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LOCULOASCOMYCETES

- MYRIANGIALES
- DOTHIDIALES
- MICROTHYRIALES
- CAPNODIALES
- HYSTERIALES

BI- TUNICATE

PLECTOMYCETES

- EUROTIALES
- ERYSIPHALES
- MELIOLALES

- HYPOCREALES
- LABOULBENIALES
- SPHAERIALES
- PHACIDIALES
- HELOTIALES — INOPER-
- PEZIZALES — OPER-
- TUBERALES — INDEHISC.

UNI- TUNICATE

Eurotiales | Plecto

- Myriangiales
- Dothidiales
- Microthyriales
- Erysiphales

Cleisto

- Hypocreales
- Laboul.
- Sphaer.
- Hysteriales

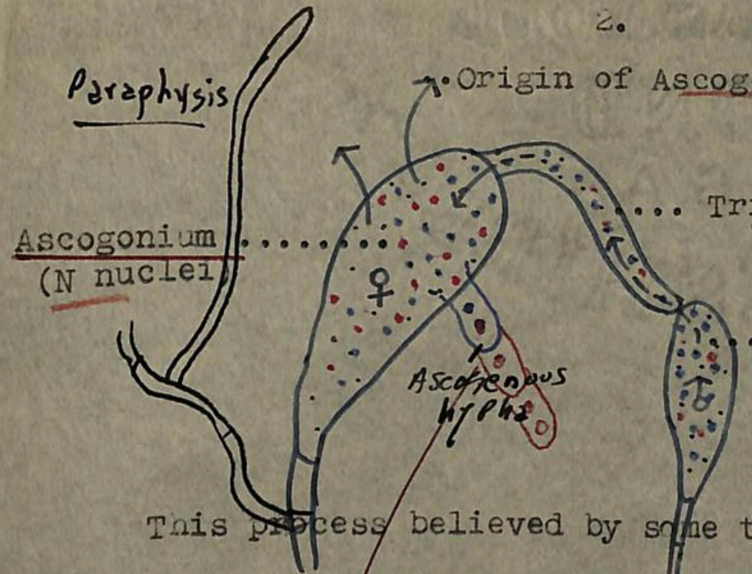
Peri

- Phacidiales
- Helotiales
- Pezizales
- Tuber.

ART. 66 CODE { A name must be rejected if it is based on a type consisting of 2 or more discordant elements .... unless possible to select one as the type.

Eurotiales — Tornales — CALICIALES
Myriangiales
Dothideales
Microthyriales
Meliolales
Erysiphales — perithecia, clearistothecia
Hypocreales
Xylariales — PYRENULALES
Sphaeriales
Hysteriales — hysterothecia — GRAPHIDALES
Phacidiales
Helotiales — apothecia — LECANORALES
Pezizales
Tuberales

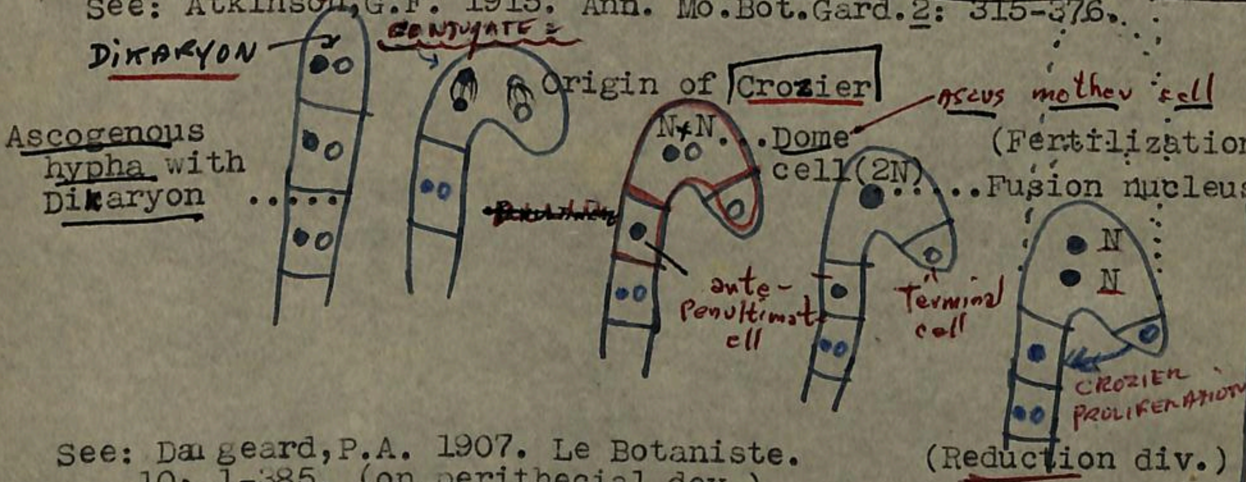
{ Ascocarps
{ Asci
BASIDIOLICHENS
CORA
DICTYONEMA

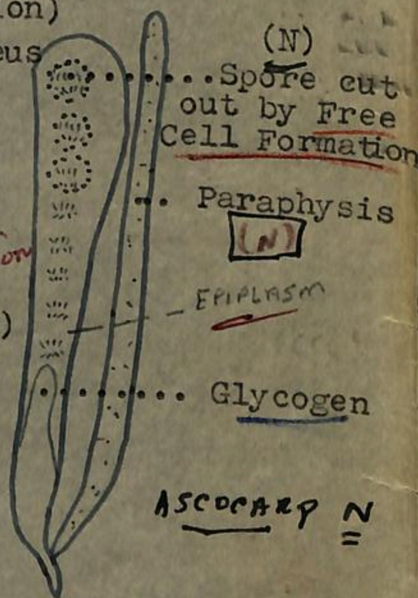


This process believed by some to be homologous to cycle in Florideae.

See: Dodge, B.O. 1912. Bul. Torrey Bot. Club 39: 139-197. Morphological relationships of Florideae and Ascomycetes.

For theory of origin from Phycos (Dipodascus, Eremascus, Ascoidea, Endogone),
See: Atkinson, G.F. 1915. Ann. Mo. Bot. Gard. 2: 315-376.





See: Dangeard, P.A. 1907. Le Botaniste. 10: 1-385. (on perithecial dev.)

Olive, E.W. 1905. Bot. Gaz. 39: 56-60. Monascus purpureus.

Walker, Leva, B. 1935. Mycologia ~~22~~ 23: 51-76. Ascoidea rubescens.

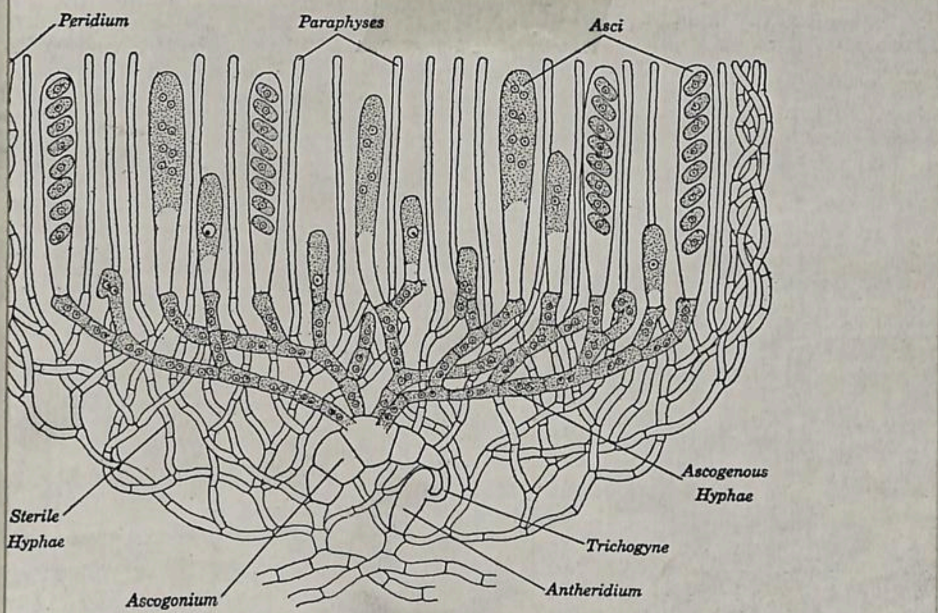
SMITH, G.M. 1938. CRYPTOGAMIC BOTANY. Vol. I. 418.

Asexual reproduction: Conidia abstricted from terminal parts of conidiophores, which may be simple or branched. These produce germ tubes. Spores various: Amero-, didymo-, phragmo-, helico-, stauro-, dictyo-, etc.

Asexual fruiting bodies include: Pycnidium, acervulus, coremium, sporodochium. (terminology similar to Hyphomycetes)

HOMOTHALLIC vs BIPOLAR HETEROTHALLIC (Aa)

SEE. GORDON, C.C. 1966. .... ONTOGENY OF ASCOCARP ... AMER. J. BOT. ... 652-662



12. Vertical section of a hypothetical ascocarp showing relationship of sex organs, ious hyphae, and sterile hyphae.

Smith, G. M. Cryptogamic Botany 1955 2nd ed.

1973. Ainsworth, Sussman & Sparrow. The Fungi. Vol. IVA.

by Ainsworth (1966) for use in the current edition of the "Dictionary of Fungi" (Ainsworth, 1971). Fungi are treated here as either a separate kingdom or, for the more conservative, as a subkingdom of the plant kingdom, with two divisions, the Myxomycota, for plasmodial forms, and the Eumycota, for nonplasmodial forms which are frequently mycelial. Five subdivisions of the latter are recognized, including the Ascomycotina (for ascomycetes) and the Basidiomycotina (for basidiomycetes), while the imperfect fungi are classified for convenience as the Deuteromycotina, although in a hierarchical classification it is incorrect to equate these fungi with the ascomycetes and the basidiomycetes to which they are subsidiary both taxonomically and by nomenclature. Most lichenized fungi (lichens) have been omitted, as they are to be the subject of a separate book.

IV. KEYS TO THE HIGHER TAXA

FUNGI

It is difficult to give a concise diagnostic definition of fungi. The main characteristics of the group are

Nutrition: heterotrophic (photosynthesis lacking) and absorptive (ingestion rare).

Thallus: on or in the substratum and plasmodial amoeboid or pseudoplasmodial; or in the substratum and unicellular or filamentous (mycelial), the last, septate or nonseptate; typically nonmotile (with protoplasmic flow through the mycelium) but motile states (e.g., zoospores) may occur.

Cell wall: well-defined, typically chitinized (cellulose in Oomycetes).

Nuclear status: eukaryotic, multinucleate, the mycelium being homo- or heterokaryotic, haploid, dikaryotic, or diploid, the last being usually of limited duration.

Life cycle: simple to complex.

Sexuality: asexual or sexual and homo- or heterothallic.

Sporocarps: microscopic or macroscopic and showing limited tissue differentiation.

Habitat: ubiquitous as saprobes, symbionts, parasites, or hyperparasites.

Distribution: cosmopolitan.

KEY TO DIVISIONS OF FUNGI

1. Plasmodium or pseudoplasmodium present . . . . **Myxomycota** I

1′. Plasmodium or pseudoplasmodium absent, assimilative phase typically filamentous . . . . **Eumycota** II

I. Myxomycota

KEY TO CLASSES OF MYXOMYCOTA

1. Assimilative phase a plasmodium 2

1′. Assimilative phase free-living amoebae which unite as a pseudoplasmodium before reproduction . . . . **Acrasiomycetes**[1] Vol. IVB

2(1) Plasmodium forming a network ("net plasmodium") . . . . . . **Labyrinthulales**[2]

2′(1) Plasmodium not forming a network 3

3(2′) Plasmodium saprobic, free-living . . . . **Myxomycetes** Vol. IVB

3′(2′) Plasmodium parasitic within cells of the host plant . . . . **Plasmodiophoromycetes**[3] Vol. IVB

II. Eumycota

KEY TO SUBDIVISIONS OF EUMYCOTA

1. Motile cells (zoospores) present; perfect-state spores typically oospores . . . . **Mastigomycotina** III

1′. Motile cells absent 2

2(1′) Perfect state present 3

2(1′) Perfect state absent . . . . **Deuteromycotina** VII

3(2) Perfect-state spores zygospores . . . . **Zygomycotina** IV

3′(2) Zygospores absent 4

4(3′) Perfect-state spores ascospores . . . . **Ascomycotina** V

4′(3′) Perfect-state spores basidiospores . . . . **Basidiomycotina** VI

III. Mastigomycotina

KEY TO CLASSES OF MASTIGOMYCOTINA

1. Zoospores posteriorly uniflagellate (flagella whiplash-type) . . . . **Chytridiomycetes** Vol. IVB

1′. Zoospores not posteriorly uniflagellate 2

2(1′) Zoospores anteriorly uniflagellate (flagella tinsel-type) . . . . **Hyphochytridiomycetes** Vol. IVB

2′(1′) Zoospores biflagellate (posterior flagellum whiplash-type; anterior tinsel-type); cell wall cellulosic . . . . **Oomycetes** Vol. IVB

[1]Excluded from the Myxomycota by Martin and Alexopoulos (1969).
[2]Excluded from this treatment.
[3]Treated as a class of the Mastigomycotina.

IV. Zygomycotina

KEY TO CLASSES OF ZYGOMYCOTINA

1. Saprobic or, if parasitic or predacious, having mycelium immersed in host tissue . . . . **Zygomycetes** Vol. IVB

1′. Associated with arthropods and attached to the cuticle or digestive tract by a holdfast and not immersed in the host tissue . . . . **Trichomycetes** Vol. IVB

V. Ascomycotina

KEY TO CLASSES OF ASCOMYCOTINA

1. Ascocarps and ascogenous hyphae lacking; thallus mycelial or yeastlike . . . . **Hemiascomycetes** p. 9

1′. Ascocarps and ascogenous hyphae present; thallus mycelial 2

2(1′) Asci bitunicate; ascocarp an ascostroma . . . . **Loculoascomycetes** p. 133

2′(1′) Asci typically unitunicate; if bitunicate, ascocarp an apothecium 3

3(2′) Asci evanescent, scattered within the astomous ascocarp which is typically a cleistothecium; ascospores aseptate . . . . **Plectomycetes** p. 43

3′(2′) Asci regularly arranged within the ascocarp as a basal or peripheral layer 4

4(3′) Exoparasites of arthropods; thallus reduced; ascocarp a perithecium; asci inoperculate . . . . **Laboulbeniomycetes** p. 221

4′(3′) Not exoparasites of arthropods 5

5(4′) Ascocarp typically a perithecium which is usually ostiolate (if astamous, asci not evanescent); asci inoperculate with an apical pore or slit . . . . **Pyrenomycetes** p. 69

5′(4′) Ascocarp an apothecium or a modified apothecium, frequently macrocarpic, epigean or hypogean; asci inoperculate or operculate . . . . **Discomycetes** p. 247

VI. Basidiomycotina

KEY TO CLASSES OF BASIDIOMYCOTINA[4]

1. Basidiocarp lacking and replaced by teliospores (encysted probasidia) grouped in sori or scattered within the host tissue; parasitic on vascular plants . . . . **Teliomycetes** Vol. IVB

1′. Basidiocarp usually well-developed; basidia typically organized as a hymenium; saprobic or rarely parasitic 2

2(1′) Basidiocarp typically gymnocarpous or semiangiocarpous; basidia phragmobasidia (**Phragmobasidiomycetidae**) or

[4]If yeastlike, see p. 11.

holobasidia (**Holobasidiomycetidae**); basidiospores ballistospores . . . . **Hymenomycetes** Vol. IVB

2′(1′) Basidiocarp typically angiocarpous; basidia holobasidia; basidiospores not ballistospores . . . . **Gasteromycetes** Vol. IVB

VII. Deuteromycotina

KEY TO CLASSES OF DEUTEROMYCOTINA

1. Budding (yeast or yeastlike) cells with or without pseudomycelium characteristic; true mycelium lacking or not well-developed . . . . **Blastomycetes** p. 24

1′. Mycelium well-developed, assimilative budding cells absent 2

2(1′) Mycelium sterile or bearing spores directly or on special branches (sporophores) which may be variously aggregated but not in pycnidia or acervuli . . . . **Hyphomycetes** p. 321

2′(1′) Spores in pycnidia or acervuli . . . . **Coelomycetes** p. 511

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LOCULOASCOMYCETES subclass. nov.

Ascis bitunicatis, in ascostromate evolutis.

The composition and relationships of the Loculoascomycetes are shown diagrammatically in FIGS. 1 and 2.

The reasons for considering the Loculoascomycetes distinct from the true Pyrenomycetes have been given previously (Luttrell, 1951). The separation is based primarily on the fact that with the ascostromatic nature of the ascocarp is correlated the production of bitunicate or two-walled asci. It is possible that ascostromatic forms could be derived from true Pyrenomycetes at many points by reduction of perithecial walls in forms in which the perithecia develop within a stroma, and this process probably has occurred—for example, in the Coryneliales and Coronophorales. However, in order to derive the species in the Loculoascomycetes from the Pyrenomycetes by this process, it is necessary to assume that the bitunicate ascus also developed at numerous points and coincidentally with the loss of perithecial walls. This seems too great a coincidence to be credible. It seems more probable that the species with bitunicate asci represent a separate monophyletic line. This conclusion is expressed in the erection of the subclass Loculoascomycetes. The primary characteristic of this subclass is the production of bitunicate asci. The ascostromatic nature of the ascocarp is a secondary correlated character.

The objections to this taxonomic hypothesis noted previously (Luttrell, 1951) now seem less serious. These were the apparent lack of correlation between the production of bitunicate asci and ascostromatic ascocarps in several species and groups. First was the occurrence of bitunicate asci in forms considered to be Discomycetes such as the Hysteriaceae, *Keithia juniperi* J. K. Miller, and species of *Lecanidion* and *Tryblidiella*. A subsequent study (Luttrell, 1953) showed that the ascocarp in *Glonium stellatum* Mühl. ex Fr., and presumably in other members of the Hysteriaceae, is an ascostroma. Pantidou and Korf (1954) found that the formation of an ascostromatic ascocarp is correlated with the production of bitunicate asci in *K. juniperi*. This species does not belong in the Discomycete genus *Keithia* but is synonymous with *Coccodothis sphaeroidea* (Cke.) Theiss. & Syd., a species which has been included among the ascostromatic forms in the Pseudosphaeriales. The report of Pantidou and Korf is of especial importance, since in this case the presence of the bitunicate ascus served as a valid indication of the correct taxonomic position of a fungus which had previously been misinterpreted. A study of species in the Patellariaceae with

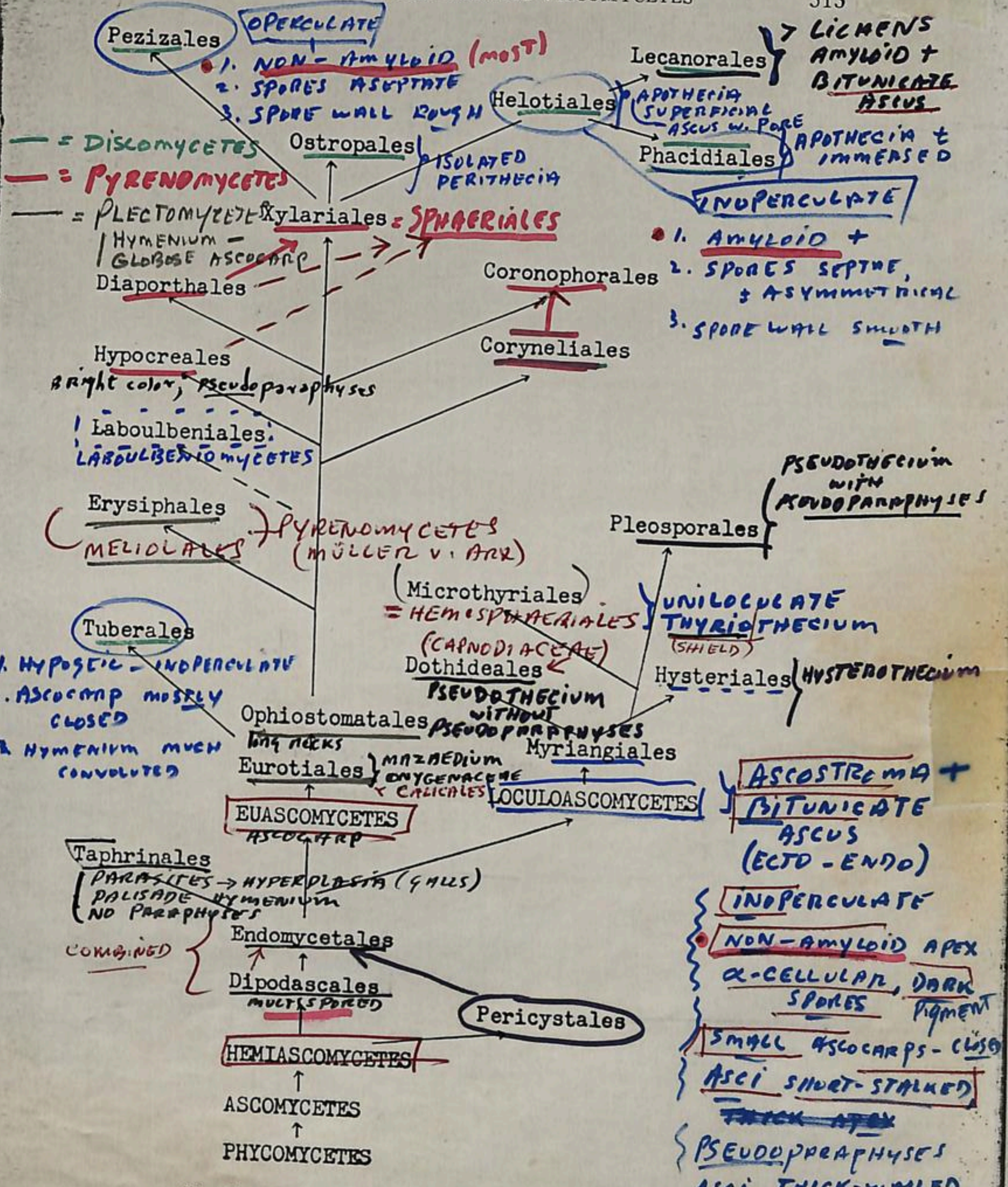
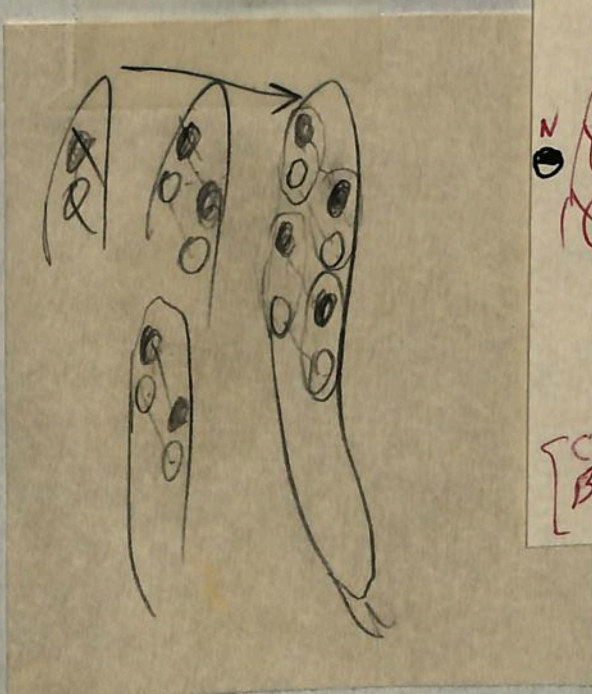
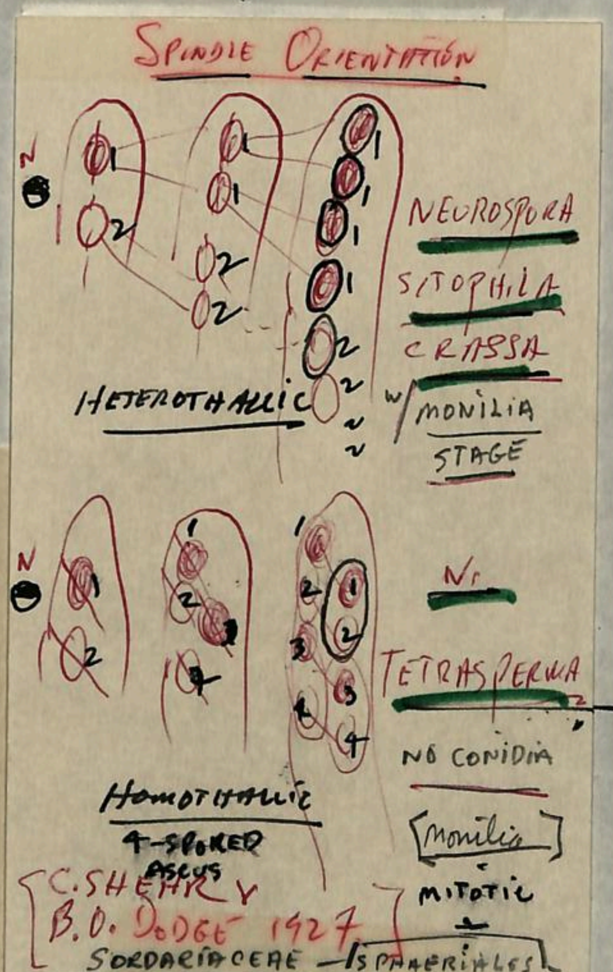
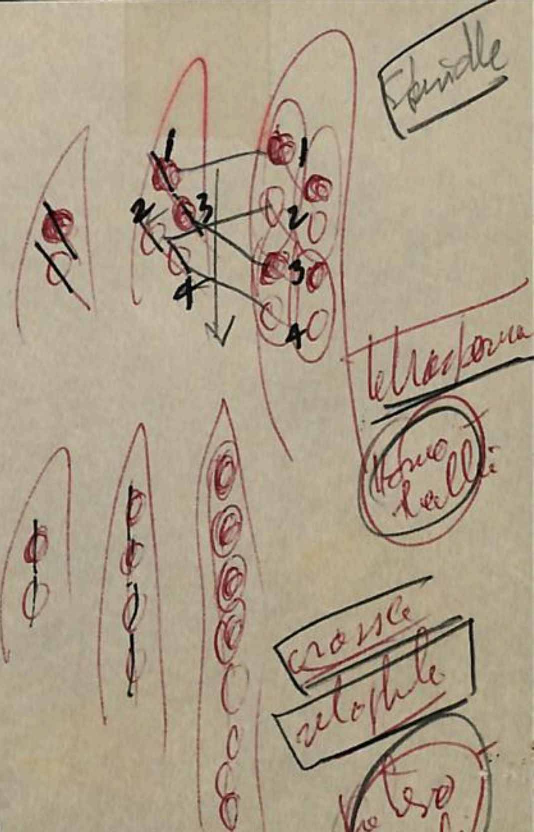


Fig. 1. Phylogenetic diagram of the Ascomycetes.



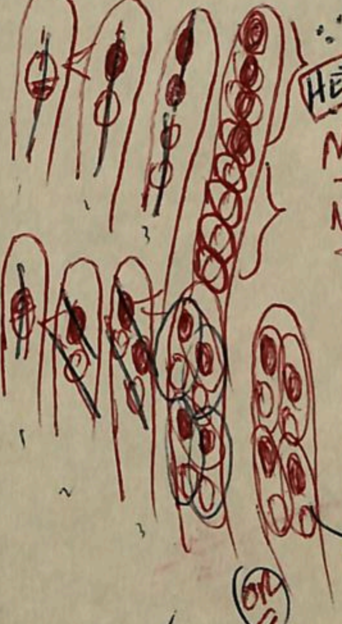

SPINDLE ORIENTATION
NEUROSPORA
SITOPHILA
CRASSA
w/ MONILIA STAGE
HETEROTHALLIC
N
N₁
TETRASPERMA
NO CONIDIA
[Monilia]
MITOTIC
HOMOTHALLIC
4-SPORED ASCUS
[C. SHEAR &
B.O. DODGE 1927]
SORDARIACEAE – [SPHAERIALES]



BEADLE. 19[illegible].

B.O. Dodge .1927

C.L. Shear J. AGRIC. RES. 34.



HETEROTHALLIC

N. CRASSA

N. SITOPHILA

VS

N. TETRA-SPERMA

HOMOTHALLIC

BISEXUAL SPORES

OR

SPINDLE ORIENTATION

B. O. DODGE 1927. J. AGR. RES. 34.
C. L. SHEAR

[Sordariaceae] [Sphaeriales]

Spore formation in <u>Neurospora</u> as shown by B.O.D. 1927.

I — II — III–IV (following spore formation)

→ ascus: 150 × 14 μ
spores: 25 × 13 μ

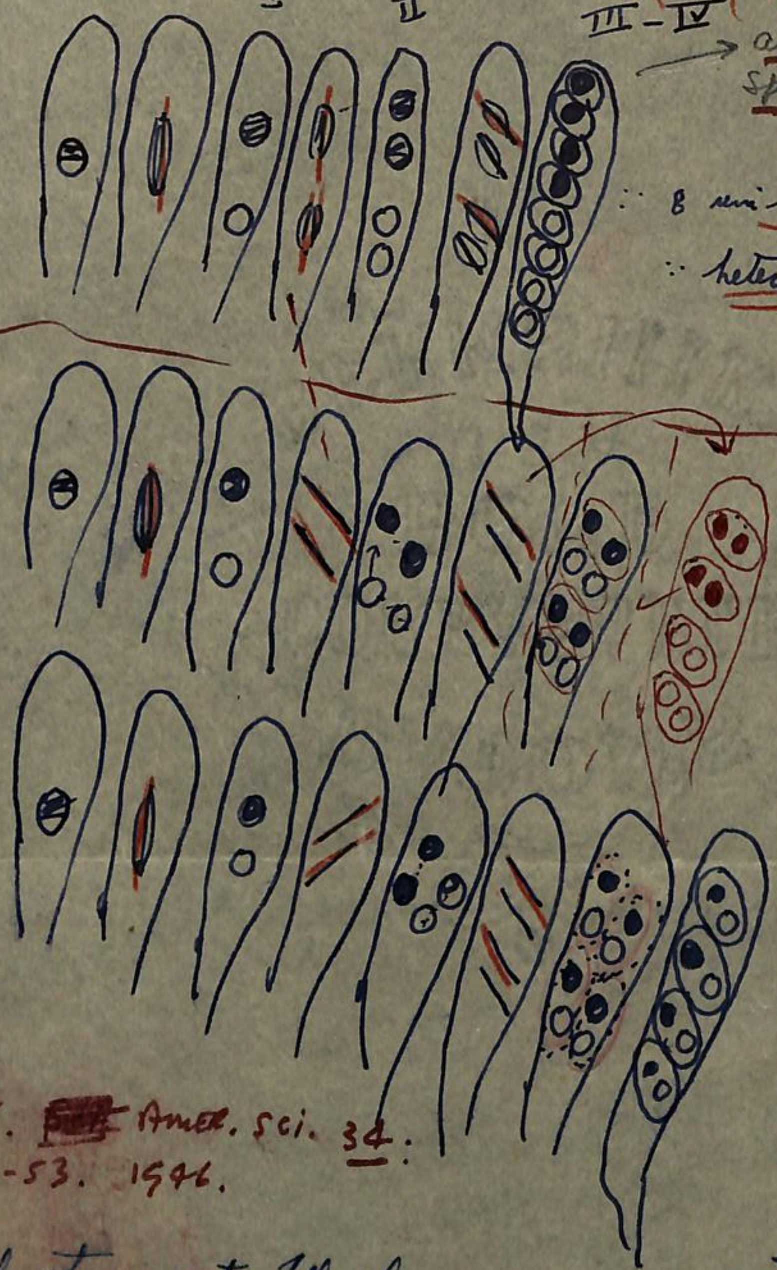
N. crassa
N. sitophila

∴ 8 uni-sexual spores. (2 nuclei)
∴ heterothallic

N. tetrasperma

in stress spindle orientation. (longitudinal vs oblique) (intranuclear)

N. tetrasperma



∴ 4 bi-sexual spores.
∴ homothallic

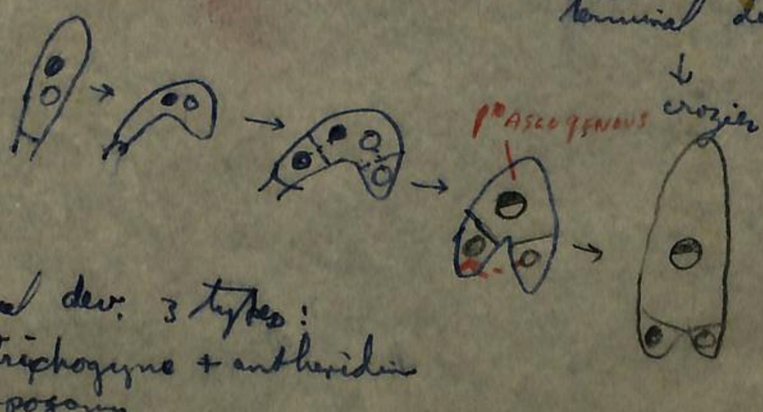
no "pseudomeiosis".

{ centriole associated w. each nucleus; free cell formation; after wall forms → nuclear ÷

Ref. G. BEADLE. Amer. Sci. 34: 31-53. 1946.

Ascogonial stages not followed.
But: conjugate ÷ in ascogenous hyphae
↓
terminal dicaryon
↓
crozier

1° ASCOGENOUS



"Nuclei dragged along by centriole."

Perithecial dev: 3 types:
a) trichogyne + antheridium
b) apogamy
c) mutual diploidization by 3° copulation element.

Euascos ... cont'd.

J. Miller's revision:

Deals chiefly with: SPHAERIALES
DOTHIDIALES
HYPOCREALES

His criteria: MORPHOLOGY OF ASCUS & SPORES
DEVELOPMENT OF ASCOCARP

Discards: Color of stroma
Position of ascocarp.

...... 5 TYPES OF ASCI ......

most primitive 1) PLECTOMYCETES (EROTIALES & MYRIANGIALES)
Monascal locules
clavate asci
no pore in ascus
different levels in stroma

2) DOTHIDIALES
Multiascal locule
Asci without pore
} LOCULOASCOMYCETIDAE

~~Pseudo~~ Paraphysoids } without free ends.

3) PSEUDSPHAESIALES
MICROTHYRIALES
HYSTERIALES
LOPHOSTOMATALES

Pseudoparaphyses present before asci arise:
Asci clavate-cylindrical: no pore.

4) SPHAERIALES
~~XXXXXXX~~
DISCOMYCETES

Asci clavate-cylindrical; with pore.
Apically free paraphyses.

5) HYPOCREALES

Asci as in 4; Pseudoparaphyses also .
Combination of 3 & 4.

ex. : Sphaerostilbe aurantiicola

m ,

3\.

Sexual fruiting bodies: 2 main types, with intermediates.

1) Perithecium; enclosed, "flask-shaped", walled, ostiole.

may be superficial, partly or wholly immersed.

include foll. Families:

Pyrenomycetes:

- Erysiphales (cleistothecium)
- Hypocreales
- Laboulbeniales (Florideae type etc.
- Sphaerales
- Hysteriales (hysterothecia)

2.) Apothecium. exposed, saucer-shaped. include foll. Families:

Discomycetes:

- Phacidiales
- Helotiales } inoperculate
- Pezizales } operculate
- Tuberales

Yeasts atypical fruiting bodies. also Labouls.

2 subclasses of Ascos: Hemiascomycetes ... no ascocarp formed. Saccharomyces, Ascoidea, Taphrina.

Euascomycetes .. ascocarps formed.

Lichens (fungi parasitic on algae) included among several Orders

zb. Calicales ... Onygenaceae (mazaedium) ~ Eurotiales

Pyrenulales .. various Pyrenomycetes (perithecia) ~ Sphaeriales, Hypocreales

Graphidiales .. Hysteriales (hysterothecia)

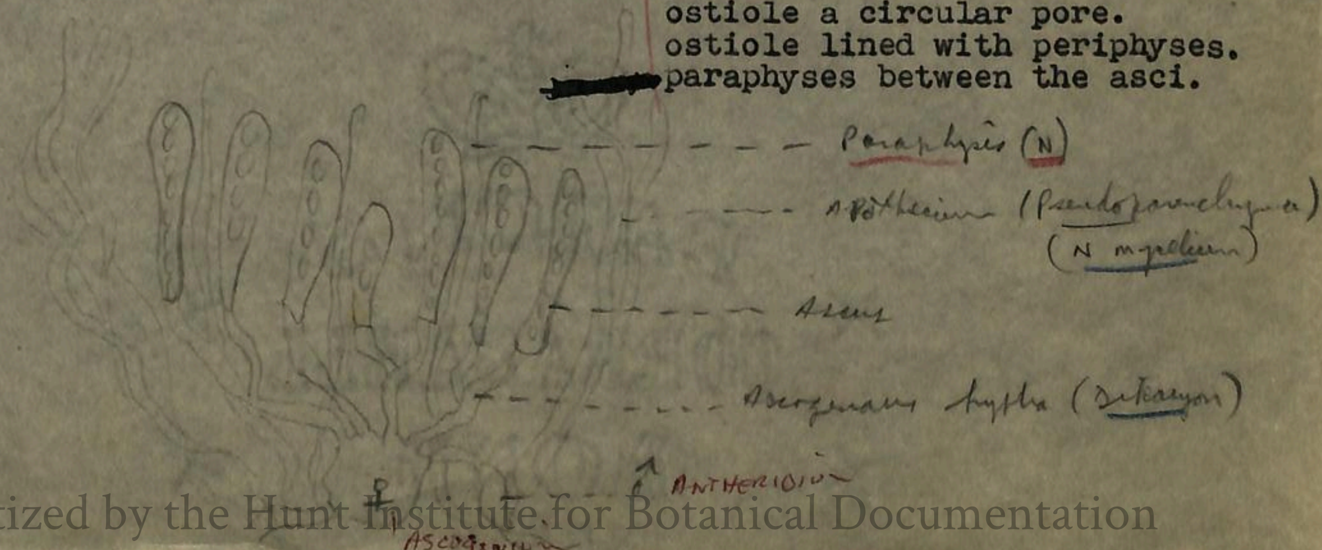
Lecanorales .. various Discomycetes (apothecia) ~ Helotiales (75% of lichens

Basidiolichenes ... Thelephoraceae (near Stereum).

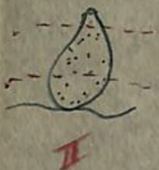
Cora pavonia

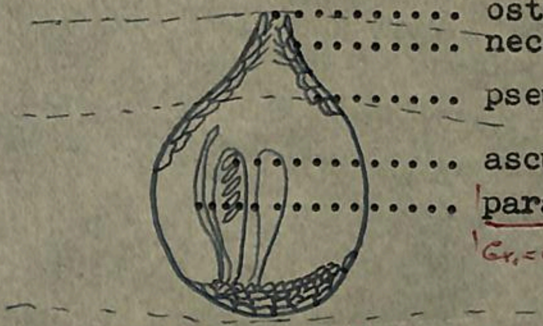
Characteristics of Perithecium :

- flask-shaped. (globose to flattened).
- papillate or beaked.
- ostiole a circular pore.
- ostiole lined with periphyses.
- paraphyses between the asci.



Ascocarps



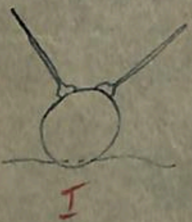


ostiole
neck lined with periphyses (Gr. = growth)
pseudoparenchymatous tissue
ascus with spores
paraphysis (Gr. = offshoot)

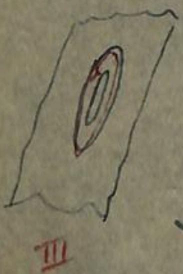
Perithecium (Gr. = a cover) (Pyrenomycetes) (Gr. = stone of a fr.)

i.e. / naked asci

HEMIASCOMYCETES ..	NO ASCOCARP	< ENDOMYCET / TAPHRINAL
PLECTOMYCETES ..	CLEISTOTHECIUM	< EUROTIALES / ERYSIPHALES
PYRENOMYCETES ..	PERITHECIUM	< SPHAERIALES / HYPOCREALES
DISCOMYCETES ..	APOTHECIUM	< HELOTIALES / PEZIZALES / TUBERALES
LOCULOACSOMYCETES ..	BITUNICATE ASCI IN ASCOSTROMA	< MYR / HYST
LABOULBENIOMYCETES ..	ECTOPARASITES on ARTHROPODS PERITHECIA	

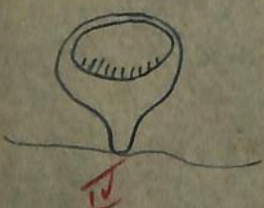


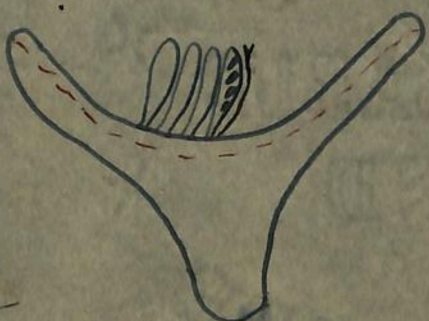
Cleistothecium (Gr. = closed) (Plectomycetes) (Gr. = twisted)



carbonaceous wall
slit band (meristematic)

Hysterothecium (Gr. = womb)

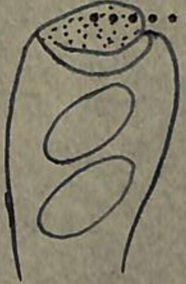




Apothecium (Gr. = cup) (Discomycetes)

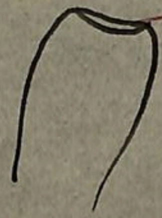
(Gr. Apotheke = storehouse)

Types of asci

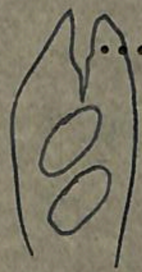


operculum

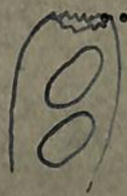
(PEZIZALES)



PORE
(HELOTIALES)

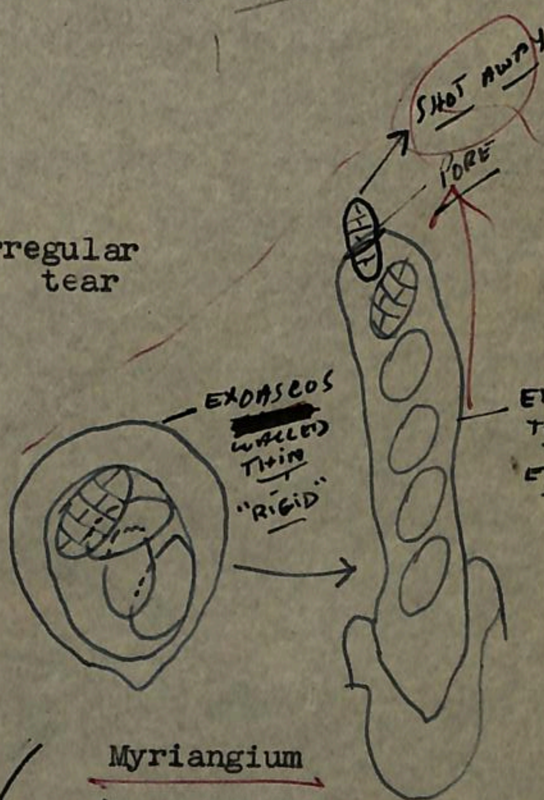


labium



irregular
tear

WITHIN ASCOCARPS



Myriangium

SCHIZOTHERIUM

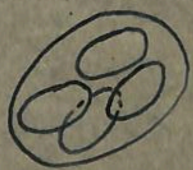
MYCOSPHAERELLA

BITUNICATE

(= PHYSOCLASTIC)

FURTADO
OLIVE
1970.

LOCULOASCOMYCETES



yeast

NO ASCOCARP
FORMED

single zygote nucleus divides to form many daughter nuclei. Thus, this species forms many ascospores within an ascus. The single ascus formed from the zygote of a protoascomycete is always without any enveloping sheath of sterile tissue.

The indirect production of asci from the zygote is due to a formation of hyphal outgrowths (*ascogenous hyphae*). All genera with this type of ascus formation are referred to the Euascomycetae. In practically all of them there is an outgrowth of more than one ascogenous hypha from the zygote (Fig. 230). Almost all of the euascomycetes have an enveloping

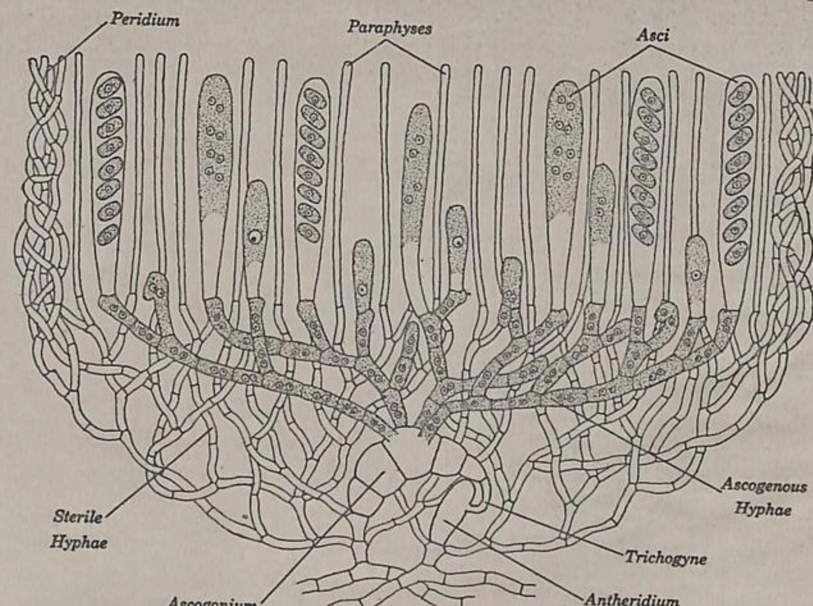
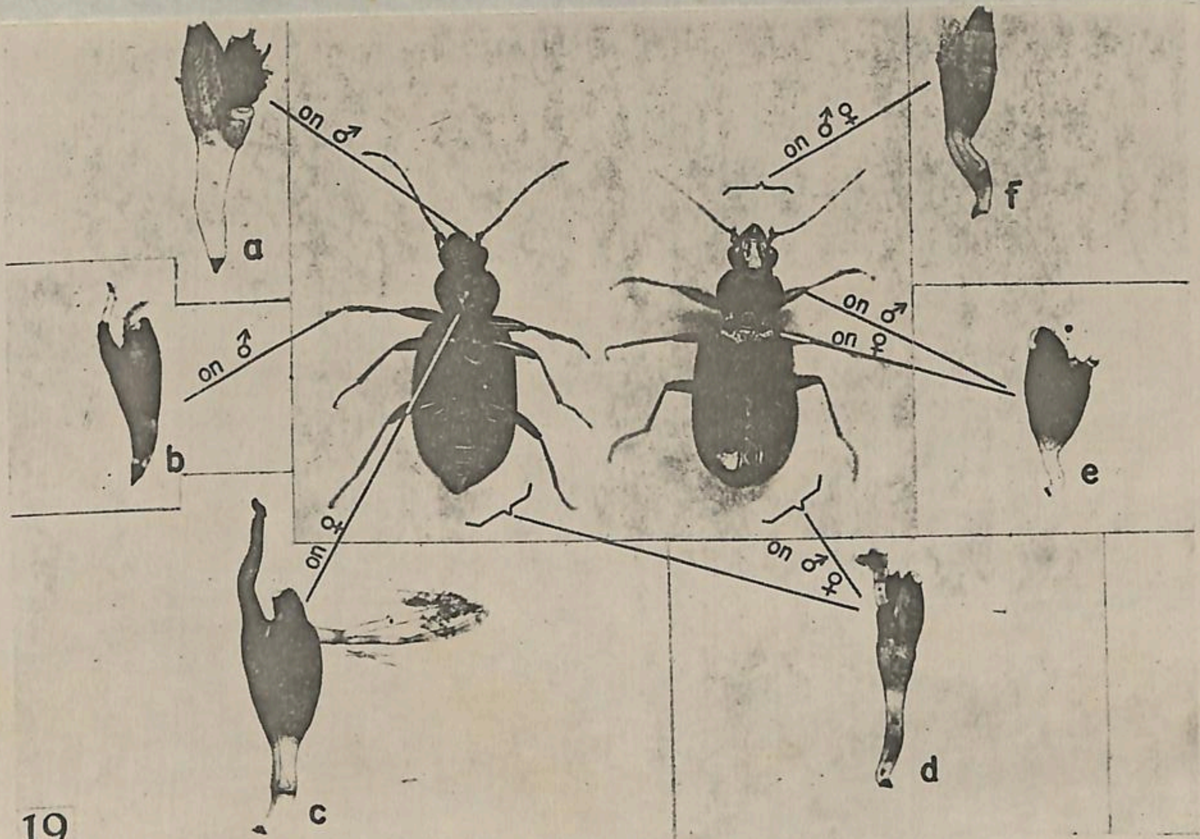


FIG. 230.—Vertical section of a hypothetical ascocarp showing relationship of sex organs, ascogenous hyphae, asci, and sterile hyphae.

tissue growing up around the ascogenous hyphae and the asci developed on them. The mass of asci and the enveloping tissue constitute the "fruiting body" or *ascocarp*. An ascocarp usually contains only the asci derived from a single zygote, but there are cases, as *Pyronema*, where the asci derived from several zygotes are included in one ascocarp. There are three general types of ascocarp: the *cleistocarp* (Fig. 243*G*) that does not open at maturity; the open more or less cup-shaped *apothecium* (Fig. 298) in which the cavity is lined with a palisade-like layer of asci; and the flask-shaped *perithecium* (Fig. 256*D*), also lined with a palisade-like layer of asci but with an apical opening or pore.

An ascogonium may be unicellular, or it may be transversely septate, with the ascogenous hyphae growing out of one or more of the median



19

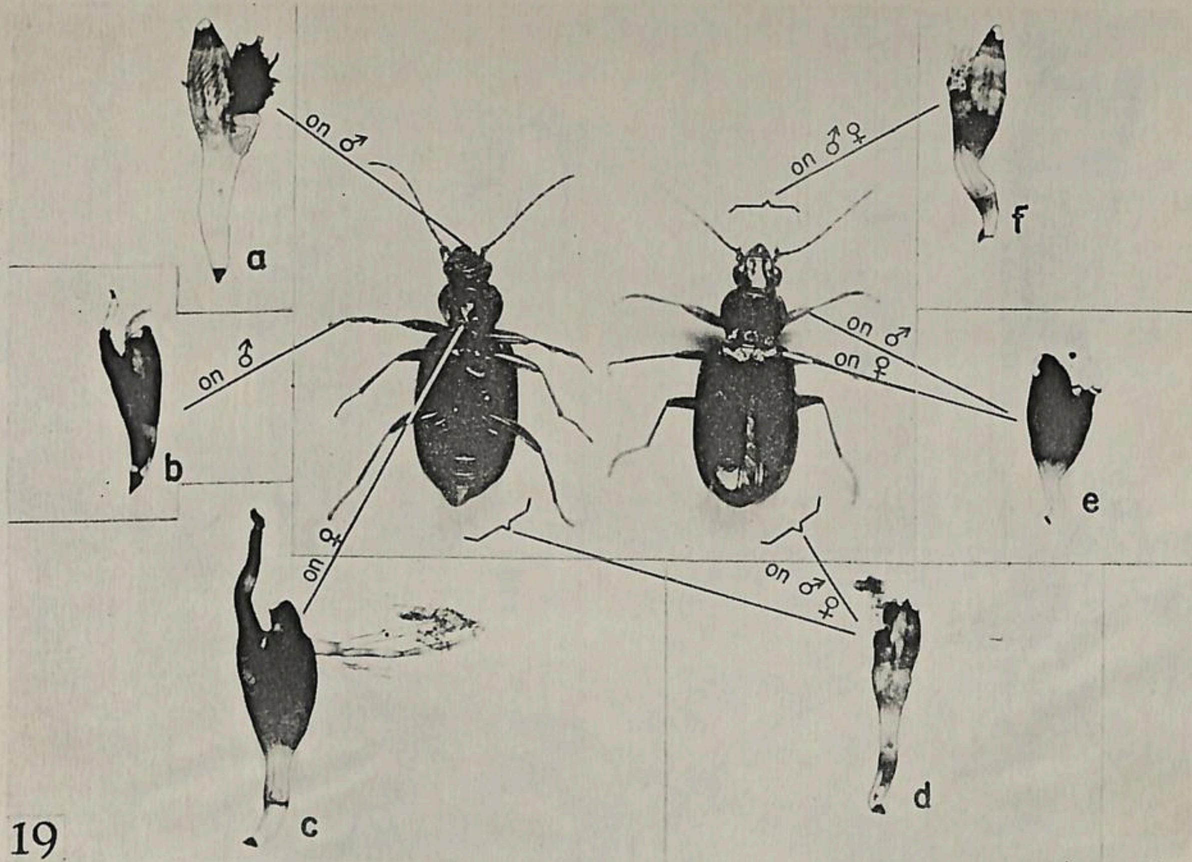
Fig. 19. Composite illustration showing the position upon the host, *Bembidion picipes* Kirby, of the 6 species of *Laboulbenia* encountered on the specimens collected in Brownfield Woods. a. *L. bembidio-palpi*, on mouth parts of the male; b. *L. truncata*, on the tarsi of the anterior legs of the male;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

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

A series of specimens collected at Charleston, Coles County, Illinois, included 15 females and 11 males. Two of the former and six of the latter were parasitized by one or more of the species of *Laboulbenia* under consideration. *L. vulgaris* occurred on two individuals of each sex and showed the usual random distribution upon the host surface. One male bore *L. truncata* on the tarsi of the anterior legs. *Laboulbenia bembidio-palpi* infested the mouth parts of two males. Three beetles, two females and one male, were infected with *L. tapirina* which grew only upon the upper surface of the integument. Two beetles of each sex were infested with *L. odobena*, and here too this fungus was found on the humerus of the right elytron of the female and on the inner, distal surface of the femur of the right anterior leg of the male. A very interesting observation was made on one of the females bearing *L. odobena*. In addition to a very heavy infestation in its usual position on the right elytron, several specimens of the fungus were growing on the upper, distal surface of the femur of the right anterior leg!

A single male collected in Chicago, Cook County,

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



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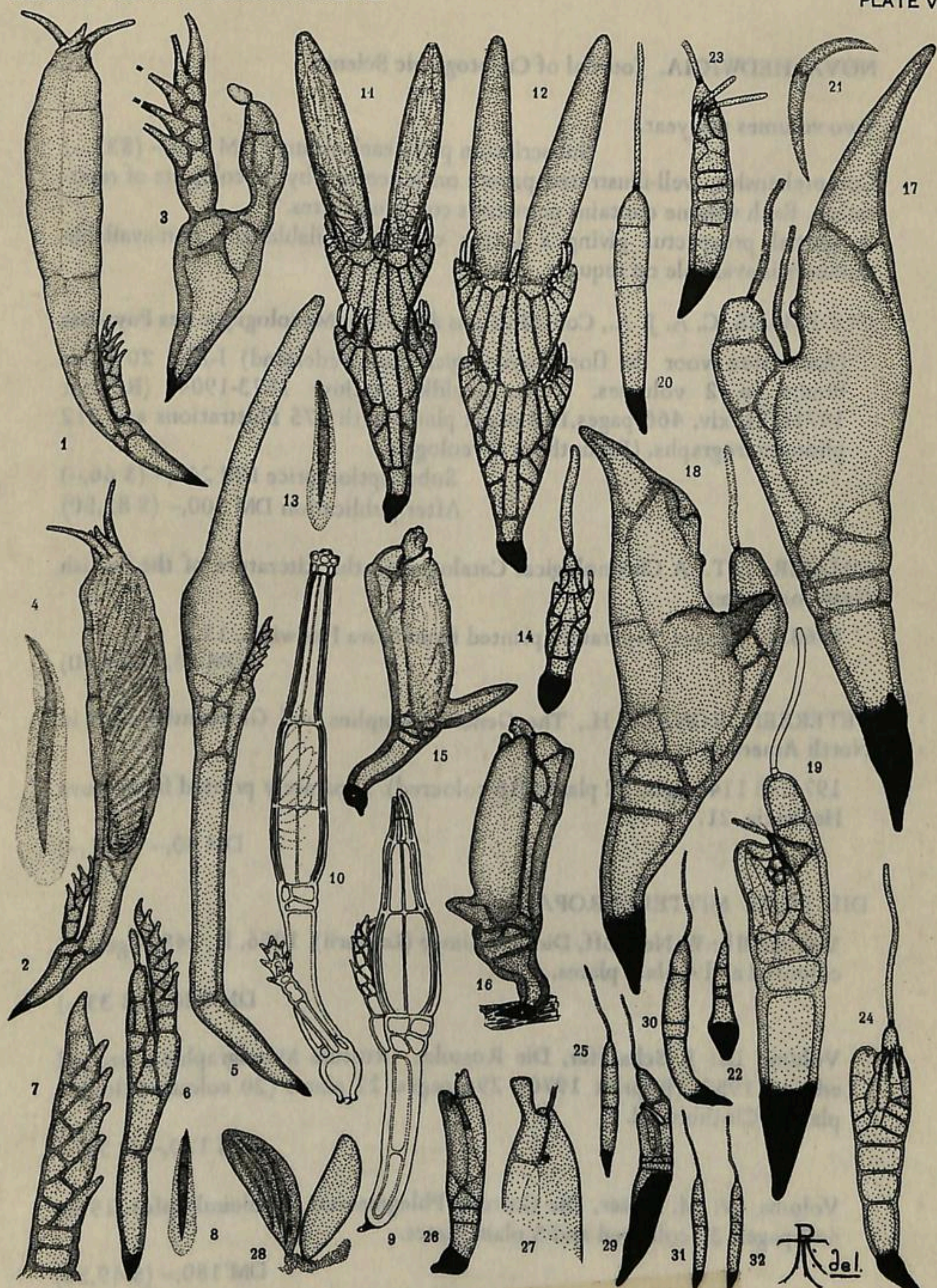

THAXTER—MONOGRAPH OF LABOULBENIACEÆ.

older systems in which the nature of the ascocarp was emphasized to the virtual exclusion of other characters, and newer ones in which microscopic characters are more prominent.

1. Asci unitunicate, or if bitunicate then in an exposed hymenium of an apothecium 2.
   Asci bitunicate, formed in an ascostroma but not in an apothecium 5.
2. Asci naked, i.e. formed as discrete free cells or in a hymenium of indefinite extent, not bounded by a stroma or by ascocarp tissue; asci indehiscent *Hemiascomycetes*
   Asci formed in ascocarps 3.
3. Asci scattered at various levels within a cleistothecium or a beaked perithecium; asci indehiscent *Plectomycetes*
   Asci forming a hymenium or arising as a fascicle at a common level in the ascocarp, or rarely single 4.
4. Ascocarp usually a perithecium, less often a cleistothecium with fasciculate asci or an ascostroma with unitunicate asci; asci inoperculate, with an apical pore or slit; not minute external parasites of insects and arachnida *Pyrenomycetes*
   Ascocarp a perithecium with inoperculate asci whose walls soon disintegrate; minute external parasites of insects and arachnida *Laboulbeniomycetes* (Fig. 55; not considered further)
   Ascocarp an apothecium or its hypogean derivative; asci operculate, inoperculate or indehiscent *Discomycetes*
5. Asci bitunicate, formed in an ascostroma but not in an apothecium *Loculoascomycetes*

CLASS HEMIASCOMYCETES

This class comprises those Ascomycotina which form unitunicate asci as free cells or in a hymenium of indefinite extent. The yeasts and their mycelium-forming or pseudomycelial relatives constitute the order Endomycetales, while the pathogenic leaf-curl fungi are placed in the order Taphrinales. In the Endomycetales the asci arise from a common cell formed by gametangial conjugation; in the Taphrinales the binucleate mycelium gives rise to binucleate ascogenous cells which develop into asci. Paraphyses are not formed by members of either order.

Order Endomycetales

Four families are usually included in this order. The Ascoideaceae includes genera with multisporous asci borne on a filamentous mycelium, e.g. *Ascoidea* and *Dipodascus*, both of which have been isolated from gummy exudates of trees. In the Spermophthoraceae, a mycelium is also present but the asci have eight or fewer ascospores and these are fusoid or narrow and elongated; members of this family are pathogens of tropical plants, especially cotton, and are introduced to their hosts by insect punctures. The Endomycetaceae are distinguished from the Spermophthoraceae by producing

THE FUNGI

An Advanced Treatise

Edited by

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VOLUME IVA

A Taxonomic Review with Keys:
Ascomycetes and Fungi Imperfecti

1973

ACADEMIC PRESS New York and London

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by Ainsworth (1966) for use in the current edition of the "Dictionary of Fungi" (Ainsworth, 1971). Fungi are treated here as either a separate kingdom or, for the more conservative, as a subkingdom of the plant kingdom, with two divisions, the Myxomycota, for plasmodial forms, and the Eumycota, for nonplasmodial forms which are frequently mycelial. Five subdivisions of the latter are recognized, including the Ascomycotina (for ascomycetes) and the Basidiomycotina (for basidiomycetes), while the imperfect fungi are classified for convenience as the Deuteromycotina, although in a hierarchical classification it is incorrect to equate these fungi with the ascomycetes and the basidiomycetes to which they are subsidiary both taxonomically and by nomenclature. Most lichenized fungi (lichens) have been omitted, as they are to be the subject of a separate book.

IV. KEYS TO THE HIGHER TAXA

FUNGI

It is difficult to give a concise diagnostic definition of fungi. The main characteristics of the group are

Nutrition: heterotrophic (photosynthesis lacking) and absorptive (ingestion rare).

Thallus: on or in the substratum and plasmodial amoeboid or pseudoplasmodial; or in the substratum and unicellular or filamentous (mycelial), the last, septate or nonseptate; typically nonmotile (with protoplasmic flow through the mycelium) but motile states (e.g., zoospores) may occur.

Cell wall: well-defined, typically chitinized (cellulose in Oomycetes).

Nuclear status: eukaryotic, multinucleate, the mycelium being homo- or heterokaryotic, haploid, dikaryotic, or diploid, the last being usually of limited duration.

Life cycle: simple to complex.

Sexuality: asexual or sexual and homo- or heterothallic.

Sporocarps: microscopic or macroscopic and showing limited tissue differentiation.

Habitat: ubiquitous as saprobes, symbionts, parasites, or hyperparasites.

Distribution: cosmopolitan.

KEY TO DIVISIONS OF FUNGI

1. Plasmodium or pseudoplasmodium present . . . . **Myxomycota** I

1′. Plasmodium or pseudoplasmodium absent, assimilative phase typically filamentous . . . . **Eumycota** II

I. Myxomycota

KEY TO CLASSES OF MYXOMYCOTA

1. Assimilative phase a plasmodium 2

1′. Assimilative phase free-living amoebae which unite as a pseudoplasmodium before reproduction . . . . **Acrasiomycetes**[1] p. 12

2(1) Plasmodium forming a network ("net plasmodium") . . . . . . **Labyrinthulales**[2]

2′(1) Plasmodium not forming a network 3

3(2′) Plasmodium saprobic, free-living . . . . **Myxomycetes** p. 53

3′(2′) Plasmodium parasitic within cells of the host plant . . . . **Plasmodiophoromycetes**[3] p. 83

II. Eumycota

KEY TO SUBDIVISIONS OF EUMYCOTA

1. Motile cells (zoospores) present; perfect-state spores typically oospores . . . . **Mastigomycotina** (p. 65) III

1′. Motile cells absent 2

2(1′) Perfect state present 3

2(1′) Perfect state absent . . . . **Deuteromycotina** VII

3(2) Perfect-state spores zygospores . . . . **Zygomycotina** IV

3′(2) Zygospores absent 4

4(3′) Perfect-state spores ascospores . . . . **Ascomycotina** V

4′(3′) Perfect-state spores basidiospores . . . . **Basidiomycotina** VI

III. Mastigomycotina

KEY TO CLASSES OF MASTIGOMYCOTINA

1. Zoospores posteriorly uniflagellate (flagella whiplash-type) . . . . **Chytridiomycetes** p. 101

1′. Zoospores not posteriorly uniflagellate 2

2(1′) Zoospores anteriorly uniflagellate (flagella tinsel-type) . . . . **Hyphochytridiomycetes** p. 112

2′(1′) Zoospores biflagellate (posterior flagellum whiplash-type; anterior tinsel-type); cell wall cellulosic . . . . **Oomycetes** p. 75

[1]Excluded from the Myxomycota by Martin and Alexopoulos (1969).
[2]Excluded from this treatment.
[3]Treated as a class of the Mastigomycotina.

IV. Zygomycotina

KEY TO CLASSES OF ZYGOMYCOTINA

1. Saprobic or, if parasitic or predacious, having mycelium immersed in host tissue . . . . **Zygomycetes** p. 191
1′. Associated with arthropods and attached to the cuticle or digestive tract by a holdfast and not immersed in the host tissue . . . . **Trichomycetes** p. 244

V. Ascomycotina

KEY TO CLASSES OF ASCOMYCOTINA

1. Ascocarps and ascogenous hyphae lacking; thallus mycelial or yeastlike . . . . **Hemiascomycetes** Vol. IVA
1′. Ascocarps and ascogenous hyphae present; thallus mycelial 2
2(1′) Asci bitunicate; ascocarp an ascostroma . . . . **Loculoascomycetes** Vol. IVA
2′(1′) Asci typically unitunicate; if bitunicate, ascocarp an apothecium 3
3(2′) Asci evanescent, scattered within the astomous ascocarp which is typically a cleistothecium; ascospores aseptate . . . . . . **Plectomycetes** Vol. IVA
3′(2′) Asci regularly arranged within the ascocarp as a basal or peripheral layer 4
4(3′) Exoparasites of arthropods; thallus reduced; ascocarp a perithecium; asci inoperculate . . . . **Laboulbeniomycetes** Vol. IVA
4′(3′) Not exoparasites of arthropods 5
5(4′) Ascocarp typically a perithecium which is usually ostiolate (if astamous, asci not evanescent); asci inoperculate with an apical pore or slit . . . . **Pyrenomycetes** Vol. IVA
5′(4′) Ascocarp an apothecium or a modified apothecium, frequently macrocarpic, epigean or hypogean; asci inoperculate or operculate . . . . **Discomycetes** Vol. IVA

VI. Basidiomycotina

KEY TO CLASSES OF BASIDIOMYCOTINA[4]

1. Basidiocarp lacking and replaced by teliospores (encysted probasidia) grouped in sori or scattered within the host tissue; parasitic on vascular plants . . . . **Teliomycetes** p. 251
1′. Basidiocarp usually well-developed; basidia typically organized as a hymenium; saprobic or rarely parasitic 2
2(1′) Basidiocarp typically gymnocarpous or semiangiocarpous; basidia phragmobasidia (**Phragmobasidiomycetidae**, p. 310) or holobasidia (**Holobasidiomycetidae**, p. 323); basidiospores ballistospores . . . . **Hymenomycetes** p. 307
2′(1′) Basidiocarp typically angiocarpous; basidia holobasidia; basidiospores not ballistospores . . . . **Gasteromycetes** p. 451

[4]If yeastlike, see p. 11.

VII. Deuteromycotina

KEY TO CLASSES OF DEUTEROMYCOTINA

1. Budding (yeast or yeastlike) cells with or without pseudomycelium characteristic; true mycelium lacking or not well-developed . . . . **Blastomycetes** Vol. IVA
1′. Mycelium well-developed, assimilative budding cells absent 2
2(1′) Mycelium sterile or bearing spores directly or on special branches (sporophores) which may be variously aggregated but not in pycnidia or acervuli . . . . **Hyphomycetes** Vol. IVA
2′(1′) Spores in pycnidia or acervuli . . . . **Coelomycetes** Vol. IVA

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FIG. 4. Ascus apices. A–D, Apical spore discharge mechanisms; E–K, some positive reactions in iodine (Melzer's Reagent), the blue reactions illustrated here as black or shaded. A, Typical apical operculum of most Pezizales; B, subapical operculum, with a thickened pad surrounding the inner portion of the opening, found in many Sarcoscyphineae (Pezizales); C, ascus apex opening by a vertical slit, also showing the subterminal, thickened ring present in some cases, found in a few Pezizales; D, typical inoperculate ascus apex, the thickened apex traversed by a delicate pore, a plug of wall material filling the pore until discharge, as in Helotiales, Ostropales, Phacidiales; E, a very broad pore, as in *Cyttaria* (Cyttariales), in the species illustrated with a distinct ring in the pore which blues in iodine, the plug at times appearing like an operculum; F, diffuse blueing of the ascus wall in iodine, as in some species of Pezizaceae, Ascobolaceae (Pezizales); G, apical blueing of the ascus, here shown restricted to a broad, ringlike zone, sometimes also extending over the apex, as in many Pezizaceae (Pezizales); H, inoperculate apex with the plug blueing in iodine (or with a very broad pore blueing and the plug itself not blue but so small that this can only be determined by viewing the ascus from above rather than from the side); J, inoperculate ascus in which a thin cylinder in the pore blues, seen in optical section as two blue lines; K, inoperculate ascus in which only a small ring surrounding a portion of the plug blues in iodine, seen in optical section as 2 tiny blue dots.

The number of nuclei in ascospores and paraphysis cells, as shown by the studies of Berthet (11), displays a remarkable consistency within the various groups, particularly in the Pezizales. Information on nuclear numbers is provided in the keys to the genera of that order because of the assumed phylogenetic significance, even though these are scarcely "key characters" of use in quick identification. Likewise, Arpin's (1a) studies on carotenoid pigments provide data which, where possible, have also been included in the key to the Pezizales for the sake of completeness and its probable importance in evolution.

The most important mounting medium, other than water, is surely Melzer's Reagent (0.5 gm iodine, 1.5 gm KI, 20 gm chloral hydrate, 20 ml H_2O), which is used both as a general differential stain and to test the iodine reaction (under oil immersion!) of the ascus apex or ascus pore. A positive reaction (often abbreviated "J+" from the German word for iodine, *Jod*) is usually some shade of blue, but occasionally violet colors may be produced. The apex of the ascus may blue, or a ring or plug may blue. At times the pore surrounding the plug will blue, and one may see either two thin vertical lines or two dots in the apex, these representing a blueing cylinder or a ring, as seen in optical section. Rarely the reaction may be a diffuse blue over the whole length of the ascus, or even portions of the apothecium may turn blue or violet in Melzer's Reagent. A negative reaction, in which no

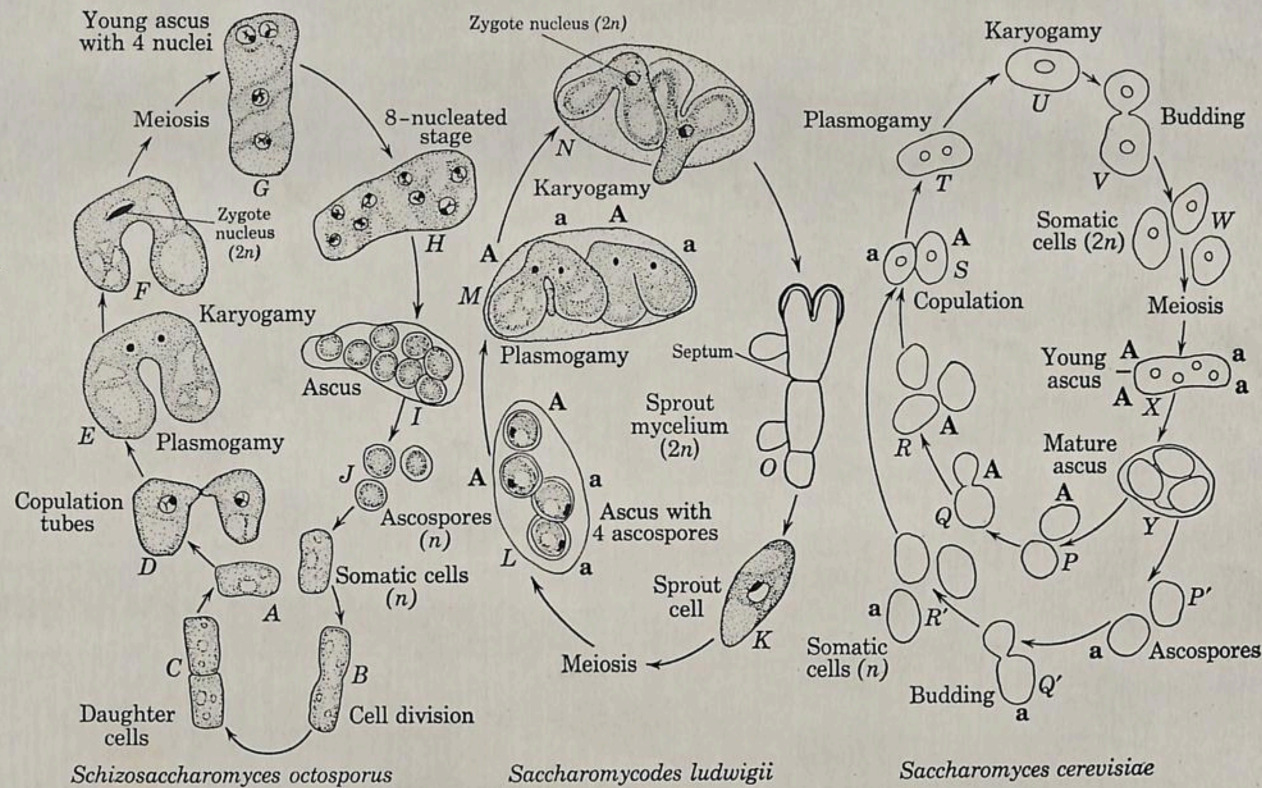


Figure 95. Comparative life cycles of three types of yeasts. *D–G*, *K–N*, redrawn from Guilliermond, 1905, *Rev. gén. bot.*, 17:336–376; *H*, constructed; *O*, redrawn from Guilliermond, 1905, *Bull. soc. mycol. France*, 19:19–32; *P–Y*, diagrammatic.

ALEXOPOULOS, C. J. 1962. INTRODUCTORY MYCOLOGY.

in AINSWORTH, SPARROW, SUSSMAN. THE FUNGI. VOL. IVA. 1973.
E.S. LUTTRELL

Family E. Pseudosphaeriaceae
Family F. Capnodiaceae
Family G. Dothideaceae
Family H. Dothioraceae
Order 3. Pleosporales, p. 176
Family A. Dimeriaceae
Family B. Venturiaceae
Family C. Mesnieraceae
Family D. Botryosphaeriaceae
Family E. Lophiostomataceae
Family F. Sporormiaceae
Family G. Pleosporaceae
Family H. Mycoporaceae
Order 4. Hysteriales, p. 195
Family A. Hysteriaceae
Subfamily 1. Hysterioideae
Subfamily 2. Lophioideae
Family B. Arthoniaceae
Family C. Opegraphaceae
Family D. Phillipsiellaceae
Family E. Patellariaceae
Family F. Lecanactidaceae
Order 5. Hemisphaeriales, p. 200
Family A. Microthyriaceae
Family B. Trichopeltinaceae
Family C. Munkiellaceae
Family D. Micropeltidaceae
Family E. Asterinaceae
Family F. Brefeldiellaceae
Family G. Aulographaceae
Family H. Parmulariaceae
Family I. Stephanothecaceae
Family J. Schizothriaceae
Family K. Leptopeltidaceae

III. GENERAL CHARACTERISTICS

A. *Bitunicate Asci*

The primary character of the Loculoascomycetes is the bitunicate ascus. The ascus wall consists of two layers which are separable in the normal course of ascospore discharge: a thin, inextensible outer layer, or ectoascus, and a thick, extensible inner layer, or endoascus. The very young ascus is thin walled (Figs. 1A, 2C). During most of its development, however, the endoascus is conspicuously thickened, especially toward the apex where it is indented or partially penetrated by a tubular channel forming a subapical chamber into which the protoplast extends (Figs. 1C, D, E, F, G, H, I; 2C; 3C). This marks the pore through which the ascospores are later ejected. Although the endoascus becomes thinner as the ascus matures, the subapical chamber characteristically remains visible as an indentation in the thicker apex (Figs. 2A, C, D; 3A). As the ascus swells prior to dehiscence the entire wall appears uniformly thin.

At dehiscence the bitunicate structure becomes apparent. The ectoascus splits at the apex; in some species it ruptures circumscissally, throwing off the apex as a thimble-shaped cap (Fig. 1D). The endoascus expands as a tubular extension which doubles or triples the original length of the ascus (Figs. 1B, D, G, H; 2C, D). The margin of the ruptured ectoascus is visible as a faint line around the ascus below a slight or definite bulge in the freed endoascus. The wall of the expanded endoascus is uniformly thin. The ascospores move up in the endoascus. One advances into the elastic pore in the tip and hangs there briefly at its widest diameter (Fig. 2D). Spores constricted at the septa are trapped momentarily at a constriction (Fig. 1B). As the first spore is shot

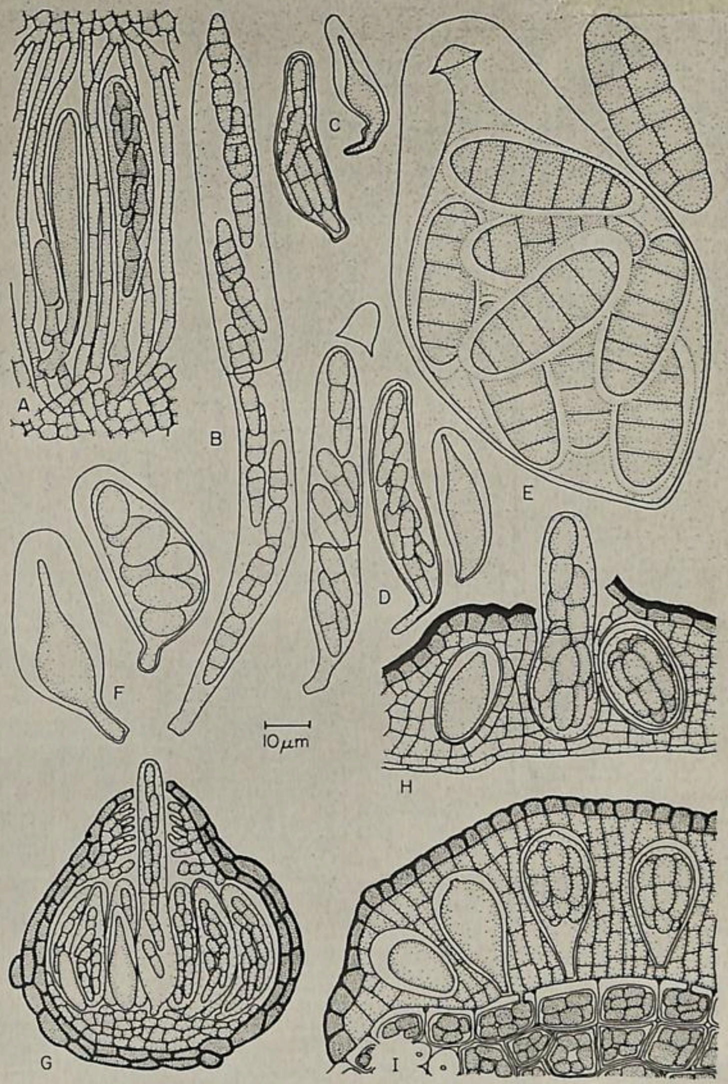
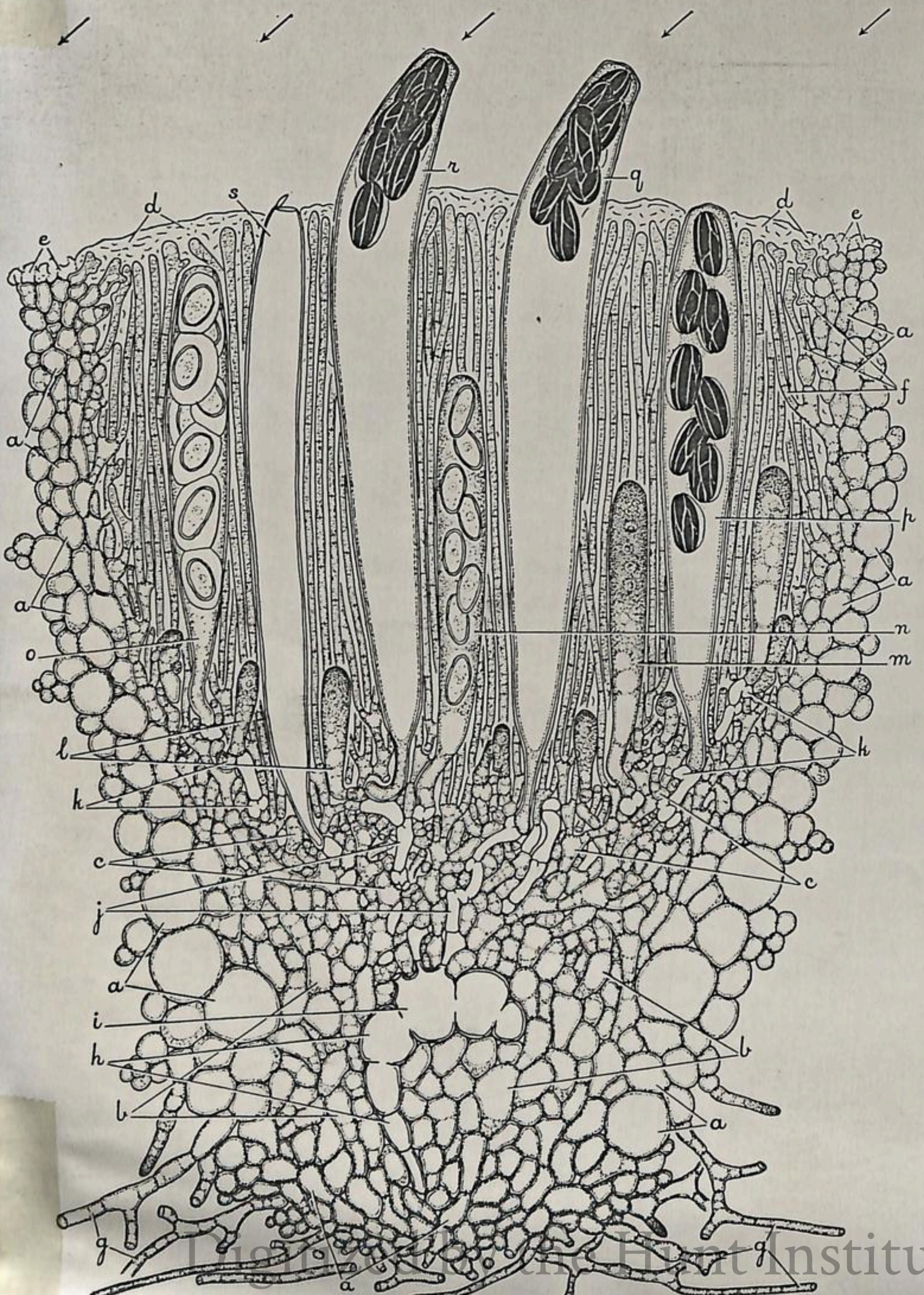


FIG. 1. (A) *Letendraea padouk*, young and mature asci among pseudoparaphyses. (B) *Dothiora schizospora*, ascus with expanded endoascus in process of spore discharge. (C) *Scirrhia acicola*, young and mature asci. (D) *Stomiopeltis* sp., young and mature asci and ascus with tip of ectoascus thrown off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

Buller, A.H.R. Researches on Fungi. VI. 1934.



period of development extends from the initiation of marginal growth to maturity."

The asci of *Ascobolus stercorarius* push upwards between the paraphyses and at first are straight. However, shortly before they discharge their spores, they protrude considerably beyond the general level of the hymenium, and their aerial parts bend heliotropically toward the source of greatest light. Two such heliotropically curved asci are shown in Fig. 132 in which is reproduced Corner's illustration (arrows added by myself) of a median-vertical section through the whole of a small fruit-body.[1] As in other

FIG. 132.—*Ascobolus stercorarius*, a common coprophilous Discomycete which has heliotropic asci and which puffs audibly. Median-vertical section of a very small apothecium. The apothecium is turbinulate in form; it was angiocarpic in origin, and the primary sheath of cortical cells which overlay a mucilage cavity and the disc became ruptured at *e e* owing to the expansion of the internal tissues, and thus the disc was exposed. The apothecium was built up originally around the archicarp from sympodial clusters of cortical hyphae and paraphyses, the intercalary parts of which now form the medulla. Details of structure are shown as follows: the *excipulum*, consisting of the *cortex a a* and the *medulla b b*; *c c*, the *hypothecium* (in which the ascogenous hyphae are situated); the *hymenium*, consisting of *asci* and *paraphyses*, above the hypothecium; *d*, *mucilage*; *e e*, the broken edges of the primary cortical sheath that at first covered the mucilage cavity and disc; *f*, rudimentary paraphyses, evidently forming part of the sympodial clusters of hyphae from which the apothecium was constructed; *g*, *secondary mycelium* composed of hyphae which have grown from the underside of the apothecium as excrescent cortical cells into the substratum; *h*, the *archicarp* (*scolecite*) consisting of a bent chain of cells with a wide pore in the centre of each septum; *i*, the *ascogonium*, one of the cells of the archicarp, which gave rise to the ascogenous hyphae; *j*, ascogenous hyphae passing upwards through the hypothecium; *k*, hooks and hook-cells which were formed at the ends of ascogenous hyphae; *l*, young asci pushing up between the paraphyses, each containing a fusion nucleus; *m*, an older ascus containing four nuclei; *n*, an ascus containing eight young spores; *o*, an ascus containing eight older spores, each surrounded by jelly; *p*, an ascus containing mature or nearly mature spores each of which has a dark-violet cell-wall marked with interlacing white lines and bears on one side a lenticular mass of jelly; *q* and *r*, two highly turgid and fully expanded asci, each containing a thin layer of protoplasm lining the cell-wall, a large central vacuole filled with cell-sap, and massed at the apex eight ripe spores which are about to be violently discharged; the asci *q* and *r* protrude beyond the layer of mucilage and their aerial parts are bent heliotropically toward the source of strongest light the direction of which is indicated by the arrows; when the operculum of the ascus *q* or the ascus *r* opens, the elastic ascus-wall will contract and drive out through the operculum not only the eight spores but also a large amount of cell-sap which will be scattered in the air in the form of a fine spray of spherical droplets; *s*, an ascus which has discharged its eight spores and has shrunk to about one-half of its original volume; at its apex the hinged operculum can be seen. Drawn by E. J. H. Corner, originally published by him in *Trans. Brit. Myc. Soc.*, Vol. XIV, 1929, but now, with his consent, altered slightly, lettered, described, and reproduced on a larger scale than formerly by A. H. R. Buller. Magnification, about 340.

[1] E. J. H. Corner, *loc. cit.*, p. 286.

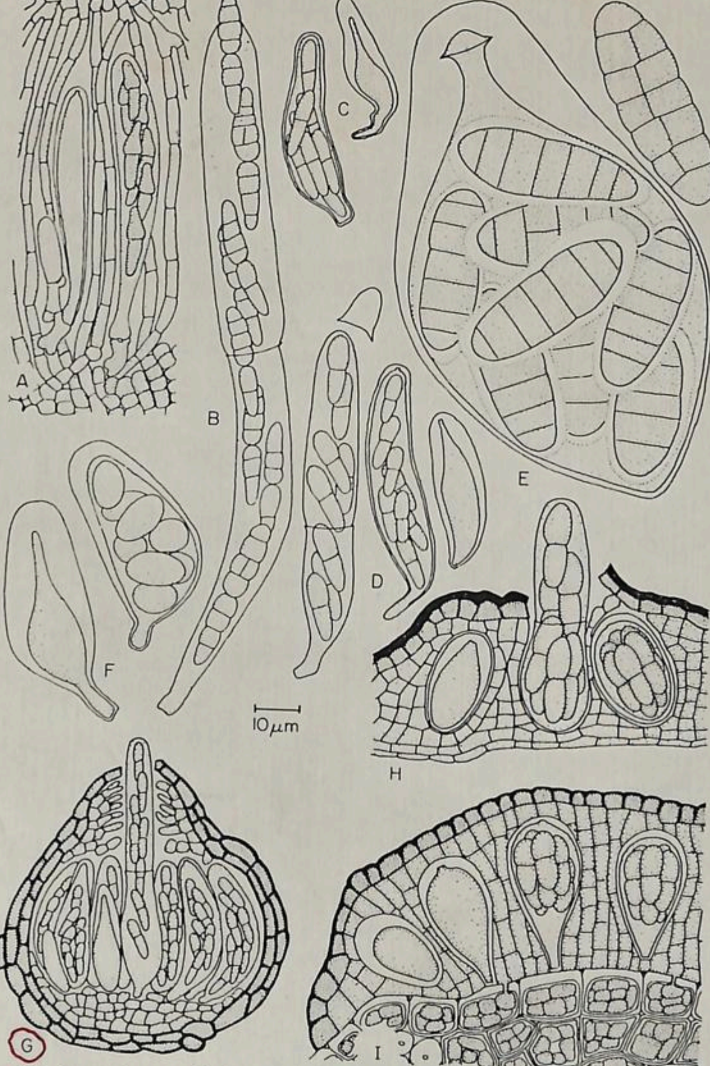


FIG. 1. (A) *Letendraea padouk*, young and mature asci among pseudoparaphyses. (B) *Dothiora schizospora*, ascus with expanded endoascus in process of spore discharge. (C) *Scirrhia acicola*, young and mature asci. (D) *Stomiopeltis* sp., young and mature asci and ascus with tip of ectoascus thrown off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

Ascomycetes ... Revision   J.H.Miller. Mycologia 41(2):99 - 127. 1949.

A natural system attempted, based upon ascus development & characteristics of ascocarp centrum dev. Color & extent of stroma & position of ascocarp relative to substrate not o nsidered fundamental.

Criteria of primitiveness:

1 globose asci
2 wall uniformly thickened
3 splitting of outer, elongation of inner wall (or gelatinizing)
4 asci irregularly grouped in fr. bod.
5 archicarp & antheridium unite to form asci.

GWM
E, M } ① — LOCULES < NO PARAPHYSES / " PERIPHYSES
D, M, M, E, H, L, S, H, } ② — TRUE PERITHECIA
P, H, P, T. } ③
INOPERC. OPERC.

Criteria of specialization:

1 cylindrical asci
2 lateral walls thin, apex thick
3 pore or lid opening
4 spermatia unite with trichogyne of archicarp

Hemiascomycetes: asci borne s ingl y or clustered on mycelium; no ascocarp.

Euascomycetes: asci in ascocarps ; ② Pyrenomycetes; Labouls
Sphaerales
Hypocreales
Dothidiales
Pseudosphaer
Microthyrial
Lophiostomat
Hysteriales

③ Discomycetes; Ostropales, Helotiales } Inoperculate
Pezizales (epigeic), Tuberales (hypogeic) } Operculate

① Plectomycetes: (PLECTASCALES) ascocarps cl osed; Eurotiales (no stroma)
Myriangiales (stroma pres.)
Erysiphales (asci arise from basal plectenchyma).

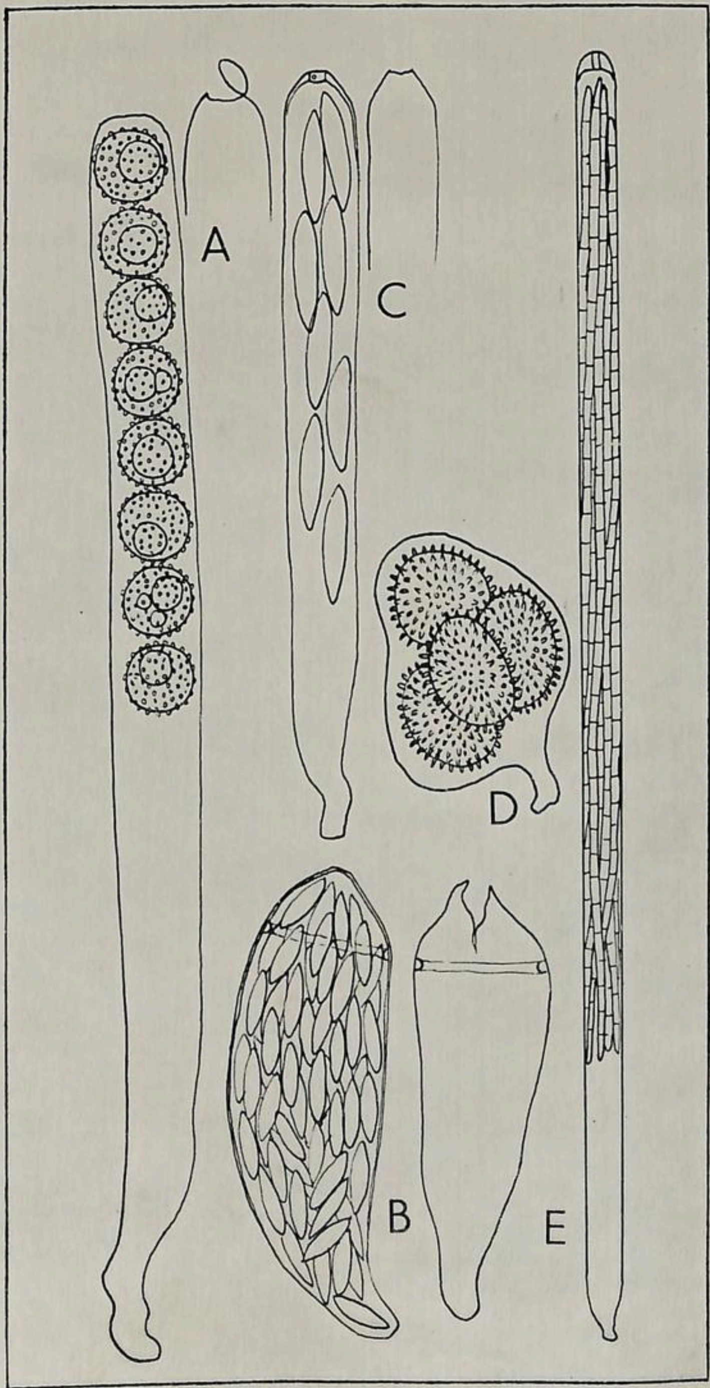


FIG. 1.—Some kinds of unitunicate asci. A. Operculate ascus of *Barlaeina amethystina*. B. Bilabiate ascus of *Ascozonus woolhopensis*. C. Inoperculate ascus of *Helotium aciculare*. D. Indehiscent ascus of *Tuber rufum*. E. Parallel-sided ascus of *Stictis stellata*. For bitunicate asci see individual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

a

DENNIS, R.W.G. - British Cup Fungi. 1960.

The Fungi of southeast England

R. W. G. Dennis

Summary. The numbers of species of fungi in southeast England are compared by orders and families with those of Rhum and Yorkshire.

When I set out over 20 years ago to collect fungi in the Isle of Rhum, several simple and obvious questions presented themselves. How big was the flora likely to be, i.e. how many species of fungi was one looking for? In what proportions were the different groups of fungi to be expected to occur? How would the fungus flora of a highland area differ from that of a lowland area in southern England with which one was familiar? Answers to questions of this kind were not then to be had. There were check lists of some groups of fungi published by the British Mycological Society, but these, though valuable summaries of the published British records, were useless for statistical purposes because they were replete with synonyms and made no attempt to estimate the number of distinct taxa actually present in the country. There have also been many published county lists of fungi but almost all of these are obviously imperfect and incomplete, obviously heavily biased in favour of 'macromycetes'; most are out of date and swollen with names of doubtful application. The most complete and reliable is probably Mason and Grainger's 'Catalogue of Yorkshire Fungi' which is 35 years old and based on a system of classification now wholly superseded. Before it could be used as a basis for comparison it would need bringing up to date as regards records and also careful editing of the species list. Rather rashly, therefore, I decided to compile from the literature and from the collections at Kew and the Commonwealth Mycological Institute a fresh check list of fungi of a representative part of lowland England. For this purpose the four south-eastern counties were selected, Kent, Surrey, East and West Sussex, which together form a rather compact area with several advantages. It has a clearly defined water boundary on three sides, with only the western boundary an arbitrary administrative line of no geographical or biological significance. It is neither too large to cope with nor too small to include samples of most kinds of lowland vegetation. Its proximity to London has led to its fungus flora being sampled by specialists in nearly every group of fungi so that the usual bias in favour of foray records is largely overcome and it was neither the home nor the favourite collecting ground of any active 19th century mycologist. This last is a great asset because the literature is not cumbered with long lists of dubious and totally unverifiable agaric records dating from the look, sniff and nibble days of mycology, when toadstools were named quite recklessly in the field without their microscopical morphological characters being checked or voucher specimens kept.

Anyone who attempts a census of fungi has to face problems unfamiliar to the enumerator of phanerogams, vascular cryptogams, bryophyta or even the lichenised fungi. Nonlichenised fungi are identifiable only when they fruit and this they do sporadically and unpredictably so that recording over

Accepted for publication 5 June 1972.

a long period of years is essential if anything approaching a true census is to be achieved. The great diversity of structure and method of reproduction met with between different groups of fungi means that few mycologists are interested in the whole range of species present and probably none is competent to name members of all groups. A true picture of a fungus flora can therefore only result from the efforts of numerous specialists and the southeast corner of England is probably as well sampled in this way as any in the world. Statistical comparisons between groups of fungi are also hampered by the considerable differences in species concept currently fashionable among specialists. In Uredinales, for example, species concepts have fluctuated wildly, between the ultra narrow and the very broad, with a broad morphological concept fashionable at the moment. In ascomycetes also a broad species concept is commonly adopted but in Agaricales on the contrary the slightest detectable differences between collections, even in purely ephemeral characters, are commonly seized on as an excuse for multiplying specific names. Worst of all the mycological enumerator has to face the problem of pleomorphism. Many, perhaps most, ascomycetes have at least one accessory spore form in their normal life cycle, classifiable among the form-genera of fungi imperfecti. Hence in any enumeration of species it is important not to count an ascomycete more than once, under the names of both the perfect and imperfect states. I have tried to avoid doing this as far as the life histories are known but there remains a list of 979 names of fungi imperfecti not certainly linked with perfect states. Except for a very few hyphomycetes with clamp connections on their hyphae it is reasonably certain that these belong to ascomycetes but it is impossible to be certain how many of them are assignable to already known ascus states and how many are fungi whose ascus state has not yet been described. Also, while the 509 names of hyphomycetes refer to reasonably distinct taxa at least in the form-genera of fungi imperfecti, the present state of coelomycete taxonomy leaves one quite uncertain how many of the names assigned to Sphaeropsidales and Melanconiales refer to morphologically distinct taxa. Far too many names in such form genera as *Phyllosticta*, *Ascochyta*, *Diplodina*, *Phoma*, *Diplodia* are based merely on the host genus on which the fungus was found, with no attempt to distinguish it morphologically from similar fungi collected on other host genera. It is also possible that names in the first four of the above genera and even in others like *Septoria* may all refer to states of the same organism. One can therefore only attempt a personal estimate of the number of different taxa represented by the list of coelomycete names. By arbitrarily excluding all 59 names in *Phomopsis* as probably duplicating names already compiled in *Diaporthe* and its segregates, 37 names in *Cytospora* as similarly duplicating names in *Valsa*, rejecting 29 names in *Diplodia*, counting only 10 out of 40 names in *Phoma* and the like I have accepted 300 out of a listed 470 names of coelomycetes as possibly representing good species additional to those in the list of ascomycetes. This, however, is clearly the part of the census most open to error and criticism.

The known fungi of southeast England then amount to 4084 species, distributed in families as set out in Table I. Cooke & Hawksworth (1970) have pointed out that many of the best known family names in fungi have never been validly published or are even illegitimate. In the present highly fluid state of fungus taxonomy, however, it seems best to wait and see how many of these families find a permanent place in a generally accepted

R. W. G. DENNIS. 1960. British Cup Fungi and Their Allies. (See XVII)

INTRODUCTION

In all but the simplest fungi, the plant body consists of very slender much branched threads, individually called *hyphae*, collectively the *mycelium*. Reproduction takes place by the production of microscopic bodies adapted for dissemination by air currents, less often by water or by insects. These are of many kinds but all differ from seeds in not containing a differentiated embryo and are conveniently referred to by the comprehensive term "*spores*". Fungi cannot be named from their mycelia alone and all but the broadest groupings of the species are based on the nature of the spores and the organs in or on which they are borne.

One group of fungi, the *Phycomycetes*, can be recognised by its mycelium, which lacks transverse walls or *septa*. Only a very few of these produce complex fruit bodies; the majority are plant parasites (Downy mildews) or microscopic moulds inhabiting water or soil. None of them is dealt with in this book.

The remaining fungi have mycelia composed of septate hyphae and fall into three main classes according to the manner in which their spores are produced.

In the *Basidiomycetes*, the large group which comprises the familiar toadstools, bracket-fungi, coral-fungi, puff-balls, stink-horns and their allies, the spores are borne, usually in groups of four, on the *outside* of a cell called a *basidium*, hence they are *basidiospores*. In most species these are shot into the air from the surface of the basidium and are dispersed by air currents. As a rule they have a slightly asymmetrical outline and the point at which they were attached to the basidium, the *apiculus*, remains visible, so that basidiospores are fairly easy to recognise as such even when detached. The basidia are normally packed close together in a continuous layer, the *hymenium*, covering the gills on the under side of the toadstool's cap or the pores beneath the bracket fungus. There are many popular books about the common Basidiomycetes and they too fall outside the scope of this book.

The second great group of fungi with septate hyphae is called the *Ascomycetes* because its distinctive spores are formed *inside* a characteristic cell called an *ascus*, and are hence called *ascospores*. Except in the simplest forms, the asci are produced in large numbers, orderly arranged like basidia in a hymenium or in smaller clusters enclosed in a common wall or sheath. A very large number of Ascomycetes are known only in close association with microscopic algae, building up often large and characteristically shaped vegetative plant bodies commonly called lichens, much more complex than the inconspicuous thread-like mycelium of the non-lichenised ascomycetes. Technically the lichen fungi have to be inserted in their appropriate places among the orders and families of the Ascomycetes but there are such enormous numbers both of lichenised and non-lichenised species that a convention has grown up by which they are usually the province of different specialists and are dealt with in different books. This artificial separation of often closely allied organisms has had most unfortunate results on both the classification and the nomenclature of the Ascomycetes but it will be adhered to here for the traditional reason, viz. the enormous number of species and genera involved in a rational amalgamation of the lichenised and non-lichenised fungi.

No fungus is known to produce both basidia and asci and it is believed that these are mutually exclusive alternative products of a nuclear fusion corres-

Melzer: p.21
p. XVII – on Taxonomy

BOUDIER, E. HISTOIRE ET CLASSIFICATION DES DISCOMYCÈTES D'EUROPE. 1907.
(221 pp.)

A – OPERCULÉS
B – INOPERCULÉS

DENNIS

NANNFELDT, J. A. 1932. STUDIEN ÜBER DIE MORPHOLOGIE UND SYSTEMATIQUE DER NICHT LICHENISIERTEN INOPERCULATEN DISCOMYCETEN.

[= PLECTOMYCETES = LOCULOASCO- = α DISCO + PYRENO
PLECTASCALES – ASCOLOCULARES – ASCOHYMENIALES]

III. ORDERS

KEY TO ORDERS OF DISCOMYCETES

1. Mycelium endophytic in the stems of *Medeola* (Liliaceae), causing fusiform swellings of the stem, penetrating the epidermis to form an indeterminate feltlike layer of paraphyses among which are dispersed asci . . . . **Medeolariales** p. 257

1′. Not parasitic on *Medeola* 2

2(1′) Mycelium endophytic in the stems of *Nothofagus* (Fagaceae), causing galls on which are borne compound, more or less spherical ascocarps in which are embedded individual apothecia . . . . **Cyttariales** p. 258

2′(1′) Not forming ascocarps on galls of *Nothofagus* 3

3(2′) Ascospores not liberated by violent discharge into the air, but instead disseminated by animals; ascocarps almost always subterranean, but if above ground then the hymenium covered with a thick, epithecial tissue through which the asci neither penetrate nor elongate to liberate ascospores. Asci spherical to clavate, in a recognizable hymenium or scattered within the tissues **Tuberales** p. 259

3′(2′) Ascospores violently discharged into the air; ascocarps almost always produced above ground, but if completely subterranean then the ascocarps becoming epigean either by lifting the soil or by animal action (the genus *Geopora*). Asci clavate to cylindrical, rarely ovoid 4

4(3′) Ascus apex as thin as, or thinner than, the side walls, opening by throwing back a lid (operculum), or rarely by formation of a longitudinal apical slit . . . . **Pezizales** p. 262

4′(3′) Asci usually distinctly thickened at the apex, with an apical pore through which the ascospores are discharged 5

5(4′) Apothecia developing within a stroma, such that one or more hymenial areas develop as palisade layers of paraphyses, soon interspersed with asci, the stroma eventually rupturing only after the hymenium is mature (either by one or more longitudinal slits or in a stellate manner) . . . . **Phacidiales** p. 278

5′(4′) Apothecia not developing within a stroma, either with the hymenium naked from the beginning or with the hymenium developing within a more or less spherical primordium opening by a pore at its apex to expose the hymenium long before the formation of mature asci and ascospores 6

6(5′) Asci cylindrical, very long and narrow, with a strongly thickened apex (at least in youth) traversed by a delicate pore, resembling the asci of the Clavicipitaceae. Ascospores filiform, nearly as long as the ascus . . . . **Ostropales** p. 282

6′(5′) Asci more or less clavate. Ascospores various, but if filiform then the asci without a greatly thickened apex . . . . **Helotiales** p. 283

IV. MEDEOLARIALES

In this order, the ascocarps are indefinite and have a palisade layer of paraphyses which have penetrated the epidermis of the swollen stem of the host plant, and that are interspersed with asci. The Medeolariales infect flowering plants which have a greatly shortened internode between the two whorls of

KORF, R. in THE FUNGI, IVA 1973.

which form the nuclei of the eight ascospores. The lower daughter nucleus remains in the lower part of the chlamydospore and is often separated from the other nucleus by a cross-wall. During these nuclear divisions the wall of the chlamydospore has stretched to form an ascus. Within the ascus the

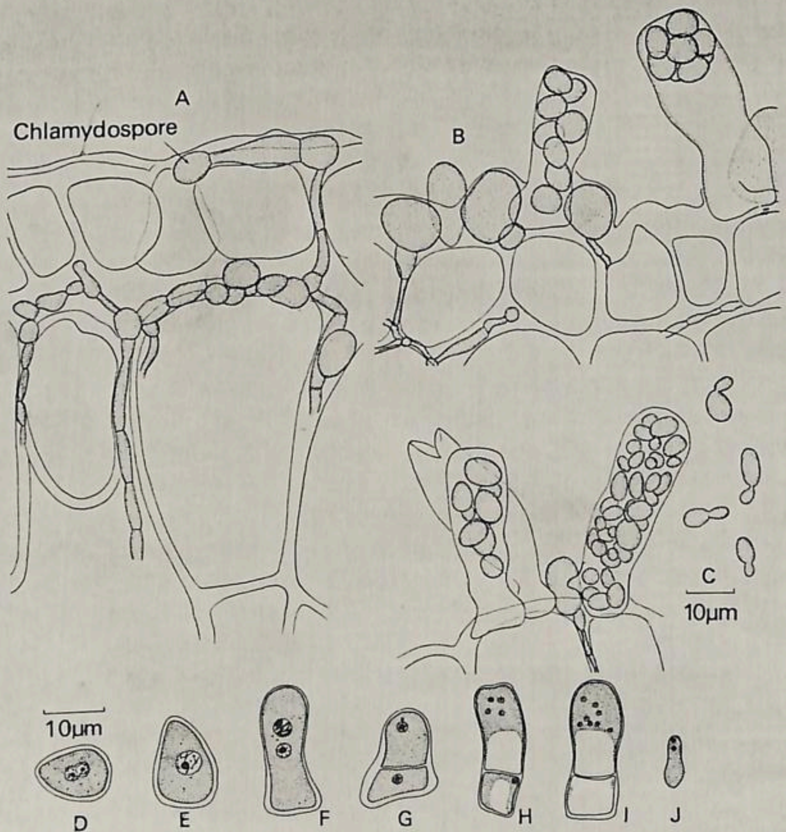


Figure 100. *Taphrina deformans*. A. T.S. peach leaf showing intercellular mycelium and subcuticular chlamydospores. B. T.S. peach leaf showing chlamydospores and asci, containing eight ascospores. C. T.S. leaf showing a dehisced ascus, and eight-spored ascus and an ascus in which the ascospores are budding. Ascospores budding outside the ascus are also shown. D–J. Cytology of ascus formation (after Martin, 1940). D, E. Fusion of nuclei in chlamydospore. F. Elongating ascogenous cell containing two nuclei formed by mitosis from the fusion nucleus. The upper nucleus has begun to divide meiotically. G. Uninucleate ascus with uninucleate basal cell. H, I. Four- and eight-nucleate asci. J. Binucleate germ tube in germinating ascospore.

ascospores may bud so that ripe asci may contain numerous buds (see Fig. 100c). The asci form a palisade-like layer above the epidermis and it is their presence which gives the leaf its waxy bloom. The ascospores or buds are projected from the asci which often opens by a characteristic slit (Fig. 100c). Following treatment with potassium hydroxide the ascus wall of *T. populina*

WEBSTER, J. INTRODUCTION TO FUNGI. 1970. (UNIV. EXETER)

Fig. 67 à 80.- Asques de Discomycètes operculés.

CHADEFAUD.

NOVA HEDWIGIA 19 (4). 1970.

ASCOSPORE DISCHARGE AND ULTRASTRUCTURE OF THE ASCUS IN LEPTOSPHAERULINA AUSTRALIS*

by João S. Furtado**

and

Lindsay S. Olive

Department of Botany University of North Carolina
Chape Hill, N.C. 27514 U.S.A.

with 13 plates

Introduction

The contemporary trend in classification and phylogeny of ascomycetes is based fundamentally on centrum development, nature of the ascocarp, and nature of the ascus, i.e. whether unitunicate or bitunicate (Luttrell, 1951, 1955; Booth, 1966; Chesters, 1968).

Ultrastructural studies of ascus and ascospore development (Bracker, 1967; Carroll, 1969; Furtado and Olive, in press) have demonstrated a basic sequence of events which seem to be common among the ascomycetes. However, studies thus fas completed have been on ascomycetes with unitunicate asci.

In view of the present emphasis on ascus type in classification, an investigation of *Leptosphaerulina australis* McAlp. by both light and electron microscopy has been undertaken. This leaf-inhabiting fungus was included in the family Pseudosphaeriaceae (Loculoascomycetes) because of the presence of bitunicate asci (Graham and Luttrell, 1961). The cytology of ascocarp development in *Pseudoplea gaeumannii* – a synonym of *L. australis*, according to Graham and Lutrell (1961) – was investigated by Wehmeyer (1955). In addition, Denison and Carlstrom (1968) have described ascocarp development in *Leptosphaerulina argentinensis*, a species that closely resembles *L. australis*.

The terminology adopted for the components of the ascospore is discussed elsewhere (Furtado and Olive, in press).

*Supported by U.S. National Science Foundation, Grant GB-7392.

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Ascomycetes (about 40,000 sp.)

Miller, J.H. Mycologia 41(2): 99-127. 1949. Revision of Classification of Ascomycetes with special emphasis on Pyrenomycetes

Bessey, E.A. P. 192-212.

Characteristics of the Class: Mycelium typically septate; Spores all non-motile; sexual phase ends in ascus with endogenously produced spores (usually 8 in number); ascogenous hyphae give rise to asci by crozier formation;

- Dikaryon in crozier tip;
- fusion of haploid nuclei;
- meiotic division produces 4 nuclei;
- mitotic division results in 8 haploid nuclei.

Spore formed by Free Cell Formation; (cut out of cytoplasm in area of mitotic spindles, Epiplasm remains as residue in ascus; also glycogen.

Ascus differs from Sporangium in being a sexual structure, but homologous with Basidium; difference being in endogenous spores vs exogenous spores of basidium.

Major part of fruiting body of Ascos composed of Monokaryon, contrasted with Dikaryon of basidios.

Fruiting bodies of most Phycos inconspicuous compared with predominance of mycelium; reverse the case in Ascos. this tendency becomes more pronounced in the Basidios.

Sexual reproduction in Ascos:

Ascogonium the female organ; antheridium the male; process has been studied carefully in only few species (Pyronema, Glomerella) making it almost impossible to generalize; but fundamental pattern may be similar.

1. ASCOIDEACEAE – 8-SPORED ASCI; ABUNDANT MYCELIUM
NO PARAPHYSES
2. SPERMOPHTHORACEAE – ZYGOTE → ASCUS SPINDLE/NEEDLE-SHAPED. 8-SPORED
3. SACCHAROMYCETACEAE – MYCELIUM ± , ± SAPROBIC.
4. ENDOMYCETACEAE – MYCELIUM ++

Endomycetales

ASCOIDACEAE → Dipodascaceae } "SLIME FLUX" IN EXUDATES OF PLANTS.

5. BASIDIOMYCETOUS YEASTS.
6. DEUTEROMYCOTINA (BLASTOMYCETES)
a) SPOROBOLOMYCETACEAE (BALLISTOSPORES)
b) CRYPTOCOCCACEAE (NO BALLISTOSPORES)

Dipodascus albidus forst found in Ecuador in slime flux of a Bromeliad; later in Sweden (on Birch).

a. Two copulating branches arise, adjacent to each other, separated by a cross wall;

b. One of these branches becomes the female gametangium, the other the male (no morphological diff.).

c. the two tips now come into contact.

d. septum dissolves.

e. male nuclei migrate to female gametangium.

f. female gametangium elongates, male does not.

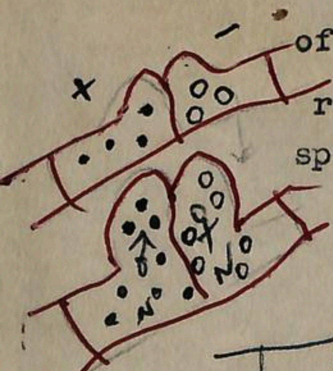
g. fusion nucleus produced. = 2N

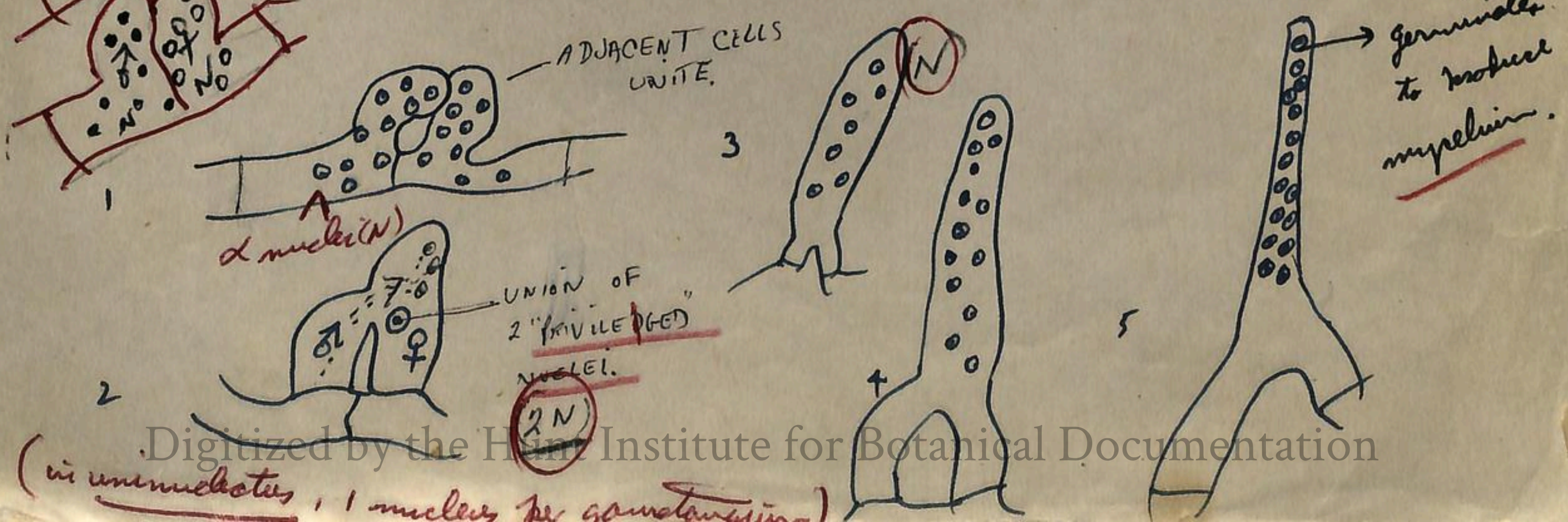
h. many daughter nuclei arise. MEIOSIS → MITOSIS

i. ascospores ~~fxx~~ formed by free cell formation; other nuclei degenerate. ; N

j. spores extruded thru opening in summit, as a sticky ball, capable of immediate germination.

Sexual reproduction above similar to that found in Endogene of the Zygomycetes. In latter, supernumerary nuclei do not remain in gametangium (absorbed in Dipodascus) ; also, no sporangium formed in Endogene, only a thick-walled hypnospore.





HEMIASCOMYCETES

ENDOMYCETALES

Guillermond, A. The Yeasts. 1920.
Stekling-Dekker, N.M. Sporogenous Y easts. 1931.
Lodder, J. Asporogenous Yeasts. 1934.

YEAST

" Fungi whose dominant growth formm is uni-cellular."

Importance to man:

Industrial ferments: acetone, alcohol

Pathogenicity: moniliasis, (Candida)

thrush (mucous membr. infect.)

cutaneous lesions (Blastomycosis)

cent. nerv. syst. (Cryptococcus)

Morphology:

Zygote converted into ascus. ie gametes fuse 1 cell enlarges (ascus) 1-8 spores

no cellulose

1) Asporogenous yeasts: ("False yeasts") no known sexual reprod. (no asci) mycelium sometimes.

2) Sporogenous yeasts: "True yeasts") asci cells divide by budding or fission. ie Saccharomyces & Schizosaccharom

no mycelium ??

Evolutionary series connects sporogenous & asporogenous yeasts

Endomycopsis (Spores & Mycelium) (S+M)

(losing ability to → mycelium) → Saccharomyces (S only)

(losing ability to form spore) → Candida (M only)

Saccharomyces (now, losing ability to → spores) → Cryptococcus

Candida (now, losing ability to → mycelium) → Cryptococcus

Cryptococcus (neither S nor M; budding only)

Asporogenous yeast

Imperfect

LINDEGREN, C.C. 1949. THE YEAST CELL. ITS GENETICS & CYTOLOGY.

Ascomycetes

Endomycetales

Saccharomycetateae

Yeast are true fungi whose growth form is unicellular.

✓Morphology of yeast cell still a matter of controversy.

Compare ideas of Lindegren, DeLamater, Wager & Penniston, others.

Chief differences in views of Lindegren & DeLamater:

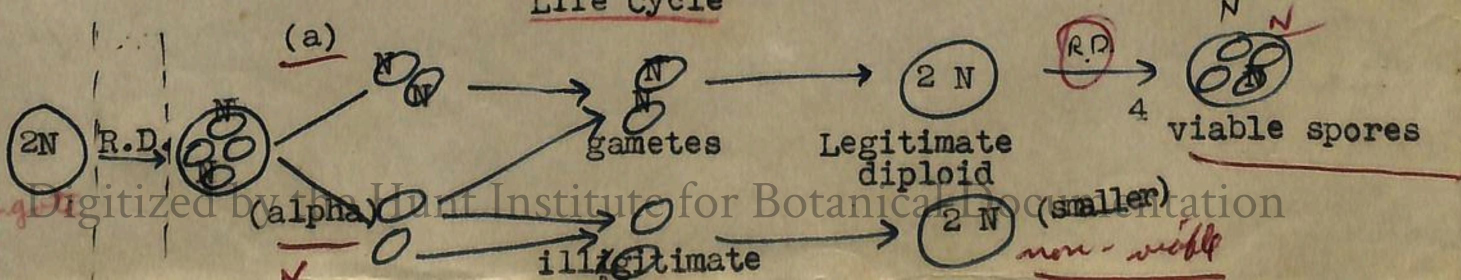
Lindegren	DeLamater
Diploid number of chromosomes 12.	Diploid number 4.
Chromosomes (chromatin of Wager) shown by Rafalko's stain.	believes Lind. destroyed chromosomes (or made them more diff. to interpret) by his staining procedure.
Believes chromosomes never divide transversely.	Thinks they do.

(DeLamater not included in Lindegren's bibliography in Yeast Cell). (DeLamater cites Lind's "Cytogene theory" which latter retracted since.) [COLD SPRING HARBOR SYMP. QUANT. BIOL. 1947.]

Lindegren: 2 mating typed in Saccharomyces (a and alpha). (1946)

Mass mating technique devised by Lind. (1943). ie parent cultures classified according to biochemical differences prior to mating; then afterward again.

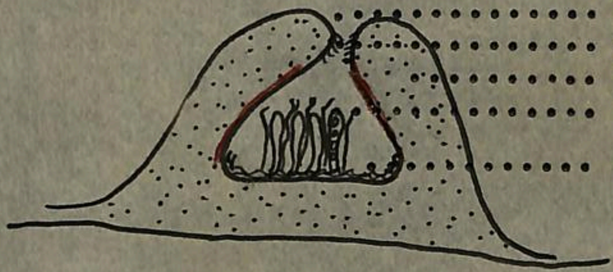
Life Cycle

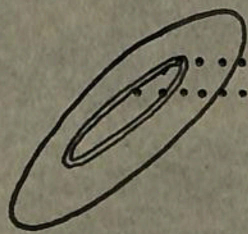


HYSTERIALES

Tehon, L.R. 1935. A Monographic Rearrangement of Lophodermium. Univ. Ill. Bull. No. 51.

Hysterothecium (Clements, 1909)





Generic differences based upon spore characters:

Lophodermium ..... acicular, aseptate
Glonium 1-septate
Hysterium .phragmospore (septate in 1 plane)
Hysterographium .... muriform(2 planes) dictyospore

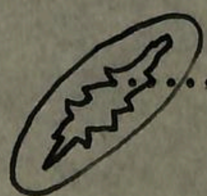
PHACIDIALES

Differ from Hysteriales in foll:

1) Ostiole an irregular split

2) Paraphyses elaborate, forming a dense layer above asci.

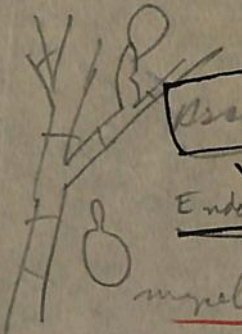
3) No meristematic band. Clithris sp. Rhytisma sp.



P-265 Henrici

Yeast (Hansen 1890)

"True fungi whose dominant growth form is unicellular."



Ascomycetes

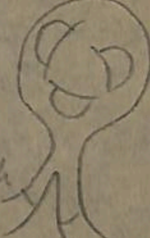
↓ mycelium & spores

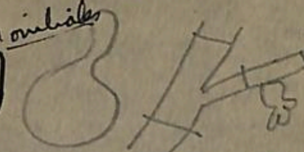
Endomycopsis forms both mycelium and budding single cells. The mycelium forms arise by fusion of contiguous cells. Losing the power to form spores, it becomes: → Candida

Losing the power to form mycelium it becomes:

↓ Spores only.

Saccharomyces, Zygosaccharomyces, Hansenula etc. not forming mycelium, existing as single budding cells. Ascospores are produced in a cell formed by 2 conjugating cells or in its progeny. Losing the power to form spores it becomes → Cryptococcus





Moniliales

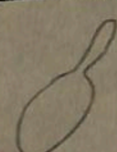
Imperfect

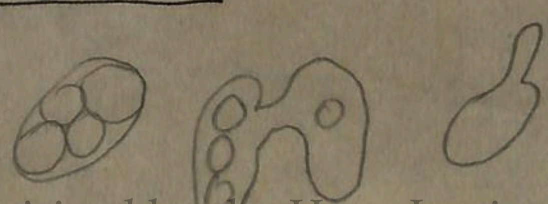
↓ mycelium only

Candida. It forms both mycelium and single budding cells but fails to form ascospores. Losing the power to form mycelium it becomes

↓ No mycelium (or) spores

Cryptococcus and other asporogenous genera; these yeasts grow as single cells, reproduced by budding, do not form either mycelium or spores.





Evolutionary Series

Endomycopsis (s + m)

↙ ↘

(s) Sacch. Candida (m)

↘ ↙

Cryptococcus (0 i.e. Budding only)

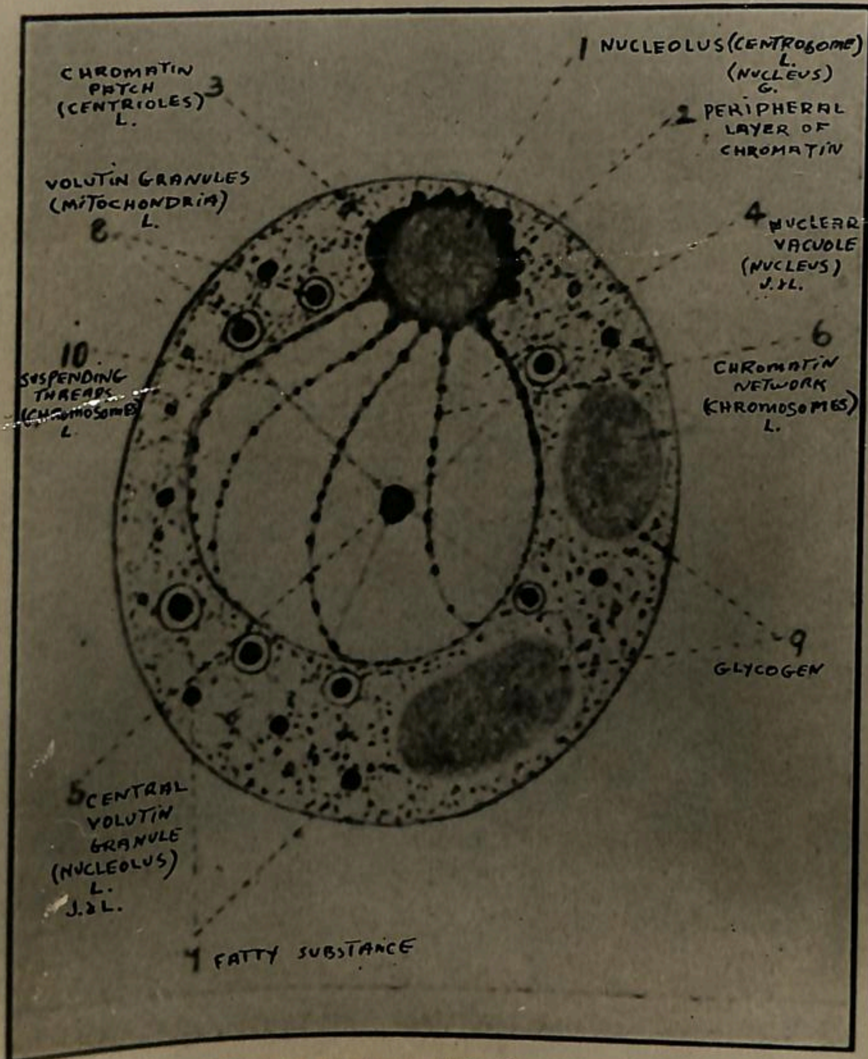
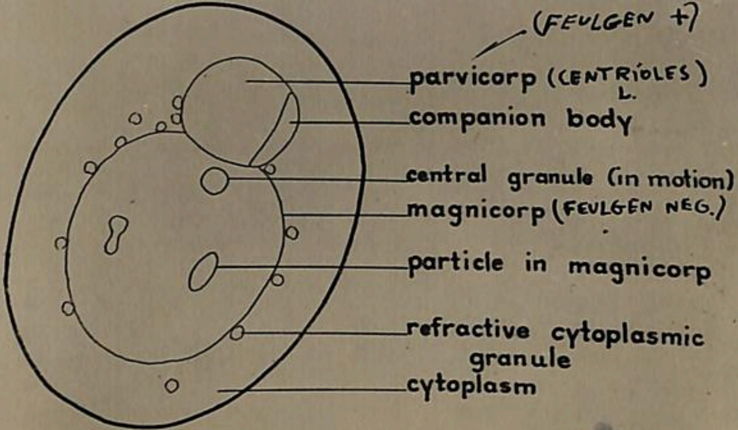


Fig. 1. Yeast cell from Wagner and Penniston.
ANN. BOT. 24: 45-84. 1910.



Text-fig. 1. Diagram of the yeast cell with parts labeled according to the terminology used in this paper.

NAGEL, L. ANN. MO. BOT. GARD. 33. 1946.

Mostly parasitic on vascular plants. (not obligate)

Dikaryon mycelium typical & forms major part of vegatative stage. (resembles ascogenous hyphae & basidio mycelium)

Host tissues hypertrophy; vegatative mycelium mostly inter-cellular.

Asci in palisade layer on surface of host.

Dikaryon elongates, karyogamy, meiosis, mitosis; 8 spores formed; these may reproduce by budding (yeast-like).

Possibly ~~close to~~ ancestral to rusts. (Savile)

Z.B. Uredinopsis spp. Aecia on Abies
Telia on Ferns

1. Parasitic
2. Grow poorly in culture
3. Dikaryotic mycelium
4. All occur on ferns or woody dicots. ∴ primitive

See: Alex. P. 215 } Life cycle.

belong to the Ustilaginales. *Filobasidium floriforme* also has dolipores. Its haploid form agrees with *Cryptococcus albidus*.

KEY TO GENERA OF BASIDIOMYCETOUS YEASTS

1. Ballistospores formed 2

1′. Ballistospores not formed 3

2(1) Mycelium with clamp connections . . . . **Sporidiobolus**
The two species in this genus, *S. johnsonii* and *S. ruinenii*, have been isolated from leaves. These yeasts are red or orange, and they follow cycle 2 (p. 22). Laffin and Cutter (1959a,b) assume that meiosis occurs in the yeast cells and not upon germination of the chlamydospores.

2′(1) Mycelium without clamp connections . . . . **Aessosporon**
The life cycle of the single species, *A. salmonicolor*, was described by van der Walt (1970b). It follows cycle 3, but on germination of the chlamydospore the promycelium is not septate and yeast cells are formed at the tip only.

3(1′) Cells red or orange . . . . **Rhodosporidium**
The four species described can be differentiated by the shape of the chlamydospores. Most of the strains have been isolated from marine sources. *R. toruloides* exhibits cycles 1 and 2, *R. sphaerocarpum*, 1 and 3 (Fell *et al.*, 1970), and *R. diobovatum*, cycle 1 (Newell and Hunter, 1970). They may be considered as perfect forms of *Rhodotorula glutinis*. The fourth species, *Rhodosporidium malvinellum*, has been described by Fell and Hunter (cf. Fell, 1970b).

3′(1′) Cells hyaline 4

4(3′) Basidiospores terminal on basidia . . . . **Filobasidium**
Olive (1968) described the first species of this genus, *F. floriforme*, isolated from *Eryanthus giganteus*. The 5 to 8 basidiospores formed on the long erect basidia have a flowerlike appearance. The species described as *Leucosporidium capsuligenum* from cider and sake-moto also belongs to this genus. It has a weak fermentative ability. Both *Filobasidium* species are heterothallic.

4′(3′) Sporidia lateral on a promycelium . . . . **Leucosporidium**
Most strains of this genus have been isolated from Antarctic soil and marine waters. They generally have a low maximum temperature of growth, namely ±19°C. The type species, *L. scottii*, is heterothallic, and the sexual cycle represented by schemes 1 and 3 are found in it. Five other *Leucosporidium* spp. accepted by Fell and Phaff (1970) only show the scheme 3 type.

IV. YEASTS CLASSIFIED IN THE DEUTEROMYCOTINA (BLASTOMYCETES)

There are two families, the Sporobolomycetaceae, characterized by the formation of ballistospores, and the Cryptococcaceae, lacking this characteristic.

A. *Family Sporobolomycetaceae*

Budding yeast cells and/or mycelium occur with or without clamp connections. Pseudomycelium may occur. Ballistospores are present.

The yeasts of this family, defined by Derx (1930), are considered to be imperfect Heterobasidiomycetes. The genera *Tilletiopsis* and *Itersonilia*, in the description by Derx (1948), have no budding cells and are therefore not included in the yeasts. Since they are classified in the same family with the yeast genera *Sporobolomyces* and *Bullera* they are discussed here. Sowell and Korf (1960) considered *Sporidiobolus* and *Tilletiopsis* as possible synonyms of *Itersonilia*. Strains of all species in this family have been isolated from plant materials and especially from leaves infected with rust and smut.

KEY TO GENERA OF SPOROBOLOMYCETACEAE

1. Budding cells formed 2

1′. No budding cells formed 3

2(1) Ballistospores symmetrical; cultures cream-colored to yellowish . . . . **Bullera**
There are four species of which *B. alba* is the type.

2′(1) Ballistospores generally asymmetrical; cultures red or pink, exceptionally cream-colored . . . . **Sporobolomyces**
Phaff (1970) accepted nine species. Mycelium without clamp connections may be formed. The ballistospores are kidney- or sickle-shaped.

3(1′) Mycelium with clamp connections . . . . **Itersonilia**
Three species have been described, of which the first one is *I. perplexans*. Sowell and Korf (1960) isolated a mono- and a dikaryotic phase from this species; the first could be obtained from the second, but not vice versa. They observed chlamydospores in both phases. Since a complete life cycle was not yet described for this genus, it is provisionally retained in the Sporobolomycetaceae. Tubaki (1952b) and Olive (1952) both studied *Itersonilia* spp. The ballistospores in this genus are kidney-shaped.

3′(1′) Mycelium without clamp connections . . . . **Tilletiopsis**
The ballistospores are sickle-shaped. Nyland (1950) described *T. washingtonensis* and *T. minor*. He observed hyaline chlamydospores. Tubaki (1952a) also studied *Tilletiopsis* spp.

B. *Family Cryptococcaceae*

Budding cells are present. Pseudomycelium (Fig. 2), true mycelium, and arthrospores (Fig. 5) may be formed. Cultures are cream colored, yellow, orange, or red.

This family comprises imperfect forms of ascomycetous and basidiomycetous yeasts. The differentiation in genera is mainly based on morphological and, exceptionally, on physiological properties. Among the latter, the assimilation of inositol very often correlates with the capacity to form starch-like compounds in the capsule. Lack of features of sexual reproduction often impedes a satisfactory classification and results in some very heterogeneous genera.

AINSWORTH, SPARROW, SUSSMAN. 1973. THE FUNGI IVA.

HELOTIALES

The Geoglossaceae of North America

Key to the Genera from E. J. Durand in Annales Mycologici 6 (5). 1908

A. Ascoma stipitate, clavate or spathulate, the ascigerous portion usually more or less compressed, rarely subglobose. . . . . Geoglosseae

B. Clavate, the ascigerous portion not or only slightly decurrent on opposite sides of the stem.

C. Spores small, elliptical, cylindrical or fusiform, continuous. Plants bright colored. . . Mitrula

C. Spores long-elliptical to cylindrical, 3-many septate when mature.

D. Ascomata Bright colored. . . . . Microglossum

D. Ascomata black or blackish.

E. Spores hyaline. . . . . Corynetes

E. Spores fuliginous or brown.

F. Hymenium without spines or setae.

G. Ascomata viscid-gelatinous. Paraphyses continuous down the stem. . . . . Gloeoglossum

G. Ascomata not viscid-gelatinous; paraphyses confined to the Hymenium. . . . . Geoglossum

F. Hymenium beset with spines or setae .Trichoglossum

B. Spathulate or fan-shaped, ascigerous portion decurrent on opposite sides of the stem. . . . . .Spathularia

A. Ascoma stipitate, pileate (or sessile in one genus with filiform spores). . . . . Cudonieae

H. Spores elliptical-fusiform, ascoma gelatinous. . . . . Leotia

H. Spores filiform or filiform-clavate

I. Ascoma fleshy-Gelatinous, asci very narrow, spores filiform; plants aquatic or semi-aquatic.

J. Stipitate. . . . . Vibrissea

J. Sessile or turbinate. . . . . Apostemidium

I. Ascoma fleshy-leathery, asci broadly clavate, spores filiform-clavate; plants terrestrial- . . . . Cudonia

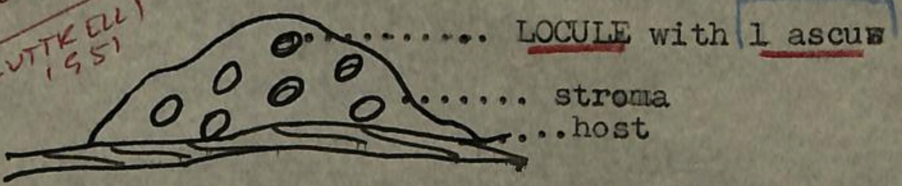
MYRIANGIALES (100 spp.)

Almost all parasitic in vascular plants.
Monascal locules (not true perithecia).
Stroma regular to lobate.
Stroma in some spp. fused with host tissue.

STROMA: "vegatative" matrix, variable in extent & structure, in or upon which spores are porduced.

Miller says: "Myriangiales may have arisen .... by the reduction of number of asci to one or uniascal locular forms may represent a primitive ancestral type for all forms in which the ascal plectenchyma develops in a stroma & is not surrounded by a special wal, such as found in : Hysteriales, Phacidiales, Hemisphaeriales, Dothidiales & Pseudosphaeriales. "

LOCULOASCOMYCETIDAE (LUTTRELL 1951) BITUNICATE ASCI

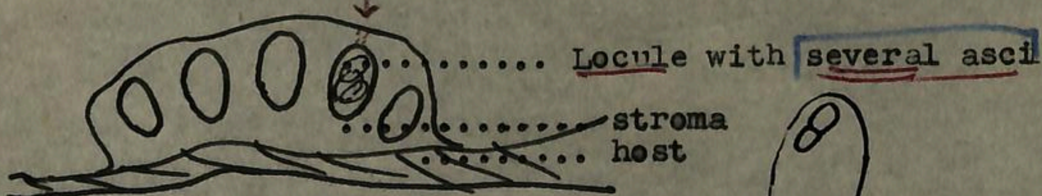


Locule is a cavity in a stroma.

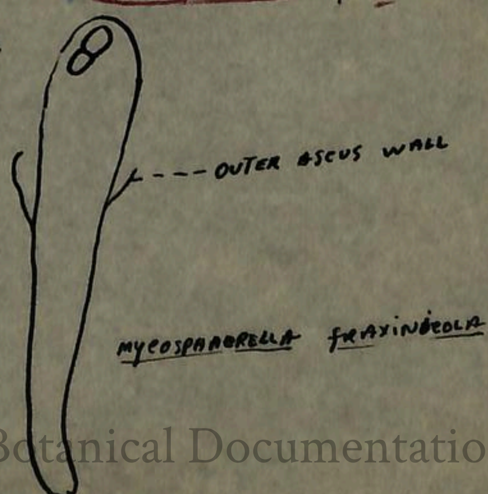
DOTHIDIALES (700 spp.)

see: Orton, C.R. 1924. Mycologia 16:49-95.

Many parasitic. (Tropical & subtropical)
Plurascal locules.
"Perithecial" wall not well differentiated.
Stroma carbonaceous outside; light within.
Stroma superficial or erumpent.
Pseudoostiole formed by disintegration of pseudotissue (LYSIGENOUS)



} not a "true" perithecium.



LOCULOASCOMYCETIDAE (LUTTRELL 1955)

MYRIANGIALES } MONASCAL

DOTHIDIALES
HYSTERIALES
MICROTHYRIALES
PLEOSPORALES } PLURASCAL

"Typical" Hypoxylon

1) Stromatic & xylariaceae, Phyllachoraceae, Diaporthaceae (Allantosphaeriaceae)

2) Nectria

1/5 18 Fam.

~~100~~ Genera 430

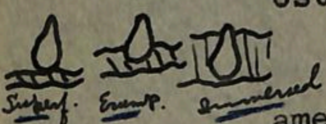
Sphaerales 10,000

Perithecial wall dark, more or less carbonaceous; Ostiole circular in cross section(usually). Paraphyses usually not numerous. Closely related to Hypocreales. ie in both, perithecium enclosed in stroma at time of its origin.

Sphaerales & Hypocreales differ from Erysiphales in having stroma and from Labouls in abundant mycelium.

At maturity, stroma may or may not be present; if it persists till maturity, perithecia are commonly embedded in it. (as Cordyceps). — innotenculate

Asci are formed in cavity of perithecium, opposite ostiole. Ascus wall may deliquesce (Chaetomiaceae, Sordariaceae) & spores lie free in perithecial cavity when mature, being extruded thru ostiole in a mass (cirrhus).



Spores extremely variable in group; globose to acicular; amerospores to dictyospores (muriform). Spores may be with appendages (Chaetomiaceae) or without.

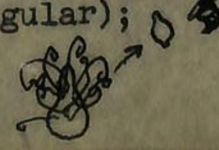
For dev. of perithecium in a "typical" member of the group, refer to Wheeler's papers on Glomerella.

Taxonomy of group (See J. Miller. Rev. of Ascos.)

Saccardo in Sylloge separates families & genera mostly on spore characters. Clements & Shear, likewise. Stroma not considered imp. Lindau, in Naturl. Pflanz., separates groups on basis of stromatic dev. Both systems have disadvantages.

Characteristics of some of the Families

Chaetomiaceae: Perithecia superficial; Ostiole surrounded by long hairs; asci 8-spored, deliquescent; spores dark, 1-celled typically lemon-shaped (or angular);



some cellulose destroyers

Chivers A.H. Monograph of Chaetomium & Ascotricha. Bull. Torrey Bot. Cl. Mem. 14: 155-240. 1915.

Skolko, A.J. & J.W. Groves. Notes on seed-borne fungi. VII. Chaetomium. Can. J. Bot. 31: 779-809. 1953. Key to 37 spp.

Chivers, A.H. Mem.Torr.Bot.Cl. 14: 155-240. 1915. Monograph of Chaetomium & Ascotricha.

no paraphyses;

Spore discharge: INGOLD. DISPERSAL IN FUNGI. 1953. 197 PP. 90 ILLUS.

SORDARIA, SPORORMIA

Sordariaceae (Fimateariaceae) perithecia usually sunk in substratum; paraphyses present; asci not deliquescent; spores surrounded by hyaline, gelatinous envelope; commonly coprophilic.

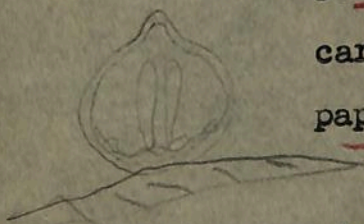
Griffiths, D. ~~& Seaver, F.J.~~ Mem.Tor.Bot.Cl. 11: 1-34. 1901.

N.Amer. Sordariaceae.

________ & Seaver, F. J. Fimetariaceae . N.Amer.Flora 3: 65-88. 1910.

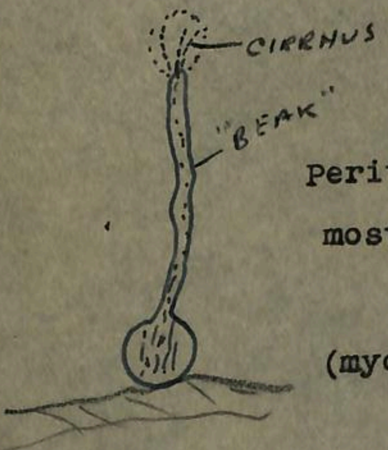
CAIN, R.F. 1934. STUDIES OF COPROPHILOUS SPHAERIALES IN ONTARIO. UNIV. TORONTO STUD. BIOL. SER. NO. 38. P. 3-126. [SORDARIA, CONIOCHAETE, BOMBARDIA, ZYGOSPERMUM, DELITSCHIA, SPORORMIA, HYPOCOPRA, CHAETOMIUM]

Sphaeriaceae



Perithecia usually free from substrate; wall leathery to carbonaceous, more or less brittle; without stroma; perithecia papillate; mostly saprobic.; spores various.

[Rosellinia sometimes placed here; but Miller & Martin place it in Xylariaceae.] NEUROSPORA

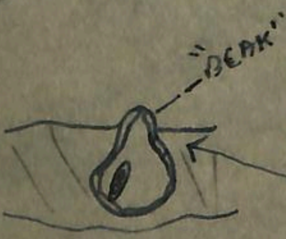


Ceratostomaceae

Perithecia with long beaks; walls leathery; spores various; mostly saprobic.

Ceratostomella (Ophiostoma) causes sap stain of wood. (mycelium penetrates wood). BEETLES in "DUTCH ELM"

Gnomoniaceae



perithecia beaked; asci thickened at tips; (→ PERITHECIA ± BEAKED) many parasitic (or saprobic) on vascular plants. no paraphyses. paraphyses ±

Gnomonia without stroma;

Glomerella with "

← Mycosphaerellaceae (asci not thick at tips) NO BEAK

VENTURIA INEQUALIS - APPLE SCAB

MILLER, Julian H. *A Monograph of the World Species of Hypoxylon.* 158 p., plates. 6¼ x 9¼ in. $6.50 GEORGIA, DEC. 30

Over 35 years of study lie back of this book which gives the species of Hypoxylon and other genera in the Xylariaceae. The chief characters used in separations are those of the asci and ascospores and those of the surface characters of the stroma. 1962

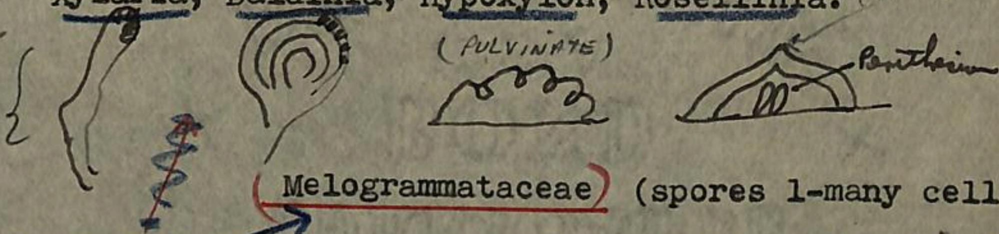
Xylariaceae

PERITHECIA WITH WELL-DEFINED PSEUDOPARENCH.
ASCI CYLINDRICAL, PERSISTENT.

spores 1-celled, DARK

Xylaria, Daldinia, Hypoxylon, Rosellinia. (PAPILLATE)

STROMA ERECT ± CLAVATE, (PULVINATE)



Melogrammataceae (spores 1-many celled).

Endothia.

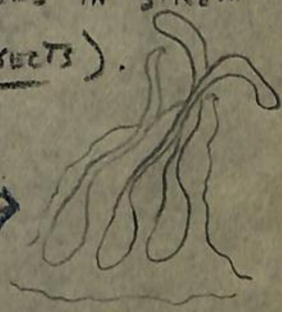
CONIDIA IN HOLLOW CHAMBERS IN STROMA.
(DISTRIBUTED BY BIRDS, INSECTS).

DIAPORTHACEAE

LONG-NECKED PERITH.; PARAPHYSES GELATINIZE AT MATURITY

DIAPORTHE VALSA

WEHMEYER 1933.
U. MICH.



Benjamin & Shanor Laboulbeniales Thaxter, R. Monograph
Spegazzini, C. "

Small, parasitic (?) on insects & arachnids.

Fungi traced back to red algae (Floridae) on basis of similarities in sexual process. etc.

Hysteriales Ainsworth & Bisby. Literature.

Hysterothecium; (elongated slit) intermediate bet. peri & apothecium.

Hysterium, Glonium, Lophodermium.

Phacidiales

Membrane covers hymenium till mature; then stellate splitting

Clithris, Rhytisma, Coccomyces.

Helotiales (7 Fam. GWM : Geoglossacaea
Sclerotiniaceae
Helotiaceae
Patellariaceae
Mollisiaceae
etc.

Asci inoperculate;

Notes on Yeast Cytology

Nagel, Llilian. Mo. Bot. Gard. 33:249-273. 1946.

New terminology:

Parvicorp: Feulgen pos., non-homogeneous; constant cell entity.

Magnicorp: Feulgen neg. (nuclear vacuole.

Central granule: in magnicorp; "balled up chromosomes of Lindegren.

C.C.Lindegren:

"The yeast cell contains a nucleus composed of a hemisphaerical centrosome and nuclear vacuole; the former contains the centroplasm, the heterochromatin and a central clear area; the latter, the chromosomes and the nucleolus; the cytoplasm contains the mitochondria ."

Wickerham L. J. Taxonomy of Yeasts. 1951. USDA Tech. Bull. 1029.

Sydow, H. Monographia Uredinearum. 4 v. 1904-24 Leipzig

364 - THURSDAY, DEC. 29 - 2

OCT 31 1949

Y east Cytology

{15 MIN. ONLY}

A. Introduction: FUNGI CLASS – ASCOMYCETES. SUBCL – HEMIASCO. ORDER – ENDOMYCETALES.

1. Extensive study begun in 1898 by: Jansens & Leblanc but especially by Wager in the same year, and by Wager & Peniston in 1910.

2. From that time to present (as illustrated in work of Lindegren) (1949), various interpretations placed on cell structure.

READ:

3. ~~[illegible]~~ Nagel(1946) in Ph.D. thesis on yeast cytology: "after 100 yrs. of cytological work, the organization of the yeast nucleus is still a matter for debate among authorities, even as to the most elementary points".

4. Mimeographed page shows some of the points on which there is still "debate".

B. The problem:

1. Difficulties (ARISE): cell size, 5-10 u. (BUT GIANT RED YEAST)
   techniques: fix., stain (REPRODUCIBLE IN NAGEL'S WORK)

2. My work briefly reviewed: (SPRING THIS YEAR)
   a. fixation series; Nawashin, Bouin
   Time series
   6, 12, 18, 24 hrs.

   b. Staining series: Heidenhain & unter-stain
   conclusion on this Robinow Giemsa.

CONCLUSIONS: (GENETICS) MICROSCOPE DEMONSTRATIONS NO PHASE, AS IN LINDEGREN.

Configurations interpreted as mitotic identified. NO SPINDLE SEEN (KATER SHOWS IT.) (i.e. CHROMOSOME LIKE PARTICLES)

See microscope demonstrations.

C. Comparative cytology

a. Lanterm slides: Wager & Pen. ('10)
Nagel ('46)
interpretations. Lindegren ('49)

? SEEMS TO BE: WHAT STAIN DO YOU USE? HENRICI
Guilliermond (1920)
Kater ('27)
Beams, Zell ('39)

E. Demonstrations: (OIL IMMERS.)

1. Saccharomyces mycelium stained in Fe Hematox-Fast Green Bouin's fix.
2. Giant yeast mitosis ? Nawashin - Giemsa (Robinow)
3. Saccharomyces mitosis ? Nawashin- Fe Hematox.
4. Publications: Ann. Bot. 1898, (WAGER), 1910
   Mo. Bot. 33: '46 (NAGEL)
   Lindegren '49
   Zell ~~'46~~ '39
   Lowy '49

{COMPACT NUCL. AMITOSIS}

MITOSIS, NO SPINDLE SEEN

B.C.

INTERPRETATIONS OF DISPUTED ENTITIES OF CELL ORGANIZATION BY VARIOUS INVESTIGATORS OF YEAST CYTOLOGY

Cell entity (146 L. NAGEL ANN. MO. BOT. G. 33:)	Janssens and Leblanc, '98	Guilliermond, '03, '10, '20	Wager and Peniston, '10	Henneberg, '16	Kater, '27	Winge and Laustsen, '35, '37	Badian, '37	Beams et al., '39	Brandt, '41	Lindegren, '45
Parvicorp (FEULGEN +)	Part of nucleus (some times nucleolus?)	Nucleus containing nucleolus	Nucleolus	Nucleus	Nucleus containing nucleolus (approx. 8 chromosomes)	Nucleus - probably 2 chromosomes	Nucleus, 2 chromosomes in both haploid and diploid	Nucleus	Euchromatin of nucleus (2 chromosome equivalents)	Centriole (bipartite)
Magnicorp (FEULGEN –)	Part of nucleus	Vacuole	Nuclear vacuole	Vacuole	Vacuole	Vacuole	Vacuole	Vacuole	Vacuole	Nuclear vacuole
Particles in magnicorp (may or may not be in motion)	?	Metachromatin (volutin	Chromatin network	Volutin	No particles in magnicorp	--	Volutin	--	Metachromatic granules	6 pairs of chromosomes
Refractive, non-fatty cytoplasmic granules	?	Basophile granules	Volutin	Volutin?	Metachromatic granules (often a reticulum extending out into cytoplasm from parvicorp)	--	--	--	Volutin - equivalent of heterochromatin and nucleolus of higher organisms also metachromatin	--
Companion body	?	--	Chromatin patch	--	--	--	--	--	--	Mentioned
Central granule of magnicorp (in motion)	Nucleolus?	--	Central volutin granule	--	--	--	--	--	--	Possibly "[illegible]ed up" chromo-[illegible] } NUCLEOLUS

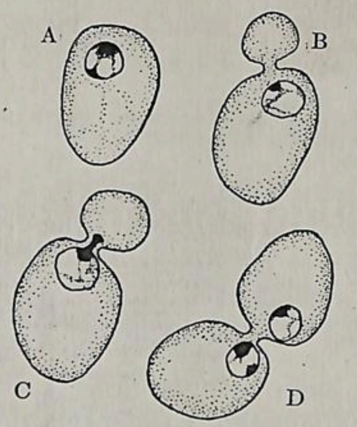


FIG. 112. Saccharomycetales, Family Saccharomycetaceae. *Saccharomyces cerevisiae* Meyen. (A) Cell before beginning of formation of bud. (B) Bud formed but still without nucleus. (C) Nucleus pushing out into bud. (D) Nucleus divided, with one daughter nucleus in each cell. (After Guilliermond: *Ann. Mycolog.*, **2**(2):184–189.)

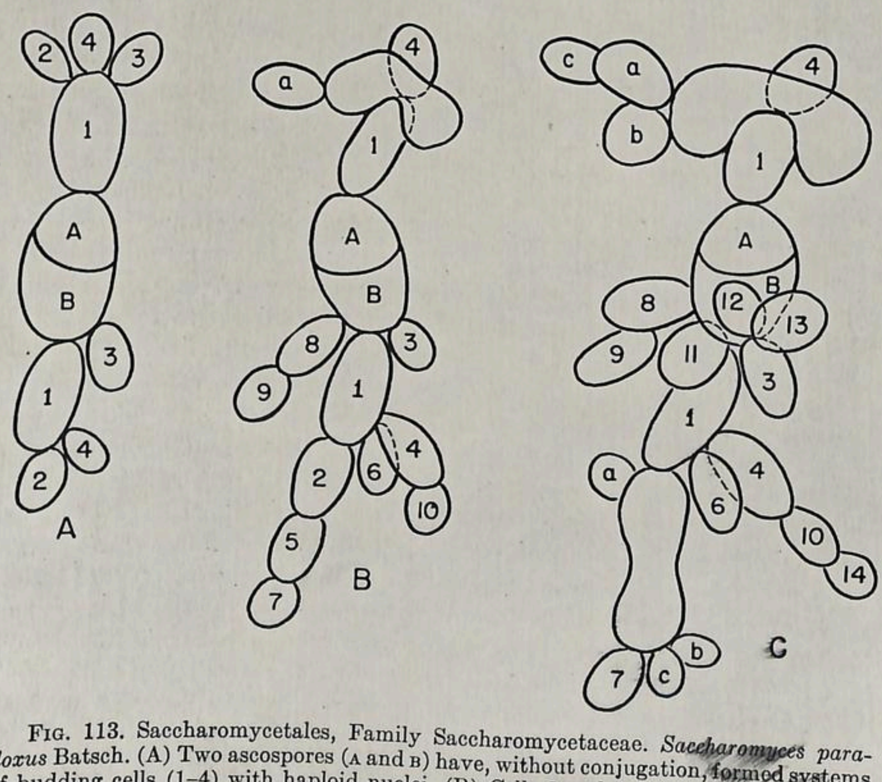


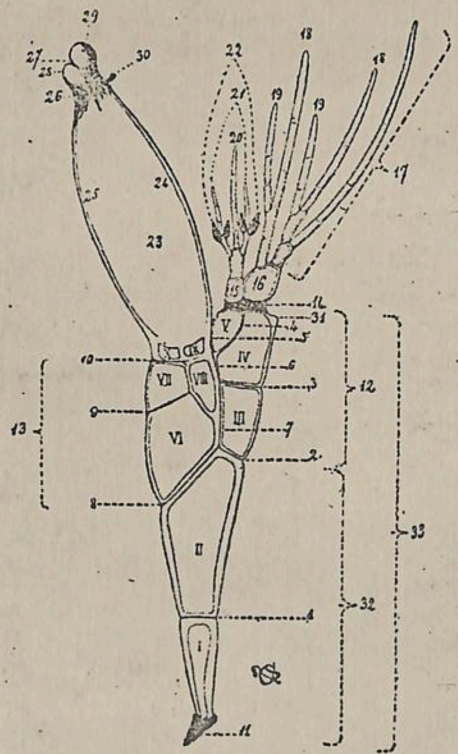
FIG. 113. Saccharomycetales, Family Saccharomycetaceae. *Saccharomyces paradoxus* Batsch. (A) Two ascospores (A and B) have, without conjugation, formed systems of budding cells (1–4) with haploid nuclei. (B) Cells 2 and 3 from ascospore A have conjugated and formed bud (a) with diploid nucleus, and there has occurred further formation of haploid buds in the system from ascospore B. (C) Cells 2 and 5 from ascospore B have conjugated and produced the diploid buds (a), (b), and (c), and further diploid buds (b) and (c) have developed from the previously formed zygote. (Courtesy, Guilliermond: *Ann. fermentations*, **2**:129–151, 257–277.)

1904.

VI. Cellula geminata ventralis infera seu sexta — célula apareada ventral inferior o sexta.

VII. » geminata ventralis supera seu septima — célula apareada ventral superior o séptima

VIII. » intermedia seu octava — célula mediana u octava.



IX. » hypocarpa dorsalis seu nona — célula basilar o pedicelar dorsal o novena.

X. » hypocarpa ventral seu decima — célula basilar o pedicelar ventral o décima.

1. Septum basale v. primum — tabique basal o primero.
2. » subbasale v. secundum — tabique subbasal o segundo.
3. » androstichi v. tertium — tabique del andróstico o tercero.
4. » subdorsale v. quartum — tabique subdorsal o cuarto.
5. » intermedium superum v. quintum — tabique mediano superior o quinto.

(sometimes known as *S. ellipsoideus*) is also used in wine-making. *Saccharomyces cerevisiae* is found in nature on ripe fruit. Grape wines are often made by spontaneous fermentation by yeasts growing on the surface of grapes. Because of the economic significance of yeasts there is an extensive literature on their cytology, genetics, ecology, nutrition and physiology and on the technology of yeast (see Cook, 1958; Ingram, 1955; Reiff *et al.*, 1960). The

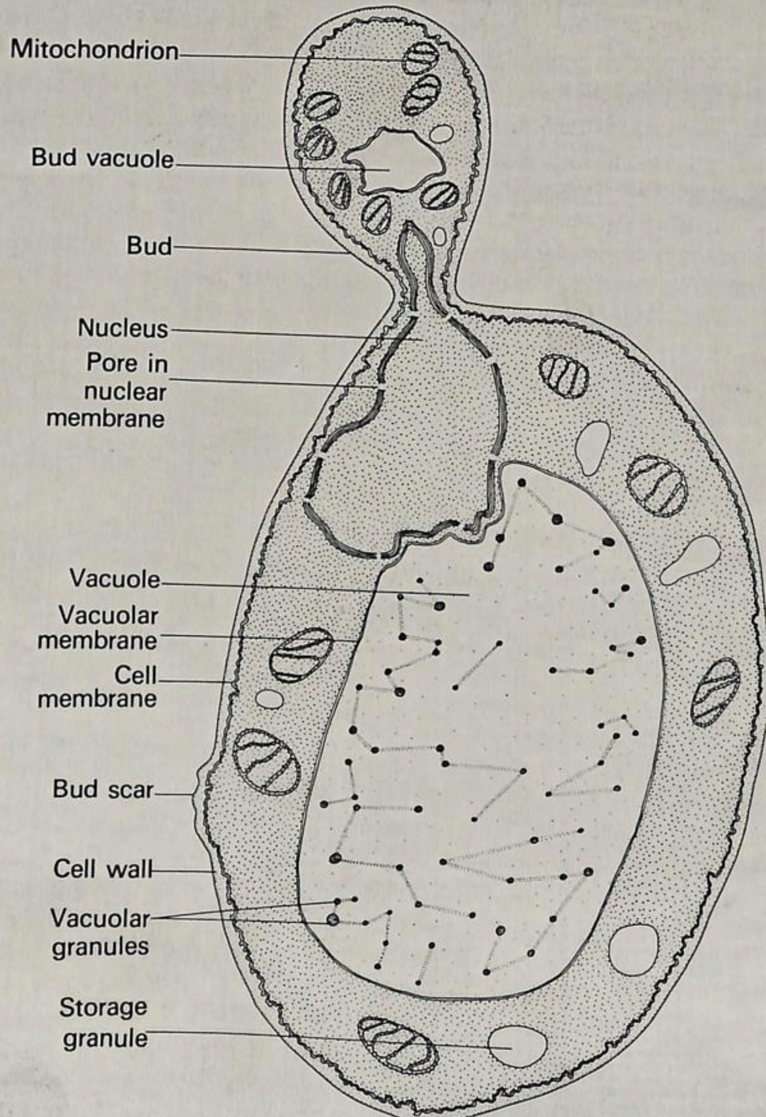


Figure 97. *Saccharomyces cerevisiae*. Diagrammatic representation of a section of a budding yeast cell as seen under an electron microscope.

WEBSTER, J. 1970. INTRODUCTION TO FUNGI

G–576

LIFE HISTORIES AND HETEROTHALLISM OF THE RED BREAD-MOLD FUNGI OF THE MONILIA SITOPHILA GROUP

BY

C. L. SHEAR AND B. O. DODGE
(Contribution from Bureau of Plant Industry)

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U. S. GOVERNMENT PRINTING OFFICE : 1927

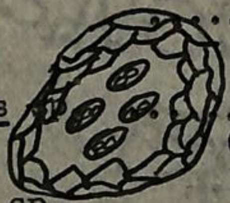
EUASCOMYCETES Plectascales — producing locu les, not true perithecia

Eurotiales (Asp ergillales) (120 spp.)

* Eurotiaceae. Interior of ascocarp filled with spores & sterile elements; ie a MAZAEDIUM. zb. Onygena & Elaphomyces. (Cleistothecium with powdery spore mass)

Some spp. of Penicillium & Aspergillus have perfect stages but mostly known in imperfect state.

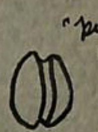
Perfect state produces ASCOGONIA & ANTHERIDIA as in other Ascos with known perfect states.



Aspergillus sp. or Penicillium sp.

...... Pseudoparenchymatous wall

.... Ascus withx spores. ("pulley wheel" type) (Asci disintegrate, releasing spores into cavity)



Ascospores upon germination, produce somatic hyphae. (N)

Conidia of imp. state " " "

TALAROMYCES spp. } PERFECT STATES
EMERICELLA spp.

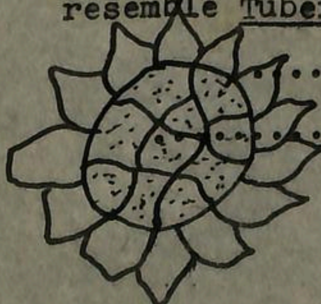
* Onygenaceae Stalked ascocarp with firm peridium; on horns, feathers, hooves (hoofs).

O. corvina on feathers.

O. equina on horn, bone.

TUBERALES?

* Elaphomytaceae Hypogeic ascocarps; no stalks, superficially resemble Tuber.



see: Dodge, C.W. 1929. Ann. Myc. 27: 147-184.

Miller, J.H. 1940. Mycologia 32: 587-600.
also: 33: 338-340.

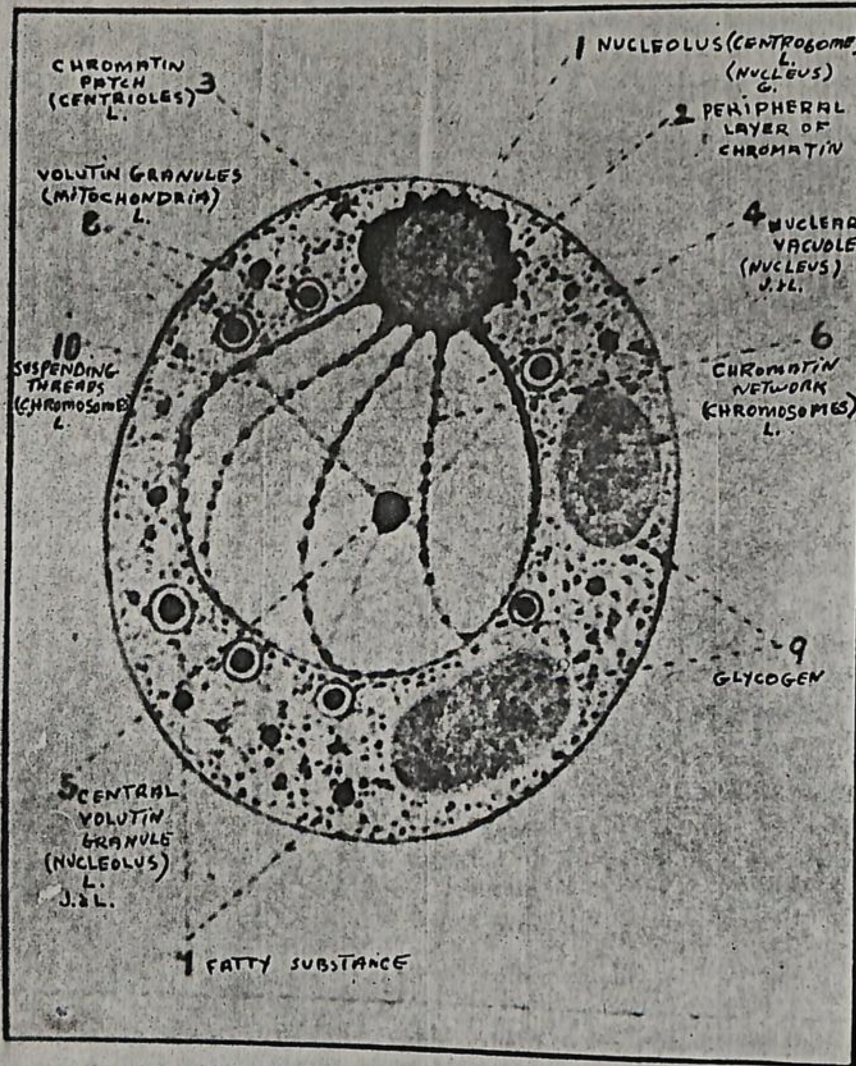
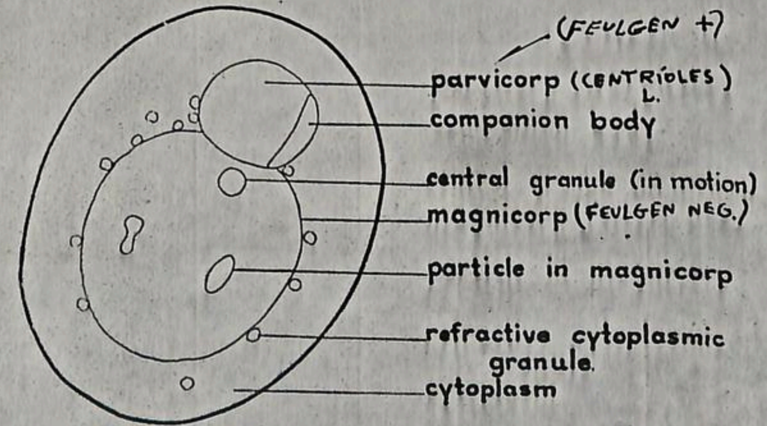


Fig. 1. Yeast cell from Wagner and Penniston.

ANN. BOT. 24: 45-84. 1910.



Text-fig. 1. Diagram of the yeast cell with parts labeled according to the terminology used in this paper.

NAGEL, L. ANN. MO. BOT. GARD. 33. 1946.

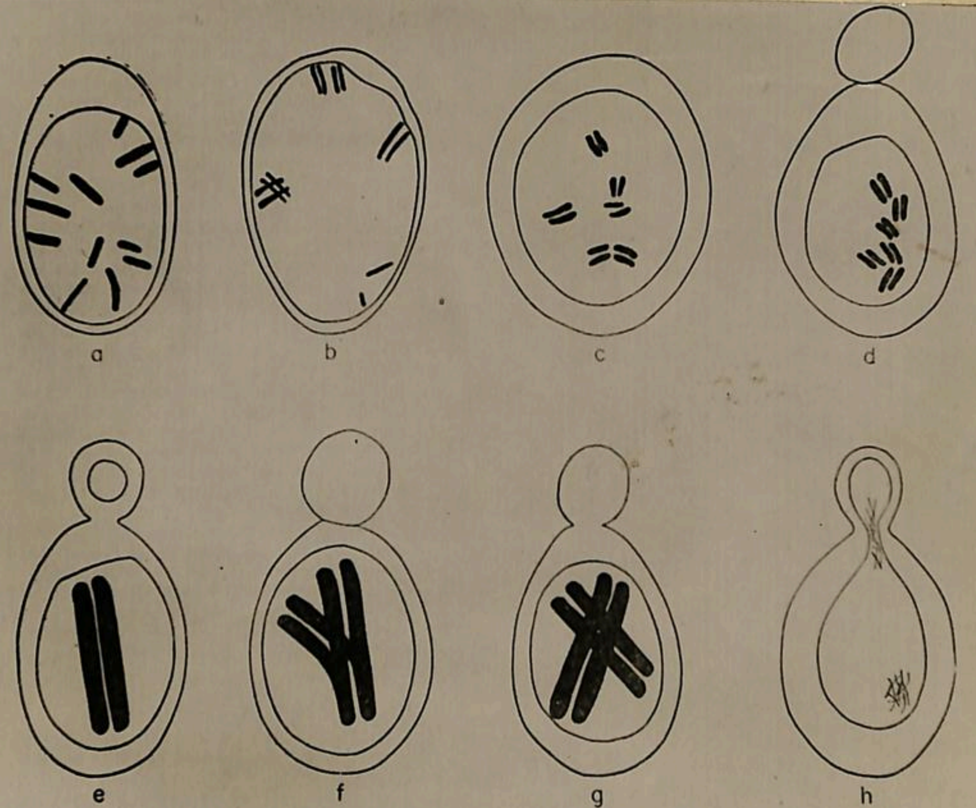


FIG. 5. Mitosis in the yeast cell. (a) Twelve chromosomes attached to the wall of the nuclear vacuole. (b) The chromosomes pairing up, still attached to the wall of the vacuole. (c) Six pairs of chromosomes free in the nuclear sap. (d) Aggregation of the six pairs into a complex. (e) A fully formed nuclear complex. (f) Longitudinal split producing two complexes. (g) Two separated complexes following the longitudinal split. (h) Chromosomes from one complex passing into the bud VACUOLE.

SEE: LINDEGREN, C.C. 1949. THE YEAST CELL, ITS GENETICS AND CYTOLOGY. P. 6-26.

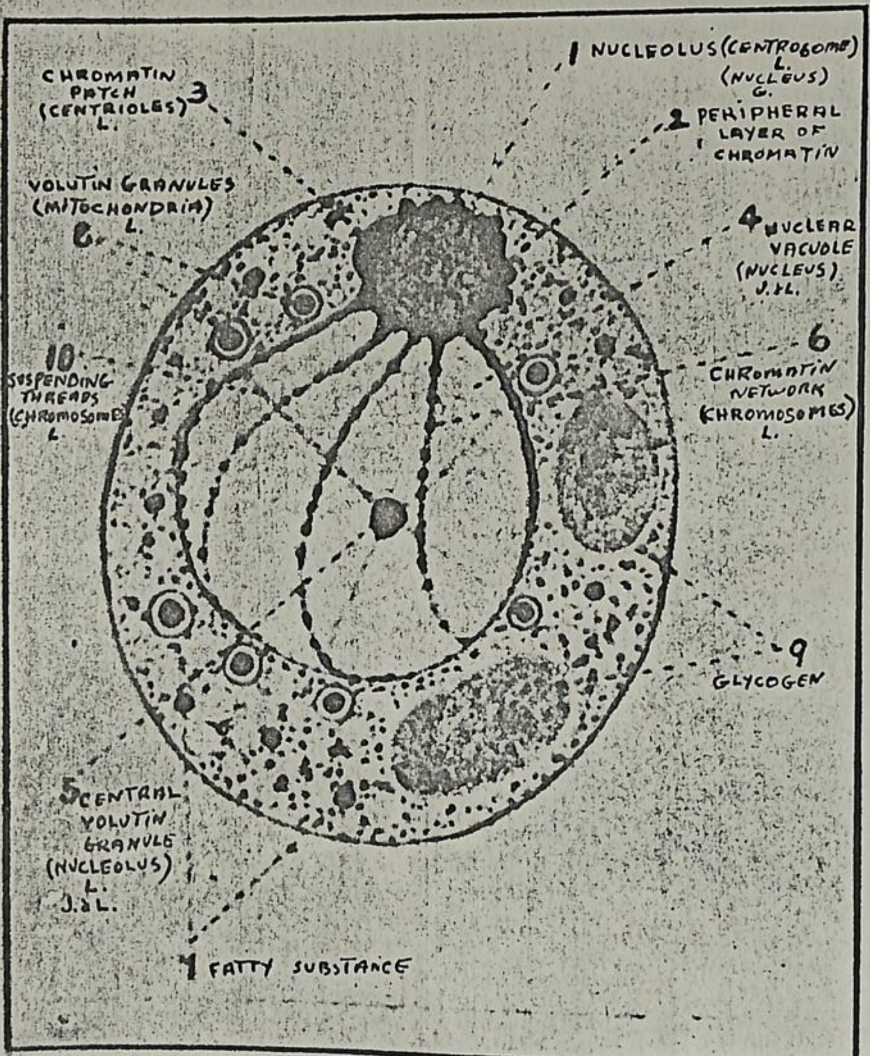
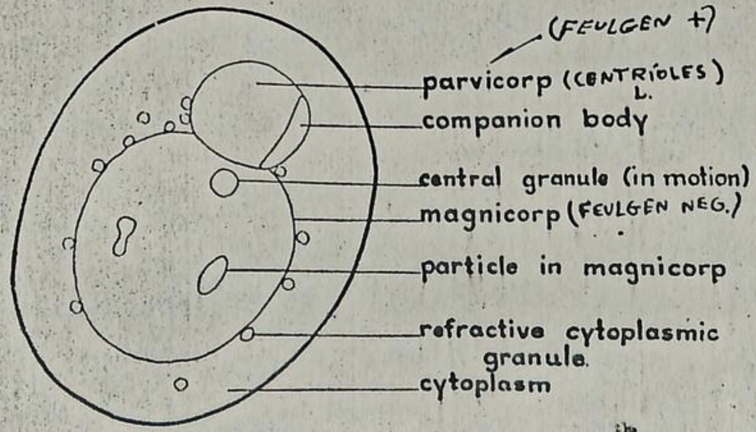


FIG. 1. Yeast cell from Wagner and Penniston.
ANN. BOT. 24: 45-84. 1910.



Text-fig. 1. Diagram of the yeast cell with parts labeled according to the terminology used in this paper.
NAGEL, L. ANN. MO. BOT. GARD. 33. 1946.

a. Stroma seated directly on substrate } Asci 16 spored hyaline : Hypocrea
" " dark : Chromocrea
b. " arising from sclerotium → 2
Asci 8-spored, 1-septate hyaline : Hypomyces

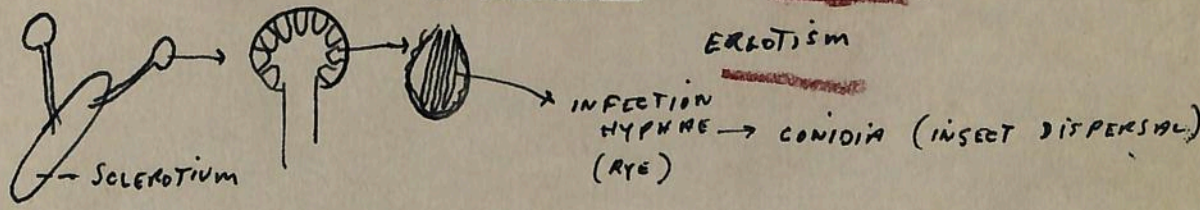
Some representative genera:

1) Cordyceps (See E.B. Main)
Mycelium penetrates insect bodies & forms sclerotia. Stromata arise from these (which are globular & borne on stalks); Perithecia embedded. Asci cylindrical & spores filiform (as in Claviceps). But: perithecial wall not brightly colored.

Cordyceps agariciformia on Elaphomyces(found in B.R. Jan. '56)
? (see: Mycologia 26: 220.)
(" Ann. Myc. 27)

2) Claviceps (See Tulasne S.F.C. 3. 1865.)
Sclerotia formed in ovaries of grasses & sedges. Fungus entirely replaces host tissues. Becomes hard & externally blackish. Sclerotia fall to ground & winter over; germinates into stipitate stromata. Asci operculate, cylindrical with filiform spores.

(Sclerotia of C. purpurea called ergot)



Ergotism.

3) Balansia (See Diehl 1950.) U.S.D.A. Agric. Monograph. 4.
like Dothichloe? Sclerotia on stems of higher plants; (not originating in ovaries). Stromata short-stipitate or sessile, arising from sclerotia.

Filiform spores - 8 per ascus.

Erysiphales (Powdery Mildews)

Powdery mildews all parasitic (obligate). Mycelium mostly superficial, with haustoria penetrating epidermal cells. Hyphae almost always hyaline (dark with age in Sphaerotheca mors-uvae), abundantly septate,;

Stunting or curling of host tissue common but not killed. Sometimes witch's brooms formed.

3 groups distinguished on basis of relationship of mycelium to, host:

a. Oidiopsideae: endoparasitic. ie mycelium branches in intercellular spaces of host after entering stomata. zb Erysiphe taurica .

b. Phyllactineae: hemiendoparasitic. superficial mycelium & special internal mycelium as above, with haustoria. Phyllactinia sp.

c. Erysipheae: ectoparasitic. Mycelium entirely superficial. Conidia differ from above; ie in chains. Erysiphe graminis, Uncinula sp.

Stevens, F.L. Monograph. Meliolales (Meliolaceae in Bessey)

Fruiting bodies resembling perithecia, but without paraphyses & periphyses.

Hyphae usually dark (unlike above); (sooty molds).

"Perithecia" without appendages; (locules)

Hyphopodia in some genera (zb Meliola); ie branched creeping hyphae which anchor the locule & produce a haustorium.

Scorias spongiosa (on front cover of Ellis & Everhart, N.AM. Pyreno.)

Harper, R.A. Carnegie Instit. Pub. 37: 1-91. 1905. Sex. Reprod. in certain Milde
(Phyllactinia)

Tulasne, L. R. &C. Sel. Fung. 1.

Erysiphales (Perisporales) ±1,000 sp.

Mostly parasitic on vascyular plants; mycelium mostly superficial; without ostiole, dehiscing by apical tear. Epidermal cells may be penetrated by haustoria. Perithecia arise on external mycelium. (Conidia produced). Cleistothecia.

* Erysiphaceae (powdery Mildews): Parasi ted of flowering plants mostly in temperate zones of world.

Salmon, E.S. Mem. Tor. Bot. Cl. 9: 1-292. Monograph 1900.
(49 sp.)

6 genera recognized by Salmon: Perithecia with distinctive appendages.

- Sphaerotheca & Podosphaera ..... with a single ascus.
- Erysiphe, Uncinula, Phyllactinia, Microsphaera ... several asci

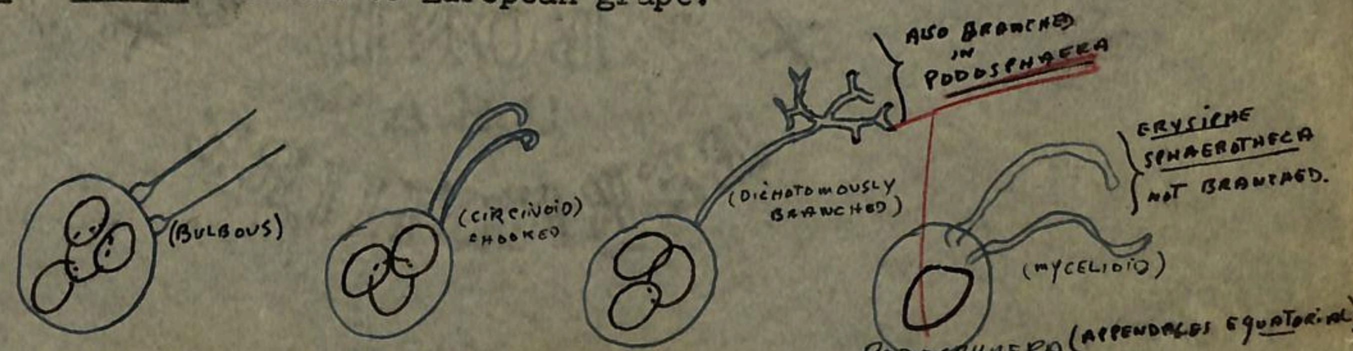
Vary in destructivness from mild to serious.

zb. E. graminis often very destructive to small grains world over.

S. humuli destructive to hops (Humulus lupulus)

M. alni common in U.S. on Syringa vulgaris.

U. necator harmful to European grape.



Phyllactinia   Uncinula   Microsphaera   PODOSPHAERA ~~Erysiphe~~ (APPENDAGES EQUATORIAL) & Sphaerotheca (APPENDAGES BASAL)
(1 ascus)

Conidia of Order hyaline, oval, i-nucleate, thin-walled; germinate by germ tube;

Perithecia always without stroma & no ostiole (cleistocarp).

Begins dev. in summer, matures following Spring.

"Sooty molds" see: Stevens, F.L. 1916. The Genus Meliola in Porto Rico. Ill. Biol. Monog. 2(4).

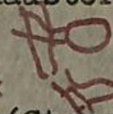
MELIOLALES

(about 600 spp. of Meliola)

1962. HANSFORD C.G. THE MELIOLINEAE. 806 pp.

Superficial, black cleistothecia; parasitic with haustoria.

Distinctive mycelium: hyphodia & setae. 1) CAPITATE : 2) MUCRONATE :



"Usually their effect upon the host isxx slight .." (Stevens)

Genusn Meliola predominantly tropival. 3) STIGMATOCYST = terminal cell with haustorium = STIGMATOPODIUM

Asci 2,4,or 8-spored.

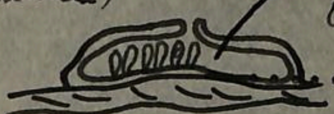
MICROTHYRIALES

→ erected by Clements & Shear (1931) (mostly tropical leaf parasites)

see: Stevens, F.L. 1939. The Microthyriaceae. Ill. Biol. Monog. (59 genera, 700 spp.)

Fungi with simple perithecia, superficial, black, ~~superficial~~, membranous to carbonaceous, dimidiate (with the outher wall covering only the top), flattened, context nearly always radiate.

(no true perithecia)



with paraphysoides (pseudoparaphyses) without free ends (anastomose)

...unequally 2-celled ascospore

..... flat basal hymenial layer

..pore (PSEUDO-OSTIOLE) (LYSIGENOUS)

(HEMISPHAERIALES) erected for these fungi by Thiessen & Sydow (1913)

Historical: 1886. Saccardo included these fungi in Dothidiales.

1913. Th. & Syd. created HEMISPHAERIALES.

1915. Atkinson considered them derived from Phacidiales & Sphaeriales

1918. Arnaud included family in Pyrenomycetes.

1920. Doidge & Ryan. followed Th. & Syd.

1931. Clements & Shear created MICROTHYRIALES.

1939. Stevens followed C.&.S.

1949. Miller, J.H. follows C.&.S. (Mycologia 41(2):99-127.1949). Revidion of Classification of Ascos with special emphasis on Pyrenomycetes.

see: Munk, Anders. The System of Pyrenomycetes. Dansk Botanisk Arkiv 15(2): 1953. Copenhagen. 163pp.

Nannfeldt, J.A. 1932. Studien über ... inoperculaten Discomyceten. Upsala.

The ascospores are hyaline, except in *Astomella.* In all American species they are unicellular and oval. Four small genera are known, however, three with two-celled and one with four-celled ascospores. The number of ascospores in each ascus varies with the species and usually within the same species. For example, according to Salmon (1900), *Uncinula aceris* on maples regularly bears eight, rarely six, ascospores in each ascus, but *Erysiphe cichoracearum* has only two, rarely three, ascospores to the ascus. *Erysiphe polygoni* usually produces three to six ascospores to the ascus, but may have as few as two or as many as eight.

For an excellent, detailed discussion of the powdery mildews consult Yarwood's paper in *Botanical Review* (1957).

Classification. In 1900 Salmon listed forty-nine species of Erysiphaceae distributed among six genera. Since then the number of genera has more than doubled. Bessey (1950) recognized fourteen. Only six of these are found in North America. These may be recognized with ease in accordance with the characters employed in the following key:

SIMPLE KEY TO THE NORTH AMERICAN GENERA OF THE FAMILY ERYSIPHACEAE

A. One ascus to the cleistothecium
  B. Appendages mycelioid, indefinite — *Sphaerotheca*
  BB. Appendages definite, their tips dichotomously branched — *Podosphaera*
AA. Several asci to the cleistothecium
  C. Appendages mycelioid, indefinite — *Erysiphe*
  CC. Appendages definite, rigid
    D. Appendages with a bulbous base — *Phyllactinia*
    DD. Appendages without a bulbous base
      E. Appendage tips dichotomously branched — *Microsphaera*
      EE. Appendage tips coiled — *Uncinula*

order MELIOLALES

Because the Meliolales resemble the Erysiphales in several respects, many authors group these two orders into one under the latter name. The differences, however, are at least as great as the resemblances, so that separation is probably justified.

The mycelium of the Meliolales is brown and mostly immersed in the substratum. The hyphae in most species bear characteristic

Ellis & Everhart. 1892. N.A.Pyrenos.

Seaver, F.J. Hypocreales. N.Amer.Fl. 1910.
Fitzgerald, I. Hypocreales of Iowa. Iowa Stud. Nat. Hist.

Hypocreales (about 1000 sp.)

Perithecia bright-colored, fleshy, not carbomaceous (as in many Sphaerales). Ostiole is apical. Stroma varies fromm compact f fleshy tissue to cottony subiculum. MOST ABUNDANT IN TROPICS.

Asci 4-8 spored; some species, spores bud.

Separation of this group from Sphaerales conventionally based upon color of fruiting bodies; this is not adequate. Mode of dev. of perithecia should form basis for distinction, but at present, inadequate knowledge .

Distinctions within the Order based upon: stroma present or not. perithecial location. spore type.

MILLER: SPHAERIALES: PARAPHYSES APICALLY FREE; WALLS THIN EXCEPT APEX.
HYPOCREALES: PSEUDOPARAPHYSES, WALLS UNIFORM THICKNESS.

* Nectriaceae ... Perithecia superficial: Nectria, Hypomyces, Sphaerostilbe.

* Hypocreaceae ... " partially or completely immersed. Cordyceps (parasit. in insects)

Clavicipitaceae .... long, slender spores; no paraphyses; poorly dev. perith. walls.

More abundant in tropics than in temperate zones. Habitat various; ie some parasitic on other fungi (Hypomyces), insects (Cordyceps) on lichens or other plants.

Form the perfect stage of some "imperfects"; ie
Nectria cinnabarina = Tubercularia vulgaris Fries
Hypocrea rufa = Trichoderma lignorum (Fr.) Hartz
Gibberella pulicaris = Fusarium roseum Link

Seaver treats 158 sp. in 39 genera for N.A.

Different taxonomic treatments: Lindau 1897, 1 Fam., 6 Subfam.
Seaver (1910) & Petch (1938), 2 Fam.

Boudier, Emile. 1907. Histoire et classification des Discomycetes d'Europe. pp 1-221. Paris.
Classified Discos into 2 groups < Operculés / Inoperculés

DISCOMYCETES vs PYRENO-

Inoperculates: Nannfeldt, J.A. 1932. (Sweden)

Seaver, F.J. The N.A. Cup-Fungi. 1951.

Chahracteristics: Asci open by pore; lie parallel in cupulate hymenium. EXCIPULUM (Epithecium) (in some) formed by extension of paraphyses beyond ascal tips. (protect asci from drying ?). Paraphyses may be pigmented at tips giving characteristic color to many apothecia.

- Apothecia usually larger than most perithecia.
- Apothecia may be sessile or stalked.
- Arise from mycelium or a sclerotium (Sclerotinia)

HELOTIALES 1400 spp

1) GEOGLOSSACEAE: Durand, E.J. 1908. The Geoglossaceae of N.A. Annale Mycologici 6(5). 222 fig. 11 Genera 42 Spp.

2) SCLEROTINIACEAE: usually arise from a sclerotium; 7 parasitic;
- Sclerotinia
- Ciboria
- Rustroemia

PEZIZALES 500 spp

Operculates: Seaver, F.J. The N.A. Cup-Fungi. 1928.

- Pezizaceae: Cupulate apothecia. (Aleuria, Lachnea, Ascobolus, PEZIZA, WYNNEA ..)
- Helvellaceae: Pileate, stipitate (Helvella, Morchella ..)

Discomycetes { Helotiales (included in Peziz.. Bessey) / Pezizales / Tuberales...hypogeic

Chronology:
- Persoon (1801) (1761-1836) external characters SYST. METH. FUNG.
- Fries (1821-32) (1794-1878) SYST. MYC.
- Durand (1900) ..... type of pseudoparenchyma
- Budier (1907) ..... operculate vs inoperculate
- Nannfeldt (1932) .... inoperculate monograph
- (Miller (1949) .... Pyrenomycetes)
- Seaver ... operculates 1928; inoperculates 1951

Helotiales — Inoperculate Discos

1) Helotiaceae

Apothecia highly variable: < 1 mm — several cm. diam. sessile — stipitate; superficial — erumpent; ± pigments; spores single — ± septate, long filiform; hyaline — dark. Apothecia smooth → hairy. Arising from sclerotium or not.

2) Geoglossaceae — CYTTARIACEAE

± Clavate (Clavaria-like); hymenium covering part or whole surface (amphigenous); if stipitate & capitate, hymenium above only; leathery to gelatinous. spores ellipsoid — fusiform — cylindric; hyaline — dark.

PEZIZALES — OPERCULATES

1) PEZIZACEAE — APOTHECIA WITHOUT STIPE & PILEUS
BULGARIA
SARCOSCYPHA
2) HELVELLACEAE — " STIPITATE & PILEATE
MORCHELLA
HELVELLA

TUBERALES

LECTURES ON MYCOLOGY

GENERAL INTRODUCTION

AND

ASCOMYCETES

By

HARRY M. FITZPATRICK

Plant Pathology Department
Cornell University

Written 1931-1934
(slightly revised in 1937)

Abroad Maire and others have published on the family. In the Argentine Spegazzini (1917) attempted a monograph, but it lacked the excellent character of Thaxter's work and was spoken of disparagingly by him. He said "it made him feel as if a cow had been wandering in his rose garden." He wished to keep the group to himself. It was a virgin field and he hoped to provide a treatment of it which would leave little to be done by others. In his last years he was forced to concede that the task was too great for the days at his command. He failed to find time in which to write a final general statement covering the group as a whole. This is a great loss to mycology, as no other mycologist will be able to provide this information as well as he. Nor is there a complete key to genera available. Clements & Shear (1931: 42) frankly concede their inability to prepare one. Thaxter at his death a few years ago was generally conceded to be the world's leading mycologist. He contributed papers on many other groups of fungi. A good statement of his life work with references to various aspects of his interesting personality is provided by Weston (1933).

Members of the Laboulbeniales, when observed in nature on the surface of the insect, appear in general as minute, usually dark colored or yellowish bristles or bushy hairs projecting from the chitinous coat singly or in pairs. Though usually scattered they are sometimes sufficiently numerous to give a furry coating. The individual plant consists of a main body or trunk termed the receptacle, attached to the insect below by a simple blackened base or foot, and differentiated above into various branches or appendages on which the sexual organs are developed. Except in rare cases there is no actual penetration of the integument of the host by a haustorium, and the insect shows no greater signs of injury than a greater restlessness owing perhaps to a slight irritation produced. In a few species a short branching hypha is put out by the blackened foot and penetrates into the body cavity. The receptacle is composed of a few cells differently arranged in different genera. The appendages are pluricellular and often are considerably branched. On some of them antheridia are borne containing spermatia or antherozoids; others develop the female organs, the ascogonia, which in time are transformed into perithecia. The ascogonium bears a trichogyne and in most of the species it is apparently fertilized by the spermatia. They escape as non-motile bodies from the antheridium and are often found clinging to the trichogyne. In some species the trichogyne is extraordinarily highly developed. That actual fertilization occurs appears not as yet to have been demonstrated cytologically. Faull (1911, 1912) working in Thaxter's laboratory with apandrous species (i.e. species in which antheridia are not developed), found that a "reduced type" of sexual fusion occurs between adjacent cells in the ascogonium. He did not study a species in which both

Pezizales   Seaver, F.J. Operculate Discos

Apothecia concave; pseudoparenchymatous; stipitate or sessile.

Peziza, Ascobolus, Lachnea, Urnula..Plectania, Cookeina..

Perithecial formation in Pyronema.   Fricker. Nat. Pf. 1938

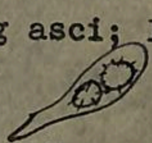
± 150 sp.

Gilkey, Helen, M. Oregon State Monographs 1. 1939.   Tuberales (truffles)   D.P.R. 1950. Jour. N.Y. Bot. Gard. 51: 101

(57 sp.) Hypogeic; closed at maturity; Peridium thick-walled;

(The New Yorker. Dec. 27, 1952. p. 47.) internally labyrinthiform-folded, bearing asci; 1-8 spores

(selling at $20. per kilo.) per ascus, spiny, warty or reticulated.



(Périgord, France) Commonly in association with Quercus, Fagus. Frank (1885)

See: "Look" Mag. Jan. 1960. observed them in association with tree roots. $15./lb. ± 300 tons per season!

From 19 states in U.S.A. > Tuber of economic importance, esp. in France, center of the truffle industry. (Life, April 1, 1952.) (D.P.R. on truffle hunting.) Spores disseminated by rodents.

Sexual process mostly unknown. ASEXUAL REPRODUCTION RARELY OBSERVED.

Frank (1885) postulated MYCORRHIZAL relationship, finding truffles on tree roots.

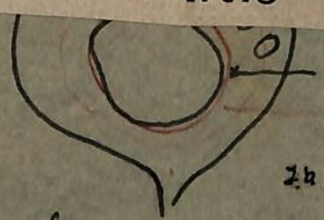
LETTER FROM PARIS

New Yorker

DECEMBER 17

DECEMBER 27, 1952

PÉRIGORD truffles, which, when stuffed like black diamonds into the liver of a Strasbourg goose, are traditional to French holiday menus, are almost impossible to find this year. Owing to the dry summer, truffles are still maturing in size and smell beneath the oak trees on their native heat[h]. Some extra warty, small-sized, [...] over-precious ones are coming to Paris at the rate of eighty kilos a day (instead of eighteen hundred, as they did during their holiday season last year), and retailing at the hitherto unheard-of price of eight thousand francs, or more than twenty dollars, a kilo. On the other hand, the noted wine merchants, the Etablissements Nicolas, have brigh[...]



PSEUDOPARENCHYMA (FOLDED)

Hymenium

Hydnocystis most primitive: like Pezizales, but hypogeic.

"The ascocarp varies in form from a nearly even bowl or cup, hymenium-lined, to a complex structure penetrated by winding canals and chambers or hypha-filled veins which open externally or are completely closed. . . . In most species 8 spores to the ascus are the rule" (P. 8 monograph),

(Spores, 10 - 80μ)

Distribution in U.S.A.: California, Oregon, Wash.

also: Maine, N. England.

[illegible] Tenn. [illegible] ([illegible] Valley) [illegible]

and: Canada (Quebec, Ontario)

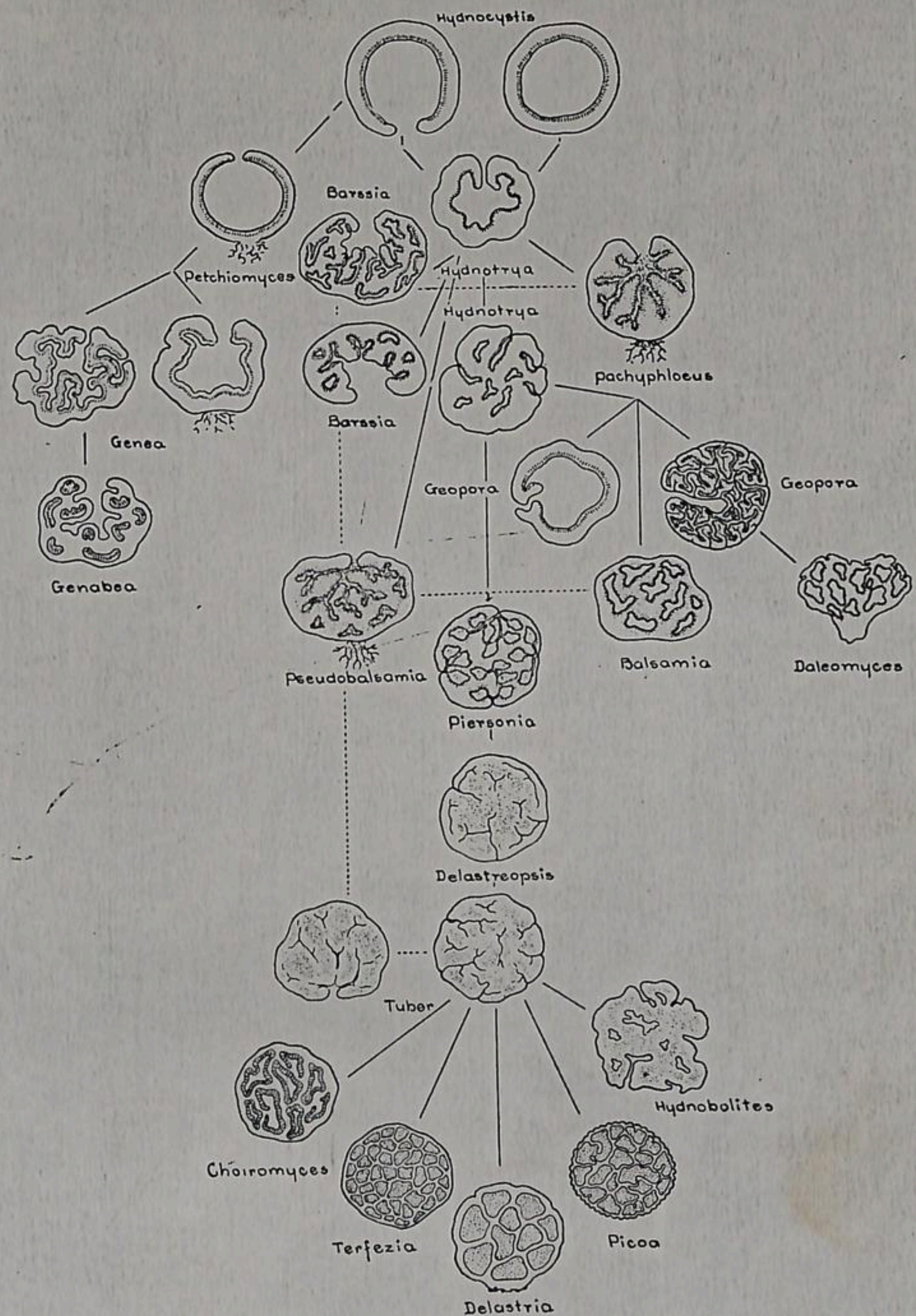
Truffle Hunt

THE truffle, an edible fungus that grows underground and is much used abroad as a flavoring for food, is comparatively little known in this country, outside of French and Italian restaurants. The truffles sold locally are imported from France or Italy, and a seven-ounce tin of them costs about five dollars. It is, however, possible to dig truffles almost anywhere hereabouts; the only requirements are a fancy for truffles and a trained truffle hound. A week or so ago, we went on a truffle hunt in Van Cortlandt Park with Lorenzo Robba, a sixty-six-year-old resident of the Bronx who has been an ardent truffle lover and booster since his childhood days in Italy. As far as Robba knows, he is the only truffle hunter in the East. A gardener by trade, he has long dreamed of launching a million-dollar truffle industry on this continent, but so far he has found it impossible to stir up much interest in the delicacy among native-born Americans, except for botanists, and even they seem to prefer classifying truffles to eating them. This country imports something like a hundred thousand dollars' worth of truffles a year—a state of affairs that Robba finds shocking. He is convinced that millions of dollars' worth of truffles lie buried in the environs of New York City alone, and that he would have little difficulty busting the European truffle monopoly if he could just get at them. Right now, he gives the truffles he digs up to the New York Botanical Garden to classify.

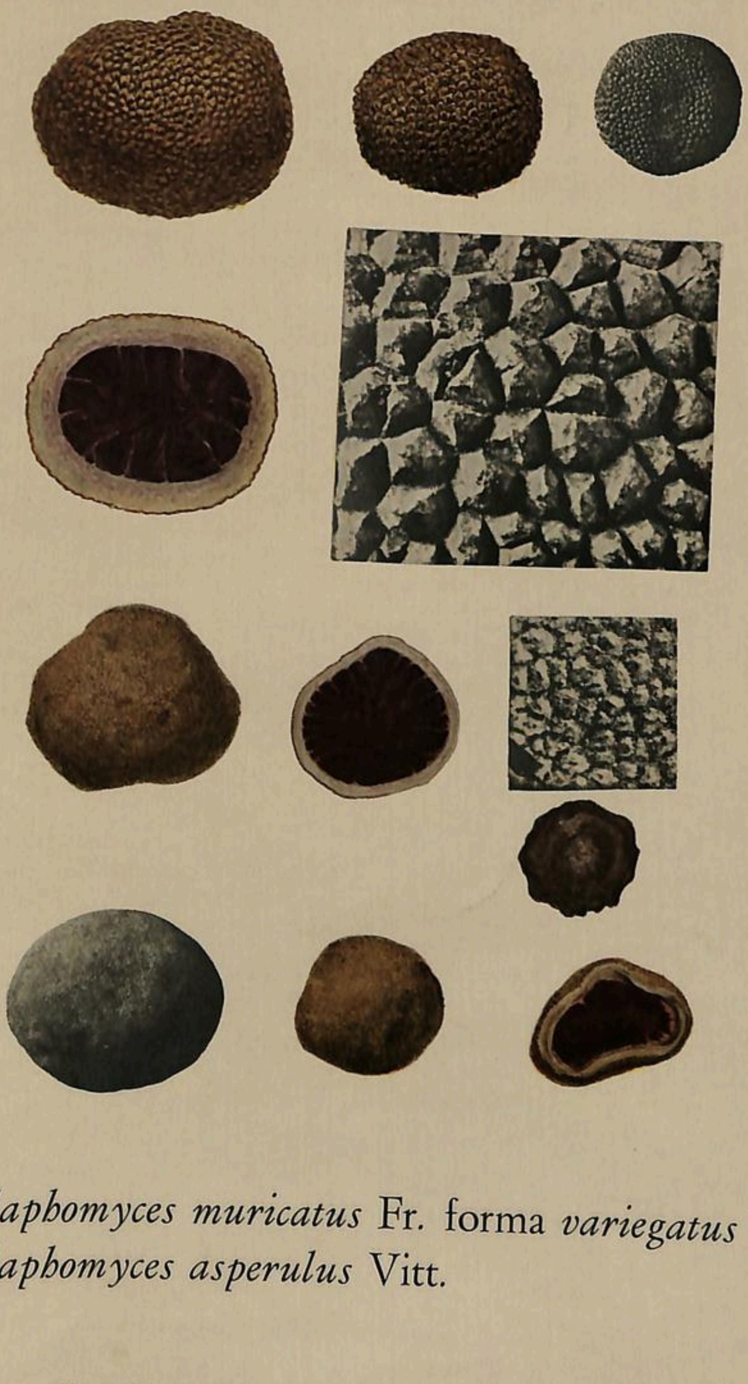
The day we met Robba was, he told us, ideal for truffle hunting—the air clear, the ground of the park unfrozen. (Heavy frost and frozen ground diminish the odor by which a hound detects the truffles' presence.) Robba was armed with a hoe that he boasted had been in his family for three generations, and accompanied by a truffle hound, Musken by name, he imported from Italy a year ago. "A fine, well-trained dog, Musken," he said, holding the hound in check as we headed into the park. "Hunting truffles is a matter of my eyes and Musken's nose. I lead him to a grove of oaks or willows, where the soil is most likely to be right for truffles, and turn him loose. If there are any truffles around, Musken will smell them. For every truffle he finds, I give him a biscuit. So far this season, he has found about a dozen."

Approaching a stand of oaks, Robba dropped the leash and called out, "Shoot!" Musken began to quarter the ground beneath the trees. "He knew nothing but Italian when I first got him, poor Musken," Robba said. "Now he understands 'Shoot' and 'Go ahead.' I have made them mean the same thing." Musken loped around, audibly sniffing. Robba informed us that he has spent nearly half a century studying the truffle, and that he has not yet exhausted the subject. There are, he said, sixty varieties of truffle in this country and a hundred and forty varieties in the world. Truffles grow among the roots of trees, and each variety of truffle has an affinity for particular varieties of tree. Poplars and filbert-nut bushes, as well as oaks and willows, produce satisfactory truffles; a poor type of truffle, scarcely worth mentioning, grows under pines and hemlocks. The only way to grow truffles commercially is to plant the sort of tree that, in the right soil, is likely to produce the desired type of truffle, and then hope. In from four to ten years, the truffles may be there, from two to twelve inches underground. Some are as small as peas, others as big as oranges; the best-flavored truffles are about the

PLATE V


Hydnocystis
Barssia
Petchiomyces
Hydnotrya
Hydnotrya
pachyphloeus
Genea
Barssia
Geopora
Geopora
Genabea
Pseudobalsamia
Balsamia
Daleomyces
Piersonia
Delastreopsis
Tuber
Hydnobolites
Choiromyces
Terfezia
Delastria
Picoa

1



2

1. *Elaphomyces muricatus* Fr. forma *variegatus* Vitt.
2. *Elaphomyces asperulus* Vitt.

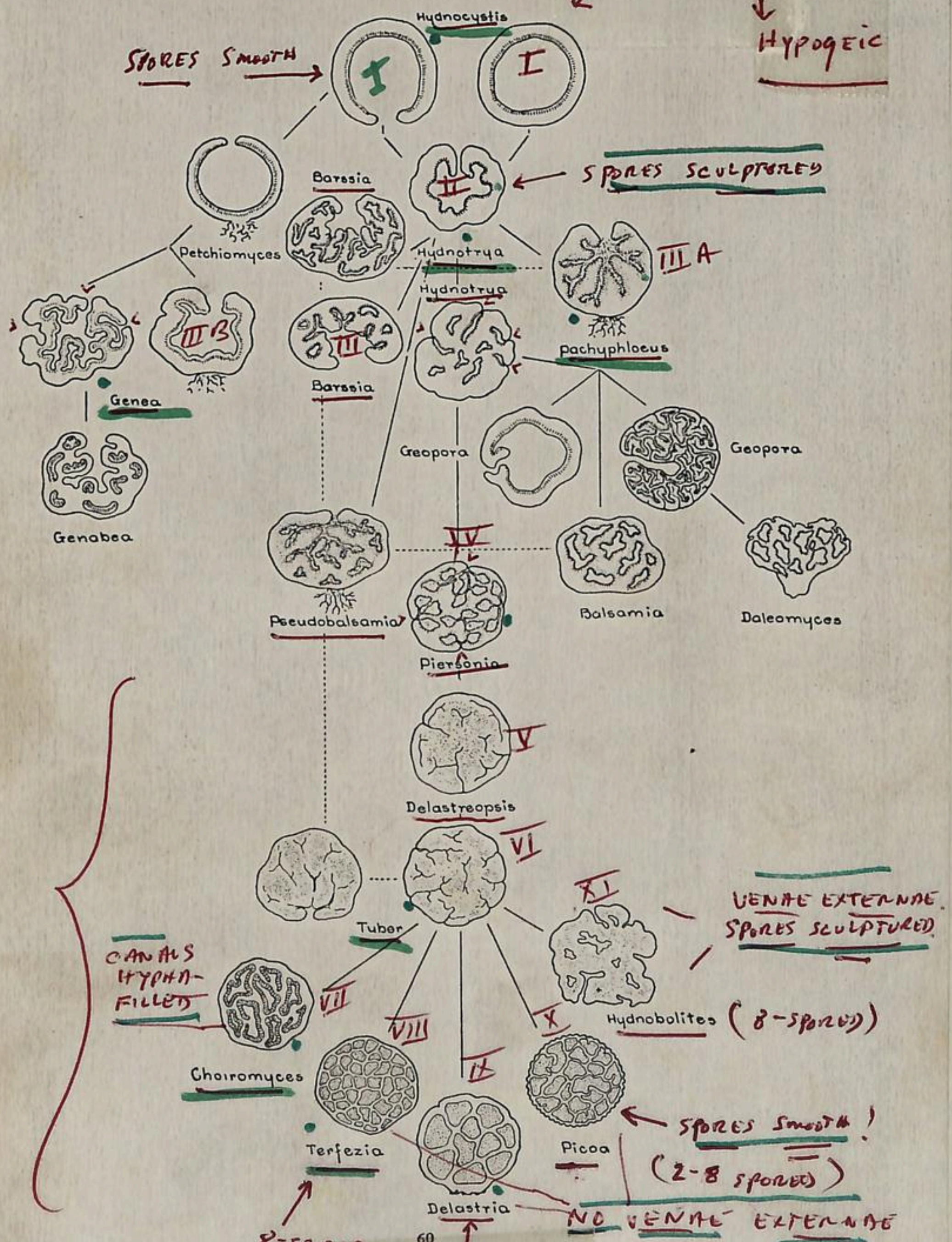
Amari, A. Ceruti, *del.*; E. Forma, *phot.*

HYMENIUM IN PALISADE; ASCOCARP HOLLOW

HYMENIUM NOT PALISADE; ASCOCARP SOLID

PLATE V

PE-ZIZALES [EPIGEIC] → HYPOGEIC



GILKEY, H. M. 1939. TUBERALES OF NORTH AMERICA. OREGON STATE COLL. CORVALLIS, OREGON

NOSOLOGY = disease
VS
PATHOLOGY = suffering

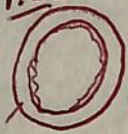
Tuberales

M.
H. Gilkey. 1939.
TUBERALES OF NORTH AMERICA. OREGON STATE COLL. CORVALIS.

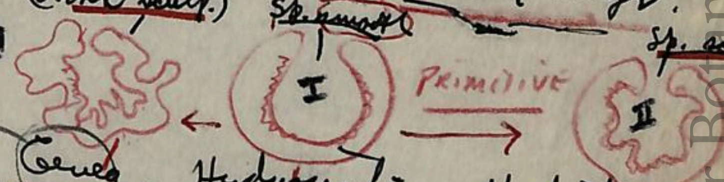
Labyrinth of CRETE
King Minos → Daedalus
Minotaur
GR. = SKILLFUL
Icarus son of Daedalus

1 — ~~Hymeniales~~

Fleshy – cartilagenous, mostly hypogeous. Ascocarp single — hymenium lining single cavity or internally divided into chambers lined with hymenium. Asci cylindrical – globose, 1 – 8 – spored. Spores smooth – sculptured.

P. 22
I  HYDNOCYSTIS (ASCI + PARAPHYSES)

1 – Hymenium (asci + paraphyses or asci only) in palisade layer. P. 56 – 57
Ascocarp hollow (Spores sculpt.) Sp. smooth

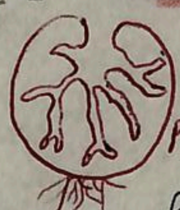
III  I PRIMITIVE II Sp. sculpt.

2 – Hymenial cavities empty } Genea, Hydnocystis, Hydnotrya
GENEA
P. 56, F. 1
P. 57, F. 29
Gilkey '39. (HYDNON GR. = EDIBLE FUNGUS) (Sp. sculpt.)
HYDNOLOGY = TRUFFLES

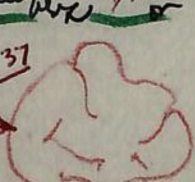
2 – Hymenial cavities hypha – filled } Choiromyces
GR. PIG

 P. 33 IV

1 – Hymenium not in palisade.

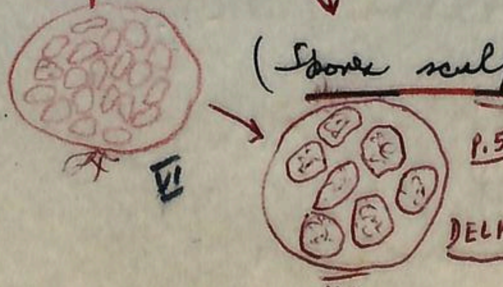

THICK CORTEX
PACHYPHLOEUS

Ascocarp with empty chambers or hypha – filled
venal internal and fertile
venal external (sterile) } Tuber (L. = SWELLING) (TOURNEFORT 1694) P. 37 P. 59, Pl. IV
(Spores sculptured)

 V

Ascocarp divided into nest – like fruiting areas,
no venae externae } Terfezia (TERFEZ – N. AFRICA)

(Spores sculptured)


VI
P. 50
DELASTRIA
VII

Hydnocystis is Peziza – like.

Reprinted from
JOURNAL OF THE NEW YORK BOTANICAL GARDEN
51: 101-102. May, 1950; 131-132. June, 1950

Truffles

Subterranean Treasures for the Epicure and Botanist

By Donald P. Rogers

FOR some two thousand years in the civilization of western Europe, whenever cooking has reached the dignity of an art, the truffle has been without a peer among resources for the epicure. It is no new thing that truffles have been granted popular acceptance as the special symbol of the gourmet, for so it was in Rome in classical times, and so again has it been ever since the French and Italian renaissance. Only during those ages when neither learning nor manners nor gastronomy has been held in wide esteem have truffles been ignored by men and left to those humbler animals who always know good food when they smell it.

An object less luscious in appearance would be hard to imagine. Truffles grow completely buried in the soil. They are usually irregular in shape and lumpy or warted on the surface; and whether pinkish or ochre-colored, as are many of the less highly flavored species, or brown to black, as are the kinds more greatly esteemed, they wholly resemble small stones. The resemblance is, in fact, so complete that one digging truffles in stony soil has to discard many likely looking pebbles for every truffle that he finds.

Although men with sufficient persistence and luck in finding a favorable area may collect truffles unaided, the most successful means of uncovering them is provided by animals, pigs or more commonly dogs, whose keener sense of smell enables them to locate the buried treasure without the aimless digging and the endless unfruitful excavations of a man with a trowel. The animals are specially trained for the purpose, and people who gather truffles for the market rely on them wholly.

From the days of Theophrastus, the great Greek botanist, and Pliny, the Roman naturalist, down to modern times the nature of truffles has been a subject of conjecture and fantastic invention. Theophrastus recognized them as vegetables; but his successors for many centuries rejected his judgment. For most of two thousand years truffles were held to be special

HIS EYES POPPING WITH PLEASURE, THE FRENCH TRUFFLE KING ALAIN PEBEYRE SNUFFLES A TRUFFLE. IF THE AROMA IS STRONG, IT IS A FINE SPECIMEN

A BIG YEAR FOR TRUFFLES

'Diamond of the kitchen' is hunted by pigs and eaten by gourmets

This month in southern France 300 tons of a small black fungus are being lovingly packed and made ready for shipment. To a few local businessmen like Alain Pebeyre (*above*), and to gourmets everywhere, this is delightful news, for it means that once again, after a series of lean years, there is a banner crop of French truffles. Pebeyre alone will process nearly 50 tons of the ugly little luxuries—and prime truffles retail at $15 a pound.

A mysterious fungus that grows under the ground, the truffle is called the "diamond of the kitchen." This is partly because it adds a superb flavor—"erotic and gustatory," Brillat-Savarin called it—to such dishes as *pâté de foie gras*, poultry stuffing and omelets, and partly because, like diamonds, truffles are scarce and hard to find. The best ones grow around the roots of stunted oak trees but only in certain kinds of soil. They need shade and rain in the summer, heavy rain in the fall and mild temperatures until the harvest months of December through February. Even in good years and in truffle-rich regions like Cahors it is not easy to find a truffle. They grow two to 12 inches underground, and it is almost impossible to guess just where they will be from one year to the next. Some experts use trained dogs and even goats to track down the truffles, but the best method (*next page*) is to hunt them with pregnant pigs.

FRESH TRUFFLES in basket are covered with dirt. Cleaned (*top*), they sell to restaurants for $100.

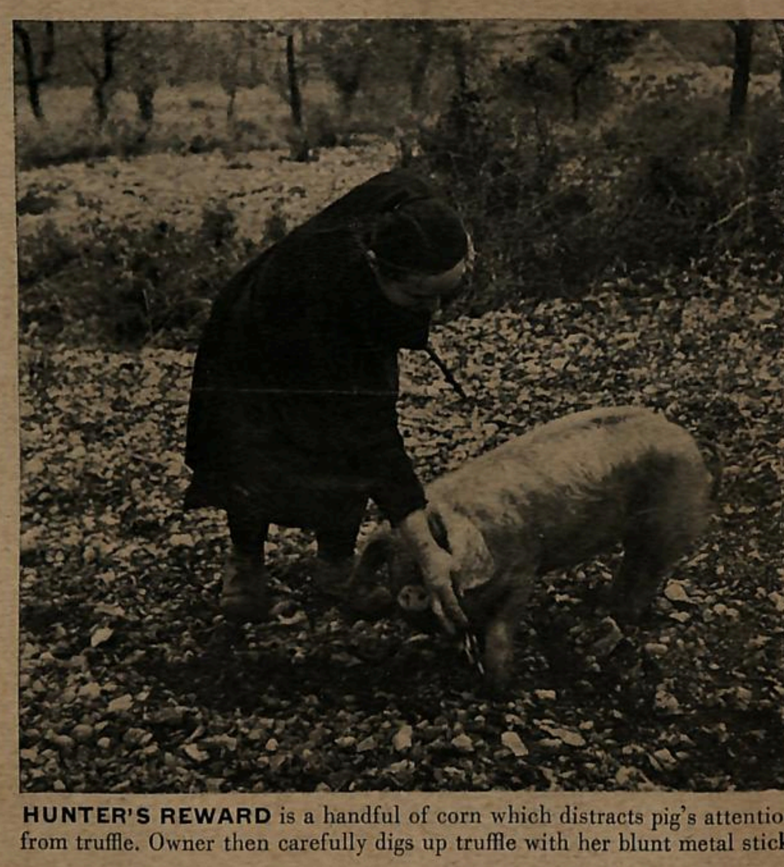
CONTINUED ON NEXT PAGE

LIFE 1-II-1952.

TRUFFLE BUSINESS (*top*) starts in the local market where buyer weighs freshly dug truffles, then haggles over price. At Pebeyre factory (*bottom*) the truffles, some of them as big as oranges, are washed, graded and usually canned. Most expensive are the peeled truffles which are used chiefly in *pâté de foie gras*.

TRUFFLE DISHES are displayed by Paris Chef Charles Delorme, a truffle specialist. From left to right are: whole truffles served in port sauce, filet of sole with a truffle decoration, *foie gras* in port aspic, pastry with *foie gras* and truffles (*rear*), chicken with truffle stuffing and scrambled eggs with truffles.

TRUFFLE HUNTER in Cahors region is a pig that can smell truffles a foot underground. Truffle experts say pregnant pigs have a sharper sense of smell.

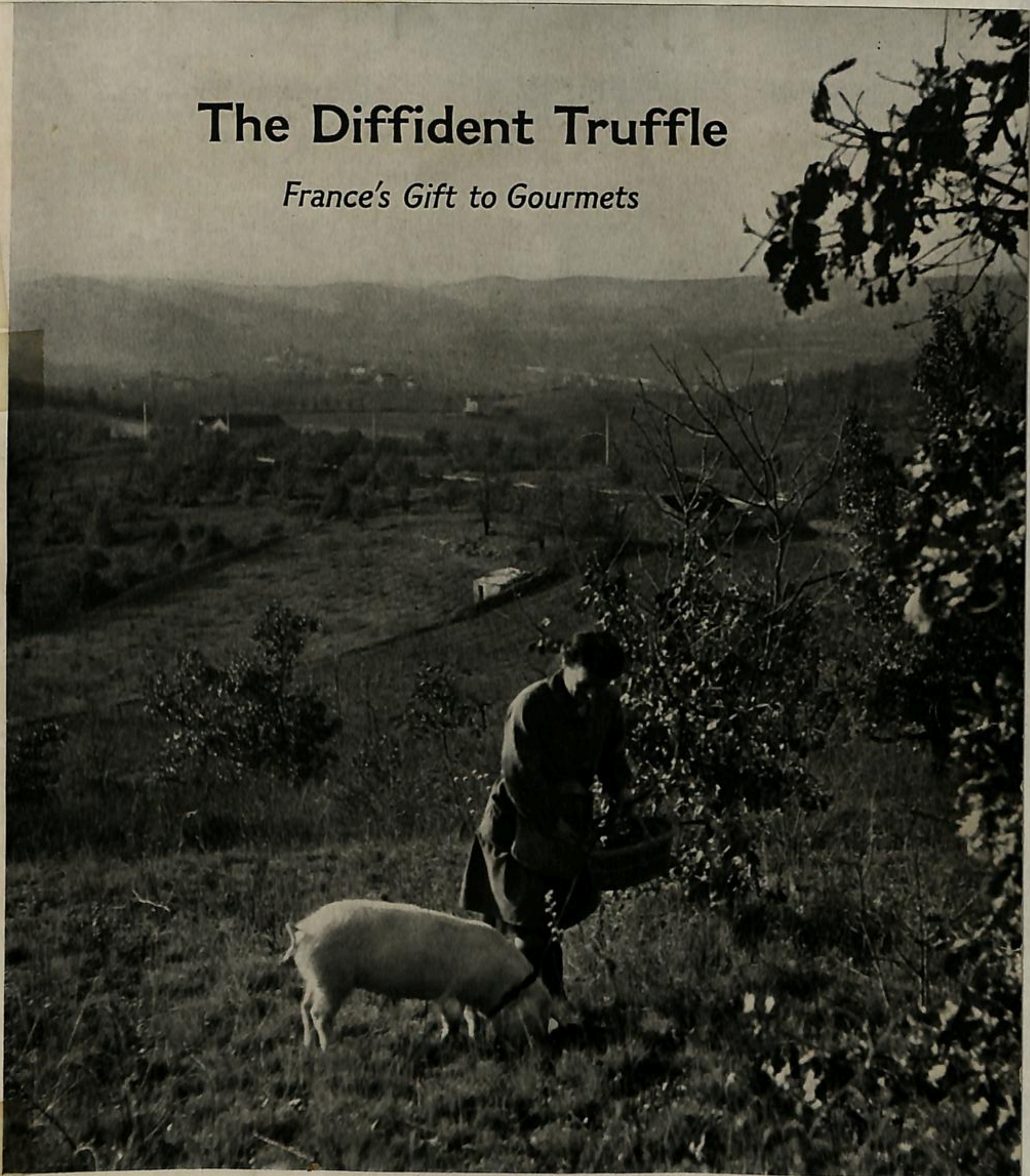


HUNTER'S REWARD is a handful of corn which distracts pig's attention from truffle. Owner then carefully digs up truffle with her blunt metal stick.

CONTINUED ON PAGE 113

The Diffident Truffle

France's Gift to Gourmets



Doisneau, Rapho-Guillumette

A WINTRY sun smiles wanly on a farmer's wife and her sow as they roam the hills above Souillac in southwestern France. Together they search for truffles, a fungus fruit prized by gourmets the world over.

Tugging at the leash and sniffing like a foxhound closing on its quarry, the sow suddenly halts beside an oak. She grunts loudly and rubs her snout in the soil.

Hastily the woman tosses a few kernels of corn to divert the animal's attention; then she bends and scoops up the earth with a trowel-like utensil. Several inches below the surface she uncovers a small, black, warty tuber—the elusive truffle, whose flavor long has made it popular in sauces, stuffings, and garnishes.

Human sense of smell can rarely detect the piquant perfume of the buried fungus. Most French truffle seekers hunt with pigs. In Italy dogs lead the search. Sardinians use goats.

NAT. GEOGR. MAG. CX (3): 419–426. 1956.

Truffle Dogs Fail California

By JACK SMITH

While I am constrained not to write on subjects covered by other sections of the newspaper (which is why I so often write about my dog), I had the luck a few years ago to break a financial news story here about the launching of a California truffle industry.

The existence of this hitherto secret enterprise was betrayed to me by a friend who happened to have been present at a table in the dining salon of the S. S. France on her last voyage to Cannes. Among others at this historic gathering were Henry Trione and J. Ralph Stone, and it was these two California gentlemen who set up the present Tristo, Ltd., Truffles Division, with headquarters in Santa Rosa.

In a report which he has kindly sent to me in advance of its general release to newspapers and financial periodicals, Stone recalls that fateful evening aboard the France:

"We were inspired, over the excellent cuisine of that luxury liner, to prove that there thrived in our Golden State the quality of truffles so identified with the Perigord area of France and the Alba region of Italy. Some mediterranean climate, similar flora — it all seemed plausible and needed only the acumen that we thought we had to substantiate that conviction."

Once the France docked, the shipboard enthusiasm of the others at the table vanished, and with it their financial support; but Trione and Stone, "undaunted and persevering," set up the business by themselves, combining their names as Tristo.

After the story was first told here, Stone reports, it was picked up for features in 18 major American newspapers and numerous TV and radio programs, besides attracting much media notice all over Europe, in South America, and even in Saudi Arabia and Hong Kong.

"You may therefore be interested," Stone says, "in knowing what Tristo, Ltd., Truffle Division, has actually accomplished, and what, after nearly five years, have been its observations and conclusions."

First, Tristo obtained truffle rights to several large sections of timberland in northern California, and imported two trained truffle dogs — Urbetta and Rondanella — from the Umbrian province of central Italy. "With wild anticipation," Stone recalls, "we awaited their arrival via Pan Am."

The partners' joy at the arrival of their trufflers was soon dampened. Urbetta evidently said "avanti" to the wrong American dog, and turned up pregnant, or as the French say, enciente. Urbetta had six puppies, and of course was meanwhile unable to help with the truffling.

"And Rondanella, alas, the more precocious of the two, soon discovered that the scent of a startled fawn, the track of a cottontail, the call of a bush-tailed squirrel, were much more of an attraction than the usual morsel of bread that was her reward for digging a truffle. Such distractions in Italy had centuries ago gone the way of stufato cacciatore, but to Rondanella, the desire was overwhelming, and she immediatly became Italo-Americanized."

Besides Urbetta's confinement and Rondanella's skylarking, there was the drought of 1975-76, which "had serious consequences in the fruiting of all fungi, so that our success was again minimized."

There was also a shortage of help. In France and Italy, truffles are hunted in small areas by large numbers of peasants. But Tristo had only a handful of graduate biology students to cover almost the entire wilderness of the Northwestern United States.

Hoping to stir up interest, Tristo held "The First California Truffle Congress" at Santa Rosa, a one-day seminar on truffles and other fungi, ending with a banquet at which one kilo of imported Italian truffles were sprinkled ove the fettucini, so that all might appreciate the delicate qualities that have made the truffle a sine qua non of European haute cuisine for centuries.

"Unfortunately," Stone laments, "the wild enthusiasm of the many participants extended just beyond the dessert and brandy."

It is not that California has no truffles. "Few people realize," Stone points out, "that there are as many species of fungi producing truffles as plants producing flowers. But, alas, our domestic discoveries, rather than giving us the nutty, delicate flavor of the French Perigord or the pungent, permeating flavor of the Italian Alba, have given us, instead, one that is suggestive of rancid bacon or fresh string beans or, in most instances, no flavor whatsoever."

However, most of Tristo's territory remains virgin. The search goes on. There must be tasty truffles somewhere in California, Tristo feels, just as there must be life somewhere else out in space.

Meanwhile, Tristo has granted Oregon State University $32,000 to seek a better truffle in the laboratory, and is hoping to persuade lumber companies to inject their seedlings with a truffle fungus, thus producing truffles in a concentrated area that could be more easily harvested.

But the main hope now, of course, is with Urbetta's puppies.

Market Time in Truffle and Foie Gras Land

Discussions Carried On in Gloomy Tone to Bar Bad Luck

By JOHN L. HESS
Special to The New York Times

CAHORS, France, Jan. 23—Nature and women, in their mysterious ways, have endowed this poor region of southwestern France with two maladies of rich price: the black subterranean relative of the mushroom known as the truffle and the distended liver of overfed geese and ducks.

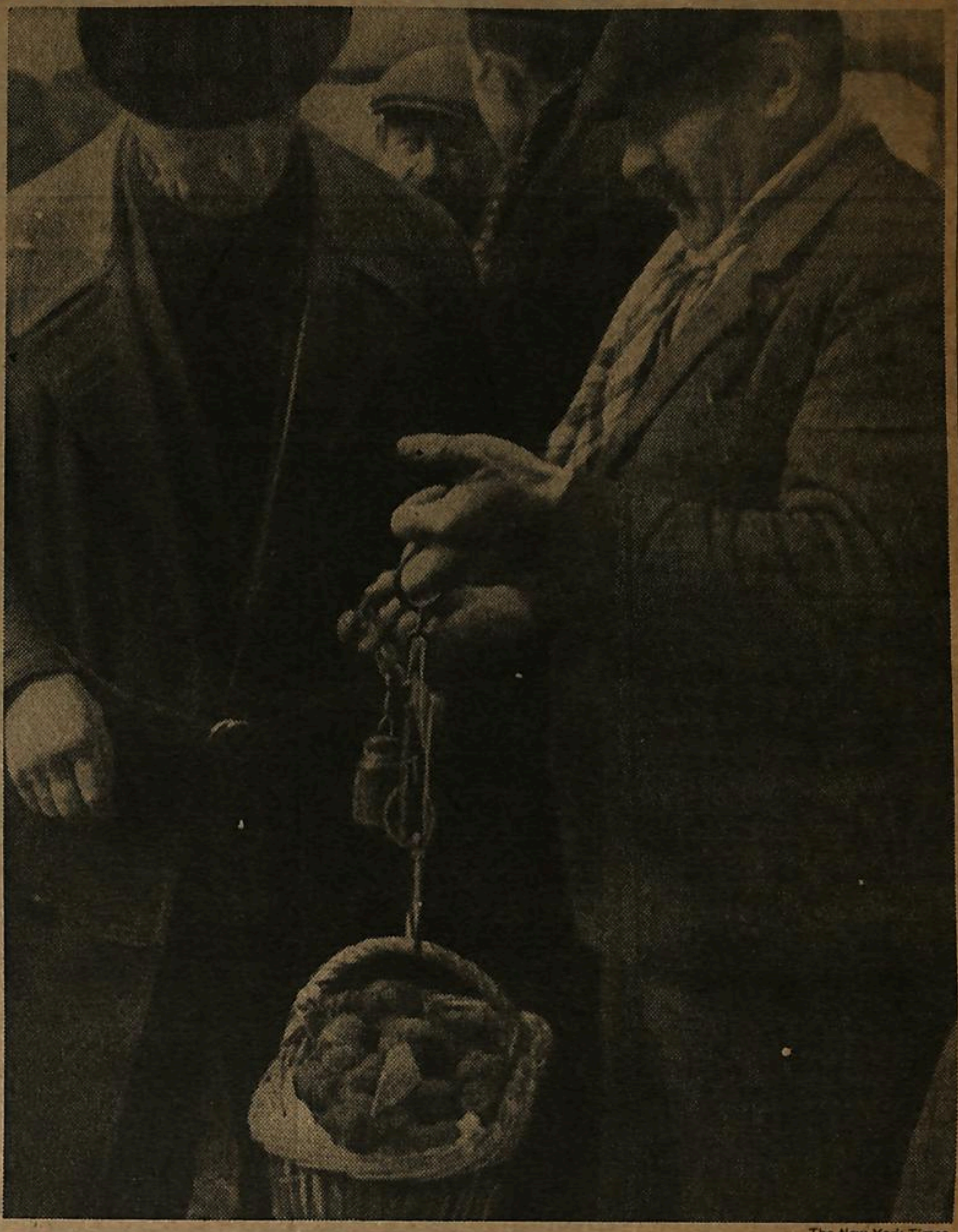
The Talk of Cahors

The appropriate tone in discussing what is the principal topic from late November to the middle of March is one of profound gloom.

As every peasant knows, it is bad luck to talk of good fortune and would only incite envy. Not to mention the tax collector. This makes selling truffles in the public market a rather unusual proceeding.

The buyers, a clump of stocky men, loiter under the trees beyond the goose market. Each wears a leather money pouch and carries a metal hand scale.

Every now and then a countryman or countrywoman will idle by, bearing a basket of eggs, groceries or a goose—or nothing at all. There is not a truffle in sight. A buyer accosts the peasant and asks what he has. After a sharp look at the buyer and at possible witnesses, the peasant delves to the bottom of the basket or into a capacious pocket, and out comes a sack of redolent brown lumps.



The New York Times

A buyer inspects truffles in a French market place. The sale is conducted surreptitiously, the seller being fearful of attracting the attention of the local tax collector.

The buyer peers at them and names a price. The seller may protest, haggle and even depart, to return or to seek another buyer. But most often he just nods and shrugs. The buyer weighs the truffles, tosses them carelessly into a wicker hamper and counts out the money from his well-filled pouch. The peasant hastily tucks it away and walks off.

Among themselves, the peasants grumble about truffle prices, which are in the area of 60 cents an ounce. This is at least 30 cents less than last year, reflecting a sharp rise in production. The rainy summer and fall, disastrous for wine grapes, were just dandy for truffles.

"Truffles is not farming, it's luck," said Emile Couderc, a 5-foot-tall farmer who cheerfully forecast disaster for the industry.

•

TRUFFLES are a fungus mystery that has defied savants at least since Plutarch and Pliny. The black Périgord variety, named for the reason and dear in both senses of the word to gourmets, is generally found in stony, porous soil around the roots of scrub oaks—but only some of them, and no one knows why.

A French peasant is credited with having discovered early in the 18th century that acorns from infected oaks, planted in similar soil, may—just may—yield truffles, too, in 10 or 15 years. One out of 10 successes is a good average. Agronomists are still trying to raise the yield by injecting truffle spores among the roots, but this artificial insemination has proved sterile.

Mr. Couderc agreed with Alain Pébeyre, the white-bearded Cahors patriarch who, at 84, is still one of the world's leading truffle merchants, that the truffle's days in these parts are numbered. They explained that few peasants had the capital or the patience to plant oaks and wait 10 years to find out whether they had money or firewood. "Besides," Mr. Pébeyre said mournfully, "the earth gets tired."

•

SOME men, Mr. Pébeyre said, can sniff out a truffle unaided or can find them by watching the female truffle fly boring into the ground to lay her eggs. But peasants generally rely on dogs or pigs.

Hereabouts, dogs are unpopular with the peasants. A hunter or a housewife may be walking innocently in the woods with a dog or may be trying to bag a truffle or two. "A lady will hardly go strolling with a pig," Mr. Pébeyre explained.

Mr. Couderc, who cautiously acknowledged owning "a few" truffle trees, said training a pig was no problem.

"You go to the fair in the spring with a bit of truffle," he explained, "and you offer it to a pig. It's better not to let the owner see it, because the price goes up. Anyhow, if the pig eats it, you buy.

"You walk him on a rope and he instinctively smells the truffle. Soon he develops a trick. He shoves his snout down on this side, then that side, then he opens his mouth. You pull him back quickly and give him some corn or a potato."

Mr. Pébeyre, who shook his head at the perfidy in the world—pork butchers, for example, who "truffle" their sausages with the cheap, black, quite harmless mushroom called trumpet of death, or merchants who dye the common, and rather tasteless, white summer truffle.

He said the true Périgord truffle was a fungus of remarkable qualities aside from gastronomy. When his workers cut themselves peeling truffles, he said, the cuts never become infected. The ancients were absolutely right, he added, in regarding the truffle as an aphrodisiac.

•

BUYERS in the goose and duck market were as gloomy as the truffle merchants about the future of their business, and for much the same reason.

It is a bit difficult to uncover the price situation, because no two dealers agree on it, but averaging indicates that goose liver, selling at about 60 cents an ounce—by the time it reaches the consumer it will cost several times that—is far dearer than last year, with demand almost unlimited. The trouble is, everwone agreed, that younger farm wives simply refuse to fatten birds any more.

Fattening is a woman's business. On a typical farm an old woman will call in her little flock of 10 or 20 birds three times a day, and using a funnel, will poke mash into their throats, working it down with a milking motion. Soon, like well-fed Frenchmen, they develop a foie gras—fat liver.

The bird reaches the market here either whole or in parts. The liver is, of course, the precious cash crop, destined mainly for Paris and the world markets. The natives happily buy up the rest—for confit, or conserve; for friton, a sort of pâté; for rillette, a mincemeat, and for cooking fat. Even the remaining carcass, roasted, is a prized local delicacy, and the blood, sold in dried cakes, is served as a pudding.

•

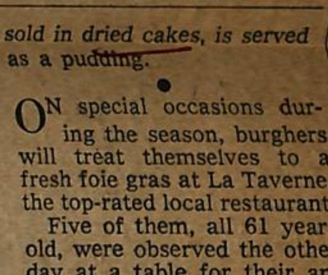
ON special occasions during the season, burghers will treat themselves to a fresh foie gras at La Taverne, the top-rated local restaurant.

Five of them, all 61 years old, were observed the other day at a table for their annual class reunion. They began with champagne and smoked salmon, followed by foie gras with capers, then a gratin de langouste with white burgundy.

Clearing the palate with a sherbet doused in calvados, they switched to the local wine and tackled a boar steak with what the chef, Pierre Escorbiac, called exotic rice (with green pepper), plus cheese, crepes suzette and a lobster dish with cheese with white burgundy.

Four hours after they had sat down they paused for a parting handshake with the chef and a few gloomy words about the truffle market. Things, they agreed, are not what they used to be, and they never will be again.

The Truffle Is Not a Trifle in Price



The New York Times (by Ernest Sisto)
A truffle

Truffles may be trifles in weight, but they resemble carats of gems in price, as a New York Times photographer discovered yesterday when assigned to record the truffle on film.

Looking at the small delicacies in Manganaro's food store at 488 Ninth Avenue, near 37th Street, he decided that three would make an attractive grouping. The price, he was told after the truffles were weighed, would be a bit more than $16.

The photographer decided that one would suffice. It cost $6 and weighed 1⅞ ounces.

In the Périgord region of southwestern France, truffles bring about 60 cents an ounce to the peasants who sell them. After that, the truffle—at least in price—mushrooms.

NEW! RED GOLD PAPRIKA PASTE

IMPORTED FROM HUNGARY

Made from the heart of paprika, Red Gold Paprika Paste is the essence of paprika, a concentrated, wholesome, **natural** food flavoring that's also a good source of Vitamin C. A drop or two, even when you've already put in paprika, when added to stews, sauces, gravies and soups just before cooking is completed, give a **burst** of garden fresh flavor and aroma plus an enticing tinge of rich, red color.

- **GRILLED CHICKEN**— mix Paprika Paste with white wine; baste for last five minutes on each side.
- **VINAIGRETTE SAUCE**— add a little dab of Paprika Paste.
- **GRILLED SHRIMPS**— mix Paprika Paste with olive oil; baste.
- **PAPRIKA BUTTER**— mix Paprika Paste with softened butter.
- **BARBECUE SAUCE**— add a dab to your favorite recipe for extra tang.

3-oz. tube $1.98 6 for $10.00

Use Paprika Paste to add zest to your cooking:

- **GRILLED FISH**— mix Paprika Paste with lemon juice and melted butter; brush on.
- **ROAST CHICKEN**— mix Paprika Paste with white wine and herbs; brush on.
- **ROAST PORK**— mix Paprika Paste with oil; baste for last three minutes.
- **SPARE RIBS**— mix Paprika Paste with oil, baste for last three minutes.
- **ROAST BEEF**— mix Paprika Paste with oil; baste for last three minutes.

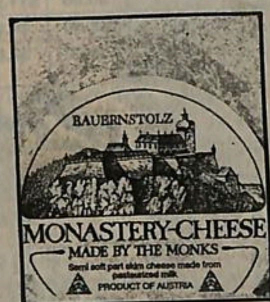
CHEESE

OCT. 27, 1979

BRYNDZA CHEESE

Imported Czechoslovakia. Soft white sheep milk cheese has a sharp flavor.

1 lb. $6.98 6 lb. Tub $35.00



TRAPPIST MONASTERY CHEESE

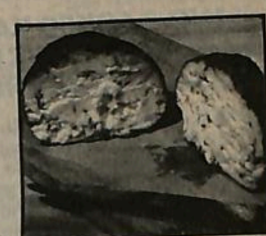
Imported from Austria. Semi-soft skim milk cheese.

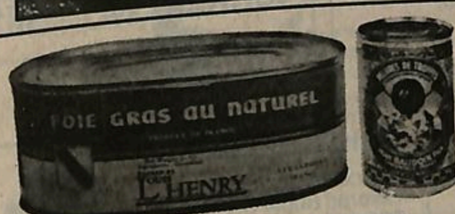
2 lb. Loaf $9.98
Gift Box of 2 $18.00

LIPTAUER CHEESE BALL

Our own cheese spread made with Cheddar cheese. Dutch caraway and our own Hungarian sweet paprika.

12 OZ. GIFT BOX ... $4.98
3 FOR $13.50 6 FOR $25.00
12 FOR $45.00





UNTIL YOU'VE TASTED THIS FOIE GRAS AU NATUREL YOU HAVEN'T TASTED FOIE GRAS

Pure liver from plump, over fed Hungarian geese is the only ingredient in this smooth, true foie gras. Packed in Strasbourg, the world's Pate' capital, under the painstaking scrutiny of the French. Not even a truffle is added to disguise the pure, perfect taste of superb foie gras. Just chill and serve.

7 oz. tin $39.95 ea. (3 for $110., 6 for $200)
21 oz. tin $110.95 ea. (3 for $300., 6 for $575.)
28 oz. tin $150. ea. (3 for $425., 6 for $800.)

TRUFFLES IMPORTED FROM FRANCE

Don't confuse these delicacies with mushrooms. They're round, pungent, wrinkled and black and found in certain regions of France, only in the months of December and January. No wonder they're so costly! And worth every penny in the flavor they bring to scrambled eggs, omelets, stuffings and sauces. Use them to make your own pates. These are packed in brine and are absolutely free of artificial coloring or flavoring. Extra brushed.

7/8 oz. TIN $19.98 =$352./lb.
3 For $55.00

Puree' de Foie with Truffles

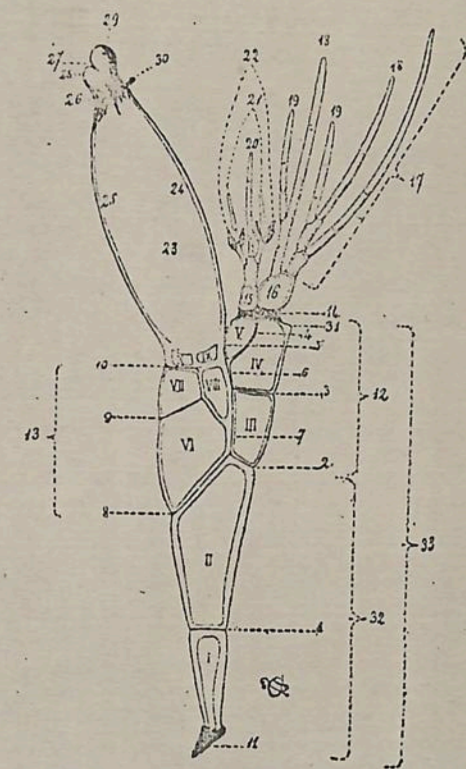
Truly great spread. Very smooth pure goose liver blended with goosefat and truffles.

2¾ oz. tin $3.98
3 for $11.00 6 for $21.00
Case of 100 ..... $305.

VI. Cellula geminata ventralis infera seu sexta — célula apareada ventral inferior o sexta.

VII. » geminata ventralis supera seu septima — célula apareada ventral superior o séptima

VIII. » intermedia seu octava — célula mediana u octava.



IX. » hypocarpa dorsalis seu nona — célula basilar o pedicelar dorsal o novena.

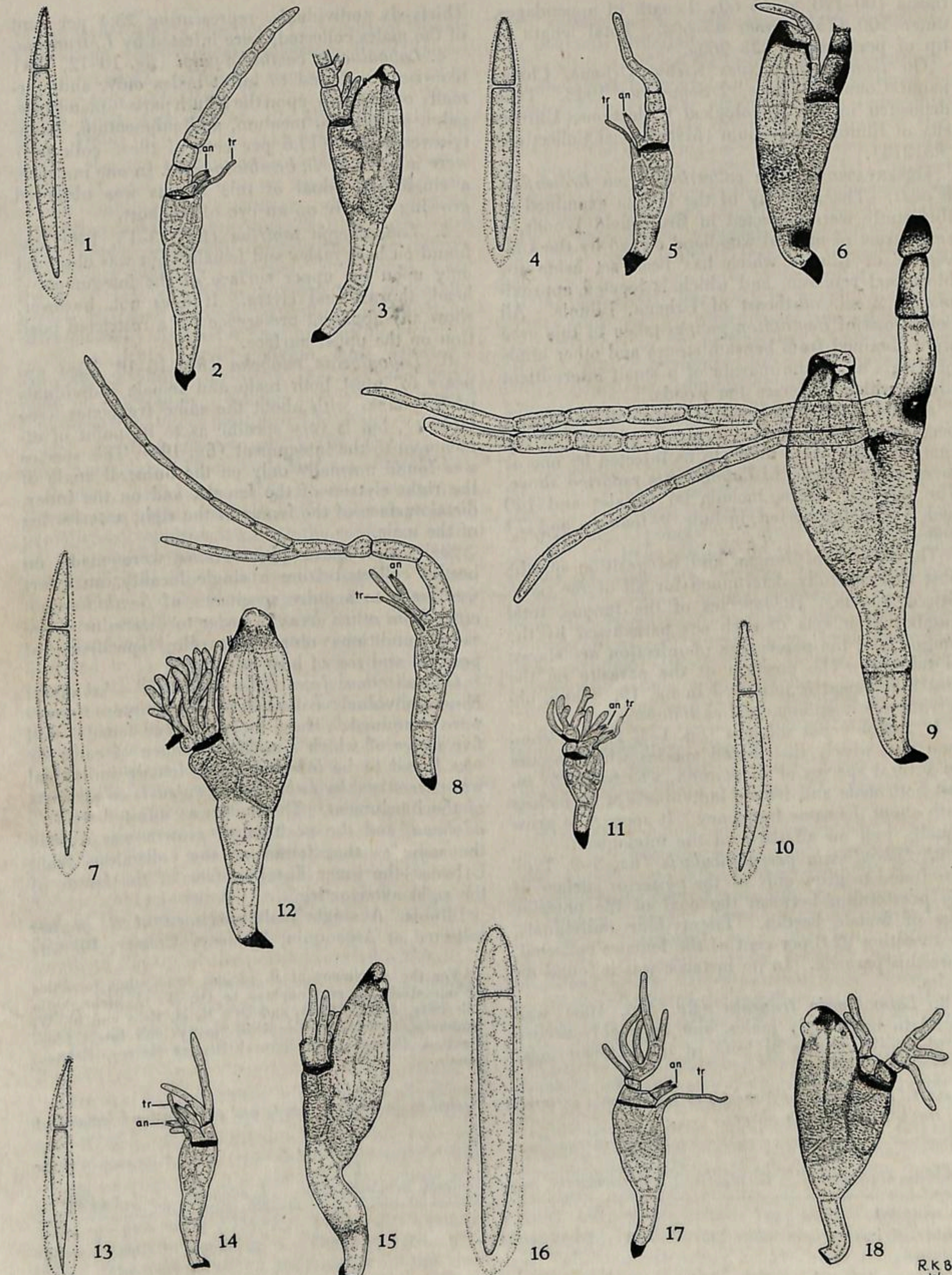
X. » hypocarpa ventral seu decima — célula basilar o pedicelar ventral o décima.

1. Septum basale v. primum — tabique basal o primero.
2. » subbasale v. secundum — tabique subbasal o segundo.
3. » androstichi v. tertium — tabique del andróstico o tercero.
4. » subdorsale v. quartum — tabique subdorsal o cuarto.
5. » intermedium superum v. quintum — tabique mediano superior o quinto.

"In the Argentine, Spegazzini attempted a monograph, but it lacked the excellent character of Thaxter's work and was spoken of disparigingly by him. He said "it made him feel as if a cow had been wandering in his rose garden."

H.M.Fitzpatrick (Notes) (P.304)
*1934.

[See p. 553 in Spegazzini]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R.K.B. del

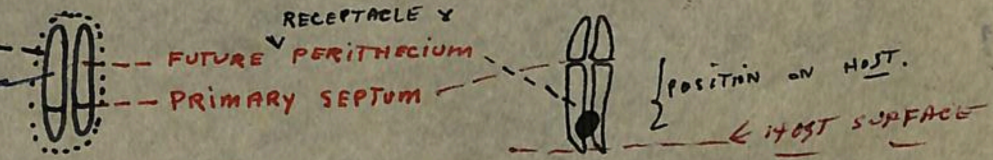
DIOECIOUS

Development of Laboulbeniales

(L. formicarum)

NO PARAPHYSES OR PERIPHYSES

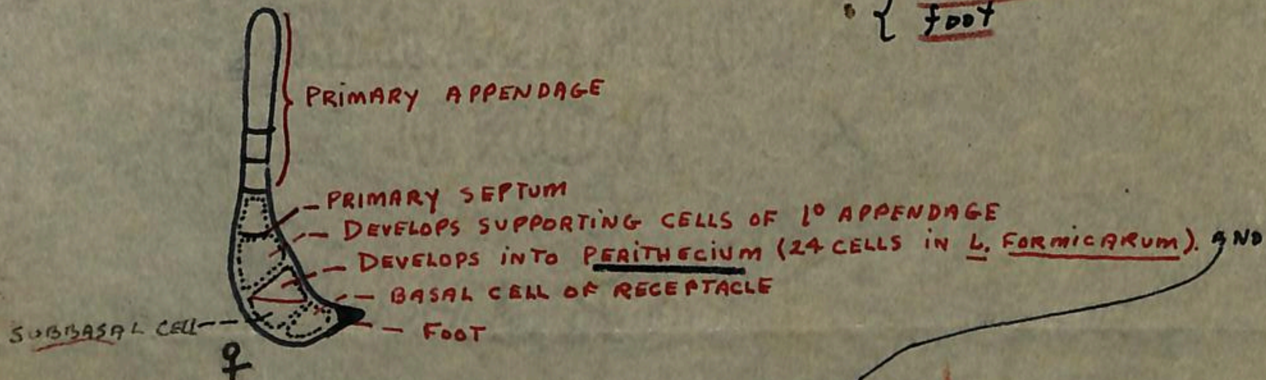
1. Ascospores discharged in paires, surrounded by gelatinous gel. capsule



2. One spore will dev. into the female; other the male (slightly smaller).

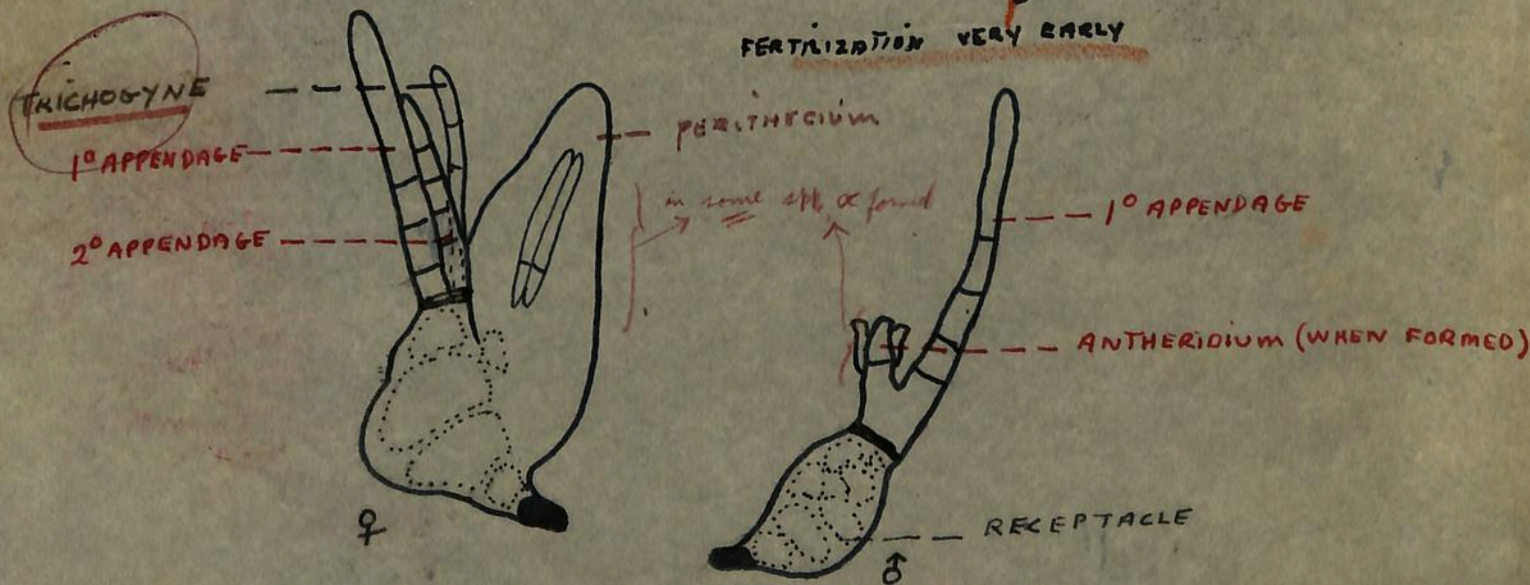
3. Gelatinous area helps anchor spores to host.

{ appendages
receptacle
foot



♀ SEXUAL APPARATUS : { TRICHOGYNE
TRICOPHORIC CELL
CARPOGENIC CELL

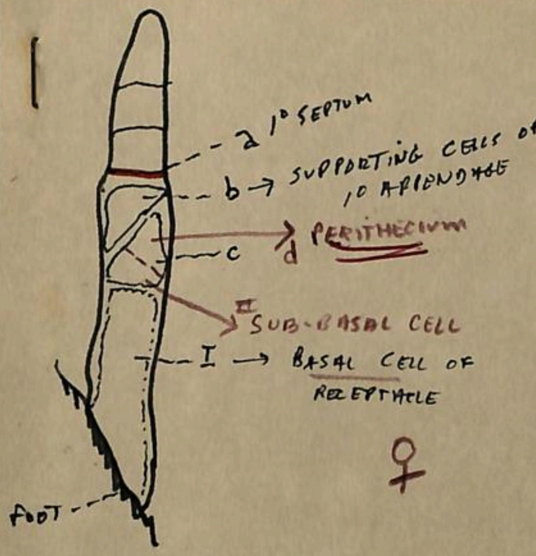
FERTILIZATION VERY EARLY



LABOULBENIA FORMICARUM

SEE: R.K. BENJAMIN & L. SHANOR. 1950. AM. J. BOT. 37(6): 471-476. THE DEV. OF ♂ & ♀ INDIVIDUALS IN THE DIOECIOUS SP. L. FORMICARUM THAXTER

1951. IBID 38(7): 555-560. EUZODIOMYCES. (DEV.)



(SIDE VIEW)

L. formicarum

Richards, A. Glenn & Myrtle N. Smith. Infection of cockroaches with Heppomyces. Histology and pathology. Ann. Ent. Soc. Amer. 49:85-93. 1956
histo

shows entrance of haustoria thru cuticle into epidermis.

see: Biol. Bull. 108:206-218.
Science 120:761-762. 1954.
Bot. Gaz. 116:195-198. 1955.

XXV. MYCOLOGICAL POETRY[1]

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

There was a little beetle once no bigger than a flea;
Like other bugs, he had six legs, and used them constantly.

He travelled up, he travelled down, he travelled in between;
He sampled many things decayed, and many that were green.

He journeyed north, he journeyed south, he followed isotherms;
He gathered many kinds of food, and many kinds of germs.

His very latest day on earth he passed upon a wattle*;
A student saw him sitting there, and clapped him in a bottle.
(*Australian name for Acacia)

He gathered others, some of which a full three inches measure,
But of them all, both great and small, this beetle was the treasure.

(Now you must know a beetle's wing, just like his leg and tail, is
Created but to be a site for Laboulbeniales.)

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

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

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

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

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

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

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

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

******

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

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[1]See also pages 5 and 13.

(1858-1932) — 103 GENERA; ±1260 SPP. · 3427 [illegible] DRAWINGS.

Monographs: { R.Thaxter 5 vol. — 1896 — 1931 — MEM. AMER. ACAD. ARTS & SCI.
C.Spegazzini 1 vol. — 1917 }

AT: (1858-1926)

BENJAMIN 1971. 125 GENERA

127 GENERA
1500 SPP.

Laboulbeniales (125 genera; 1500 sp.) ±

SEE: * SHANOR, MYCOLOGIA 1955: 1-12. PRES. ADDRESS.

Subclass Electo
Series Pyreno
Order Disco
Laboul.

1840-1848. Laboulbène & Follin first drew attention to these fungi growing on insects.

1850. Rouget first to describe sp. with figures.

1885. C.H.Peck 1853 — ROBIN & MONTAGNE } 1st LABOULBENIA DESCRIBED.

1911-12. Faull

1949 .... Shanor & Benjamin
PERITHECIA STALKED; NO PARAPHYSES, OR PERIPHYSES

Semi-microscopic ascos of uncertain relationship; species parasitic on chitinous integument of insects & mites.

Monoecious & dioecious sp.

Ascogonium gives rise to asci (4-8 spored, ≠ 2-celled), enclosed in perithecium with ostiole.

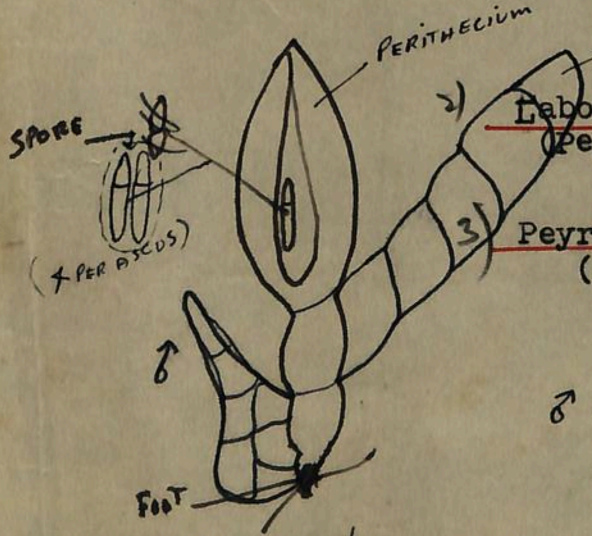
Perithecium with stalk cell, 3 basal cells, 4 longitudinal rows of 4 or more cells each, forming an inner & outer row.

Attachment is by a "foot" which may or may not penetrate insect body (rhizomycelium). HAUSTORIUM — SEE RICHARDS, G. 1956.

3 Families: 1) Ceratomycetaceae; spermatia exogenously produced on more or less undifferentiated cells of appendages. NO ANTHERIDIA.

2) Laboulbeniaceae; (Peyritsch) antheridia simple or variously grouped, with free efferent tubes.

3) Peyritschiellaceae; (Thaxter) antheridia compound, discharging into & from a common chamber.



♂ USUALLY CONSPICUOUSLY SMALLER THAN ♀, EXCEPT IN L. FORMICARUM (DIOECIOUS)

{ MONOECIOUS / DIOECIOUS } — FIRST DEMONSTRATED IN LABOULBENIA FORMICARUM BY BENJAMIN & SHANOR. 1950.

[from The Fungi IVA.]

Laboulbeniomycetes

Benjamin, R.K. 1971. Introduction & supplement to Roland Thaxter's Contribution towards a monograph of the L—aceae. J. Cramer. 153 pp.

Pre-Thaxter — Thaxter — Post-Thaxter phases

Thaxter's monograph — 5 parts (1896 - 1931)
Pt. I. 1896, Pt. II 1908, Pt. III 1924, Pt. IV 1926, Pt. V. 1931.

40 years of study: described 103 genera, ±1260 spp. & 13 var. 3427 line drawings in 166 plates
"The magnitude of his effort is difficult to comprehend unless one is engaged in a similar type of study." Benj.

Thaxter's classification adopted with slight modifications.

Spegazzini described 8 new genera of Laboulbs from Argentina and ± 270 new spp or varieties
"Spegazzini was a taxonomic innovator and his subdivision of the genus Laboulbenia was truly remarkable." Benj. 1971.

François Picard (1916-17) described ± 20 spp in addition to 9 spp in collaboration with Edouard Chatton — mostly from Europe & N. Africa

René Maire betw. 1912—1920 described 19 new spp. from N. Africa

Since 1931, ± 100 papers on Laboulbs

Among new genera proposed is Filariomyces forficulae from Louisiana, by Shanor 1952.

Chadefaud (1960) proposed a red algal vs Phycomycetes hypothesis for the origin of Lobouls.

Host - Parasite Relationships

(I) - Host specificity

Obligate parasites with high degree of host specificity the rule but few studies made. Richards & Smith (1954) studied 15 spp of cockroaches (12 genera). Conclusion = Herpomyces spp are highly but not completely host specific. No evidence of polymorphism.

(II) Position specificity

Precise location of spp observed since Peyritsch 1875.

1951 study of Benjamin & Shanor on 259 specimens of beetle Bembidion picipes infected with Laboulbenia odobena: all ♀ beetles had parasite on the "humeral angle of rt. elytron"; all ♂ had parasite on "inner distal surface of femur of rt. anterior leg."

Position probably due to mating pattern of insects But other infections occur in ± equal numbers in same position on ♂ & ♀.

Physiological variation of different parts of host integument may prevent fungus development. Richards & Smith (1955) studied Blatta orientalis & found spores deposited on all parts of roaches in lab conditions. But almost all fungi developed on upper 90% of antennae — a few on mouth parts.

III Sex of host specificity

Examples: Host: *Bembidion picipes*. 6 spp of Lab.

only on tarsi — { *Laboulbenia truncata*: on 23.4% ♂ — none on ♀

on post. surface prosternum, bet. coxi of ant. legs — { *L. perpendicularis*: on 22.8% ♀ — none " ♂

only on mouth parts — { *L. bembidio-palpi*: " 17.5% ♂ — none " ♀

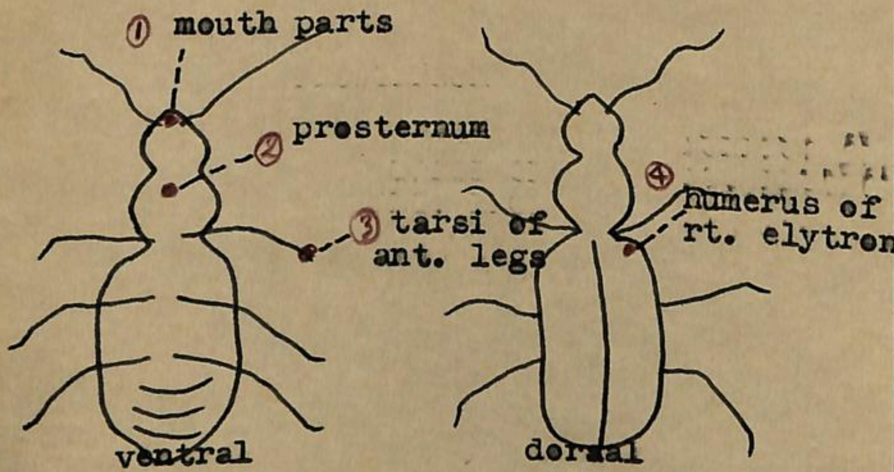
Benjamin & Shanor. 1952. Amer. Jour. Bot. 39(2):125-131.

6 spp. of Laboulbenia showing host specificity

on the beetle Bembidion picipes.

SPECIFICITY

On the aquatic, gyrinid beetle, Orectogyrus specularis, "no less than 16 distinct species of Chitonomyces were reported by Thaxter from this one host, and all are to be found on very definite and restricted areas on either the terminal abdominal segment or the neighboring genital lobes. So specific are these species of Chitonomyces for their position on the host that the identity of the sp. may be predicted accurately if only the place of collection and position on the host is known." Shanor. Mycologia 47:10. 1955.



2 spp. non-specific

IN BATON ROUGE: ON LABIDURA RIPARIA (EARWIG); PERIPLANATA. (ANTENNAE)

"It seems to us almost impossible to imagine species of Laboulbeniales growing on the external surface of insects without having haustoria penetrating into the insect for nourishment." Richards et al. 1956.

(some spp. increase up to 100,000 X size of original spore!)

HELOTIALES ← INOPERCULATES

The Geoglossaceae of North America

Key to the Genera from E. J. Durand in Annales Mycologici 6 (5). 1908

A. Ascoma stipitate, clavate or spathulate, the ascigerous portion usually more or less compressed, rarely subglobose. . . . . Geoglosseae

B. Clavate, the ascigerous portion not or only slightly decurrent on opposite sides of the stem.

C. Spores small, elliptical, cylindrical or fusiform, continuous. Plants bright colored. . . Mitrula ✓

C. Spores long-elliptical to cylindrical, 3-many septate when mature.

D. Ascomata Bright colored. . . . . Microglossum ✓

D. Ascomata black or blackish.

E. Spores hyaline. . . . . Corynetes

E. Spores fuliginous or brown.

F. Hymenium without spines or setae.

G. Ascomata viscid-gelatinous. Paraphyses continuous down the stem. . . . . Gloeoglossum ✓

G. Ascomata not viscid-gelatinous; paraphyses confined to the Hymenium. . . . . Geoglossum ✓

F. Hymenium beset with spines or setae . Trichoglossum ✓

B. Spathulate or fan-shaped, ascigerous portion decurrent on opposite sides of the stem. . . . . Spathularia ✓

A. Ascoma stipitate, pileate (or sessile in one genus with filiform spores). . . . . Cudonieae

H. Spores elliptical-fusiform, ascoma gelatinous. . . . . Leotia ✓

H. Spores filiform or filiform-clavate

I. Ascoma fleshy-Gelatinous, asci very narrow, spores filiform; plants aquatic or semi-aquatic.

J. Stipitate. . . . . Vibrissea

J. Sessile or turbinate. . . . . Apostemidium

I. Ascoma fleshy-leathery, asci broadly clavate, spores filiform-clavate; plants terrestrial- . . . . Cudonia

NOTES ON THE ESTABLISHMENT AND MAINTENANCE OF TRUFFIÉRES (TRUFFLE ORCHARDS).

By Edmund B. Lambert, Senior Mycologist
Division of Vegetable Crops & Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, United States Department of Agriculture, Beltsville, Maryland.

Introduction

While assembling these notes, principally from the papers of Malencon[1] and Kaltenbach [2], the writer gained the impression that some of the statements set down as solemn facts probably are not fully proved, yet taken as a whole the operations described seem to represent a practical and successful method of cultivating the Perigord truffle. The establishment of artificial truffiéres by setting out young oaks in new regions was first developed by Joseph Talon in 1810. The widespread adoption of Talon's method appears, however, to have been due largely to the observations and demonstrations of Auguste Rousseau about 40 years later.

As pointed out by Malencon, truffle culture does not consist merely in the planting of oaks and several years later gathering the truffles at their base. It is a delicate art wherein the choice of the terrain, its physical and chemical nature, its orientation, preparation given the soil, selection of the trees, attention which one gives the trees, pruning and many other factors are all points that must be seriously considered.

Inoculation of the Soil

In certain areas in Southern France truffle spores are apparently present in most of the suitable soils so that truffles develop spontaneously around young oak trees. In some localities, where the spores are not in the soil truffles have been induced to grow around non-bearing oak trees by transferring moist soil presumably containing live truffle mycelium from near truffle-bearing trees to the base of the trees in the new locality. Such inoculations are usually made at the ends of the lateral roots which grow out in the soil about as far as the branches above. Kiefer is cited by Malencon as having obtained truffles in this manner two years after inoculating trees of moderate age.

1/ Malencon, M. G. Les truffes européenes, historique, morphogénie, organographie, classification, culture. Revue Myc. 3 (n.s.) : 1-92. 1938.

2/ Kaltenbach, D. Aspects of truffle growing in France and Italy. Inter. Rev. Agr. 26: 267-278. 1935.

Another method of inoculation which is sometimes used is to sow pieces of truffles or truffle tissue fermented with soil. This method is said to be somewhat erratic owing to the capricious germination of the truffle spores. Matruchet has grown the truffle mycelium in cultures made on sterile media from tissues of young truffles and has also germinated the spores. For some unknown reason this type of inoculum does not seem to have come into widespread use.

When seedling oaks are grown in nurseries in which the soil contains the truffle fungus, the roots of the seedlings become naturally infected and the young trees quite consistently bear truffles when transplanted to other localities. As far as the writer can judge from the literature, this is the method that gives the best results and is most commonly followed in the establishment of new truffiéres.

Selection of suitable location

In France, the Perigord truffle grows between latitude 44° and 46° north. In northern France it is comparatively rare and is largely supplanted by Tuber uncinatum, T. aestivum and T. mesentericum in Bourgoyne territory near Paris. However, la truffe Perigord (Tuber melanosporum) has been gathered near Verdun, and it would seem that continued research may indicate that it is adapted further north than the line usually drawn. The annual rainfall in this region is from 20 to 40 inches distributed quite uniformly throughout the year. The summers are cooler and the winters less severe than in regions of comparable latitude in the United States. In this country, the climate of our southeastern States and of the coastal regions of the Far West would seem to come the nearest to duplicating the climate of truffle-growing regions in France.

Soil, Texture, Reaction and Drainage

The type of soil best adapted for truffle culture is a shallow calcareous soil containing a moderate amount of clay, well drained and aerated. The presence of a permeable subsoil is indispensable in localities where surface drainage is poor or where water is likely to remain for any considerable length of time. A loam texture is favorable. Pure sand or heavy clay soils are not favorable. A certain amount of sand contained in calcareous clay soil may be beneficial since it may serve to loosen up and aerate heavy soil.

Chatin points out that more than 3% calcium must be present and many successful truffiéres have a calcium content of as high as 30%.

The truffle does not seem to use silica but tolerates its presence in extremely variable proportions. It may be 8% in certain truffiéres and 80% in others (Carpentras). Rousseau describes truffle soils in the Carpentras regions with 56% stoney elements (calcium carbonate) and gravel and 44% finer elements clay loam and sandy loam. Another truffiére in Vienne was described as having 50% calcium with 30% clay, 15% quartz sand, and 5% humus.

Secondary, but constant, constituents of truffle producing soils are said to be magnesium carbonate, organic matter, phosphates, and iron oxide. The amount of clay most advantageous in the soil may be different in different localities depending on the permeability of the sub-soil, the amount of drying out, the amount of rainfall, etc. There is too much clay when the soil is frequently water-logged, on the other hand a certain amount of clay is necessary to maintain a moderate moisture content in hot dry weather. Excessively drained soils may support truffles better on the north side of a hill because of less drying out. Generally, however, hillside exposure to the south is considered best for the maturation of the truffle. As one gets into high altitudes and latitudes the south exposure becomes more preferable. A comparatively shallow soil has the advantage of compelling a shallow root system of the truffle-bearing oaks so that the truffles will not grow too deep below the surface. The soil must be kept moist for the best growth of truffles. The clay faction of the soil is therefore important in maintaining a moderate moisture content with high humidity in the interstices of the soil without saturation which would shut out the air.

The tolerance for different amounts of calcium and silica and somewhat different physical conditions indicates that many soil types are favorable for truffles, but it is clear that there must be free calcium carbonate present and that truffles will not tolerate a saturated soil.

Selection of the trees

Trees and shrubs of several genera bear truffles; hornbeam, walnut, pine, cedar, hazel and others, but the oak like the Perigord truffle, is recognized as the first choice for truffle culture. Although all of the European oaks will bear truffles, there are 4 species that are considered best: *Quercus pedunculata* (Ehrh.) Wild., *Q. sessiliflora* Sm., *Q. ilex* Linn., and *Q. coccifera* Linn. The first two are better adapted to comparatively colder localities and the last two to warm regions. *Q. ilex* is evergreen and is sometimes called the lustrous green oak.

The question of whether acorns from the truffle-bearing trees are superior for truffle culture has not been settled. It is Malencon's opinion that, within varieties, acorns from trees without truffles are as good as those from truffle-bearing trees. He is also inclined to discount the belief among many truffle growers that acorns from heavy bearing truffle trees will produce trees that in turn bear more truffles than most trees of the same variety.

The writer would be inclined to the hypothesis that clones from heavy bearing trees should make the most productive artificial truffiéres. This opinion is based on the assumption that the reaction of the truffle fungus to its host plant is dependent on a heritable character which could be much more readily perpetrated by clonal propagation than by seed. The experience gained during the past two decades by investigation concerned with the yield of tree crops such as nuts, rubber, and fruits of various kinds would seem to lend weight to this hypothesis.

Propagation of seedlings

The acorns are stratified in layers of clean sand somewhat moist but not moist enough to induce premature germination. They are kept in a cool place. When treated in this manner they germinate uniformly and vigorously. After the acorns have swollen and send out a primary root 1/2" to 1" long, they are separated and sorted out. Although many of the rootlets are broken at this time no harm is done because secondary roots form which make better lateral growth. Lateral roots are preferred to tap roots in as much as they grow closer to the surface of the soil. These young seedlings can be set out directly in orchards but since truffle soils are usually poor, better results are obtained by planting them in a seedling nursery and growing the young trees in rich soil for a few years. In this way the beginning of production of truffles may be advanced one or two years. In the nursery the germinated acorns are set out in furrows 1 1/2" to 2 1/2" deep and 1 foot apart in the row, with the rows 1 foot apart. Every effort should be made to obtain rapid growth of the young trees. Light dressings of sodium nitrate and of thoroughly decomposed manure are desirable during the first 2 years. Fresh manure should not be used.

Setting out the young trees

The trees are transported from the nursery to the truffière when 2 or 3 years old. When they are transplanted a ball of earth is taken with them but the end of the tap root is again cut off to induce lateral rooting.

In the truffière the evergreens (*Q. ilex* and *Q. coccifera*) are spaced 25 feet and the more hardy species 30 feet. They are planted in check rows. A closer spacing than this reduces the number of years in the truffle-bearing period since the trees cease bearing when the roots of nearby trees approach each other.

For the next three or four years after the young trees have been planted out in the truffière, each tree is cultivated lightly in April, not to exceed 3 or 4 inches deep. After this spring cultivating the soil is not disturbed for a yard from the tree trunks. When the trees come into production they are cultivated lightly over the surface after each harvest is complete (March and May), to aerate the soil and induce new surface root development. Any summer cultivation to reduce evaporation must be strictly surface cultivation to avoid injury to the growing roots and the truffle fungus. The placing of flagstones around the truffle-bearing trees has been advocated to increase production.

Irrigation and Fertilization

In some localities where dry summers are encountered irrigation has been found to be very advantageous. The soil should be moistened by capilarity but not flooded. Usually only a fraction of an inch of water is required during dry weather in July and August. Too much water in late fall may reduce the total yield and adversely affect the truffle flavor.

The question of the advisability of fertilization of the older trees seems to be somewhat controversial. Many growers claim any type of fertilizer will injure bearing trees. On the other hand Zacharewicz, Director of Agricultural Services, Vaucluse, recommends for his district the following complete fertilizer per tree: Sodium nitrate 300 grams, potassium chloride 400 grams; superphosphate 2 kilograms; gypsum 1 kilogram. Fertilizers should be applied in April and lightly raked in.

Pruning

The method of pruning the tops of the trees is based on the theory that the habit of growth of the branches of the tree regulates the root distribution. The leader and vertical shoots are cut back for several years and the tree is made to look like a much flattened inverted cone almost disk-shaped. It is believed that this tree form discourages tap-root growth and encourages widespread lateral root growth. As a consequence more truffles will be produced near the surface of the soil. The lower branches are removed to prevent excessive shading of the soil.

Bearing trees

Truffles begin to appear in from 7 to 15 years, sometimes a few years later. The production persists for 20 to 30 years. Trees 100 years old may bear truffles but not consistently and in great quantity. When a truffière becomes unproductive with age a new one may be replanted on the same area. Rejuvenation is sometimes practiced by cutting off the trees at the ground level and cutting back all but one or two sprouts from each of the old trees. These form new trees that remain productive for several years.

It is a peculiar fact that the trees making the most luxuriant growth usually are not the best producers, while the poor looking trees are frequently excellent producers.

Development of truffles

The details of the development of the truffles have not been worked out. It is to be assumed that the initiation of the truffle results from a sexual process similar to well known processes preceding the formation of ascocarps in closely related genera. A sure sign of the presence of the truffle fungus in a new truffière is the "burned" appearance of the vegetation under the truffle trees. This is due to the extensive growth of the truffle mycelium and occurs 5 or 6 years after the trees are planted. Young truffles begin to form in southern France in the fall and mature from December to February which is the harvest time.

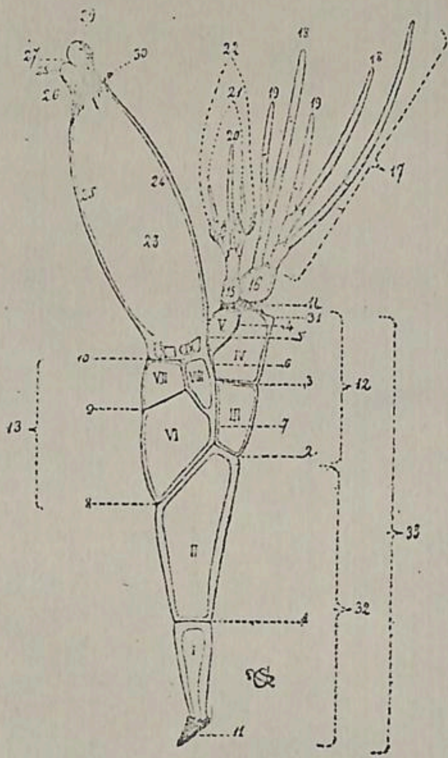
In many cases the truffles can be located by the cracks which they cause in the soil, but they are usually "hunted" with the aid of trained pigs or dogs.

May 26, 1952.

VI. Cellula geminata ventralis infera seu sexta — célula apareada ventral inferior o sexta.

VII. » geminata ventralis supera seu septima — célula apareada ventral superior o séptima

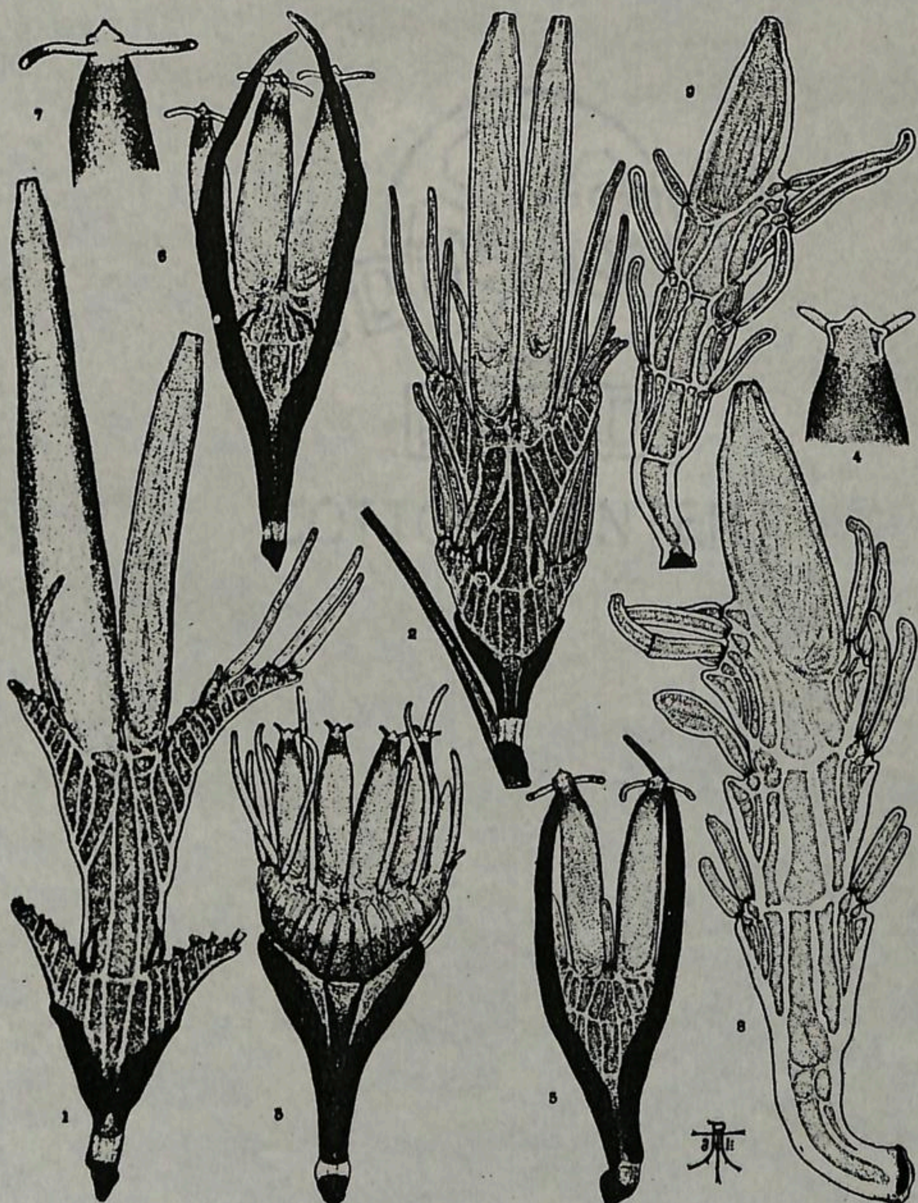
VIII. » intermedia seu octava — célula mediana u octava.



IX. » hypocarpa dorsalis seu nona — célula basilar o pedicelar dorsal o novena.

X. » hypocarpa ventral seu decima — célula basilar o pedicelar ventral o décima.

1. Septum basale v. primum — tabique basal o primero.
2. » subbasale v. secundum — tabique subbasal o segundo.
3. » androstichi v. tertium — tabique del andróstico o tercero.
4. » subdorsale v. quartum — tabique subdorsal o cuarto.
5. » intermedium superum v. quintum — tabique mediano superior o quinto.



THAXTER,-LABOULBENIACEAE

COCKAYNE, BOSTON.

PLATE I

Fig. 1. Section through portion of ascocarp of *Genea brachytheca*
2. Spore of *Genea brachytheca*
3. Spore of *Genea Thaxteri*
4. Spore of *Genea hispidula*
5. Spore of *Genea intermedia*
6. Spore of *Genea Harknessii*
7. Spore of *Genea cerebriformis*
8. Spore of *Genea compacta*
9. Spore of *Genea arenaria*
10. Spore of *Genea macrosiphon*
11. Spore of *Genea Gardneri*
12. Spore of *Genea echinospora*
13. Spore of *Geneabea fragilis*
14. Spore of *Hydnotrya carnea*
15. Cross section of spore of *Hydnotrya carnea*
16. Cross section of immature spore of *Hydnotrya cubispora*
17. Spore of *Hydnotrya cubispora*
18. Cross section of immature terminal spore of *Hydnotrya cubispora*
19. Spore of *Hydnotrya cerebriformis*
20. Spore of *Hydnotrya ellipsospora*
21. Spore of *Daleomyces Shearii*
22. Spore of *Daleomyces Gardneri* of same magnification as Figure 21.
23. Spore of *Daleomyces Gardneri* more highly magnified
24. Ascus containing immature spores of *Pachyphloeus virescens*
25. Mature spore of *Pachyphloeus virescens*
26. Spore of *Pachyphloeus citrinus*
27. Spore of *Pachyphloeus melanoxanthus*
28. Spore of *Balsamia platyspora*

PLATE II

Fig. 29. Section through portion of ascocarp of *Hydnocystis californica*
30. Spore of *Tuber argenteum*
31. Spore of *Tuber Gardneri*
32. Spore of *Delastreopsis phleboderma*
33. Ascus and spore of *Delastreopsis oligosperma*
34. Spore of *Choiromyces compacta*
35. Spore of *Choiromyces Setchellii*
36. Spore of *Picoa carthusiana*
37. Spore of *Terfezia spinosa*
38. Spore of *Delastria rosea*
39. Spore of *Geopora glabra*
40. Spore of *Geopora magnata*
41. Spore of *Geopora Harknessii*
42. Sectioned ascocarp of *Geopora Harknessii*
43. Ascocarp of *Petchiomyces kraspedostoma*
44. Spore of *Petchiomyces kraspedostoma*
45. Spore of *Hydnobolites californicus*
46. Spores of *Pseudobalsamia magnata*
47. Ascus and spores of *Pseudobalsamia magnata* var. *nigrens*

Benjamin, R.K. 1971.

A Descriptive Key to the Genera
of the Laboulbeniales

At the end of the introductory section of his second monograph, Thaxter (1908, pp. 236-239) provided a key to the genera of Laboulbeniales which he recognized at that time. He did not supplement or revise this in his later works. His presentation was intended to indicate, in a general way, natural relationships, and the nature of the male sexual organ was used as a primary key character. The absence of antheridia on species of many genera, either at any stage of development or on mature individuals, renders this key difficult if not impossible to use in many instances, and, of course, it now is out of date. In the key presented below, I have utilized the characteristics of the antheridia only when these are a well-marked feature of the intact and normally developed mature individual. Other morphological characteristics that are reasonably easy to observe, provided one has well-developed and unbroken specimens for study, have been selected as primary key characters. The organization of the key does not necessarily reflect natural relationships. Host data are included only to provide supplemental information and these should not overly influence the final disposition of an unknown, for many genera having a more or less narrow host range do include an occasional species adapted to a member of an unrelated host group. Host-group specificity does, however, appear to be extremely narrow in many genera as indicated in the key. Many of the data incorporated into the key are taken directly from Thaxter's descriptions or those of other students, but I have supplemented these with my own, often unpublished, observations of the past twenty years. Thus, there will be found an occasional conflict between what I say and what Thaxter or others, including myself, have reported. The key has been constructed mostly on the basis of the characteristics of the generic type or on what I regard as those features best representing the genus as presently understood. Forms will be encountered that will be nearly if not impossible to place. This is inevitable, for construction of a key that would take into account the many variations found in some of the larger genera would be extremely complex and has not been attempted here. Indeed, several of Thaxter's species are not accurately placed at present and eventually will have to be reclassified. Hopefully, the following key will provide a guide to the systematic study of the genera currently recognized.

Before attempting to use this key for the determination of genera, the student who already has not had an opportunity to do so should become completely familiar with the general characteristics of the Laboulbeniales as presented in the introductory sections of Part 1 and 2 of the monograph and supplemented in the later parts. He should peruse the illustrations and note the many variations that are known to occur in the structure of the receptacle, appendages, perithecia, and antheridia. The beginning student first should collect and prepare a series of study specimens showing various stages of development of a number of representatives of common genera following the procedures outlined in the section on Collection, Preservation, and Preparation of Specimens.

1. Spore appearing continuous (actually 2-celled, but upper cell very small and not observed readily); dioecious; female receptacle appearing unicellular and without an appendage; male individual minute, consisting of two superposed cells and a terminal, simple antheridium; known only on species of the subfamily Aleocharinae of the Staphylinidae (Coleoptera) . . . . *Amorphomyces*

1'. Spore obviously 2-celled; monoecious, dioecious, or male organs lacking; receptacle consisting of more than one cell; appendages usually present, various 2

2. Receptacle a more or less massive, multicellular, turbinate structure forming a distal, cup-like depression within which arise numerous strile appendages, stalked perithecia, and antheridial branchlets bearing exogenous spermatia; known only on species of Hydrophilidae (Coleoptera). . . . . *Zodiomyces*

2'. Receptacle otherwise 3

3. Perithecium, together with its true stalk- and basal cells, borne on a more or less elongate stalk of two or more superposed cells or terminating a simple, uniseriate, cellular receptacle lacking branches of any kind. 4

3'. Perithecium, together with its true stalk- and basal cells, sessile or, if appearing stalked, the stalk consisting only of the true stalk-cell and one or more of the modified basal cells of the perithecium; if perithecium terminating a simple, indeterminate receptacle, then the latter producing one or more branches. 11

4. Perithecium terminating a simple, multicellular receptacle and bearing a lateral, often rudimentary appendage (=the original primary appendage); true stalk- and basal cells of the perithecium becoming continuous with the cavity of the perithecium proper; dioecious, the male consisting of three superposed cells and a terminal simple antheridium; known only on species of Limnichidae (Coleoptera). . . . . *Aporomyces*

4'. Perithecium and its stalk readily distinguishable from the body of the receptacle. 5

5. Outer wall of the perithecium, exclusive of the basal cells, composed of only four or five tiers of wall-cells. 6

5'. Outer wall of the perithecium, exclusive of the basal cells, composed of six or more tiers of wall-cells. 9

6. Perithecium bearing an appendage. 7

6'. Perithecium without an appendage 8

7. Perithecium terminal on a long multicellular stalk that is continuous with a 4-celled receptacle; the upper cell of the latter bearing a lateral tuft of antheridial (?) branchlets; (structure of the perithecium not described); known only on the genus *Hyraena* of the family Limnebiidae (Coleoptera). . . . . *Thripomyces*

beniales. The ascospore is regarded as an embryo that develops directly into a gametophyte constituted, not of a mycelium, but of a simple *cladome* organized like that of certain Florideae. The basal cell of the ascosporal embryo gives rise to the *basal segment* of the axis bearing the *basal pleuridia*; the distial cell gives rise to the *apical cell* that forms the remaining segments of the axis. Thus, the cladome consists basically of a more or less well-developed uniseriate axis of few to many cells one or more of which, above the basal cell, may give rise laterally to cellular productions, called *pleuridia*; these, in turn, may bear sex organs or sterile branchlets or secondary cladomes. According to the arrangement of the pleuridia, Chadefaud distinguishes four morphological types of thalli:

1. *Eupleuridial* species. – Axis well-developed, with pleuridia formed on all segments of the cladome except those at the summit. Examples given for this type include the genera *Histeridomyces*, *Peyritschiella*, *Skelophoromyces*, and *Stichomyces*.

2. *Basipleuridial* species. – Only those pleuridia arising from the basal segment well-developed; basal segment usually divided into two superposed sub-segments; segments forming the distal part of the axis more or less

Prof. Chadefaud's treatment of the Laboulbeniales is interesting and thought-provoking. It does not, however, offer anything new regarding the origin of the Laboulbeniales, and each of the four morphological types he proposes brings together genera that probably are not otherwise closely related phylogenetically.

in Benjamin 1971.

XXV. MYCOLOGICAL POETRY[1]

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

There was a little beetle once no bigger than a flea;
Like other bugs, he had six legs, and used them constantly.

He travelled up, he travelled down, he travelled in between;
He sampled many things decayed, and many that were green.

He journeyed north, he journeyed south, he followed isotherms;
He gathered many kinds of food, and many kinds of germs.

His very latest day on earth he passed upon a wattle*;
A student saw him sitting there, and clapped him in a bottle.
(*Australian name for Acacia)

He gathered others, some of which a full three inches measure,
But of them all, both great and small, this beetle was the treasure.

(Now you must know a beetle's wing, just like his leg and tail, is
Created but to be a site for Laboulbeniales.)

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

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

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

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

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

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

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

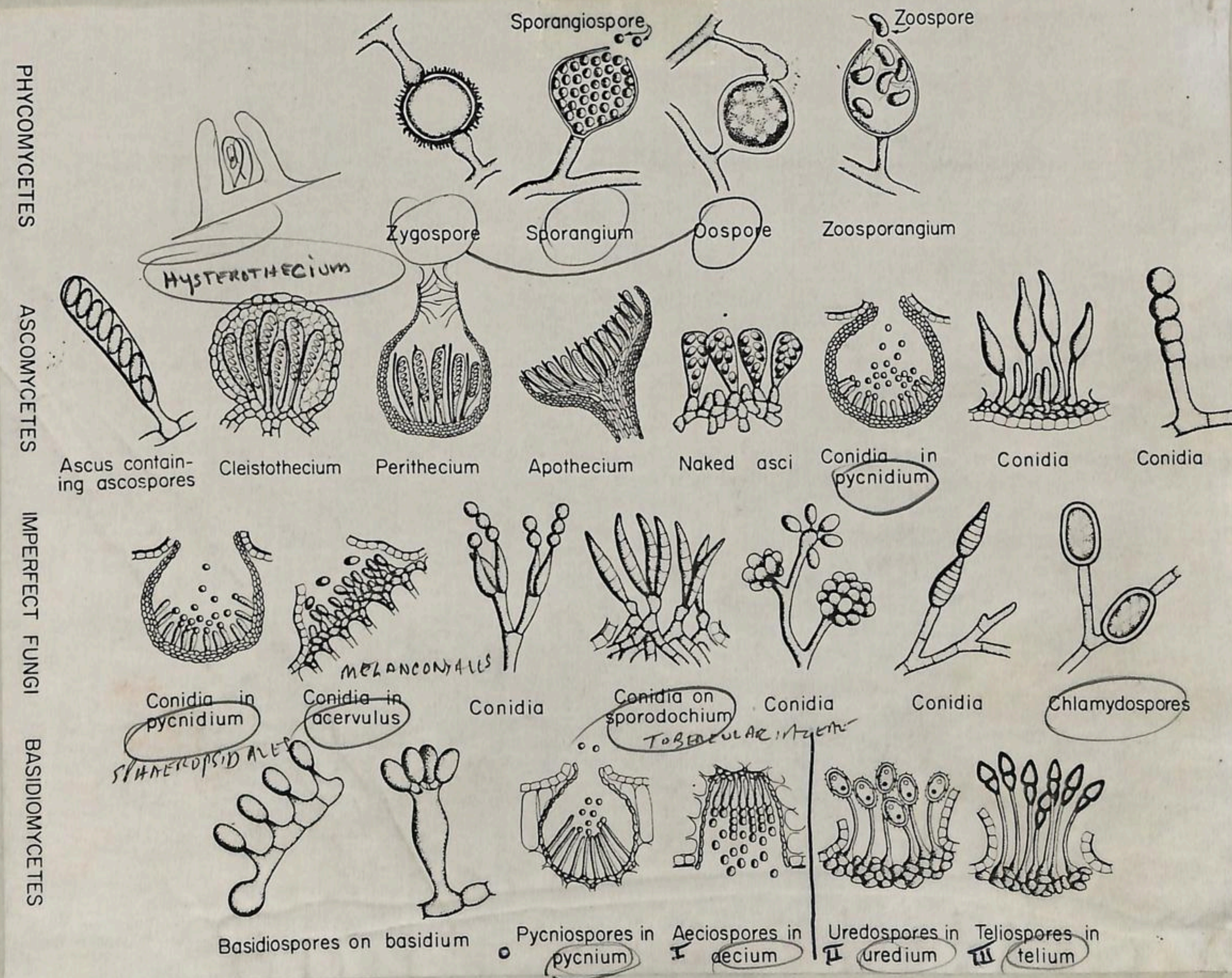
"Its foot has toes with well-formed nails, its antherozoids can swim,
And the ascus holds a single spore, with a strongly chitinized rim."

******

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

[1] See also pages 5 and 13.

M.S.A. NEWSLETTER. DEC. 1961.



PHYCOMYCETES
Sporangiospore
Zoospore
Zygospore
Sporangium
Oospore
Zoosporangium
HYSTEROTHECium
ASCOMYCETES
Ascus containing ascospores
Cleistothecium
Perithecium
Apothecium
Naked asci
Conidia in pycnidium
Conidia
Conidia
IMPERFECT FUNGI
Conidia in pycnidium
Conidia in acervulus
MELANCONIALES
Conidia
Conidia on sporodochium
Conidia
Conidia
Chlamydospores
SPHAEROPSIDALES
BASIDIOMYCETES
Basidiospores on basidium
o Pycniospores in pycnium
I Aeciospores in aecium
II Uredospores in uredium
III Teliospores in telium