

THE CLASSIFICATION OF PLANTS, VIII.

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Below is presented a synopsis of the fifteen plant phyla given in the preceding paper of this series. The classification of the fungi follows with a key to the orders.

The following changes should be made in the arrangement of the families of Anthophyta as presented in the sixth paper: Transfer the Parnassiaceae from Saxifragales to Ranales following the Ranunculaceae. Interchange the position of Loganiaceae and Oleaceae. Also interchange the position of Bromeliaceae and Dioscoreaceae.

SYNOPSIS OF THE PLANT PHYLA.

A. Plant body unicellular or filamentous, or if a solid aggregate through the ovary, when present, not an archegonium; never seed-producing; nonsexual, with a simple sexual life cycle, or with an alternation of generations.

I. Cells typically with poorly differentiated nuclei and chromatophores, reproducing by fission; motile or nonmotile, colored or colorless, with or without chlorophyll but never with a pure chlorophyll-green color; resting spores commonly present.

Phylum 1. SCHIZOPHYTA.

II. Cells with well differentiated nuclei, and if holophytic usually with definite chromatophores; with or without chlorophyll; colorless, green, or variously tinted by coloring matters.

(I.) Nonsexual, unicellular plants without chlorophyll having a plasmodium stage of more or less completely fused amoeboid cells from which complex sporangium-like resting bodies are built up. Phylum 2. MYXOPHYTA.

(II.) Plants not developing a plasmodium, but the cells normally covered with walls in the vegetative phase.

1. Unicellular or filamentous plants containing chlorophyll, either brown with silicious, two-valved walls or green with complex chromatophores, the walls not silicified; conjugating cells not ciliated, isogamous.

Phylum 3. ZYGOPHYTA.

2. Plants not with silicified, two-valved walls, if with a direct conjugation of nonmotile cells or branches then without chlorophyll.

(1.) Plants with chlorophyll; if without chlorophyll then either without a true mycelium, or if a mycelium is present having a sexual phase with ciliated, motile sperms.

a. Antheridium when present not consisting of a globular structure containing sperm-bearing filaments; often with an alternation of generations.

(a.) Plants green with chlorophyll or colorless, nearly all producing nonsexual zoospores, the sexual forms isogamous or heterogamous.

Phylum 4. GONIDIOPHYTA.

(b.) Plants with chlorophyll hidden by a brown, red, or purple pigment, always with a multicellular body and with sexuality.

((a.)) Mostly marine brown algae with phycohaecin; isogamous or heterogamous, with ciliated sperms, both gametes discharged from the gametangia. Phylum 5. PHAEOPHYTA.

((b.)) Mostly marine red algae with phycoerythrin; heterogamous, with stationary eggs and non-ciliated sperms.

Phylum 6. RHODOPHYTA.

b. Filamentous, aquatic, green algae with globular antheridia containing sperm-bearing filaments, the sperms being biciliated; nonsexual spores absent. Phylum 7. CHAROPHYTA.

(2.) Plants without chlorophyll and with a true mycelium; sexual reproduction if present without motile sperms; sometimes with an alternation of generations.

Phylum 8. MYCOPHYTA.

B. Plant body a solid aggregate, if filamentous, only so in the embryonic condition; ovary an archegonium, if a reduced archegonium then the plants seed-bearing; always with an antithetic alternation of generations in the normal life cycle.

I. Without vascular tissue; sporophyte parasitic on the gametophyte during its entire life; homosporous; small plants without roots or true leaves. Phylum 9. BRYOPHYTA.

II. Always with vascular tissue in the sporophyte which becomes an independent plant at maturity, with roots and leaves except in a few degenerate forms.

1. Sporophyte not seed-producing, the sperms breaking out of the antheridium to enter the necks of the archegonia; homosporous or heterosporous.

a. Sperms comparatively large, multiciliate; the sporophylls not in cones unless the sporophytes have jointed stems and small whorled leaves.

(a.) Stems not jointed, the leaves usually large and compound and spirally arranged, rarely in whorles; sporophylls never in cones.

Phylum 10. PTENOPHYTA.

(b.) Stems jointed and fluted, bearing small, whorled leaves; sporophylls in cones.

Phylum 11. CALAMOPHYTA.

b. Sperms small, biciliate; the leaves small and simple, covering the continuous stem in spirals or sometimes opposite; sporophylls usually in cones or sometimes forming zones alternating with the sterile leaves. Phylum 12. LEPIDOPHYTA.

2. Sporophyte producing seeds, the female gametophyte always parasitic in the megasporangium (ovule) during its entire life, the male gametophyte developing a pollen-tube through which the sperms are discharged; always heterosporous.

a. Carpels (megasporophylls) open, without stigmas or true ovaries, the ovules and seeds naked and the pollen (male gametophytes) falling directly into the micropyle.

- (a.) Sperms so far as known ciliated and motile; ovules with a pollen-chamber; sporophylls in spiral rosettes or aggregated into cones.
Phylum 13. CYCADOPHYTA.
- (b.) Sperms without cilia, ovules without definite pollen-chambers; sporophylls in cones which may be highly specialized, or reduced.
Phylum 14. STROBILOPHYTA.
- b. Carpels or the set of carpels (megasporophylls) closed at maturity, with stigmas and with ovularies enclosing the ovules and seeds; pollen (male gametophytes) falling on the stigma and developing long pollentubes; flowers well developed, usually with a perianth, often highly specialized or reduced. Phylum 15. ANTHOPHYTA.

The following arrangement of the fungi is the result of several years of study in attempting to discover the natural relationships of the thallophytes without chlorophyll. It is no doubt far from what must be the final arrangement, yet it is believed to represent the phyletic classification so far as present investigation has indicated lines of sequence and homologies. Where there has been no decided evidence to the contrary, the system and terminology have not been changed from that which is in rather general use.

In classifying fungi, as well as other groups, the supposed relationships cannot be determined by taking a single character or set of characters into consideration but every part and function in the entire life cycle must be duly considered. Many essentially similar structures and processes have developed entirely independently of one another. In recent years, it seems that various attempts have been made to read the ordinary antithetic life cycle into the higher fungi. It is probable that alternation of generations had several independent origins even in the unicellular forms, and the original cycle may have been modified in various ways. One thing is clearly evident, that it is possible to have an alternation of sexual and nonsexual phases with both generations having either the haploid or diploid number of chromosomes.

The lichens have not been distributed farther than the subclasses, perhaps not as far as present day knowledge would warrant but we need much more morphological and cytological investigation of both the ordinary Ascomycetae and the Ascolichenes before a fairly certain arrangement is possible.

Whether the Mycophyta, as delimited by the writer, represent two main origins and two phyla or whether the Phycomycetae should be joined with the Gonidiophyta are still open questions, but there is at least a very serious array of objections against the hypothesis that the typical Ascomycetae and the Laboulbeniaceae have had their origin from the red algae rather than from the more primitive Gonidiophyta. The marine nature of the red algae, with their lack of semiparasitic aerial forms, as well as the

very great difference in the type of alternation of generations point to the conclusion that the evident similarities between the two groups are rather to be regarded as analogous developments. Unless the case can be made much more evident than at present, even the more or less superficial similarity between the structures of the ascocarp and cystocarp cannot be urged as very strong evidence in favor of a direct origin from the Rhodophyta.

Whether all the fungi containing an ascus should be placed in a single class and whether the Teliosporeae should be retained in a class distinct from the Basidiomycetae are questions which depend on one's definition or conception of a class. It is very desirable to have a system that is fairly consistent for the entire plant kingdom, if botany is to be a science and not simply a group of disjointed subjects.

FUNGI.

I. SCHIZOPHYTA. Fission Plants.

1. **Schizomycetae.** Fission Fungi.
 - a. Bacteriales. Bacteria.
 - b. Desmobacteriales. Filamentous Bacteria.
 - c. Rhodobacteriales. Purple Bacteria.
2. **Myxoschizomycetae.** Slime Bacteria,
 - a. Myxobacteriales.

II. MYXOPHYTA. Slime Molds.

1. **Plasmodiophoreae** (?) [Parasites.]
 - a. Plasmodiophorales.
2. **Myxomycetae** [Saprophytes.]
 - (1.) *Acrasieae.*
 - a. Acrasiales.
 - (2.) *Myxogastreae.*
 - a. Ceratiomyxales.
 - b. Myxogastrales.

IV. GONIDIOPHYTA. Zoospore Plants.

1. **Archemycetae.** Primitive Fungi.
 - a. Chytridiales.
2. **Monoblepharideae.** [With normal gametes.]
 - a. Monoblepharidales.

VIII. MYCOPHYTA. Typical Fungi.

A. PHYCOMYCETAE. Algal Fungi.

1. **Zygomycetae.**
 - a. Mucorales. Black Molds.
 - b. Entomophthorales. Insect-cholera Fungi.
2. **Oomycetae.**
 - a. Ancylistales.
 - b. Saprolegniales. Water Molds.
 - c. Peronosporales. Common Mildews.

B. MYCOMYCETAE. Higher Fungi.

3. **Ascomycetae.** Sack Fungi.
 - (1.) *Hemiasceae.* Intermediate Sack Fungi.
 - a. Ascoideales.
 - (2.) *Aspergilleae.* Tuber Fungi.
 - a. Aspergillales. Little Tuber Fungi.
 - b. Tuberales. Truffles.

- (3.) *Discomycetae.*
 - a. Hysteriales. Slit Fungi.
 - b. Phacidiales. Little Cup Fungi.
 - c. Pezizales. Cup Fungi.
 - d. Protocaliciales.
 - e. Helvellales.
- (4.) *Discolichenes.*
 - a. Coniocarpales.
 - b. Graphidales.
 - c. Cyclocarpales.
- (5.) *Pyrenomycetae.*
 - a. Hypocreales.
 - b. Dothideales.
 - c. Sphaeriales.
 - d. Perisporiales. Powdery Mildews.
- (6.) *Pyrenolichenes.*
 - a. Pyrenulales.
 - b. Mycoporales.
- (7.) *Exoasceae.*
 - a. Exoascales.
 - b. Saccharomycetales. Yeast-plants.
- (8.) *Deuteromycetae.* Imperfect Fungi.
 - a. Moniliales. Common Molds.
 - b. Melanconiales. Black-dot Fungi.
 - c. Sphaeropsidales. Spot Fungi.
- 4. **Laboulbenieae.** Beetle Fungi.
 - a. Laboulbeniales.
- 5. **Teliosporeae.** Brand Fungi.
 - a. Tilletiales. Stinking Smuts.
 - b. Ustilaginales. Loose Smuts.
 - c. Uredinales. Plant Rusts.
- 6. **Basidiomycetae.** Basidium Fungi.
 - (1.) *Protobasidiae.*
 - a. Auriculariales. Ear Fungi.
 - b. Tremellales. Jelly Fungi.
 - c. Dacryomycetales.
 - (2.) *Hymenomycetae.*
 - a. Agaricales.
 - (3.) *Hymenolichenes.*
 - a. Corales.
 - (4.) *Gastromycetae.*
 - a. Hymenogastreales. False Truffles.
 - b. Sclerodermatales. Thick-skinned Puffballs.
 - c. Lycoperdales. Puffballs.
 - d. Nidulariales. Bird-nest Fungi.
 - e. Phallales. Stink-horns.

Key to the Orders of Fungi.

The Fungi are Thallophytes without chlorophyll but sometimes inclose chlorophyll-containing Algae in the meshes of their bodies.

1. Plant body not a true mycelium, usually unicellular, or the cells sometimes in simple or branched filaments; some forms with a plasmodium, others with a sack-like body containing cells; the resting or spore stage sometimes consisting of a sporangium-like body without cell structure, with enclosed spores. 2.
1. Plant body a more or less perfectly developed mycelium consisting of septate or nonseptate hyphae. 7.

2. Plants consisting of minute, distinct cells with walls, or with the cells arranged in simple or branched filaments; the cells sometimes in a gelatinous mass; often ciliate; nuclei poorly differentiated.

SCHIZOMYCETAE. 3.

2. Plant body of minute distinct cells in a pseudoplasmodium, the whole mass motile; fruiting bodies of definite form somewhat like the sporangia of slime molds; saprophytes.

MYXOSCHIZOMYCETAE. **Myxobacteriales.**

2. Plant body of oval or elongated, comparatively large, nonmotile cells which increase by budding; commonly present in sugary solutions and fruit juices causing alcoholic fermentation. **Saccharomycetales.**

2. Plant body when mature consisting of cells in a sack-like structure; usually parasitic in the cells of algae, pollengrains in water, and occasionally in the cells and tissues of higher plants.

ARCHEMYCETAE. **Chytridiales.**

2. Plant body a motile plasmodium of naked cells, the fruiting stage usually a so-called sporangium, usually without cell structure excepting the spores within; saprophytic, rarely parasitic.

MYXOMYCETAE. 4.

3. Cells spherical, rod-shaped, curved, or spiral, free or in simple or loose aggregates or filaments, motile or nonmotile, some with cilia or flagella; not with a purple pigment in the protoplasm. **Bacteriales.**

3. Cells spherical, rod-shaped, or spiral, containing a purple pigment called bacterio-purpurin. **Rhodobacteriales.**

3. Cells in filaments surrounded by a sheath, or filaments without a sheath but with active movement by means of an undulating cell membrane. **Desmobacteriales.**

4. Parasitic in the cells of living plants, the cells forming a plasmodium; the fructification consisting of a mass of free cells.

Plasmodiophorales.

4. Saprophytes developed on decaying organic matter. 5.

5. Amoeboid cells massed together in an imperfect plasmodium; ripe fructification consisting of masses of free cells, sometimes on a stalk. **Acrasiales.**

5. Vegetative body a true plasmodium; with free, white stalked spores or with spores in a sporangium-like receptacle. 6.

6. With free, white, stalked spores. **Ceratiomyxales.**

6. With spores in sporangium-like receptacles. **Myxogastrales.**

7. Mycelium nonseptate, or if septate still with cenocytic divisions; spores not in asci nor on basidia, usually formed as the result of the conjugation of two similar or dissimilar hyphal branches; zoospores or conidia present in most forms and in some cases nonmotile, non-sexual spores in special sporangia. 8.

7. Mycelium definitely septate; spores in the normal forms borne in asci or on basidia, in some groups the basidia developing from chlamidospores; numerous imperfect forms with only the conidial stage known. 11.

8. Mycelium with septa; reproduction by means of true eggs and free-swimming spermatozoids; aquatic molds.

MONOBLEPHARIDEAE. **Monoblepharidales.**

8. Sexual spores produced by the conjugation of two equal or nearly similar hyphal branches; mycelium saprophytic or parasitic on plants and animals, especially on insects; no zoospores produced.

ZYGOMYCETAE. 9.

8. Sexual spores produced by the conjugation of a large branch and a small branch, the smaller penetrating the larger by means of a tubular process; mycelium parasitic or saprophytic; aquatic molds on living or dead animals or aerial plant parasites, often with non-sexual zoospores. OOMYCETAE. 10.

9. Saprophytic, or occasionally parasitic on other molds. **Mucorales.**
 9. Parasitic on insects, as flies, grasshoppers, plant lice, etc. **Entomophthorales.**
10. Mycelium poorly developed, with septa; endophytic parasites, mostly in fresh water algae, some in the roots of higher plants. **Ancylistales.**
 10. Saprophytic or parasitic, mostly aquatic molds; mycelium well developed; nonsexual reproduction by zoospores. **Saprolegniales.**
 10. Parasitic on the higher plants; nonsexual reproduction by aerial conidia which may give rise to zoospores. **Peronosporales.**
- 11—
11. Hyphae usually forming sporocarps having spores enclosed in asci. **ASCOMYCETAE.** 12.
 11. Plant body minute, erect, few-celled, growing parasitic on insects; perithecia on a receptacle; asci usually 4-spored. **LABOULBENIEAE. Laboulbeniales.**
11. Parasites with basidia coming from chlamidospores (teleutospores) which are with or without stalks. **TELIOSPOREAE.** 31.
 11. Hyphae usually forming sporocarps bearing basidiospores on basidia arising directly from the mycelium. **BASIDIOMYCETAE.** 33.
 11. Hyphae bearing only conidia, in pycnidia, or the conidia superficial borne on loose or innate hyphae; asci or basidia not known. **DEUTEROMYCETAE.** 29.
12. Fungi symbiotic with algal cells. **ASCOLICHENES.** 13.
 12. Fungi without helotic algae in their bodies. 17.
 13. Asci on an apothecium. **DISCOLICHENES.** 14.
 13. Asci in a perithecium. **PYRENOLICHENES.** 16.
 14. Paraphyses forming a powdery mass with the spores, the paraphyses growing beyond the asci, forming there a network, adhering to the disk of the apothecium which soon breaks up into a powdery mass with the spores. Algae belonging to the Gonidiophyta. **Conyocarpales.**
14. Paraphyses not forming a powdery mass with the spores. 15.
 15. Disk of the apothecium linear, ellipsoid, or somewhat angular. Algae belonging to the Gonidiophyta. **Graphidales.**
 15. Disk of the apothecium circular. Algae belonging to the Gonidiophyta or to the Cyanophyceae. **Cyclocarpales.**
16. Cavity of the perithecium simple, not divided by complete or incomplete partitions. **Pyrenulales.**
 16. Cavity of the perithecium divided by complete or incomplete partitions. **Mycoporales.**
17. Asci with a variable number of spores, usually many-spored. **HEMIASCEAE. Ascoideales.**
 17. Asci with a definite number of spores in typical cases, separate from each other, not forming a definite fruiting body. **EXOASCEAE.** 18.
 17. Asci with a definite number of spores in typical cases, collected on or in an ascocarp. 19.
 18. Asci approximate and forming an indefinite hymenium; mostly parasitic **Exoascales.**
18. Asci entirely isolated; vegetative reproduction by budding of the cells; plants producing alcoholic fermentation. **Saccharomycetales.**
 19. Asci collected in enclosed tuber-like bodies or fasciculate, and surrounded by a spherical, cylindrical, pyriform or shield-like wall, the perithecium. 24.
 19. Asci collected in a flattened, concave or convex hymenial layer (Ascoma). **DISCOMYCETAE.** 20.
 20. Apothecia pulverulent, spheroidal, plants saprophytic. **Protocaliciales.**
20. Apothecia not pulverulent. 21.

21. Ascoma more or less completely closed at first, opening free at or before maturity, and plane, concave, or rarely convex. 22.
21. Ascoma open from the first, normally convex and commonly with the surface pitted or with gyrose furrows. **Helvellales.**
22. Ascoma long enclosed in a tough covering which is torn open at the maturity of the spores. 23.
22. Ascoma soon becoming free, without special covering; mostly fleshy cuplike fungi. **Pezizales.**
23. Ascoma mostly elongate, the cones opening by a longitudinal fissure. **Hysteriales.**
23. Ascoma roundish, the cover rupturing by radiating or stellate fissures. **Phacidiales.**
24. Asci arranged at different levels in the perithecium or in a hymenium lining enclosed cavities. **ASPERGILLEAE.** 25.
24. Asci in fascicles arising from a common level. 26.
25. Asci arranged at different levels, sometimes forming skein-like masses. **Aspergillales.**
25. Asci in a definite flat hymenium lining cavities, permanently enclosed; fruiting body mostly subterranean. **Tuberales.**
26. Cleistothecia globose, scattered, without apparent ostiole, usually with appendages, mostly attached to an apparent mycelium or membrane; in one family flat shield-shaped perithecia with ostiole present. **Perisporiales.**
26. Perithecia typical with distinct ostiole. 27.
27. Perithecia (and stroma if present) fleshy or membranous, bright-colored (white, red or blue). **Hypocreales.**
27. Perithecia (and stroma if present) hardened, never fleshy, rarely membranous, dark-colored (black or dark brown). 28.
28. Walls of the perithecia scarcely distinguishable from the stroma. **Dothideales.**
28. Perithecia with distinct walls either free or imbedded in a stroma. **Sphaeriales.**
29. Conidia borne on short stalks in pycnidia. **Sphaeropsidales.**
29. Conidia superficial, borne on loose or innate hyphae; no true pycnidia present. 30.
30. Hyphae somewhat superficial, often floccose. **Moniliales.**
30. Hyphae innate with the matrix; parasitic; the conidia borne on a pseudo-pycnidium, formed from the altered tissue of the host. **Melanconiales.**
- 31—
31. Chlamydospores produced in the ovaries, leaves or stems of the host, usually black, not stalked. 32.
31. Chlamydospores (teleutospores) usually stalked, producing black or brown pustules under the epidermis of leaves or stems; often developing on the same or on a different host clusters of cup-like or crater-like aecidia with spores formed in chains inside of a membranous pseudoperidium. **Uredinales.**
32. Chlamydospores developing a several-celled basidium (promycelium) which bears the spores at the sides of the cells. **Ustilaginales.**
32. Chlamydospores developing a nonseptate basidium which bears the spores at the apex. **Tilletiales.**
33. Fungi symbiotic with algal cells. **HYMENOLICHENES.** **Corales.**
33. Fungi without helotic algae in their bodies. 34.
34. Plants gelatinous, basidia divided, transversely or longitudinally or deeply two-forked. **PROTOBASIDIAE.** 35.
34. Plants fleshy, coriaceous, woody, or rarely somewhat gelatinous; basidia nonseptate. 36.
35. Basidia transversely septate. **Auriculariales.**

35. Basidia divided obliquely or lengthwise, commonly into four parts. **Tremellales.**
35. Basidia deeply two-forked, not completely divided. **Dacryomycetales.**
36. Basidia on a distinct membranous hymenium, naked at maturity and covering gills, pores, spines, or a smooth or wrinkled surface. **HYMENOMYCETAE. Agaricales.**
36. Basidia enclosed within a definite peridium but sometimes exposed at maturity, the spores then borne in a more or less deliquescent gleba. **GASTROMYCEAE. 37.**
37. Spores borne in a more or less deliquescent gleba which is at first enclosed in an egg-like body but at maturity elevated on an elastically expanding stalk or base. **Phallales.**
37. Spores remaining within the peridium or in the hymenial cavities until maturity. 38.
38. Basidia united into a hymenium which lines the walls of irregular cavities. 39.
38. Basidia uniformly distributed through the peridium or forming skein-like masses. **Sclerodermatales.**
39. Hymenial cavities remaining together within the peridium, their boundaries mostly disappearing at maturity. 40.
39. Hymenial cavities (sporangioles) separating at maturity from the cup-like peridium. **Nidulariales.**
40. Remaining fleshy until the maturity of the spores; no capillitium. **Hymenogastrales.**
40. Fleshy when young, at maturity filled with dust-like spore masses mixed with the capillitium. **Lycoperdales.**
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