

KEYS TO THE ORDERS, FAMILIES, AND GENERA OF THE GASTEROMYCETES ¹

S. M. ZELLER *

These keys are presented with no claim for originality. They have been prepared with full use of published keys, helpful literature, and personal advice from colleagues. Undoubtedly the most helpful have been the publications of our late colleague, Dr. Ed. Fischer, especially his most recent monograph (1933). Others whose assistance and advice have been sought and are thankfully acknowledged are Dr. W. C. Coker, Dr. H. M. Fitzpatrick, Dr. W. H. Long, Dr. G. W. Martin, and Dr. D. P. Rogers. Publications by the following authors have been used for ready reference: Bataille (1923), Coker & Couch (1928), Cunningham (1942), Fischer (1933), Hollós (1904), Kambly & Lee (1936), Lohman (1927), Lohwag (1926), Long (1907), (1917), (1940), (1941 [2]), (1942 [2]), (1943 [3]), (1944), (1945), and (1946 [3]), Longnecker (1927), Malençon (1931), Martin (1936), (1941), Morgan (1889-1893), Pilat (1934), Rea (1942), Stevenson and Cash (1936), and White (1901), (1902).

The following keys include all of the genera considered acceptable by the author. Genera which have been reduced to synonymy or may be considered doubtful are not mentioned here. Some of them have been dealt with elsewhere ² or will be given consideration later when certain of the genera will be treated specifically. The new orders, Gautieriales and Tremellogastrales, have been previously discussed.²

¹ Published as Technical Paper No. 536, with the approval of the Director of the Oregon Agricultural Experiment Station. Contribution from the Department of Botany of Oregon State College and The New York Botanical Garden, Cryptogamic Herbarium, co-operating.

*Dr. Zeller died Nov. 4, 1948.

² Zeller, S. M. Notes on certain Gasteromycetes, including two new orders. *Mycologia* 40: 639-668. 1948.

It is realized there are several ways to build keys. One method is to follow strictly along lines of phylogeny, while another is merely an implement of plant identification. The keys presented below are primarily for plant identification without particular emphasis on relationships, although both methods are employed. For that reason, factors that may be used to separate two families or genera may not be the outstanding character or characters of the unit, but merely a sure way to distinguish them.

It will be helpful if colleagues will offer criticism on the keys as a whole or in part and on the general plan of organization of the Gasteromycetes as presented here.

KEY TO ORDERS OF THE GASTEROMYCETES

- I. Gleba or spore mass surrounded by, or extending out to, a peridium at maturity (rarely without peridium), with one to many cavities, or lacunae filled with gel or basidia-bearing hyphae or nests.
 - A. Original structure of gleba maintained until maturity, mostly bulb-like, hypogeous (sometimes epigeous), rarely stalked.
 1. Gleba more or less fleshy, not cartilaginous; basidia in a true hymenium (except in *Melanogastraceae*)1. *Hymenogastres*
 2. Gleba and/or peridium cartilaginous or gelatinous or both.
 - a. Spores ellipsoid, fusoid; with longitudinal ribs (costate).
 2. *Gautieriales*
 - b. Spores spherical, ellipsoid, ovoid, echinulate or sculptured.
 3. *Tremellogastres*
 - c. Spores bacillar, ellipsoid, smooth; basidia phalloid.
 4. *Hysterangiales*
 - B. Gleba disorganized or fallen apart at maturity; peridium usually opening at maturity.
 1. Gleba a powdery or pulpy spore mass at maturity (except *Arachniaceae*).
 - a. Gleba chambered by the outgrowth of tramal plates or pegs, walls of chambers covered with at least a rudimentary hymenium of basidia.
 - 1'. Gleba interspersed with or surrounded by a pseudoparenchymatous, spongy receptacle, which finally through its extension elevates the gleba, or holds it on the inner wall of a hollow chamber; spore mass pulpy, usually slimy and odoriferous, without capillitium5. *Phallales*
 - 2'. Gleba without receptacle; spore mass powdery at maturity (except *Arachniaceae*), with some sort of capillitium.
 - a'. Peridium with one or more gelatinous layers.
 3. *Tremellogastres*
 - b'. Peridium without gelatinous layer6. *Lycoperdales*

- b. Gleba with symmetrically distributed basidia, or with basidia-bearing nests or lacunae arising through the dissolution of fundamental tissue, without a well organized hymenium (except *Batarrea*)7. *Sclerodermatales*
2. Glebal cavities isolated from one another as hard or brittle peridioles or "egg-like" bodies, through the dissolution of the tissue lying between; peridioles adhering to the inside of the peridium or forcibly ejected8. *Nidulariales*
- II. Gleba or spore mass until maturity on the under or inner side of a centrally stalked cap or peridium; basidia at first in a true hymenium. 9. *Podaxales*

ORDER I—HYMENOGASTRALES

Fructifications *mostly* hypogeous, bulblike, occasionally pear- or spindle-shaped, stalked, or epigeous; rarely with a stemlike columella; peridium remaining indehiscent to maturity, seldom disintegrating early; gleba of one or more cavities, lacunae filled with gel or with basidia-bearing hyphae or nests, holding original structure to maturity; peridium and gleba essentially fleshy, not cartilaginous; conidiophores when present borne in hymenium with basidia (*Holocotylon*) or in a separate fructification (*Leucophleps*, conidial stage of *Leucogaster*).

KEY TO FAMILIES IN THE HYMENOGASTRALES

- I. Fructification minute, with a single glebal cavity at maturity.
- A. Spores smooth (coralloid development of fructification).
Family 1. *Protogasteraceae*
- B. Spores verrucose (campanulate development of fructification).
Family 2. *Gasterellaceae*
- II. Fructification with many cavities, or basidial nests, or gel-filled cavities.
- A. Gleba with basidial nests or gel-filled cavities, or cavities lined with a false or rudimentary hymeniumFamily 3. *Melanogasteraceae*
- B. Gleba with open cavities lined with a true hymenium.
1. Spores smoothFamily 4. *Rhizopogonaceae*
2. Spores verrucoseFamily 5. *Hymenogasteraceae*
3. Spores echinulateFamily 6. *Hydnangiaceae*

PROTOGASTERACEAE

Fructifications subspherical, hypogeous, very small, uniloculate, coralloid development; cavities lined with a basidial hymenium; spores smooth.

One genus, *Protogaster*.

GASTERELLACEAE

Fructifications very small, depressed globose, epigeous, campanulate development; gleba finally uniloculate, but at times with one circle of cavities formed by vertical, centripetal invaginations which reach the center forming a false columella; cavities lined with a basidial hymenium; spores verrucose, dark.

KEY TO THE GENERA OF THE GASTERELLACEAE

- I. Gleba at first and at maturity consisting of a single, hymenium-lined cavity1. *Gasterella*
- II. Gleba at first with a percurrent columella around which is one circle of cavities formed by vertical, centripetal invaginations which reach the center forming a false columella, and break away again at maturity; finally uniloculate2. *Gasterellopsis*

MELANOGASTERACEAE

Fructifications subglobose, usually hypogeous, sometimes stipitate at maturity; gleba of lacunae with basidia in nests or in a rudimentary hymenium from the walls of jelly-filled or pseudo-parenchyma-stuffed cavities; gleba not becoming powdery; capillitium none.

KEY TO THE GENERA OF THE MELANOGASTERACEAE

- I. Gleba black or brown with basidia scattered through gel-filled lacunae.
 - A. Gleba black marbled with whitish veins*Melanogaster*
 - B. Gleba dark brown, marbled with light brown veins.
 - 1. Spores ellipsoid, smooth*Alpova*
 - 2. Spores spherical, echinulate; peridium and septa with lactiferous ducts*Maccagnia* (Not known in North America)
 - 3. Spores citriform, rough with loose epispore, as in *Hymenogaster*.
Chondrogaster (Not known in North America)
- II. Gleba light colored to white.
 - A. Fructifications not stipitate.
 - 1. Gleba lacunate, not chambered, hard.
Corditubera (Not known in North America)
 - 2. Gleba chambered, with an irregular hymenium lining chambers filled with hyphal tissue or gel.
 - a. Spores borne on basidia.
 - 1'. Spores ellipsoid, smooth, without a gelatinous sheath.
Cremeogaster
 - 2'. Spores mostly spherical, pitted, covered by a gelatinous sheath*Leucogaster*
 - b. Spores borne on conidiophores*Leucophleps*

B. Fructification stipitate; volvate stem; spores oblong, hyaline.

Torrencia (Not known in North America)

RHIZOPOGONACEAE

Fructifications subglobose, hypogeous or epigeous; peridium simple, with or without rhizomorphic fibrils over the surface; gleba fleshy, not cartilaginous, with open irregularly arranged cavities, or cavities diverging from the base or from a branched or simple columella; original structure of gleba maintained to maturity; basidia in true hymenia; spores smooth, tinted.

KEY TO THE GENERA OF THE RHIZOPOGONACEAE

- I. Fructifications mostly hypogeous, with rhizomorphic fibrils over the surface of the peridium, hymenium of basidia and paraphyses.
 - A. Gleba without columella or conspicuous dendroid tramal plates.

Rhizopogon
 - B. Gleba with columella or conspicuous dendroid tramal plates.

Truncocolumella
- II. Fructifications epigeous, with no superficial fibrils, hymenium of basidia, conidiophores, and paraphyses *Holocotylon*
- III. Fructifications with hollow stems, epigeous; spores ellipsoid, smooth.

Le Ratia (Not known in North America)

HYMENOGASTERACEAE

Fructifications globose, hypogeous, with or without rhizomorphic fibrils over the surface of the peridium; peridium simple; gleba fleshy, not cartilaginous, dark, with or without columella; with true basidial hymenium; spores dark, verrucose.

KEY TO THE GENERA OF THE HYMENOGASTERACEAE

- I. Fructifications without columella.
 - A. Spores verrucose, mostly citrifiform *Hymenogaster*
 - B. Spores angular, as in *Leptonia* * *Richoniella*
- II. Fructifications with dendroid or percurrent columella, spores verrucose, mostly citrifiform *Gymnoglossum*

HYDNANGIACEAE

Fructifications hypogeous, subglobose or subpileate; with or without a columella or stipe, with campanulate development;

* Editor's note: This genus of the Agaricaceae is included in *Rhodophyllus* by most modern authors.

gleba fleshy, not cartilaginous, maintaining original structure to maturity; with true basidial hymenium; sometimes with lactiferous ducts; spores echinulate, slightly tinted, usually spherical.

KEY TO THE GENERA OF HYDNANGIACEAE

- I. Gleba without columella, or tissues without lactiferous ducts; spores subglobose.
 A. Spores thick-walled; gleba gelatinous, cavities filled with spores.
Sclerogaster
 B. Spores with thinner walls; gleba fleshy, not gelatinous. *Hydnangium*
 II. Gleba with columella, and with lactiferous ducts in some or all tissues *Arcangeliella*
 III. Gleba with columella or stipe; tissues without lactiferous ducts but always with islands of pseudoparenchyma *Elasmomyces*

ORDER II—GAUTIERIALES

Fructifications hypogeous, sessile; peridium wanting or present, when present stipose, loosely filamentous or pseudoparenchymatous; gleba gristly translucent and white when fresh, becoming brittle and brownish as spores mature; columella from a basal rhizomorph; basidia in a hymenium; septa usually gelatinous-cartilaginous, of gelified hyphae; basidiospores of various shapes, mostly broad fusiform, verrucose or longitudinally costate, brown.

One family, 7. *Gautieriaceae*, with characters of the order. There is one genus, *Gautieria*.

ORDER III—TREMELLOGASTRALES

Fructifications hypogeous or epigeous, mostly sessile; peridium of two or more layers, the outer of fundamental tissue, the inner of a gelatinous nature, continuous or interrupted by sutures of fundamental tissue; gleba centripetally developed, pulverulent at maturity; columella simple or wanting; spores spherical, echinulate, verrucose or cristate.

KEY TO THE FAMILIES OF THE ORDER TREMELLOGASTRALES

- I. Peridium with a gelatinous inner layer interrupted by sutures of fundamental tissue; spores spherical, echinulate or cristate.
 Family 8. *Tremellogasteraceae*
 II. Peridium with a simple, continuous gelatinous inner layer; spores spherical, minutely verrucose Family 9. *Gastrosporiaceae*

TREMELLOGASTERACEAE

Fructifications hypogeous or epigeous, mostly sessile; peridium of two or more layers, the outer of fundamental tissue, the inner of a gelatinous nature, interrupted by sutures of fundamental tissue; gleba centripetally developed, pulverulent at maturity; spores spherical, echinulate or cristate.

KEY TO THE GENERA OF THE TREMELLOGASTERACEAE

- I. Inner layer of the peridium very thick, with branched sutures of fundamental tissue dividing the gelatinous portion of the inner peridium radially and periclinally into two more or less definite layers; spores spherical, echinulate ... *Tremellogaster* (Not known in North America)
- II. Inner layer of the peridium thinner, of one gelatinous layer interrupted by radial sutures of fundamental tissue; spores spherical, echinulate and cristate or cristate only ... *Clathrogaster* (Not known in North America)

GASTROSPORIACEAE

Fructifications hypogeous, subglobose, from a single rhizomorph; peridium duplex, outer layer thin, of fundamental tissue (fibrous); inner layer gelatinous, continuous; columella simple; gleba pulverulent or deliquescent at maturity; spores spherical, minutely verrucose, slightly tinted or nearly hyaline.

One genus, *Gastrosporium*, not found in North America.

ORDER IV—HYSTERANGIALES

Fructifications mostly hypogeous, globose or elongate, mostly from rhizomorphic strands; peridium simple or with 2 to 3 layers, or with an inner gelatinous layer (tramal peridium); gleba cartilaginous, gelatinous; basidia phalloid; spores smooth, ellipsoid to bacillar; tramal structure radiating from the base or as continuations from the mycelial strands, diverging from sterile base, or from gelatinous or cartilaginous columella. Rarely with a percurrent columella (*Rhopalogaster*).

KEY TO FAMILIES IN THE HYSTERANGIALES

- I. Tramal peridium not continuous.
 - A. Tramal peridium not well developed or if so, cartilaginous, thin, interrupted by fertile or infertile cavities which are usually not filled by peridial tissue Family 10. *Hysterangiaceae*

- B. Tramal peridium thick, gelatinous, interrupted by thin plates (sutures) of peridial tissue having unbroken connection with the fundamental peridium and sectors of the gleba. .Family 11. *Protophallaceae*
 II. Tramal peridium continuous, thick, gelatinous. .Family 12. *Gelopellaceae*

HYSTERANGIACEAE

Fructifications hypogeous, mostly with rhizomorphic strands or heavy mycelial spawn; peridium simple or with 2 or 3 layers; gleba cartilaginous, gelatinous, tramal structure radiating from the base or from a gelatinous columella (columella percurrent in *Rhopalogaster*); spores smooth, ellipsoid, or bacillar.

KEY TO GENERA OF THE HYSTERANGIACEAE

- I. Fructifications with prolonged, tapering, stalk-like sterile base, or extended into a branched, but not percurrent, columella.
 A. Thicker branches of the columella not dividing the gleba into sharply delimited sectors.
 1. Fructifications not stalked*Hysterangium*
 2. Fructifications with short stalk, extending into the gleba as a hemispherical, sterile base*Jaczewskia*
 B. Thicker branches of the columella dividing the gleba into sharply delimited sectors; fructifications with a prolonged, tapering, stem-like sterile base, pear-shaped*Phallogaster*
 II. Fructifications with a stalk-like, unbranched percurrent columella.
Rhopalogaster

PROTOPHALLACEAE

Fructifications subglobose, hypogeous or epigeous; peridium usually thin, of primary tissue covering a thick gelatinous tramal peridium which is interrupted by radial sutures having unbroken connection with the peridium and gleba, which is gelatinous or cartilaginous, olivaceous or brownish, usually sectored by gelatinous plates radiating from the base or from a columella; cavities empty then filled with spores; basidial hymenium lining cavities; spores small, bacillar, olivaceous.

KEY TO GENERA OF THE PROTOPHALLACEAE

- I. Gleba a powdery mass at maturity*Calvarula*
 II. Gleba gelatinous-cartilaginous at maturity*Protuberata*

GEOPELLACEAE

Fructifications subglobose, hypogeous; peridium thin, filamentous, surrounding a thick, continuous, gelatinous layer (tramal peridium); gleba dark, cartilaginous or gelatinous; cavities lined with basidial hymenium; columella simple or branched (pendant in *G. hahashimensis*); spores small, smooth, colored.

One genus, *Gelopellis*, not known in North America.

ORDER V—PHALLALES

Fructifications at first with a gelatinous universal veil, which is left at maturity as a cupulate volva at the base of a subspherical or ovoid, or a latticed or stem-like, pseudoparenchymatous receptacle which may be with or without a cap; gleba usually mucilaginous at maturity, surrounded by the receptacle, lying between its branches, or on the exterior of the cap or on the modified upper portion of the stem; spores bacillar, smooth.

KEY TO THE FAMILIES OF THE PHALLALES

- I. Receptacle simple, hollow, ovoid Family 13. *Claustulaceae*
- II. Receptacle stalk-like, hollow, cylindrical or fusiform, with or without a bell-shaped cap; gleba borne on exterior of cap or on the outside of a modified upper portion of the stem Family 14. *Phallaceae*
- III. Receptacle latticed, lobed, or with irregular branches, stalked or stalkless; gleba surrounded by the receptacle or lying between its arms.
Family 15. *Clathraceae*

CLAUSTULACEAE

Fructifications spherical, smooth; peridium of 2 layers, the outer rind thin, of filamentous tissue, inner layer gelatinous, continuous; receptacle a hollow, indehiscent, pseudoparenchymatous sphere; gleba lining the interior of the receptacle, confined to one layer of cells; spores smooth, ellipsoid.

One genus, *Claustula*, not known in North America.

PHALLACEAE

Volva cupulate or sheathing, of 2 layers, the outer thin rind of filamentous primary tissue, the inner a thick, continuous, gelatinous layer; gleba surrounding the upper part of the receptacle;

receptacle porous, stalk-like, with or without a bell-shaped cap and sometimes with a continuous or meshy indusium; spores olivaceous or greenish, smooth, small, bacillar.

KEY TO THE GENERA OF THE PHALLACEAE

- I. Receptacle simple, stalk-like, without a freely hanging campanulate cap, upper part wholly covered by a spore mass (gleba) or covered in a girdling zone only.
- A. Gleba-covered part of the receptacle without a pseudoparenchymatous sheath or reticulum.
1. Receptacle in young stages not percurrent in the volva; fructifications growing on wood.
Xylophallus (Not known in North America)
 2. Receptacle in young stages percurrent in the volva; fructifications growing on the ground; buttons hypogeous.
 - a. Gleba covering a ring-like zone on the receptacle, below a sterile tip *Staheliomyces*
 - b. Gleba covering most of the upper part (head) of the receptacle *Mutinus*
- B. Glebal part of the receptacle covered by the pseudoparenchymatous sheath or reticulum.
1. Sheath closely fitting, smooth, granulose, papillose or netted.
Jansia (Not known in North America)
 2. Glebal part of the receptacle covered by a loosely fitting pseudoparenchymatous reticulum.
Floccomutinus (Not known in North America)
- II. Receptacle composed of a hollow stem and a campanulate cap upon the outer surface of which the mass of spores (gleba) is borne.
- A. Indusium or reticulum not present at maturity.
1. Cap and gleba continuous over the apex of the receptacle; cap gelatinous, fastened at lower edge to the stem.
Aporophallus (Not known in North America)
 2. Apex of the receptacle covered by a pseudoparenchymatous cap or disk; gleba throughout pierced by numerous pseudoparenchymatous plates or strands, extending from the upper end of the stem or cap *Itajahya*
 3. Apex of the receptacle with an uncovered pore into the hollow of the receptacle, edge of the cap free; gleba not pierced by plates to the upper surface, but underlaid by a meshiness over the cap.
Phallus
- B. Stem of the receptacle with a pseudoparenchymatous reticulum (indusium) hanging from under the cap.
1. Reticulum (indusium) very short, collar-like, hidden under the cap; the latter perforated, lattice-like.
Echinophallus (Not known in North America)
 2. Indusium at maturity longer than the cap, mostly net-like; cap not perforated *Dictyophora*

CLATHRACEAE

Volva at first enclosing the whole fructification, of 2 layers, the outer a thin filamentous layer, the inner a thick gelatinous layer (tramal peridium) interrupted by thin plates or sutures of primary, filamentous tissue making connection with the outer layer of the volva and sectors of the gleba; receptacle latticed, or with coral-like ramifications, stalked or sessile; gleba surrounded by portions of the receptacle or lying between its branches, dark olivaceous; spores small, bacillar, smooth.

KEY TO THE GENERA OF THE CLATHRACEAE

Receptacle latticed or as meridian-like branches over the apex, branches fastened or with free ends at apex, like spokes of a wheel or like the upward rays on a crown; stalked or sessile.

A. Branches of receptacle solid, thick, composed of many layers of chambers.

1. Receptacle sessile, branches bound together lattice- or net-like.

Clathrus

2. Receptacle sessile, with meridian-like branches bound together at apex only.

a. Walls of the innermost chamber of receptacle branches not opening at maturity *Colonnaria*

b. Walls of innermost chamber of receptacle branches finally parting as wing-like appendages.

Blumenavia (Not known in North America)

3. Receptacle stalked, with arms free at apex.

Ascroë (Not known in North America)

B. Branches of receptacle slender, terete, stalked, or bandlike, a single tube, or composed of very few layers of chambers.

1. Receptacle with branches bound together lattice-like.

a. Receptacle long stalked; the latticed upper part hemispherical to spheroid, with small meshes *Simblum*

b. Receptacle tapering downward, sessile or short stalked; lower meshes narrow, strongly elongated vertically, upper isodiametric, very small *Colus* (Not known in North America)

2. Receptacle with only vertical branches bound together at the apex.

a. Receptacle sessile *Laternea*

b. Receptacle stalked *Pseudocolus*

3. Upper end of receptacle with extended arms.

a. Branches of the receptacle coming off vertically from the wall of the stem *Lysurus*

b. Receptacle branches arising from the edge of a seam or an orbicular extension of the upper end of the stem and spreading horizontally at maturity.

Ascroë (Not known in North America)

- II. Receptacle stalked, beset by irregular coral-like processes extending radially from the upper end and between which the spore masses (gleba) lie*Kalchbrennera* (Not known in North America)

ORDER VI—LYCOPERDALES

Fructifications mostly epigeous, sessile, single or in groups on a stromatic layer, rarely substipitate, globose, pyriform, etc.; peridium 2-4-layered, dehiscing by an apical pore, by several pores, by irregular or stellate cleavages, or crumbling at maturity; gleba wholly fertile or sterile below, becoming a powdery mass or chambers breaking apart and forming at maturity small hollow peridioles; basidia borne in a hymenium; capillitium present (except in *Arachniaceae*).

KEY TO THE FAMILIES OF THE LYCOPERDALES

- I. Whole peridium brittle, disintegrating at maturity; glebal chambers remaining intact but their walls scissile allowing the chambers to fall apart as peridioles, as fine sand-like particlesFamily 16. *Arachniaceae*
- II. Endoperidium persistent; glebal chambers disintegrating into a powdery mass at maturity.
- A. Exoperidium not opening stellately at maturity (*Mycenastrum* possible exception).
1. Peridium 2-layered, dehiscing by an apical stoma or breaking irregularly.
- a. Threads of capillitium smooth, branched, with or without a conspicuous, thick, main filament.
- 1'. Fructifications not on a stroma ..Family 17. *Lycoperdaceae*
- 2'. Fructifications singly or many on a stroma.
- Family 18. *Broomeiaceae*
- b. Threads of capillitium with small, short, pointed (spine-like) side branchesFamily 19. *Mycenastraceae*
2. Peridium 2-3-layered, indehiscent or rupturing irregularly at apex; capillitium unbranchedFamily 20. *Mesophelliaceae*
- B. Exoperidium opening stellately at maturity.
- Family 21. *Geastraceae*

ARACHNIACEAE

Fructifications epigeous, small; peridium thin, fragile, breaking irregularly or crumbling at maturity to liberate the peridioles; gleba made up of numerous spherical chambers lined with a hymenium, forming at maturity a mass of minute, separate peridioles which are like grains of sand; capillitium and sterile base none; spores smooth.

KEY TO GENERA IN THE ARACHNIACEAE

- I. Fructifications sessile, columella wanting*Arachnion*
 II. Fructifications stipitate, columella present*Araneosa*

LYCOPERDACEAE

Fructifications single or in groups, mostly epigeous, subglobose to pyriform or nearly stipitate; gleba wholly fertile, or sterile below; outer peridium mostly a layer of pseudoparenchyma, rarely with a rind that is skin-like or permeated with soil particles, wholly or partially disintegrating at maturity, laying the inner peridium bare; inner peridium usually papery and thin, rarely corky and thick, usually dehiscing by an apical pore; rarely (in *Lycoperdopsis*) the two layers adhere to each other forming a simple pseudoparenchymatous rind, usually opening by an apical pore; capillitium well developed, sometimes falling into pieces.

KEY TO GENERA IN THE LYCOPERDACEAE

- I. Peridium of a loosely interwoven endoperidium and closely adhering pseudoparenchymatous exoperidium.
Lycoperdopsis (Not known in North America)
- II. Peridium with a sharply differentiated, thicker textured endoperidium which is laid bare at maturity by sloughing the exoperidium.
- A. Endoperidium dehiscing by an apical pore (sometimes basal in *Disciseda*).
1. Threads of capillitium smooth, more or less symmetrical, without a conspicuous main stem.
- a. Exoperidium wholly disintegrating.
- 1'. Capillitium accompanied by membranes at maturity.
Morganella
- 2'. Capillitium not accompanied by membranes at maturity.
Lycoperdon
- b. Exoperidium like a rind, or skin-like, or permeated with soil particles, and finally separating (circumscissilely) from a discoid or scutellate base exposing the endoperidium*Disciseda*
2. Threads of capillitium very much branched, with a conspicuous main stem and slender branches with tapering pointed ends; spores with long pedicels*Bovistella*
- B. Endoperidium without apical pore, dehiscing by irregular rupture.
1. Threads of capillitium smooth, without conspicuous main stem or conspicuous branching.
- a. Capillitium smooth or granular, broken, leaving blunt ends, sparingly branched.

- 1'. Endoperidium breaking up and falling away, usually leaving a sterile base covered by a definite membrane; capillitium threads usually broken *Calvatia*
- 2'. Endoperidium cartilaginous, very thin above, splitting into several irregular tooth-like segments at apex .. *Arachniopsis*
- b. Capillitium threads simple, smooth, short with sharp ends.
Bovistoides (Not known in North America)
2. Threads of capillitium much branched with main stem and branches with long tapering pointed ends; free, not attached.
- a. Capillitium threads not thickly interwoven, dispersing readily when exposed *Bovista*
- b. Capillitium threads densely interwoven into balls *Lanopila*

BROOMEIACEAE

Fructifications singly or many on a stroma, mostly ovoid, hemispheric, or subglobose; exoperidium thin, wholly or partly disintegrated at maturity, endoperidium papery or thickish, laid bare at maturity, opening by an apical pore; capillitium present, threads more or less symmetrical, without a conspicuous, thick, main filament.

KEY TO THE GENERA OF THE BROOMEIACEAE

- I. Fructifications more or less singly on a stroma, somewhat hemispheric *Lycogalopsis*
- II. Fructifications many on a stroma, mostly ovoid.
- A. Stroma thick, stalked, or columnar.
Broomeia (Not known in North America)
- B. Stroma sessile, resupinate, or patellate *Diplocystis*

MYCENASTRACEAE

Fructifications large, subglobose to depressed globose; peridium duplex, exoperidium thick, spongy, smooth or areolate, endoperidium thick and leathery, or thin and membranaceous; capillitium branched with short pointed spines; spores spherical to ellipsoid, verrucose.

KEY TO THE GENERA OF THE MYCENASTRACEAE

- I. Outer peridium smooth, thick, spongy, drying thin, fragile; inner peridium thick, corky, splitting stellately at maturity *Mycenastrum*
- II. Outer peridium thick, coriaceous, areolate with irregular pyramidal sections; inner peridium thin *Calbovista*

MESOPHELLIACEAE

Fructifications hypogeous or epigeous, singly or several in a stroma; peridium usually 2-3-layered, indehiscent or rupturing irregularly at the apex; capillitium unbranched; spores globose or ellipsoid, variously roughened or with a gelatinous sheath.

KEY TO THE GENERA IN THE MESOPHELLIACEAE

- I. Spores globose, echinulate, reticulate, or verrucose.
 - A. Gleba with a sterile base *Radiigera*
 - B. Gleba without a sterile base.
 - a. Endoperidium without apical dehiscence *Abstoma*
 - b. Endoperidium dehiscing by a simple stoma or lacerated opening *Bovistina*
- II. Spores ellipsoid, smooth or irregularly roughened.
 - A. Gleba with a large, hard, central core.
 - Mesophellia* (Not known in North America)
 - B. Gleba without a central core.
 - Castoreum* (Not known in North America)

GEASTRACEAE

Fructifications at first hypogeous, or epigeous from the first, rounded or stalk-like below; peridium duplex; outer peridium 2-3-layered, pseudoparenchymatous layer within surrounded by a fibrous layer, at maturity opening out stellately (in *Trichaster* the inner and outer peridium opening together); inner peridium papery thin, loosening from the outer peridium and dehiscing by a pore, or irregularly, or by many pores; gleba with a sterile columella from which the tubular chambers radiate.

KEY TO THE GENERA IN THE GEASTRACEAE

- I. Endoperidium exposed as a whole at maturity, opening by a single, or rarely several pores.
 - A. Endoperidium sessile or on a short stalk *Geastrum*
 - B. Endoperidium on several thin stalks, with several pores above.
 - Myriostoma*
- II. Endoperidium disintegrating at maturity.
 - A. Endoperidium with a prominent sterile base; columella soft, weak.
 - Geasteroides* Long (Not *Geastroides* Battarra)
 - B. Endoperidium and exoperidium remaining joined and opening stellately together; without a sterile base; columella hard, sub-woody.
 - Trichaster* (Not known in North America)

ORDER VII—SCLERODERMATALES

Fructifications mostly epigeous; sporocarp sessile, on a false stem, or if stipitate, borne entirely above the stem or its expanded summit; peridium of 1-4 layers, dehiscing by an apical stoma, or by irregular fissuring or circumscissilely; gleba pulverulent at maturity, with or without capillitium; basidia symmetrically distributed or in nests or cavities arising through the dissolution of the tissue, without a well organized hymenium (except possibly in *Batarrea*).

KEY TO THE FAMILIES OF THE SCLERODERMATALES

I. Peridium mostly simple.

A. Capillitium wanting or rudimentary.

1. Gleba mostly veined or lacunate, developing internally or centrifugallyFamily 22. *Sclerodermataceae*
2. Gleba with veins definitely extending centripetally from the peridiumFamily 23. *Sedeculaceae*
3. Gleba breaking up into small peridioles..Family 24. *Pisolithaceae*

B. Capillitium well developed; gleba entirely homogeneous.

Family 25. *Glischrodermataceae*

II. Peridium with distinct exo- and endoperidium.

A. Sporocarp with a distinct, firm or gelatinous stalk; endoperidium persistent, papery, breaking away from the exoperidium at maturity.

1. Stalk firm, fibrous or woodyFamily 26. *Tulostomataceae*
2. Stalk made up of anastomosed strands forming a rough, lacunose stem, usually quite gelatinous when fresh.

Family 27. *Calostomataceae*

B. Sporocarp sessile; exoperidium thick, splitting more or less readily from the endoperidium, so as to form astral rays.

Family 28. *Astraeaceae*

SCLERODERMATACEAE

Fructifications mostly epigeous, rarely hypogeous or emergent, subglobose, sessile or with an irregular root-like stem; peridium mostly simple, rarely 2-layered, firm, rarely thin, membranous, breaking open irregularly or in lobes or decaying; gleba with sharply defined basidia-bearing sectors, which are partitioned from one another by sterile veins, and in which the basidia are regularly scattered through the tissue (rarely, if ever, with hymenium-lined cavities or with fascicled, nested basidia); basidia broadly club-shaped; gleba crumbling to a powder of spores and disintegrating tissues at maturity; spores usually sculptured; capillitium wanting, or rudimentary.

KEY TO THE GENERA OF THE SCLERODERMATACEAE

- A. Fructifications sessile or with elongate root-like base.
1. Peridium smooth, finely warted or coarse surface.
 - a. Spores without a distinct hilum or pedicel *Scleroderma*
 - b. Spores with a hilum or pedicellate *Pompholyx*
 2. Peridium spiny or coarsely pyramidally warted.

Caloderma (Not known in North America)
- B. Fructifications with slender stem.
- Pirogaster* (Not known in North America)

SEDECULACEAE

Fructifications leathery, without sterile base or radicle; peridium thick, leathery above, almost obsolete and dehiscing below; gleba becoming powdery at maturity, with broad veins extending inward from the peridium; spores brown, pedicellate or with sterigmatal scar.

One genus, *Sedecula*.

PISOLITHACEAE

Fructifications mostly stalked, rarely sessile (in *Pisolithus*); stems root-like or hard and wood-like; sporocarps subglobose, pear-shaped, or hemispherical; peridium thin or layers not separating readily, breaking away irregularly; gleba dark, made up of roundish or irregular basidia-bearing sectors or peridioles which loosen and break away at maturity; capillitium none; spores colored, sculptured.

KEY TO THE GENERA OF THE PISOLITHACEAE

- I. Sporocarp sessile or with a rootlike stalk; peridium thin *Pisolithus*
- II. Sporocarp with a hard woodlike stalk; peridium thick, hard.

Dictyocephalos

GLISCHRODERMATACEAE

Fructifications subglobose, on a superficial mycelium; peridium simple, thin but hard and tough, opening by an apical pore; gleba with evenly distributed basidia (without sterile veins), capillitium arising from the inner side of the peridium (as in *Calvatia*); spores sculptured.

One genus, *Glischroderma*, found in Europe only.

TULOSTOMATACEAE

Fructifications at first hypogeous, sporocarp elevated by the prolongation of a basal tissue into a stout, fibrous, stemlike or cushion-like process; peridium duplex, outer layer partly evanescent, partly remaining as a cuplike volva at the base of the stem, inner layer thin, dehiscing by an apical pore, several pores or circumscissilely; gleba without chambers or chambered by the labyrinthine separation of the tissues from one another; basidia regularly and evenly distributed in the glebal tissue or forming a rudimentary hymenium on the walls of chambers; capillitium well-developed, attached to the inside of the peridium; spores variously sculptured.

KEY TO THE GENERA OF THE TULOSTOMATACEAE

- I. Basidia borne irregularly in fascicles or nests; endoperidium dehiscing irregularly or through a stoma.
 - A. Stem more or less readily breaking from the sporocarp, as out of a socket.
 1. Sporocarp dehiscing by an apical stoma *Tulostoma*
 2. Sporocarp dehiscing by a roughly stellate stoma *Schizostoma*
 3. Sporocarp dehiscing irregularly *Queletia*
 - B. Exoperidium continuous with the outer layer of the stem, endoperidium forming more or less of a cup or collar on the margin of the expanded apex of the stem; stem not volvate *Phellorinia*
 - C. Exoperidium not continuous with the stem, sporocarp seated on the expanded apex of the stem; stem volvate *Chlamydopus*
- II. Basidia borne in an elementary hymenium lining cavities; endoperidium dehiscence circumscissile or through numerous pores *Battarrea*

ASTRAEACEAE

Fructifications epigeous or at first hypogeous, sessile; peridium of several layers, the outer two or three becoming the very heavy exoperidium, which dehisces stellately; the endoperidium thin, membranous; columella none; gleba separated by delicate sterile veins into basidia-bearing sectors in which the basidia are regularly distributed throughout the context; basidia broadly club-shaped; spores spherical, sculptured; capillitium none.

One genus. *Astraeus*.

CALOSTOMATACEAE

Fructifications epigeous or at first hypogeous, stalked with a root-like, lacunose basal process; peridium duplex, exoperidium

cartilaginous, extended below into a rootlike stalk and often cupulate around the base of the sporocarp; endoperidium cartilaginous, with an ornate apical stellate stoma below which the spore sac is suspended; gleba pulverulent; spores spherical or ellipsoid, smooth or sculptured.

One genus, *Calostoma*.

ORDER VIII—NIDULARIALES

Fructifications small, sessile, cupulate, campanulate or depressed globose; peridium of one to four layers, dehiscing by rupture of an epiphragm or lid over the top, or when this is absent, by irregular fissuring of the wall; gleba enclosed in one or many globose or lens-shaped peridioles; peridioles attached to the inner wall of the peridium by a mucilaginous secretion or by threadlike funiculi, escaping singly or they may be forcibly ejected from the exoperidium; capillitium none.

KEY TO THE FAMILIES OF THE NIDULARIALES

- I. Exoperidium more or less urceolate and firm at maturity; glebal chambers (peridioles) egglike, remaining attached or free within outer peridium, empty Family 29. *Nidulariaceae*
- II. Exoperidium collapsed at maturity; single spherical, glebal chamber violently discharged at maturity, filled with gel or gelatinous tissue.
Family 30. *Sphaerobolaceae*

NIDULARIACEAE

Fructifications epigeous, with hard peridium which opens cup-like at maturity; gleba with a few mostly flattish, rounded, closed chambers (peridioles), the hard walls of which are lined with basidial hymenium and in the mature fructification are isolated or freed from the cup-like fructification by ejection or by the deliquescence of the intervening tissue.

KEY TO THE GENERA OF THE NIDULARIACEAE

- I. Peridioles without funiculus.
 - A. Fructification roundish, without typical epiphragm *Nidularia*
 - B. Fructification beaker-shaped, with epiphragm *Nidula*

- II. Peridioles with funiculus; fructifications top-shaped, with epiphragm.
 A. Peridium composed of three layers, middle layer of pseudoparenchyma; spores mixed with filaments*Cyathus*
 B. Peridium composed of one layer, not pseudoparenchyma; spores not mixed with filaments*Crucibulum*

SPHAEROBOLACEAE

Fructifications tiny, spherical at first; peridium of several layers, of which the second inner layer is formed of turgescient cells appearing as a radial palisade; gleba of basidia-bearing sectors separated by sterile veins, or of basidia-bearing cavities formed by the splitting of tissues; the gleba becomes gelatinized at maturity and is ejected as a whole from the peridium.

KEY TO THE GENERA OF THE SPHAEROBOLACEAE

- I. Basidia borne irregularly throughout the basidia-bearing sectors. *Sphaerobolus*
 II. Basidia borne in hymenia on the walls of cavities*Nidulariopsis*

ORDER IX—PODAXALES

Fructifications epigeous, stalked or with percurrent columella, pileate at maturity, angiocarpic; stipe long or short, continued to the apex of the fructification as a columella; peridium simple or 2-3-layered at maturity, left at maturity in part as pileus, or volva, or annulus on the stem; gleba at first with hymenium of basidia covering the walls of chambers or pores or lamellae, persistent or pulverulent; capillitium wanting (except in *Podaxis*); spores colored.

KEY TO FAMILIES OF THE PODAXALES

- I. Gleba not powdery at maturityFamily 31. *Secotiaceae*
 II. Gleba powdery at maturityFamily 32. *Podaxaceae*

SECOTIACEAE

Fructifications mostly epigeous, stalked or sessile, at first campanulate, like an agaric button, angiocarpic; stalk continued above as a percurrent columella; peridium mostly as a cap covering the gleba, free at maturity or opening by a transverse slit; gleba chambered or with irregular pores or with anastomosing, lamel-

loid, tramal structures, dark brown to blackish, sometimes with cystidia, not becoming a powdery spore mass at maturity; spores dark, smooth or sculptured; capillitium none.

KEY TO THE GENERA OF THE SECOTIACEAE

- I. Stems not volvate, not annulate; gleba brown.
 - A. Fructifications short-stemmed or sessile; pileus mostly globose to depressed globose, spores smooth or sculptured*Secotium*
 - B. Fructifications with long stems; pileus cylindrical to conic, slender, acute at apex; spores smooth*Galeropsis*
- II. Stems volvate and/or annulate; spores black or very dark brown.
 - A. Gleba lamelloid, radiating and hanging free from the margin of the expanded apex of the stem; stem volvate; spores black ..*Montagnea*
 - B. Gleba of anastomosed lamellae, attached to the underside of the expanded top of the stem (pileus), free from the stem; stem annulate; spores black*Longula*
 - C. Gleba of anastomosed to poroid lamellae, suspended from the lower surface of the pileus, free; stem with a cupulate or sheathing volva; annulus usually persistent; spores black (rusty black in *ours*).
Gyrophragmium

PODAXACEAE

Fructifications angiocarpic, like agaric buttons, epigeous at maturity, clavate, ovoid or fusiform, stalked or almost sessile; stem firmly fibrous, extending percurrently as a columella; peridium pileate, simple or plicately scaly, brittle, easily splitting, margin loosening from the stipe at maturity or opening by longitudinal splitting; gleba at first chambered by anastomosing tramal tissues or lamelloid tramal plates, powdery at maturity; basidia persisting in *Podaxis*; capillitium well developed as elaters, or wanting; spores dark, smooth.

KEY TO THE GENERA OF THE PODAXACEAE

- I. Fructification sessile or nearly so; gleba without capillitium.
Endoptychum
- II. Fructification with long stipe; gleba with capillitium (elaters) ..*Podaxis*

LITERATURE CITED

1. **Bataille, M. F.** Flore analytique et descriptive des Hyménogastrocées d'Europe. Soc. Myc. France, Bul. 39: 157-196. 1923.
2. **Coker, W. C., and J. N. Couch.** Gasteromycetes of the eastern United States and Canada. Univ. N. Carolina Press. Chapel Hill. Pp. 1-201. 1928.

3. **Cunningham, G. H.** The Gasteromycetes of Australia and New Zealand. John McIndoe, Printer, 76 Vogel St., Dunedin, New Zealand. Pp. 1-236. 1942.
4. **Fischer, Ed.** Gasteromyceteae. In Engler & Prantl. Die Natürl. Pflanzenfam. (II ed.) 7a: 1-122. 1933.
5. **Hollós, L.** Die Gasteromyceten Ungarns. Oswald Weigel, Leipzig. Pp. 1-278. T. 1-29. 1904.
6. **Kambly, P. E., and R. E. Lee.** The Gasteromycetes of Iowa. Univ. Iowa Studies Nat. Hist. 17 (No. 4): 117-185. 1936.
7. **Lloyd, C. G.** Mycological writings, Cincinnati, Ohio. 1-7: *illus.* 1898-1925.
8. **Lohman, M. L.** The Iowa species of *Lycoperdon*. Univ. Iowa Studies Nat. Hist. 12 (No. 4): 5-28. *illus.* 1927.
9. **Lohwag, H.** Zur Entwicklungsgeschichte und Morphologie der Gasteromyceten. Beih. zum Bot. Centralbl. 42: 177-334. *illus.* 1926.
10. **Long, W. H.** The Phalloideae of Texas. Jour. Myc. 13: 102-114. *illus.* 1907.
11. —. Notes on new or rare species of Gasteromycetes. Mycologia 9: 271-274. 1917.
12. — and **O. A. Plunkett.** Studies in the Gasteromycetes. I. The genus *Dictyocephalos*. Mycologia 32: 696-709. 1940.
13. — and **D. J. Stouffer.** II. *Bovistina*, a new genus. Mycologia 33: 270-273. 1941.
14. —. III. The family Arachniaceae. Mycologia 33: 350-355. 1941.
15. —. IV. A new species of *Geaster*. Mycologia 34: 13-16. 1942.
16. —. V. A white *Simblum*. Mycologia 34: 128-131. 1942.
17. — and **D. J. Stouffer.** VII. The genus *Schizostoma*. Mycologia 35: 21-32. 1943.
18. —. VIII. *Battarrea laciniata*. Mycologia 35: 546-556. 1943.
19. — and **D. J. Stouffer.** IX. The genus *Itajahya* in North America. Mycologia 35: 620-628. 1943.
20. —. X. Seven new species of *Tylostoma*. Mycologia 36: 318-339. 1944.
21. —. XI. The genera *Trichaster* and *Terrostella*. Mycologia 37: 601-608. 1945.
22. —. XII. Five species of *Tylostoma* with membranous exoperidia. Mycologia 38: 77-90. 1946.
23. —. XIII. The types of Miss White's species of *Tylostoma*. Mycologia 38: 171-179. 1946.
24. — and **D. J. Stouffer.** XIV. The genus *Chlamydopus*. Mycologia 38: 619-629. 1946.
25. **Longnecker, W. M.** The geasters of Iowa. Univ. Iowa Stud. Nat. Hist. 12: 29-43. 1927.
26. **Malençon, G.** La Série des Asterosporés. Travaux cryptogamiques dédiés à Louis Mangin, pp. 377-396. 1931.
27. **Martin, G. W.** Key to the families of fungi exclusive of the lichens. Univ. Iowa Stud. Nat. Hist. 17: 83-115. 1936.

28. —. Outline of the fungi. Univ. Iowa Stud. Nat. Hist. **18** (Suppl.): 1-64. 1941.
29. **Morgan, A. P.** North American fungi. Jour. Cincinnati Soc. Nat. Hist. **11**: 141-149. 1889; **12**: 8-22; 163-172. 1890; **13**: 5-21. 1891; **14**: 141-148. 1892; **15**: 171-172. 1893.
30. **Pilat, A.** Sur le genre *Gastrosporium* Mattiolo (Gastéromycètes). Soc. Myc. France, Bul. **50**: 37-48. 1934.
31. **Rea, P. M.** Fungi of Southern California. I. *Mycologia* **34**: 563-574. 1942.
32. **Stevenson, J. A., and Edith K. Cash.** The new fungus names proposed by C. G. Lloyd. Lloyd Library and Museum, Bul. **35**: 1-209. 1936. (See pp. 156-203.)
33. **White, V. S.** Tylostomaceae of North America. Tor. Bot. Club, Bul. **28**: 421-444. *illus.* 1901.
34. —. The Nidulariaceae of North America. Tor. Bot. Club, Bul. **29**: 251-280. *illus.* 1902.
35. **Zeller, S. M.** *Protogaster*, representing a new order of Gasteromycetes. Ann. Mo. Bot. Garden **21**: 231-249. *illus.* 1934.
36. —. New and noteworthy Gasteromycetes. *Mycologia* **31**: 1-32. *illus.* 1939.
37. —. Further notes on fungi. *Ibid.* **33**: 196-214. *illus.* 1941.
38. —. Representatives of the Mesophelliaceae in North America. *Ibid.* **36**: 627-637. *illus.* 1944.