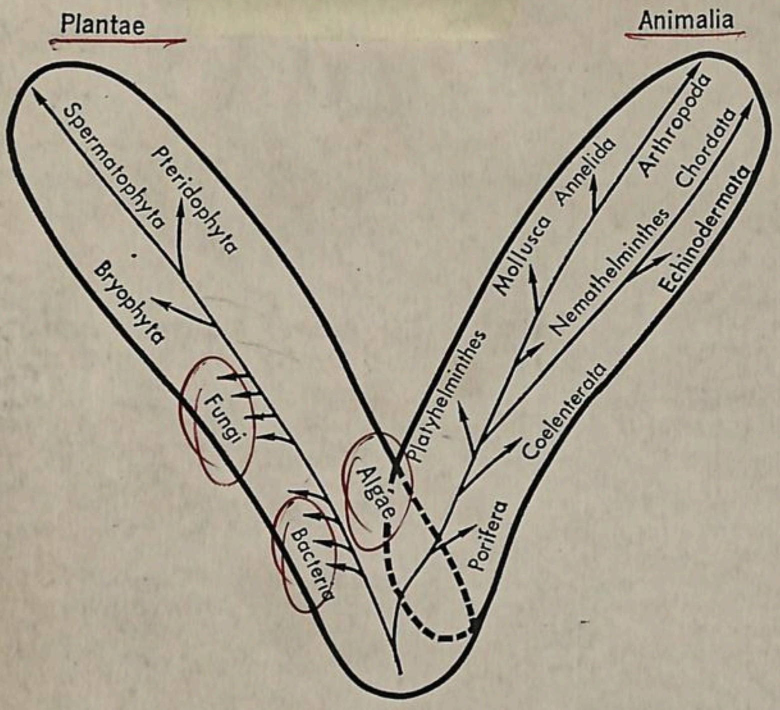

Fig. 1. Simple plant/animal two-kingdom evolutionary scheme; reproduced with kind permission from *Science* 163: 150-160. 1969 (fig. 1, R. H. Whittaker). Copyright 1969 by the American Association for the Advancement of Science.

broad evolutionary relationships we can discern among the phyla to allow grouping of these into our kingdoms.

The first kingdoms incorporated into the formal classifications of Linnaeus (1735) and others were those two groups of organisms that appeared obviously distinct to the early naturalists, the plants and animals. Such a two-kingdom system still seemed obvious two hundred years later at the beginning of the present century, the rooted habit and photosynthesis of plants being contrasted with the motility and food-ingestion of animals. Fungi, though non-photosynthetic, were thought of as rooted and could be

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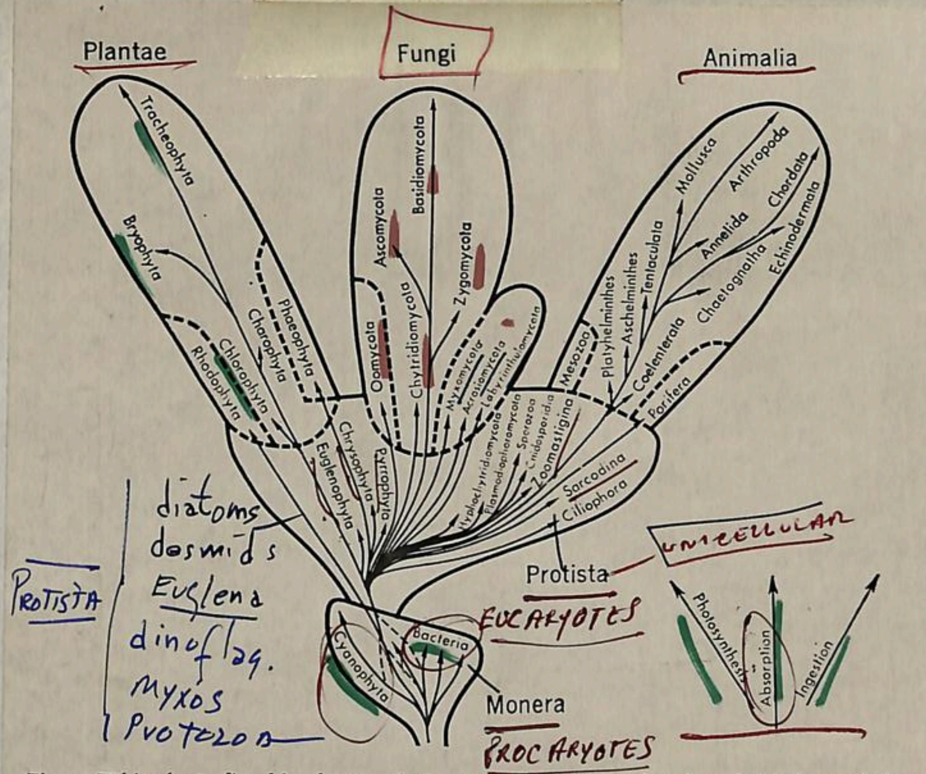


Fig. 3. Whittaker's five-kingdom evolutionary scheme; reproduced with kind permission from *Science* 163: 150-160. 1969 (fig. 3 R. H. Whittaker). Copyright 1969 by the American Association for the Advancement of Science.

strong affinities with Phaeophyta (Plantae) and Oomycota (Fungi) and no obvious affinities with Ciliophora or Sporozoa.

Secondly, higher kingdoms in both schemes are polyphyletic (on present ideas) to a degree that is profoundly disturbing to the ideal of a natural classification. Drawing the protistan line at the unicell/multicell boundary forces Whittaker to include Rhodophyta and Phaeophyta in Plantae with the green plants; Oomycota, Myxomycota, Acrasiomycota and Labyrinthulomycota with the "true" Fungi; and Mesozoa and Porifera with the Metazoa in Animalia. As Whittaker himself says, his three kingdoms of higher organisms appear less as kingdoms than as alliances of separate

Taxon 23: 261-270. 1974. G.F. Leedale.

Marcel V. LOCQUIN

# SYNOPSIS GENERALIS FUNGORUM

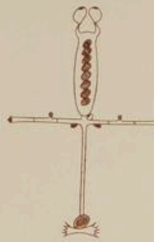
excerpta ex libro
**DE TAXIA FUNGORUM**

*Subdivisiones, Classes, Ordines et Familiae ita disposita 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 Diachaeales | *Lamprodermaceae, Macbrideolaceae, Diachaeaceae.* |
| *PHYSAROMYCETIDAE* | |
| 7 Physarales | *Fuligaceae, Badhamiaceae, Heterobadhamiaceae, Diperidiaceae, Triperidiaceae, Myxorostafinskiaceae, Physaraceae, Trichamphoraceae, 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 | *Tretopileaceae, Asterococcaceae, Bartonellaceae.* |
| 2 Krassilnikoviales | *Krassilnikoviaceae.* |
| 3 Pasteuriales | *Pasteuriaceae.* |
| 4 Cavosteliales | *Cavosteliaceae.* |
| 5 Endemosarcales | *Endemosarcaceae.* |
| 6 Acytosteliales | *Acytosteliaceae.* |

Ib (Premycotina) Rickettsiales

## II. ACTINOMYCOTINA

### 4. BACTERIOPHAGOMYCETES

| | |
|---|---|
| 1 Caulobacteriales | *Gallionellaceae, Caulobacteriaceae.* |
| 2 Bacteriophagales | *Bacteriophagaceae* |
| 3 Phytobacteriophagales | *Phytobacteriophagaceae.* |
| 4 Enzymophagales | *Enzymophagaceae.* |
| 5 Micromonosporales | *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, Phagomyxaceae.* |
| 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, Myococcaceae, Siferiaceae, Nevskiaceae.* |
| 4 Actinomycetales | *Actinobacteriaceae, Erisipelotrichaceae, 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, Megachytriaceae.* |

### 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. Stauratheleaceae, Vialaeasceae.* |
| 9 Xylariales | *Neurosporaceae, Xylariaceae, Sarcostromellaceae, Fassariaceae.* |
| 10 Coniochaetales | *Coniochaetaceae.* |
| 11 Helotiales | *Ascocorticiaceae, Helotiaceae, Hyaloscyphaceae, Dermataceae, Hemiphacidiaceae, Orbiliaceae, Cyttariaceae, Sclerotiniaceae, Bulgariaceae, 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, Parodiellaceae, Paradiopsidaceae, Phaeosaccardinulaceae.* |
| 22 Sphaerothecales | *Sphaerothecaceae.* |
| *PEZIZOMYCETIDAE* | |
| 23 Pezizales | *Ascobolaceae, Pyronemaceae, Pezizaceae, [illegible]* |
| 24 Morchellales | *Helvellaceae, Morchellaceae.* |
| 25 Sarcoscyphales | *Sarcoscyphaceae.* |
| 26 Tuberales | *Hydnotryaceae, Geneaceae, Tuberaceae.* |
| *ASCOMYCETIDAE* | |
| 27 Lecanorales | *Lecanoraceae, Acaroporaceae, Pertusariaceae, Umbilicariaceae, Lecideaceae, Cladoniaceae, Teloschistaceae, 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,* |
| 33 Hysteriales | *Hysteriaceae, Arthoniaceae, Roccellaceae.* |
| 34 Dothiorales | *Botryosphaeriaceae, Dothioraceae, Parmulariaceae.* |
| 35 Uleomycetales | *Uleomycetaceae, Atichiaceae, Piedraiaceae.* |
| 36 Capnodiales | *Hemisphaeriaceae, Polystomellaceae, Stigmateaceae, Chaetothyriaceae, Capnodiaceae, Schizothyriaceae, Micropeltaceae, Trichothyriaceae, Microthyriaceae, Eoceramiaceae, Trichopeltinaceae, Leptopeltaceae, Entopeltaceae, Dictyopeltinaceae, Perisporiopsidaceae, Englerulaceae, Asterinaceae.* |
| *MAZAEDIOMYCETIDAE* | |
| 37 Caliciales | *Cypheliaceae, Sphaerophoraceae, Caliciaceae, 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, Anixiaceae, Coniochaetidiaceae, Thermoascaceae, Thielaviascaceae, Eurotiaceae, Cephalothecaceae, Amorphothecaceae, Melanosporaceae, Backusiaceae, Eremomycetaceae, Eoterfeziaceae, Xeromycetaceae, Xylogonaceae, Hexagonellaceae, Preussiaceae.* |
| 45 Elaphomycetales | *Terfeziaceae, Elaphomycetaceae.* |
| 46 Mesophelliales | *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, Schizzosaccharomycetaceae, Nematosporaceae.* |
| 3 Taphrinales | *Protomycetaceae, Taphrinaceae, Conidiascaceae,* |
| 4 Eccrinales | *Eccrinaceae, Caryophanaceae, Asellariaceae.* |
| 5 Harpellales | *Harpellaceae, Genistellaceae.* |
| 6 Kickxellales | *Kickxellaceae, Dimargaritaceae, Spinaliaceae.* |
| 7 Palavasciales | *Palavasciaceae, Parataeniellaceae.* |
| 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 Populariales | *Populariaceae. & autres familles de formes.* |
| 18 Cacumisporiales | *Cacumisporiaceae. & autres familles de formes.* |
| 19 Anellophorales | *Anellophoraceae & autres familles 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, Gomphaceae, Clavariaceae, Pterulaceae, Sparassidaceae Bondarzewiaceae, Hybogasteraceae, Hericiaceae, Auriscalpiaceae.* |
| 2 Poriales | *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, Gomphidiaceae, Bounelliulaceae.* |
| 5 Gautierales | *Gautieraceae, Rhizopogonaceae.* |
| 6 Agaricales | *Hygrophoraceae, Lentinellaceae, Lentinaceae, Tricholomaceae, Lyophyllaceae, Marasmiellaceae, Mycenaceae, Pleurotellaceae, Panellaceae, Phaeomarasmiaceae, Conocybaceae, Lachnellaceae, Pleurotaceae, Inocybaceae, Melanophyllaceae, Cystodermaceae, Lepiotophyllaceae, Entolomaceae, Laccariaceae, Leucopaxillaceae, Leucocortinariaceae, Cortinariaceae, Crepidotaceae, Lacrimariaceae, Rhodogasteraceae, Thaxterogasteraceae, Corrugariaceae, Agaricaceae, Secotiaceae, Strophariaceae, Weraroaceae, Agrocybaceae, Bolbitiaceae, Setchelliogasteraceae, Psathyrellaceae, Panaeolinaceae, Coprinaceae, Montagneaceae, Podaxaceae,* |
| 8 Amanitales | *Amanitaceae, Amidellaceae, Brouniellaceae, 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, Battarreaceae, 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 | *Dimorphimycetaceae, Rickiaceae, Peyritschiellaceae, Enarthromycetaceae, Monoicomycetaceae, Haplomycetaceae.* |
| 3 Laboulbeniomycetales | *Herpomycetaceae, Stigmatomycetaceae, Idiomycetaceae, Teratomycetaceae, Corethromycetaceae, Laboulbeniaceae, Rhacomycetaceae, Clematomycetaceae, Compromycetaceae, Chaetomycetaceae, Ecteinomycetaceae, Misgomycetaceae.* |

### 13. FUTUROMYCETES

| | |
|---|---|
| Amorphomycetales | *Amorphomycetaceae.* |

*Principe de l'idoneité la meilleure. F. GONSETH.*
*Ontogenèse récapitulant la phylogenèse. CUVIER.*
*Evolution hélicocyclique. GAUSSEN, MANGENOT, LOCQUIN.*
*Onde transsociée. L. de BROGLIE, emend. LOCQUIN.*
*Probabilité de vie. LOCQUIN.*
*Parasite postérieur au parasité. LOCQUIN.*

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

*Il a été publié dans la Revue mycologique* **OBSERVATIONES ET DISPUTATIONES MYCOLOGICAE.**

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*Edité avec le concours de l'UAE service* ONDEDITION, BP 229.16, 75765 Paris Cedex 16 France

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

②

↑ Era — Period

Appalachian Rev.

Mesozoic (Reptiles)
- 225 Triassic — Gymnosperms dominant — First Dinosaurs (Pterosaurs)
- 165 Jurassic — Dicots > Cycads & Conifers common
- 135 Cretaceous — 1st Monocots — Gymnos decline } Dinosaurs at peak

Laramide Rev. (Rockies, Andes, Alps, Himalayas)

— Kainos = new

Cenozoic (Mammals)

GR. palaios = ancient — kainos = recent

- 75 Paleocene
- 65 Eocene — eos = dawn — Tertiary
- 45 Oligocene = few — Monocots & other Flowering Plants
- 35 Miocene — meion = less
- 20 Pliocene = more — Man emerges
- Pleistocene — pleistos = much — Rancho La Brea Asphalt Pits Sabe-toothed tiger — 4 ice ages (extinction of plants & animals) (±20,000 BC last stage)
- Recent — Rise of Herbaceous Plants, Decline of Woody "

Quarternary

( Grand Canyon — Pre-Cambrian to Present )

INTERPRETATION

Fossil Record now carefully correlated & interpreted but older ideas rather fantastic: "Freaks of Nature" — "Devices of the Devil" etc.

(=b) 1726 Johann Schleuchzer. "Homo Diluvii Testis" ie Fossils attributed to Noah's Flood — Skeletons of Salamanders from Oligocene Swiss Lakes, mistaken for human remains.

* 1726 Johannes Beringer. "Lithographia Wirceburgensis" Ardent fossil collector — Students played hoax by carving figures in rock which he then accepted as bona fide fossils!! Finally his own name was inscribed in rock to simulate a fossil.

| Eichler (1883) | Bold (1956) | Common Name | Numbers |
|---|---|---|---|
| A. Cryptogamae<br>Thallophyta<br>Fungi | Schizomycota | Bacteria | 1450 |
| | Myxomycota | Slime Molds | 450 |
| | Phycomycota | | |
| | Ascomycota | Fungi | 75000 |
| | Basidiomycota | | |
| Algae | Cyanophyta | Blue-green Algae | 1400 |
| | Rhodophyta | Red Algae | 2500 |
| | Chrysophyta | Golden-brown Algae | 6700 |
| | Pyrrhophyta | Dinoflagellates | |
| | Phaeophyta | Brown Algae | 1000 |
| | Euglenophyta | Euglenoids | 350 |
| | Charophyta | Green Algae | 5700 |
| | Chlorophyta | | |
| Bryophyta<br>Hepaticae | Hepatophyta | Mosses and Liverworts | 23000 |
| Musci | Bryophyta | | |
| Pteridophyta<br>Lycopodineae<br>Equisetineae<br>Filicinae | Psilophyta | Psilophytes | 30 |
| | Microphyllophyta | Lycopods | 1200 |
| | Arthrophyta | Horsetails | 40 |
| | Pterophyta | Ferns | 9000 |
| B. Phanerogamae<br>Gymnospermae | Cycadophyta | Cycads and Ginkgo and Conifers | 750 |
| | Ginkgophyta | Gymnosperms | 750 |
| | Coniferophyta | | |
| | Gnetophyta | | |
| Angiospermae | Anthophyta | Angiosperms | 285000 |
| | | | 413570 |

See Schuster p. 138

*For Botanists, Mycologists, Lichenologists, Phytopathologists, Bacteriologists, Pharmacologists, Microbiologists, Biologists ...*

a new descriptive GENERA of Fungi published in 1970-1971.

# DE TAXIA FUNGORUM

**auctore : Marcel V. LOCQUIN**

**Président de l'Université Agricole Européenne**

**Directeur du Centre Mycologique**

**Vol. 1 Syllabus :** Fungi = MYCOTA are described in a new natural ternary system.

| *Subdivisio* | *Classae* | *Subclassae* |
|---|---|---|
| Myxomycotina | Myxogastromycetes | Myxogastromycetidae, Stemonomycetidae, Physaromycetidae. |
| | Exosporomycetes | Steliomycetidae, Ceratiomycetidae. |
| | Poikilosporomycetes | Krassilnikovimycetidae, Cavosteliomycetidae, Prostelidomycetidae. |
| Actinomycotina | Bacteriophagomycetes | Bacteriophagomycetidae, Micromonosporomycetidae, Actinophagomycetidae. |
| | Acrasiomycetes | Plasmodiophoromycetidae, Labyrinthulomycetidae, Acrasiomycetidae. |
| | Actinomycetes | Mycobacteriomycetidae, Actinomycetidae Leprariomycetidae. |
| Deuteromycotina (ad interim) | Papulasporomycetes | |
| | Conidiasporomycetes | |
| | Meristemaconidiomycetes | |
| Mycotina | Phycomycetes | Archimycetidae, Oomycetidae, Phycomycetidae. |
| | Ascomycetes | Discomycetidae, Loculomycetidae, Mazaediomycetidae. |
| | Basidiomycetes | Heterobasidiomycetidae, Homobasidiomycetidae, Coenobasidiomycetidae. |

The whole describes 12 classae, 105 orders, 315 families,7560 genera of which many are new. Some previously *Phages* and *Bacteria* are included.
Each genus is briefly described with mention of the type species, the basinyms, the list of the species with the authors. Observations are made upon the taxonomic positions that are accepted. References to the main general books are given. Latin diagnoses of new taxa are published.
The first volume begins with a general chapter : Phylogeny, Descriptive technique, Observations. It ends with tables and index of 26.000 names of genera yet published.
The book is written in three langages mixed together : Latin, English and French.

**Vol. 2 Icones :** Dark and white illustrations of macro and microcharacters of the type or central species of genera described in Vol. 1.
Dictionnary of mycological descriptors in Latin, English, French, German, Russian, Tchecoslovaquian, Spanish, Portuguese, Japanese languages.

**Vol. 3. Synonymia :** List of taxa with synonyms and references.
General equivalence between color codes used in mycology.

**Vol. 4. Tabulae analyticae :** summarized taxinomic survey, in 350 tables.
18 × 25 cm each.

*For : mycologists, zoologists, microbiologists :*

New : To be published in 1971

# A MONOGRAPH OF MYXOMYCOTINA

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# MONOGRAPHIE DES MYXOMYCOTINA

**auctore : Marcel V. LOCQUIN**

**Président de l'Université Agricole Européenne**

**Directeur du Centre Mycologique**

En un volume 18×25 cm les Taxa reconnus valables des MYXOMYCOTINA (= *Mycetozoa*, = *Myxomycètes)* sont décrits et figurés.
La systématique suivie est celle de ***De Taxia Fungorum***
Les quelque 500 espèces sont réparties en 112 genres groupés en 53 familles, 18 ordres et 3 classes :

| | | |
|---|---|---|
| Myxogastromycetes | Liceales | Liceaceae. Tubiferaceae. Reticulomyxaceae, Reticulariaceae, Enteridiaceae, Alwisiaceae, Cribrariaceae, Lindblaceae. |
| | Trichiales | Listerellaceae, Prototrichiaceae, Dinanemaceae, Perichaenaceae, Trichiaceae, Arcyriaceae, Oleomyxaceae. |
| | Echinosteliales | Echinosteliaceae. |
| | Myxopouchetiales | Myxopouchetiaceae |
| | Stemonitales | Schenellaceae, Clastodermaceae, Comatrichaceae, Stemonitaceae, Symphytocarpaceae. Amaurochaetaceae, Collodermaceae |
| | Diachaeales | Lamprodermaceae, Macbrideolaceae, Diachaeaceae |
| | Physarales | Fuligaceae, Badhamiaceae, Heterobadhamiaceae, Diperidiaceae, Trichamphoraceae, Physaraceae, Crateromyceaceae, Triperidiaceae, Myxorostafinskiaceae. |
| | Crateriales | Crateriaceae, Cienkowskiaceae, Leocarpaceae |
| | Didymales | Didymiaceae, Lepidodermaceae, Didermaceae. |
| Exosporomycetes | Echinosteliopsiales | Echinosteliopsiaceae |
| | Ceratiomyxales | Ceratiomyxaceae |
| | Protosteliales | Schizoplasmodiaceae, Protosteliaceae. |
| Poikilosporomycetes | Asterococcales | Asterococcaceae, Bartonellaceae |
| | Krassilnikoviales | Krassilnikoviaceae |
| | Pasteuriales | Pasteuriaceae |
| | Cavosteliales | Cavosteliaceae |
| | Protosteliopsiales | Protosteliopsaceae |
| | Acytosteliales | Acytosteliaceae |

*Genera* : Tubulina, Licea, Orcadella, Tubifera, Hymenobolina, Reticulomyxa, Lycogala, Reticularia, Dictyaethalium, Enteridium, Liceopsis, Alwisia, Cribraria, Dictydium, Lindbladia, Listerella, Kowalskia, Prototrichia, Alexopoulius, Calomyxa, Dianema, Arcyodes, Perichaena, Cornuvia, Oligonema, Calonema, Trichia, Prototrichia, Metatrichia, Echinotrichia, Hemitrichia, Arcyria, Arcyrellina, Eleomyxa, Schenella, Barbeyella, Curtisiella, Clastoderma, Enerthenema, Comatricha, Stemonitopsis, Collaria, Paradiachaeopsis, Laxaria, Sinuaria, Hagelsteinia, Stemonitis, Symphytocarpus, Brefeldia, Amaurochaete, Colloderma, Echinostelium, Minakatella, Paradiachaea, Lamproderma, Lamprodermopsis, Macbrideola, Diachaeopsis, Diachaea, Myxopouchetia, Pycnochaete, Fuligo, Badhamia, Myxomyces, Myxobadhamia, Heterobadhamia, Physarocolumella, Diperidium, Nodomyces, Triperidium, Physaromyces, Trichamphora, Myxiris, Physarum, Polyphysarum, Emotella, Crateromyces, Craterium, Physarella, Cienkowskia, Erionema, Leocarpus, Physarina, Mucilago, Japania, Didymium, Myxojahnia, Cleretiella, Lepidoderma, Wilczekia, Leptoderma, Simpliderma, Chondrioderma, Diderma, Schizoplasmodiopsis, Echinosteliopsis, Ceratiomyxa, Schizoplasmodium, Prostelium, Asterococcus, Grahamella, Hemobartonella, Bartonella, Krassilnikovia, Pasteuria, Blastocaulis, Cavostelium, Prosteliopsis, Acytostelium.

L'ouvrage contient la description normalisée en Français des taxa avec : basinymes, synonymes, répartition géographique dans l'ensemble du globe, descripteurs normalisés et glossaire en Latin, Anglais, Français.

Les tableaux de détermination sont en deux langues : Anglais - Français. Il se termine par un historique de l'étude des *Myxomycotina*, une liste mondiale des myxomycètologues, un index des taxa, une bibliographie systématique générale.

Illustrations par dessins au trait et photographies.

| | | |
|---|---|---|
| En souscription, (avant parution, 1971) | $ 50.00 ou | F. 275.00 |
| Après publication, after publication, | 60.00 ou | 330.00 |

*Reprinted from Canadian Journal of Botany, 33 : 60-104.* 1955

# A PHYLOGENY OF THE BASIDIOMYCETES[1]

BY D. B. O. SAVILE[2]

## Abstract

Thirteen phylogenetic principles of general or mycological application are presented. Adherence to these principles makes it difficult to accept any starting point for the Basidiomycetes other than a primitive ascomycete very close to *Taphrina* and parasitic upon ancient ferns. From the ancestral basidiomycete one line led to the rusts and another, via the parasitic Auriculariaceae, to the remaining Heterobasidiomycetidae and the Homobasidiomycetidae. In this second line the trend has been toward increasing saprophytic ability, increasing frequency of clamp connections, and increasing complexity of fruit body. The evolution of the rusts is traced from the taphrina-like ancestor to the higher Melampsoraceae. A generalized phylogeny of the Phycomycetes and Ascomycetes and a chronology of the strictly parasitic groups of fungi are given. It is clear that parasitism, far from being recent and derived from saprophytism, is generally ancient in the fungi; that the Ascomycetes arose from parasitic, aquatic Phycomycetes; and that saprophytism has in general been derived from parasitism.

## Introduction

Almost every mycologist must have been intrigued by the riddle of the origin and evolution of the Basidiomycetes and the nature of their relationship to the Ascomycetes. A number have ventured to express their views in print; but the diversity of these views has been as striking as the failure of any of them to gain wide acceptance. The support provided for most of these schemes has ranged from the specious to the fantastic, forcing the cautious appraiser of them to say with D'Arcy Thompson (58), after Bacon, that "the arguments commonly used in such cases may be said to allure, rather than to extort assent".

It is the fashion among some biologists to ridicule all phylogenetic studies as wasted time and mere idle speculation. But phylogeny is the ultimate basis of all natural classifications; and, as such, commands our attention both for its theoretical importance and for its practical value. This statement is fully as true for mycology as for other branches of biology, as is indicated by the dependence of progress in the various fields of applied mycology upon sound taxonomy.

It will be more constructive to try to remedy the defects of phylogeny than merely to condemn it on the performance of some of its less successful adherents. Before proceeding to my own views on the origin of the Basidiomycetes I shall therefore present, in the next section, the most complete list that I have been able to draw up of the principles that must guide the student of evolution in the fungi.

Although the scheme here proposed had its inception many years ago in connection with the origin of the rusts, it was necessary to develop and test several of the guiding principles listed below, before it could be presented in

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[1] *Manuscript received August 11, 1954.*

*Contribution No. 1409 from the Botany and Plant Pathology Division, Science Service, Canada Department of Agriculture, Ottawa, Ontario.*

[2] *Senior Mycologist.*

ANN. REV. PHYTOPATH. 5. 1967. 343-374.

# ULTRASTRUCTURE OF FUNGI[1,2,3]

By Charles E. Bracker

*Department of Botany and Plant Pathology, Purdue University*
*Lafayette, Indiana*

Ultrastructure research is adding a new dimension to mycology and plant pathology. For example, we can now think of morphogenesis not only in terms of the shape, size, and arrangement of cells but also as a multitude of minute but significant integrated changes of subcellular components. Interacting hosts and pathogens are subject to similar scrutiny. In plant pathology, as in other disciplines, the electron microscope and other tools of ultrastructure research are helping to explain structural bases for functional processes at a level that fills much of the gap between anatomy and molecular biology. This review is not a comprehensive summary of fungus ultrastructure, but concentrates on topics that have not been reviewed previously (1, 71, 112) and on those that have generated some degree of controversy or uncertainty.

What constitutes a fungal cell? There is no rigid concept. All fungi are eukaryotic, with the nuclear material being surrounded by a membranous nuclear envelope, and with protoplasts that are more organized and compartmentalized than those of the prokaryotic bacteria, Actinomycetes, and blue-green algae (121, 154). Among the eukaryotes, however, fungal cells are relatively simple. Some have cell walls; some do not. Some are motile; some are not. Mitochondria are ubiquitous; plastids are absent. Vacuoles, endoplasmic reticulum (ER), and ribosomes are widespread. In addition, a variety of tubules, vesicles, crystals, and other inclusions occur in specific cells. Raper & Esser (129) summarized the cytology of fungi by concluding that "the fungal cell differs from most other cells in one important respect: it is smaller."

Protoplasmic membranes are emphasized in this discussion. As major structural and functional components of cells, membranes are involved in compartmentalization, transport, synthesis, enzyme localization, energy transduction, control of selective permeability, and cytokinesis. Biological membranes are lipoprotein sheets (usually 50 to 100 Å thick) that are dynamic and polymorphic, with the capacity for manifold transformations. At high magnification, various fungal membranes exhibit dissimilar substruc-

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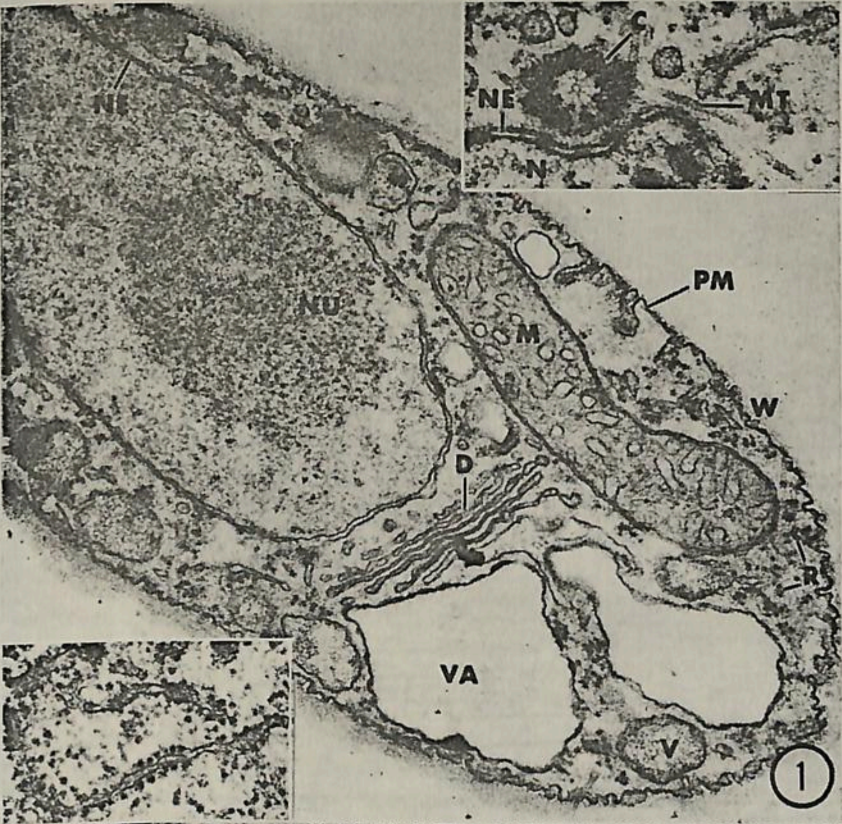
[1] The survey of literature pertaining to this review was concluded in February 1967.

[2] The following abbreviations are used: EM (electron microscope), ER (endoplasmic reticulum).

[3] Purdue University AES Journal Paper No. 3041. Certain of the unpublished studies reported were supported by National Science Foundation Grant No. NSF GB-03044. I gratefully acknowledge the assistance of Constance Williams, Anna-Maria Bracker, D. James Morré, and workers who were kind enough to provide information that was unpublished or in press.



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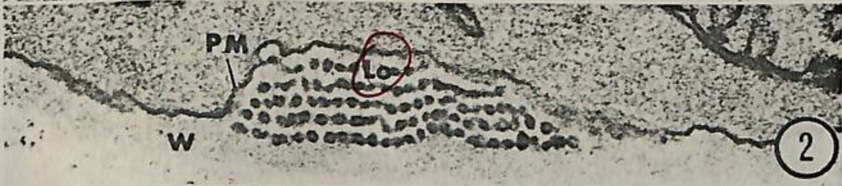

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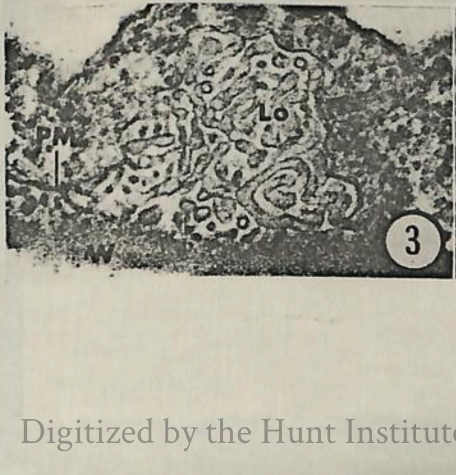

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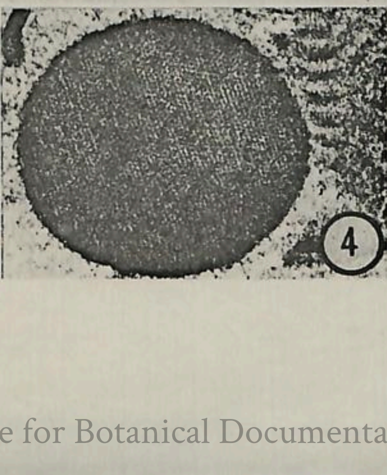

④

Mycologia 68. 1976

# ULTRASTRUCTURE OF SEPTA IN HYPHAE AND BASIDIA OF *TULASNELLA*

SAEED R. KHAN AND P. H. B. TALBOT

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## SUMMARY

In *Tulasnella* sp. there is a primary septum at the base of the basidium, and an adventitious septum, which differs in ultrastructure and development, at the base of the protosterigma. The adventitious septa are similar to those formed in somatic hyphae when a cell accumulates protoplasm from an adjoining cell in the process of becoming empty. The *Tulasnella* basidium is regarded as a holobasidium.

*Tulasnella* basidia have figured prominently in discussions of basidiomycete classification and basidial terminology (see Talbot, 1973), largely because septa at the bases of the protosterigmata are an almost constant feature in this genus. Most authors consider that this type of basidium is a phragmobasidium, a basidium divided by septa. That the basidia in *Tulasnella* are holobasidiate, with adventitious septa formed at the bases of the protosterigmata, has been postulated (Donk, 1964; Talbot, 1968, 1970, 1973). The association of these septa with progressive cytoplasmic flow from the metabasidium to the protosterigmata and subsequently into the spores is very obvious using ordinary stains and light microscopy. With congo red stain it is often possible to see a dolipore septum at the base of the *Tulasnella* metabasidium but not in a septum that cuts off a protosterigma (Talbot, 1970): this may indicate that the former is a primary and the latter an adventitious septum.

This electron microscopic study was undertaken in order to determine if there are developmental and structural differences between the subbasidial septa and those at the bases of the protosterigmata in a species of *Tulasnella*.

## MATERIALS AND METHODS

The isolate (No. 0727) of *Tulasnella* sp. used in this study was obtained from mycorrhiza of the terrestrial orchid, *Acianthus caudatus* R. Br., and was induced to sporulate in culture by Dr. J. H. Warcup using the soil-on-agar method of Stretton, McKenzie, Baker and Flentje (1964).

Soon this cell begins to hump up further near its center as most of the protoplasm moves into this region, while the outer periphery becomes thinner; this phase is called the "hat-shaped stage" (B). By this time a membranous layer, the sheath, has developed over the entire upper surface of the cell. It is a stretchable, pliable, and highly impermeable layer that obviously protects the protoplast from desiccation during sporogenesis. Eventually, the protoplast withdraws completely from the peripheral "brim," allowing the sheath to collapse onto the surface of the substrate, thus giving support to the base of the stalk that is about to develop (C). At this time, a finely granular basal core becomes apparent within the protoplast; because of its function in stalk formation, it has been named the *steliogen* (C–E). The steliogen now begins to mold a hollow tube into which it extends a narrow portion of itself (D, E). Concurrently, the sheath apparently continues to be produced by the protoplast, and as the protoplast migrates upward on the developing inner stalk tube the sheath becomes applied to the latter to form a second layer of the stalk (E). Finally, as stalk elongation ceases the steliogen is left at the tip of the stalk, while the protoplast withdraws from around it, secretes a surrounding cell wall and becomes the spore (F). The subtending remnant of the steliogen, now devoid of cytoplasm, is referred to as the *apophysis*. The entire sporulation process may be completed in little more than an hour in *S. ovatum*, and in less than half an hour in *Protostelium mycophaga*.

In species such as *S. ovatum*, the apophysis is a very distinctive part of the sporocarp (FIG. 4b), but in other apophysate species it is less so. With the exception of *Cavostelium*, the spores of apophysate species tend to be deciduous. Those of *Schizoplasmodium cavostelioides* are forcibly discharged. In *S. ovatum* and *S. gracile*, the spore appears to articulate with the apophysis, from which it becomes detached. In *Protostelium mycophaga*, the apophysis articulates with the stalk and falls off with the spore. Still other modifications of this structure probably exist but have not yet been studied in detail. One group of protostelids lacks the apophysis and the spores are non-deciduous.

The stalks as well as the walls of spores and cysts—unless they are quite thin—give a faintly to distinctly positive test for cellulose in chloriodide of zinc.

### KEY TO THE FAMILIES AND GENERA OF PROTOSTELIDA

I. Flagellate cells produced.........................Family Cavostelidae
Single Genus: *Cavostelium*

II. Flagellate cells absent..........................Family Protostelidae
- A. Spores typically deciduous, sub-spore apophysis present.
  - 1. Reticulate plasmodia present, uninucleate amoebae absent.......................................................*Schizoplasmodium*
  - 2. Reticulate plasmodia absent, uninucleate amoebae common..*Protostelium*
- B. Spores non-deciduous, apophysis lacking.
  - 1. Reticulate plasmodia produced.....................*Schizoplasmodiopsis*
  - 2. Reticulate plasmodia absent, uninucleate amoebae common (also multinucleate protoplasts in some species)...............*Protosteliopsis*

*Descriptions of the taxa*—

PROTOSTELIDA Olive & Stoianovitch. J. Protozoology **13**: 171. 1966.

A simple and probably primitive group of holozoic Mycetozoa with amoeboid uninucleate to multinucleate protoplasts, the latter in the form of reticulate plasmodia in two genera; cells with 1 or 2 anterior flagella present in one genus; pseudopodia typically filose; contractile vacuoles present; nucleus with single prominent central nucleolus, dividing mitotically; sporocarp consisting of a non-cellular, short to slender stalk bearing 1, or sometimes 2, spores apically; sexual reproduction unknown.

CAVOSTELIDAE L. Olive (Syn.: Cavosteliaceae L. Olive, Mycologia **56**: 885. 1964.)

This is a group of amoebo-flagellates, the shift between amoeboid and flagellate stages occurring very readily. There are typically 1 or 2 anterior whiplash flagella. The cells are mostly uninucleate, though multinucleate protoplasts (but not reticulate plasmodia) are sometimes present. Pseudopodia are commonly filose. The sporocarps are small, relatively short-stalked and 1–2-spored; the spores are uninucleate and apophysate but non-deciduous. A single genus has been described.

*Cavostelium* L. Olive, Mycologia **56**: 885. 1964.

The family characteristics apply equally to the genus. Two species are known, of which the type species is *C. apophysatum*.

### KEY TO THE SPECIES OF CAVOSTELIUM

Sporocarps 1–2-spored.........................................*C. apophysatum*
Sporocarps consistently 2-spored...................................*C. bisporum*

THE BOTANICAL REVIEW

VOL. 40 JULY-SEPTEMBER, 1974 NO. 3

# THE ORIGIN OF ASCOMYCETES AND BASIDIOMYCETES
## THE CASE FOR A RED ALGAL ANCESTRY

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### SUMMARY

An updated argumentation is presented in favour of the red algal ancestry of the Ascomycetes and Basidiomycetes. The features they present in common with red algae, especially in life cycle and ultrastructure, are considered as less easily explained by convergent evolution than biochemical similarities between those fungi and Chytridiomycetes. The origin of higher fungi is supposed to be through parasitic red algae giving rise to parasitic fungi, the borderline of red algae and higher fungi being considered a delay in caryogamy which has some morphological consequence on the cysts where this event finally occurs.

### RESUMÉ

Une argumentation mise à jour est présentée en faveur de l'origine rhodophycéenne des Ascomycètes et des Basidiomycètes. Les caractères qu'ils présentent en commun avec les algues rouges, spécialement du point de vue des cycles reproductifs et de l'ultrastructure sont de l'avis de l'auteur moins aisément expliqué par une évolution convergente que les similitudes biochimiques entre ces champignons et les Chytridiomycètes. L'origine des champignons

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[1] Chargé de Recherches du Fonds National Belge de la Recherche Scientifique.

ship to fungi, the specialisation in research and teaching that has occurred since then has made it accidental that a few mycologists like Jackson or Chadefaud came into contact with red algae. It is noteworthy that they, like myself, who also have some interest in algae, have become partisans of the red algal ancestry of higher fungi.

## II. SIMILARITIES AMONG HIGHER FUNGI AND RED ALGAE

Authors previously cited have emphasized as similarities among higher fungi and red algae:

1. Lack of flagellated cells and presence of a trichogyne.
2. Septa with pores.
3. Anastomoses among adjacent filaments sometimes formed in red algae by a mechanism close to clamp connection formation.
4. Development of cysts producing filaments from the fertilised female cell and parallelism in complex alternance of generations. This aspect is especially well set forth by Jackson (1944) and Chadefaud (1944, 1953b, 1957, 1960, 1972).
5. Morphologically similar structures (conceptacles, perithecia, aecia . . . ) protecting reproductive organs.
6. The cladomian (bushy habit with lateral branches of limited growth) morphology of the Ascomycetes of the order Laboulbeniales.
7. Similarity between floridean starch and glycogen, and the storage of trehalose.

I would like to comment on this last point that the occurrence of glycogen in fungi is frequently given as a proof of their intermediate character between animals and plants. Since the storage product of red algae is called floridean starch, it is usually forgotten that it is a product close to glycogen (Fleming et al., 1956). Until now red algae are the only eukaryotic algae known to possess branching enzymes able to branch amylopectin as fungal branching enzymes do (Fredrick, 1968, 1970), and those fungal enzymes are unable to introduce additional branching on either floridean starch or glycogen (Gunja et al., 1960).

The use of the electron microscope has recently disclosed that they also show similarities in mitosis. The ultrastructure of mitosis and its phylogenetic implications are reviewed by Pickett-Heaps (1969, 1972). There are already a number of works dealing with Ascomycetes (Robinow & Marak, 1966; Schrantz, 1970a; Zickler, 1970; Beckett & Crawford, 1971; Peterson et al., 1972; McKeen, 1972) and Basidiomycetes (Motta, 1969; Girbardt, 1971; McCully & Robinow, 1972a & b), but the study of red algae is very recent (Peyrière, 1971; McDonald, 1972). As in the Ascomycetes, the red algae studied preserve their nuclear envelope during mitosis and show a polar body which is not a centriole, being devoid of microtubular ultrastructure.

moïdées, appartenant aux g. *Sistotremastrum* J. Eriksson, 1958, et *Paullicorticium* J. Erikss., 1958 ; — 3. les g. *Hyphoderma* Wallr., 1933, *Cristella* Donk, 1956, *Galzinia* Bourd. et *Botryobasidium* Donk, 1931 ; — 4. en outre, des Champignons que l'auteur range parmi les Xénasmatacées (g. *Acanthobasidium* Oberw., 1965) ; les Corticiacées s. s. (g. *Radulomyces* Christiansen, 1960, et *Tubulicium* Oberw., 1965) et les Corticiacées - Athélioïdées (g. *Athelidium* Oberw., 1965), parce que d'autres caractères que la forme en urne des basides les séparent des Corticiacées - Sistotrémoïdées.

Le type urniforme, ainsi réparti chez les Basidiomycètes « primitifs », pourrait aussi être rapproché de celui des *Brachybasidium* (fig. 4) et des *Vuilleminia*. D'autre part, il nous paraît intéressant parce que, en nous plaçant du point de vue que nous avons récemment adopté (CHADEFAUD, 1975) concernant la valeur morphologique des basides, nous pensons qu'il éclaire certaines voies de l'évolution de celles-ci, d'une part celle qui a conduit à l'*homobaside*, et d'autre part, peut-être celle qui a pu aboutir à l'*asque*.

C'est ce que nous allons exposer, en prenant comme point de départ l'hétérobaside des Trémelles.

1. On sait que l'***hétérobaside des Trémelles*** (g. *Tremella* et alliés) se compose d'un corps basidial, dans lequel des cloisons longitudinales séparent quatre segments fertiles, au-desus d'un article stérile sans noyau, et de quatre rameaux épibasidiaux qui, nés chacun d'un des segments fertiles, portent à leur sommet une basidiospore, au bout d'un stérigmate.

Selon nos conceptions actuelles (1975), le corps basidial est un *ascoïde primaire* (*a1*) (1), qui a la valeur d'un *tétrasporocyste*. Ancestralement, il devait produire, avec méïose, quatre *tétraspores* haploïdes, logées dans un *épiplasme*. Une fois émises, ces tétraspores pouvaient engendrer chacune un mycélium gamétophytique (2).

Au premier stade de l'évolution (hypothétique), nous avons admis qu'à partir de cet ascoïde primaire (*a1*) s'est organisée ce que nous appellerons ici une *éo-baside*. Pour cela (fig. 1) : 1. Après la méïose, la sporulation a été remplacée par des cloisonnements, qui ont isolé quatre segments (*ss*) haploïdes, au-dessus d'un article stérile contenant un épiplasme sans noyau. Nous avons comparé ce cloisonne-

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(1) Comme des asques, les *ascoïdes* doivent contenir, à maturité, des spores et un *épiplasme*. D'autre part, comme celui des asques, leur sommet doit pouvoir être garni d'un *appareil apical*.

(2) En réalité, il devait s'agir d'un *pro-gamétophyte*, porteur d'ascoïdes secondaires (*a2*). (Voir notre Note de 1975).

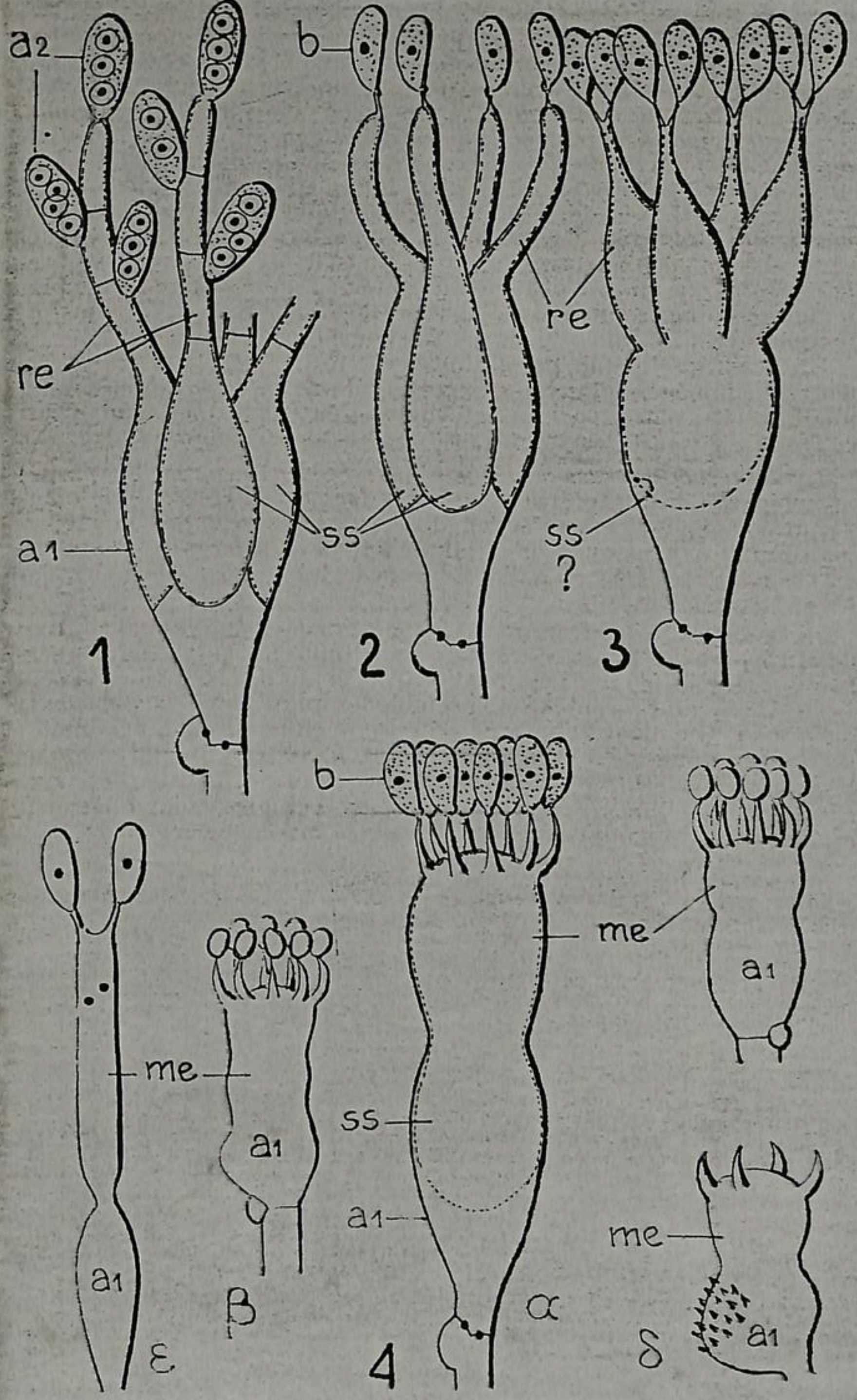

FIG. 1 à 4. — ***Hétérobasides et basides urniformes.***

1. Eo-baside (hypothétique) ; 2. Hétérobaside des Trémelles (schéma) ; 3. Hétérobaside des Tulasnelles (schéma ; en partie d'après CHRISTIANSEN, 1959 : *T. inclusa*) ; 4. Basides urniformes et analogues (α : schéma : β : Sistotrema ; γ : *Botryobasidium* ; δ : *Acanthobasidium* ; ε : *Brachybasidium* ; β, γ et δ d'après OBERWINKLER, 1965).

*a1* : ascoïde primaire (= tétrasporocyste = masse basidiale) ; *ss* : segments ségrégatifs (= tétraspores) ; *re* : rameaux épibasidiaux (= pro-gamétophytes) ; *me* = masse épibasidiale (= rameaux épibasidiaux fusionnés) ; *a2* : ascoïdes secondaires (= deutérosporocystes, producteurs de deutérospores) ; *b* : basidiospores (= ascoïdes secondaires transformés en spores). En raison du caractère théorique de cet article, toutes les figures ont été schématisées.

ment à celui qui, dans le thalle de certaines Chlorophycées - Siphonées (g. *Valonia* et *Siphonocladus*), isole des *segments ségrégatifs* ; 2. Ces segments, qui primitivement devaient émettre chacun une spore, demeurent dans l'ascoïde (*al*), et sur place chacun d'eux engendre un *rameau épibasidial* (*re*), qui est le siège de *mitoses haploïdes post-méiotiques*, puis se cloisonne et se garnit d'*ascoïdes secondaires* haploïdes, ou *deutérospores*. Celles-ci, une fois libérées, engendrent chacune un mycélium gamétophytique (3).

A partir de l'éo-baside, qui est hypothétique, le passage à l'*hétérobaside des Trémelles* (fig. 2) aurait comporté : 1. une réduction des rameaux épibasidiaux (*re*), dans lesquels il n'y a plus de mitoses post-méiotiques ni de cloisonnement, et sur lesquels ne se forme plus qu'un ascoïde secondaire, en position terminale ; — 2. la transformation de cet ascoïde (*a2*) en une basidiospore (*b*).

On remarquera que l'évolution ainsi présentée aurait comporté deux phénomènes de *demi-aposporie* : d'une part celle qui a remplacé les tétraspores par les segments ségrégatifs (*ss*), et d'autre part celle qui a converti les ascoïdes secondaires en basidiospores (*b*) (4).

2. L'*hétérobaside des Tulasnelles* (g. *Tulasnella* ; fig. 3) que les mycologues ont interprétée de diverses façons (cf. Heim, 1957), nous paraît pouvoir être assez facilement comparée à celle des Trémelles, mais toutefois sans que cela implique une proche parenté avec celles-ci. On constate ainsi qu'elle diffère de la baside des Trémelles par les caractères suivants :

a) Dans l'ascoïde primaire (*a1*), non seulement il n'est pas produit de tétraspores, mais en outre il ne se délimite pas non plus des segments ségrégatifs (*ss*). Cela peut tenir à ce qu'il s'en forme un seul à paroi très mince, contenant ensemble les quatre noyaux issus de la méïose ? Ce segment unique est représenté en pointillé sur la fig. 3 ; il serait comparable à celui que nous avons observé dans l'asque de la Truffe *Tuber rufum* (fig. 13) ;

b) Sur cet ascoïde, les rameaux épibasidiaux (*re*) sont fortement renflés, avec un sommet effilé, en principe bifide et porteur de deux basidiospores (*b*) (Christiansen : *T. inclusa*). La présence de celles-ci indique qu'il y a dans chacun de ces rameaux au moins une mitose post-méïotique, mitose qui n'existe plus chez les Trémelles. Toutefois, il est fréquent que le sommet effilé des rameaux épibasidiaux

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(3) D'après les conceptions que nous avons formulées, en 1944 et 1960, sur le cycle des Hyméno- et Gastromycètes, ce mycélium, et au stade de l'hétérobaside celui qu'engendrent les basidiospores, serait en réalité un basidio-sporophyte primaire haploïde. A partir de celui-ci, après des périttogamies se développerait un basidio-sporophyte secondaire dicaryotique, générateur des carpophores.

(4) D'après notre Note de 1975, les rameaux (*r*) sont homologues à des progamétophytes. Dès lors, outre les *demi-apospories*, l'évolution aurait comporté leur *condensation* avec les ascoïdes (*al*).

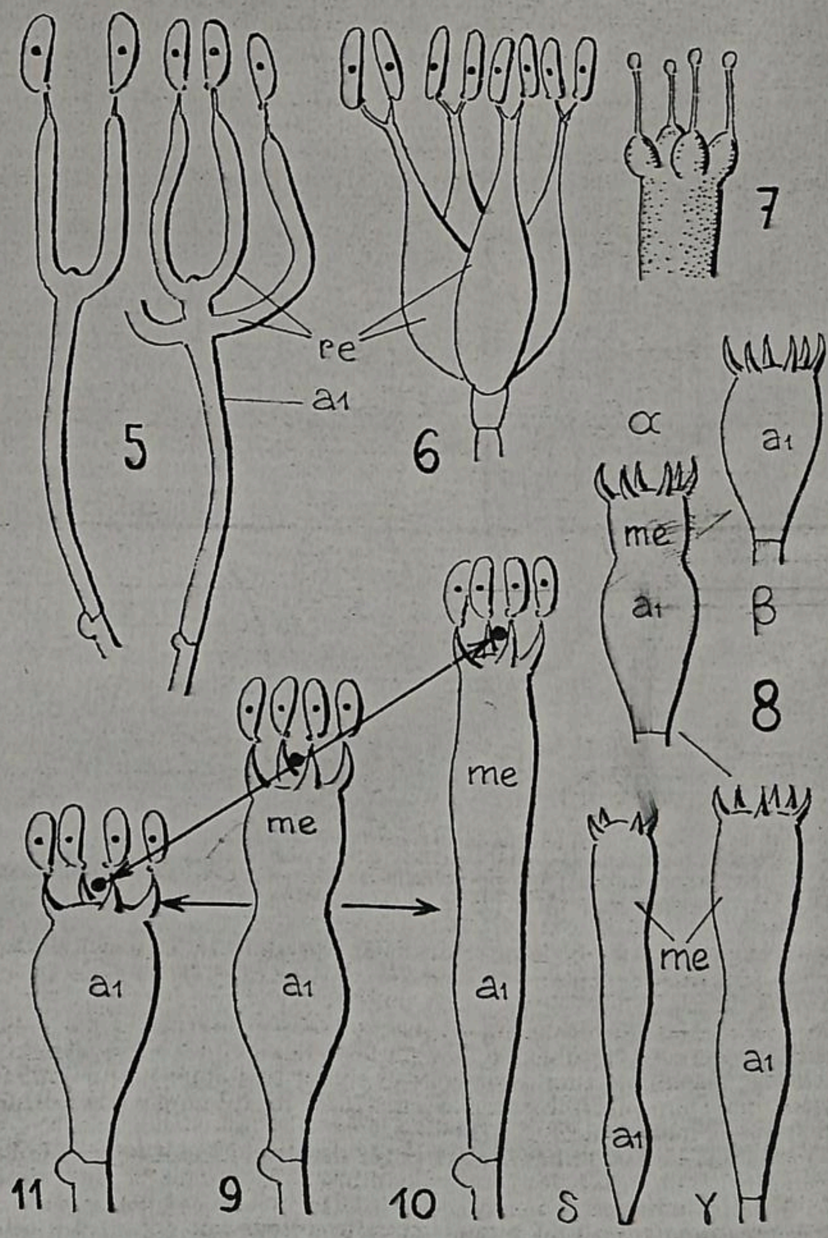

Fig. 5 à 11. — *Hétérobasides, basides urniformes, origine des homobasides.* 5. Hétérobasides d'un *Dacrymyces* (Calocéracée) ; 6. Hétérobaside des *Sebacina* (schéma ; d'après Oberwinkler, 1965 : *S. vermifera*) ; 7. Homobaside de l'*Hygrophorus niveus*, à l'état jeune (d'après Chadefaud, 1944 et 1960) ; 8. Basides urniformes à demi ou complètement transformées en homobasides, soit par disparition de la masse épibasidiale (*Paullicorticium cremeum* α ⟶ *Paullicorticium pearsonii* β), soit par élongation. (*Paullicorticium cremeum* α ⟶ *Sistotremastrum* γ et *Hygrophorus* δ) ; 9 à 11. de la baside urniforme (9) à l'homobaside, par élongation (10 = stichobaside) ou par disparition de la masse épibasidiale (11 = chiastobaside ; schémas). (8 α, β et γ d'après Oberwinkler, 1965).

Mêmes lettres que sur les fig. 1 à 4, avec en plus : *ma2* masse formée par les ascoïdes *a2* fusionnés ; *sp*, sporoplasme ; *ssp*, sac sporal (= sac sporogène).

demeure simple, et ne porte qu'une seule basidiospore. De la sorte, le nombre des basidiospores par baside peut varier de 4 (pas de mitoses post-méïotiques) à 8 (une mitose par rameau) ;

c) Enfin, les basidiospores n'ont pas la dorsiventralité caractéristique des basidiospores typiques. Cela peut prouver qu'elles sont moins évoluées, c'est-à-dire demeurées morphologiquement plus proches de l'ascoïde secondaire, dépourvu de dorsiventralité, dont elles dérivent. Ainsi, les *Tulasnella* seraient moins évolués que les Trémelles par deux caractères : ils ont parfois conservé, dans leurs rameaux épibasidiaux une mitose post-méïotique, et leurs basidiospores n'ont pas atteint le stade de la dorsiventralité. Ils sont par contre plus évolués que les Trémelles par l'absence de segments ségrégatifs dans les ascoïdes primaires (ou leur réunion en un seul ?). Ces remarques impliquent que les Tulasnelles ne dérivent pas des Trémelles : tout au plus doivent-elles dériver d'un ancêtre commun.

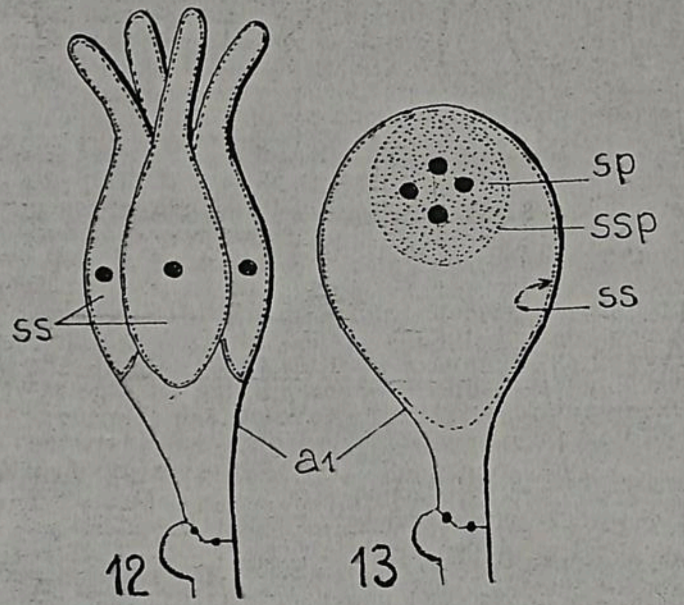

Fig. 12 et 13. — L'hétérobaside des Trémelles (12) et l'asque du *Tuber rufum* (13), à l'état jeune : schémas comparatifs.

*ss*, segments ségrégatifs ; *sp*, sporoplasme ; *ssp*, sac sporal (13 : fig. originale inédite, à soumettre au contrôle de la microscopie électronique).

3. La *baside urniforme* (fig. 4) paraît facile à interpréter par comparaison avec l'hétérobaside des Tulasnelles : que les quatre rameaux épibasidiaux renflés de celle-ci soient fusionnés en une *masse épibasidiale* unique (*me*) et elle aura une morphologie urniforme, ainsi que le montrent les fig. 3 et 4 α.

Toutefois, la baside urniforme porte des basidiospores morphologiquement typiques. Elles sont au nombre de 8 si, dans la masse épibasidiale, chacun des 4 noyaux issus de la méiose subit une mitose post-méïotique ; il n'y en a que 4 si cette mitose fait défaut. En fait, il y en a 4, 6 ou 8, selon les espèces.

Les figures 4 β, γ, δ, et ε montrent quelques unes des variantes de cette baside. On notera surtout que la masse basidiale est souvent pourvue d'une gibbosité du côté ventral (4 β et δ) et que chez les *Acanthobasidium* (fig. 4δ) cette gibbosité porte de petits aiguillons. Cela accentue la différence existant entre cette masse, dérivée de l'ascoïde primaire (*a1*) et la masse épibasidiale (*me*), qui équivaut aux rameaux épibasidiaux des ***Tulasnella*** et ***Tremella***.

4. Un certain nombre d'*hétérobasides* ont évolué autrement que la baside urniforme. Ainsi :

— chez les Calocéracées (fig. 5), l'ascoïde primaire (*a1*) et les rameaux épibasidiaux (*re*) sont grêles et allongés ; il n'y a pas de segments ségrégatifs dans l'ascoïde primaire, et le nombre des rameaux est généralement réduit à deux. Il peut cependant être encore de 3 ou 4, mais cela est peu fréquent ;

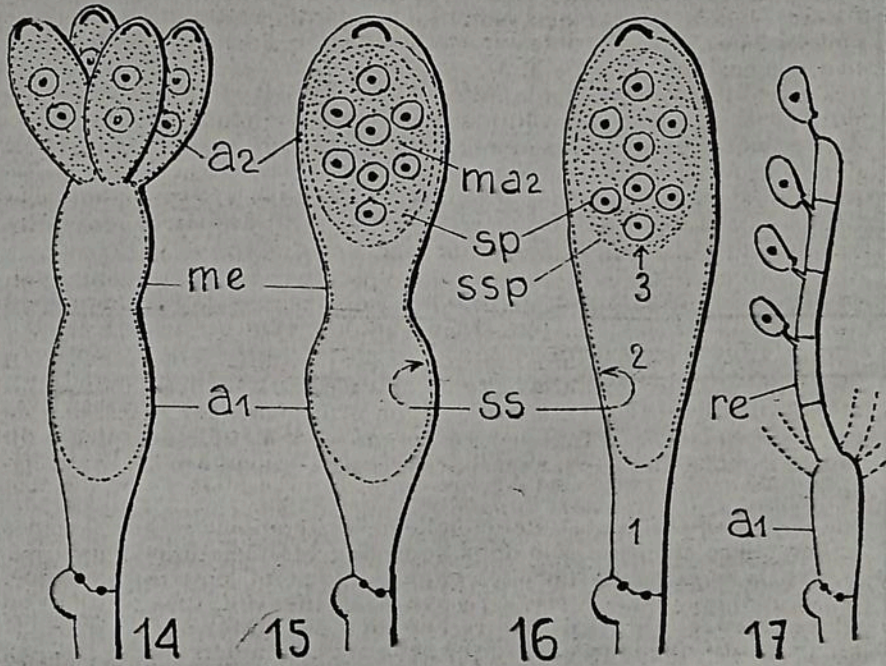

Fig. 14 à 17. — L'origine de l'asque (14 à 16) et de l'archéobaside (17). (Voir le texte).

Dans l'asque la « sporulation » de l'ascoïde primaire *a1* a donné le segment ségrégatif *ss* (= sac ascal), et celle des ascoïdes secondaires *a2*, fusionnés entre eux et avec *a1*, le sporoplasme *sp*, logé dans un sac sporogène *ssp* (v. aussi fig. 13). On remarquera la coexistence de trois épiplasmes, le premier basal (1), le second moyen (2), le troisième périsporal (3). On notera aussi que l'asque ainsi représenté serait d'un type primitif, qui chez la plupart des espèces aurait été simplifié.

— chez les *Sebacina* (fig. 6), on retrouve au contraire des rameaux épibasidiaux (*re*) renflés, et en principe bifides (Oberwinkler : *S. vermifera*), comme ceux des Tulasnelles, mais à leur base l'ascoïde primaire (*a1*), très réduit, n'est pas distinct.

BULL. SOC. MYC. FR., t. 92, fasc. 1, 1976. (135-146)

# HÉTÉROBASIDES, BASIDES URNIFORMES ET HOMOBASIDES ; ARCHÉOBASIDES ET ASQUES,

### par Marius CHADEFAUD.

## Résumé.

Partant d'un type ancestral (hypothétique) dans lequel des tétrasporocystes ascoïdes produisaient des tétraspores haploïdes, génératrices de pro-gamétophytes haploïdes, sur lesquels des ascoïdes secondaires émettaient des deutérospores, l'évolution, principalement par le jeu d'apospories plus ou moins complètes, aurait donné l'éobaside (hypothétique), à tétraspores remplacées par des segments ségrégatifs, et pro-gamétophytes par des rameaux épibasidiaux portant les ascoïdes secondaires. De l'éobaside seraient ensuite dérivés, séparément, par des évolutions divergentes : 1. l'archéobaside (des Urédinales et Auriculariales), à rameau épibasidial unique, dans lequel a migré la méïose ; — 2. les hétérobasides, puis les homobasides, caractérisées par la régression des rameaux épibasidiaux, préalablement réunis en une masse « épibasidiale » dans les basides urniformes ; — 3. les asques dans lesquels il y aurait eu condensation totale et fusion de l'ascoïde primaire, de la masse « épibasidiale » et des ascoïdes secondaires. Chez les Basidiomycètes, les ascoïdes secondaires sont devenus les basidiospores.

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Dans son remarquable article sur les « Basidiomycètes primitifs », OBERWINKLER (1965) attire l'attention, à propos des Corticiacées-Sistotrémoïdées, sur les basides d'un type particulier observables dans ce groupe, les *Urnenbasidien* ou « basides urniformes », dont le corps se compose de deux masses superposées, séparées par un étranglement sans cloison : 1. une masse inférieure ou *masse hypobasidiale*, qui est en réalité, comme on le verra plus loin, la *masse basidiale* s. s., et qui est assez souvent pourvue d'une gibbosité du côté ventral ; 2. une *masse supérieure épibasidiale*, dont le sommet est entouré d'une couronne de 4 à 8 stérigmates (nombre variable selon les espèces), portant chacun une basidiospore morphologiquement typique.

Ce type de baside est figuré : 1. d'abord chez des *Sistotrema* Fr., représentants d'un genre qui avait été rangé parmi les Hydnacées (SACCARDO ; CLÉMENTS et SHEAR ; etc...), ou les Polyporacées (F. MOREAU), ou les Tulasnellacées (VON ARX) ; — 2. les autres Sistotré-

FRANZ TRAUB y HANS R. HOHL.
A NEW CONCEPT FOR THE TAXONOMY OF THE FAMILY DICTYOSTELIACEAE (CELLULAR SLIME MOLDS).

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- Polar granules -

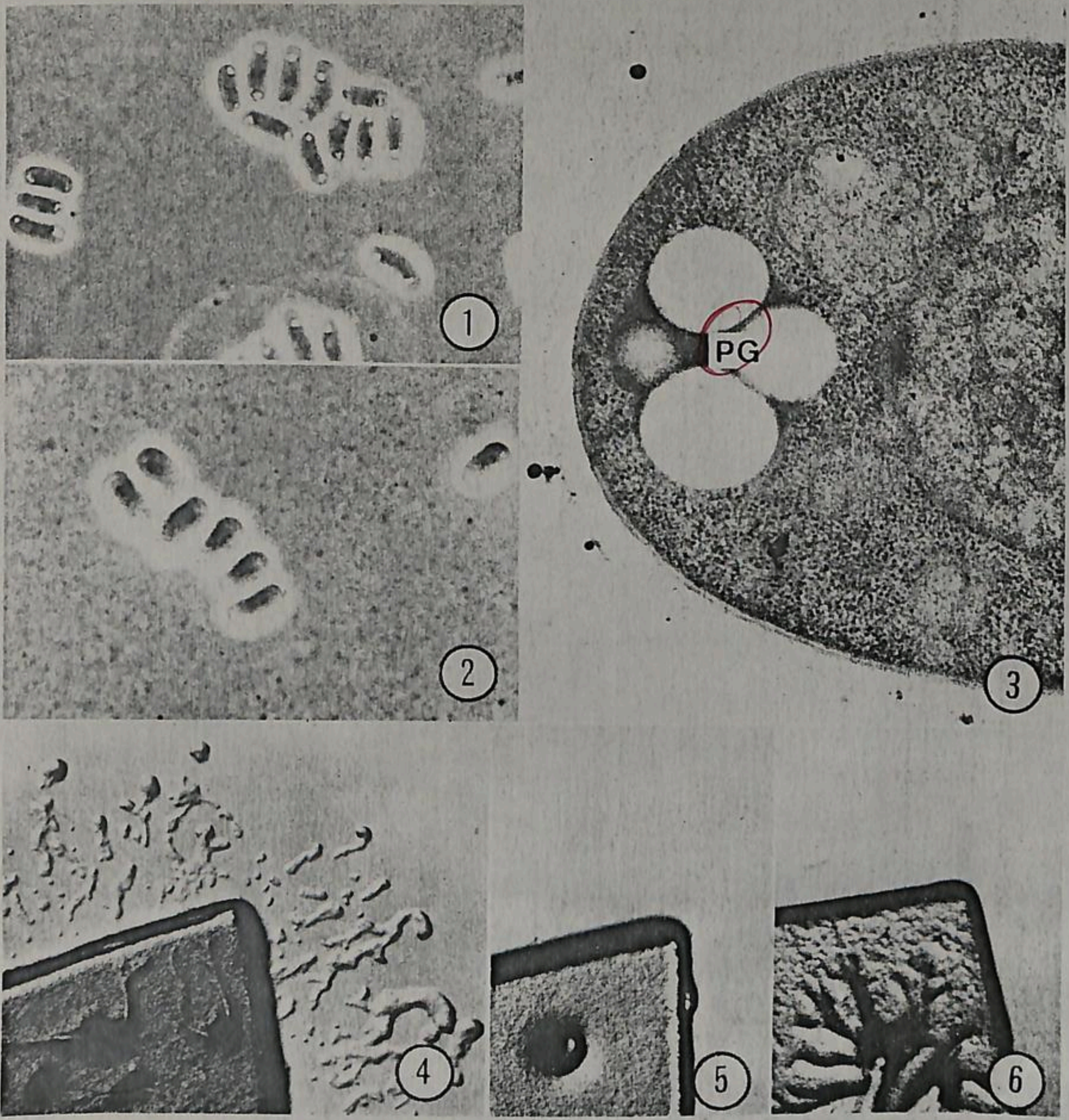


Fig. 1–6. **1.** Spores from a PG-positive strain (GR-6) with prominent polar spore granules (PG). × 1200. **2.** Spores from a PG-negative strain (GR-11). Note the absence of the PG character. × 1200. **3.** Electron micrograph of PG structure. Electron transparent vesicles partly or fully embedded in an electron dense matrix; strain VS-3, osmium tetroxide-glutaraldehyde fixation, poststained with lead citrate and uranyl acetate. × 42,000.—Fig. 4–6. Bonner's cellophane square test. **4.** Edge of a cellophane square with young aggregates. Congregative, radial outward streaming of myxamoebae of a PG-negative strain on agar containing $10^{-6}$ M cAMP; strain GR-11. × 38. **5.** Control experiment: No outward moving of myxamoebae in the absence of cAMP. × 38. **6.** A PG positive strain in the Bonner test: No emigration of myxamoebae from the cellophane square at the aggregation stage despite the presence of $10^{-6}$ M cAMP in the underlying agar; strain GR-6. × 38.

contained polar refractile granules in their spores. The same granules were also observed in all strains of the genus *Polysphondylium* tested. Each of these polar spore granules (PG), already noticed by earlier investigators (e.g., Raper and Fennell, 1967), is formed by a group of tightly aggregated small vesicles. The inclusions are located in a predominantly polar, sometimes subpolar or more central position of the spores (Fig. 1), each spore normally possessing two of these structures. In strains lacking the PG character the small vesicles are still present but scattered throughout the spore amphispore (obsol.); (3) the middle layer of a three-layered spore wall.

**meta-** (prefix), changed in form or position; between; with; after; **-basidium,** see basidium; **-biosis,** the association of two organisms acting or living one after the other; cf. synergism; **-cellulose,** cellulose of lichens and fungi; **-chronic,** see colour; **-physis** (Petrak) = paraphysis.

**Metabasidiomycetidae,** subclass of Basidiomycetes proposed by Lowy (*Taxon,* 17: 125, 1968) for taxa considered intermediate between hetero- and homobasidiomycetes.

**Metabolic products.** Fungal metabolites are many and diverse. In addition to those associated with protein synthesis and respiration many special products have been isolated and, frequently, chemically defined. Some of these are waste products while others such as pigments, toxins, and antibiotics clearly have biological functions. Because of their synthetic abilities fungi are used in industry for the production of alcohol, citric acid and other organic acids, various enzymes, riboflavin, etc. (see Industrial mycology).

Many fungal products, even when chemically defined, have been given trivial names derived from the scientific names of the fungi involved, e.g., 'griseofulvin' from the epithet of the binomial *Penicillium griseofulvum*, and more than 400 such names have been compiled in this *Dictionary*.

When no reference is given under a name further details can usually be obtained from Miller (1961) or Shibata *et al.* (1964); references to the *Phil. Trans. R. Soc.* or *Biochem. J.* without authors are to Raistrick *et al.* (1931–64) which has been fairly fully indexed.

*Lit.:* Raistrick *et al.* (1931–64). Studies in the biochemistry of micro-organisms. [This important series, almost exclusively devoted to fungi, ran to 116 parts in *Phil. Trans. R. Soc.*, **B220:** 1–367, 1931 and *Biochem. J.*, **25** (1931)–**93** (1964)]; M. W. Miller, *The Pfizer handbook of microbial metabolites*, 1961; Shibata, Natori, & Udagawa, *List of fungal products*, 1964 (Univ., Tokyo Press); Birkinshaw in Ainsworth & Sussman, **1**, chap. 9 (review).

See also antibiotic, antigen, ergot, Hallucinogenic fungi, Industrial mycology, Lichen products, Mycotoxicoses, Pigments, Poisonous fungi, Toxins.

**Metabotryon** Syd. (1926) = Pycnodothis (Sphaeropsid.), fide Clem. & Shear.

**Metabourdotia** L. S. Olive (1957), Tulasnellales (Ceratobasidiaceae). 1, Tahiti.

**Metacapnodium** Speg. = Phragmocapnias (Capnod.), fide Clem. & Shear.

**Metachora** Syd. & Butler = Phyllachora (Sphaer.), fide Clem. & Shear.

**Metacoleroa** Petrak (1927), Pleosporales (1.B2). 1, N. Temp.

**Metadiplodia** Syd., Sphaeropsidales. 38 (fide Zambett.), cosmop.

Ainsworth - Dictionary 1971

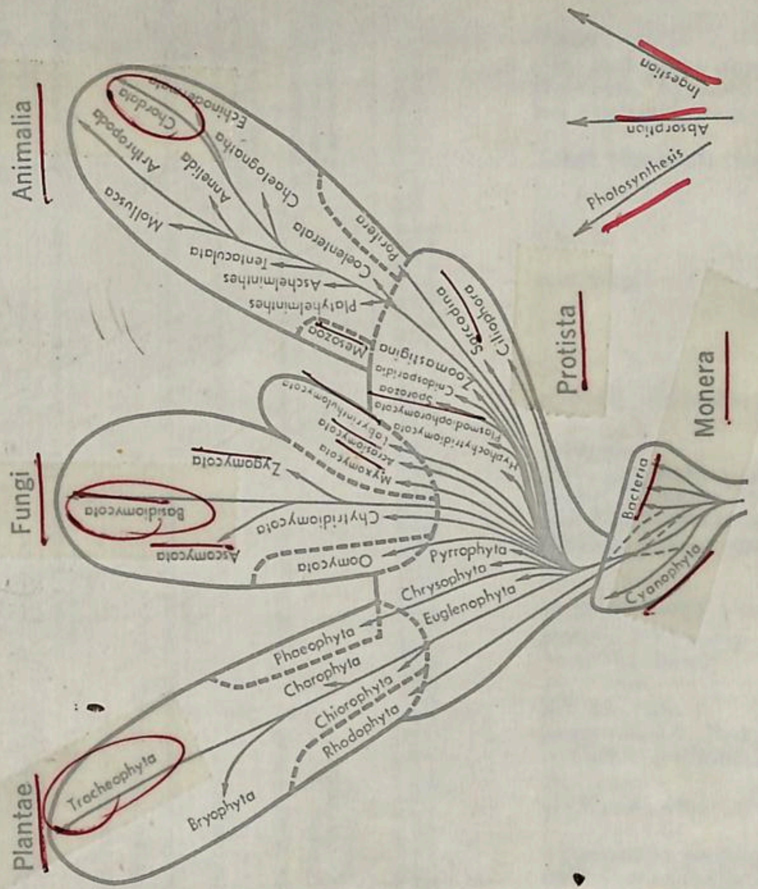
During recent years there has been increasing support for the view that two Kingdoms of living things are insufficient and that fungi and other heterotrophic micro-organisms are neither plants nor animals. Haeckel, a century ago, devised a 4-kingdom system and representative modern examples of similar systems are provided by H. F. Copeland, *Classification of lower organisms*, 1956, and F. A. Barkley, *Outline classification of organisms*, ed. 3, 1970, while the 5-kingdom arrangement by R. H. Whittaker (*Science*, 163: 160, 1969) is summarized by the diagram reproduced opposite.

These developments have emphasized the uncertainties which still underlie the status, circumscription, and taxonomy of fungi. Here, following Whittaker, the fungi are treated as a Kingdom but this should cause little inconvenience to traditionalists. (For further details on the status of fungi see the reviews by G. W. Martin: *Mycol.*, 47: 779, 1955 ('Are fungi plants?') and in Ainsworth & Sussman, 3 (1968), chapt. 25).

As regards circumscription, bacteria (including actinomycetes) are excluded, but myxomycetes and cellular slime moulds (Acrasiomycetes) are included as are certain other plasmodial forms (Hydromyxomycetes, Plasmodiophoromycetes). Among non-plasmodial groups the Oomycetes, which are considered to be algae by Kreisler (1969) and others are retained, and Sparrow is followed in classifying Hyphochytridiomycetes as fungi rather than algae.

The taxonomic framework, which remained virtually unchanged in the previous five editions of the *Dictionary*, has been updated. The chief modifications are that Phycomycetes is no longer recognized, Loculoascomycetes is used for the bitunicate ascomycetes, and the rusts and smuts are grouped together as the Teliomycetes. The main difference between the classification adopted in this *Dictionary* and those commonly employed is that the three main Classes of fungi—Ascomycetes, Basidiomycetes, and Deuteromycetes (Fungi Imperfecti)—are here given Subdivisional status (see the Table, pp. 216–217). This treatment is largely a matter of convenience for it allows a number of familiar and widely used names, such as Pyrenomycetes, Discomycetes, Hymenomycetes, Gasteromycetes, Hyphomycetes, and Coelomycetes, to be used correctly as Class names as required by the International Code of Botanical Nomenclature (see Nomenclature). It does, however, not imply that the Classes recognized are of necessity natural units. Several of the Classes are clearly heterogeneous but most mycologists will probably find them currently acceptable categories for the primary sorting of the many generic names which have been proposed.

Lichenized fungi are not here integrated with non-lichenized fungi but the genera of lichens are listed and grouped as a separate series of which the starting point is LICHENES.



Diagrammatic representation of the 5-Kingdom System of Whittaker
(From Whittaker, 1969)

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in Science 163: 160.