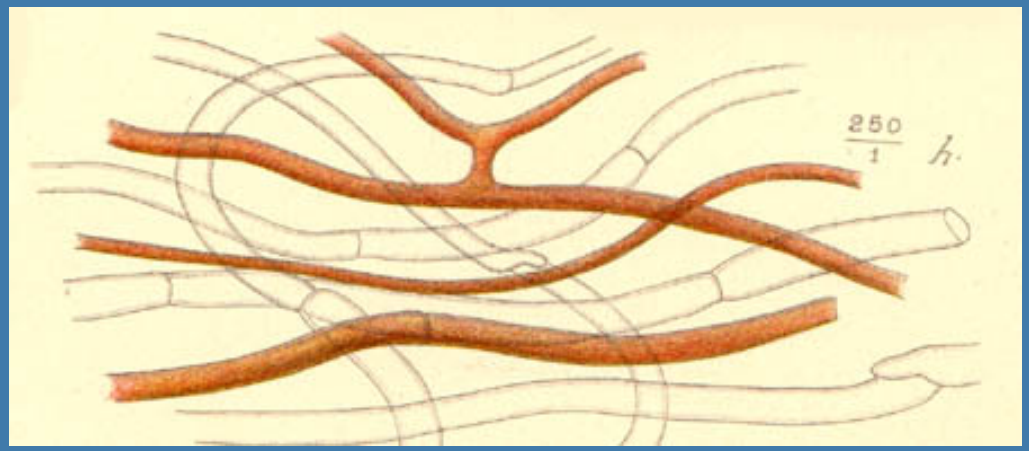
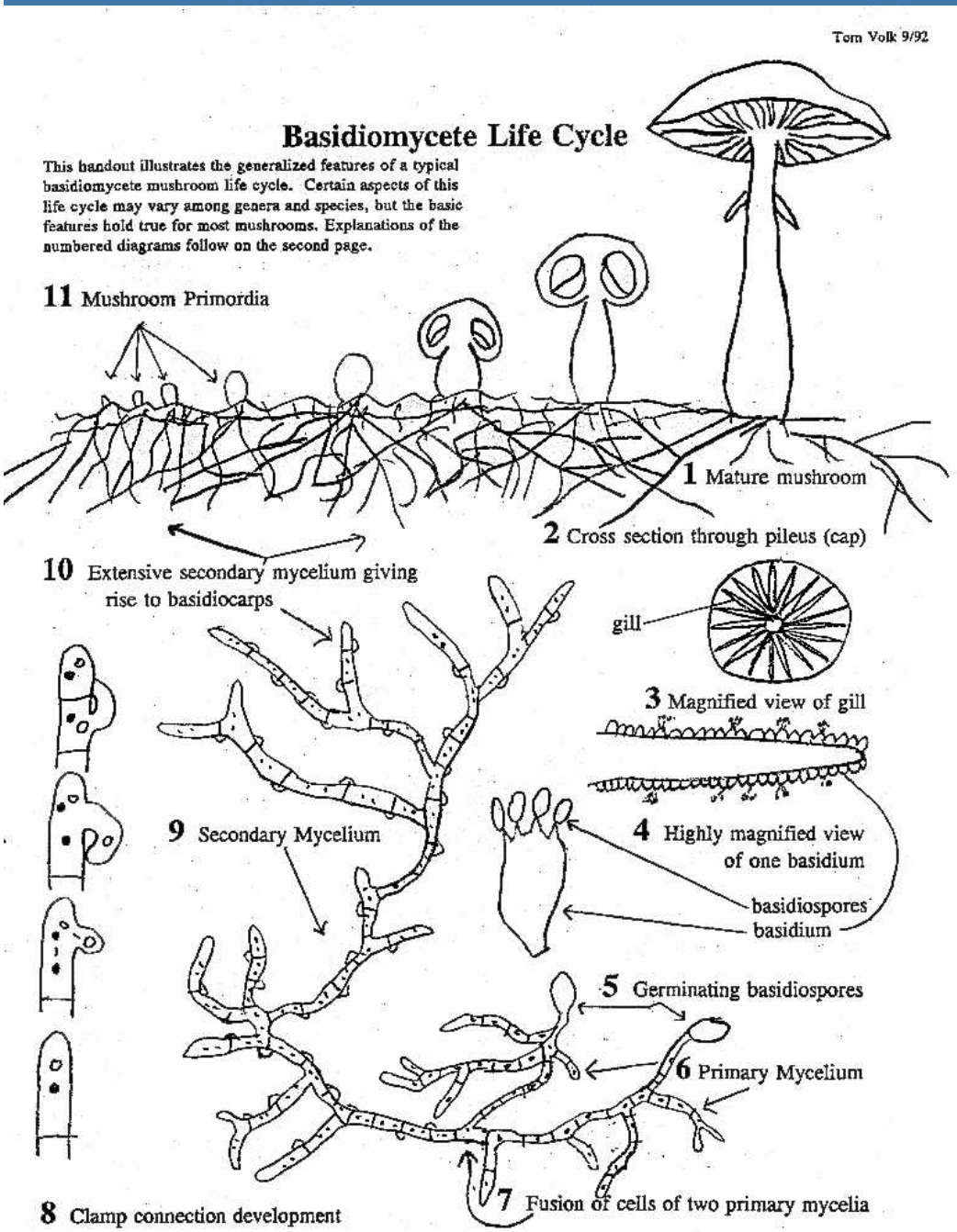
6. Primary mycelium: Monokaryon

- Monokaryon - genetically identical haploid (*n* number of chromosomes).

- The basidiospore and initial hyphae following basidiospore germination (usually) are haploid, monokaryotic. Nuclei contain only one copy of each chromosome.





Major stages
Basidiomycota Life Cycle

1) Sporocarp
2) Gilled Hymenophore
3) Hymenium
4) Basidium
5) Basidiospore
6) Monokaryon
7) **Fusion of monokaryons**
8) Clamp connections
9) Dikaryon
10) Mycelium
11) Sporocarp priomordia

7. Fusion of monokaryons

- Anastomosis - fusion of branches of the same or different hyphae
- Mating event - fusion of compatible primary mycelium monokaryons and formation of secondary mycelium dikaryon
- Sexual compatibility - recognition and fusion of monokaryons
  - Most basidiomycetes are heterothallic
  - 20-25% of heterothallic taxa are unifactorial (bipolar);
  - 75% of heterothallic taxa are bifactorial (tetrapolar) with A and B loci
- Controlled by mating type genes (MAT)

7. Fusion of monokaryons

3 mating systems

Homothallic

- dikaryon formation occurs in single, self-compatible thallus
- ~25% of all species of basidiomycetes

Heterothallic

- self-sterile (self-incompatible) individuals
- requires the union of two, unique compatible thalli
- ~75% of all species of basidiomycetes

Secondary homothallic

- Basidiospores are binucleate, one nucleus of each mating type, germinating spores are already dikaryotic

7. Fusion of monokaryons

Controlled by Mating Type Genes (MAT locus)

- MAT locus consists of a few to several tightly linked genes

- Unifactorial (bipolar)
  - one locus or factor (A)
  - requires 2 unlike alleles for mating type compatibility
  - 25% of heterothallic species

- Bifactorial (tetrapolar)
  - two unlinked loci or factors on different chromosomes (A and B)
  - requires 4 unlike alleles for mating type compatibility
  - 75% of heterothallic species

7. Fusion of monokaryons

Unifactorial (bipolar) mating system

- one locus (unifactorial) controls mating
- two different alleles (bipolar) required for compatibility of nuclei
- Hymenomycetes can have from tens to more than one hundred alleles per locus

(A is locus, numbers, e.g., 1,2,3... are different alleles)

- A1 X A2 (karyogamy) ----> A1A2 diploid
- meiosis ----> A1 + A2 haploid (spores)
- Daughter nuclei are same ‘sexes’, i.e. mating type, as parents

7. Fusion of monokaryons

Bifactorial (tetrapolar) mating system

- two loci control mating: A and B
- four different alleles (tetrapolar) - two at each locus - required for mating compatibility of nuclei

- numerous alleles/locus exist, as in unifactorial systems

- A1B1 X A2B2 (karyogamy) ----> A1B1A2B2 diploid meiosis & reassortment ----> A1B1, A2B2, A1B2, A2B1

Two resulting “sexes” not represented by parental genotypes
Potential for hundreds of “sexes” in the mating population

7. Fusion of monokaryons

Ultimate function of A & B loci discerned via partial compatibility crosses

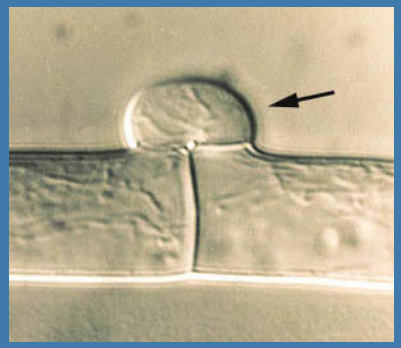
- fusion between A1B1 X A1B2 (identical A alleles)
  no clamp connections formed
  "flat" reaction

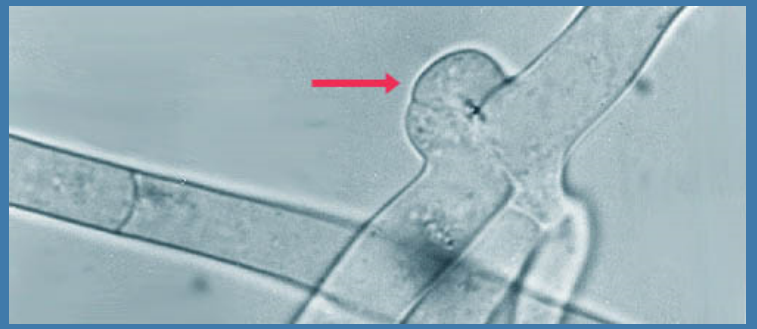
- fusion between A1B1 X A2B1 (identical B alleles)
  clamp connections formed but no migration of nuclei
  "barrage" reaction, clamp connections present

- fusion between A1B1 X A2B2
  Compatible, dikaryon, fertile sporocarp

7. Fusion of monokaryons

- A locus
  - Two closely linked subloci (Aα) and (Aβ) with multiple alleles; expressed as functional unit and any cross involving strains differing at either Aα or Aβ is compatible
    - In *S. commune*, Aα has 32 alleles, Aβ has 9 alleles
- A locus controls:
  - Specific nuclear pairing
  - Initiation of clamp
  - Separation of clamp by septum
  - Compatibility at A locus only gives "barrage" reaction:
    - Nuclear pairing and initiation of clamp only
    - e.g. fusion between A1B1 X A2B1 (identical B alleles)
      no clamp connections formed

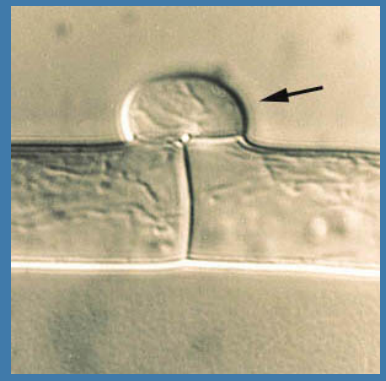




7. Fusion of monokaryons

- B locus
  - Two closely linked subloci (Bα) and (Bβ) each with multiple alleles; expressed as functional unit and any cross involving strains differing at either Bα or Bβ is compatible
    - In *S. commune*, Bα and Bβ have 9 alleles each
- B locus controls:
  - Septal breakdown
  - Nuclear migration
  - Pheromone and receptor, recognition factors
  - Compatibility at B locus only gives "flat" reaction
    - Nuclear migration occurs, but no clamp initiation
    - fusion between A1B1 X A1B2 (identical A alleles)

  e.g. clamp connections formed but no migration of nuclei



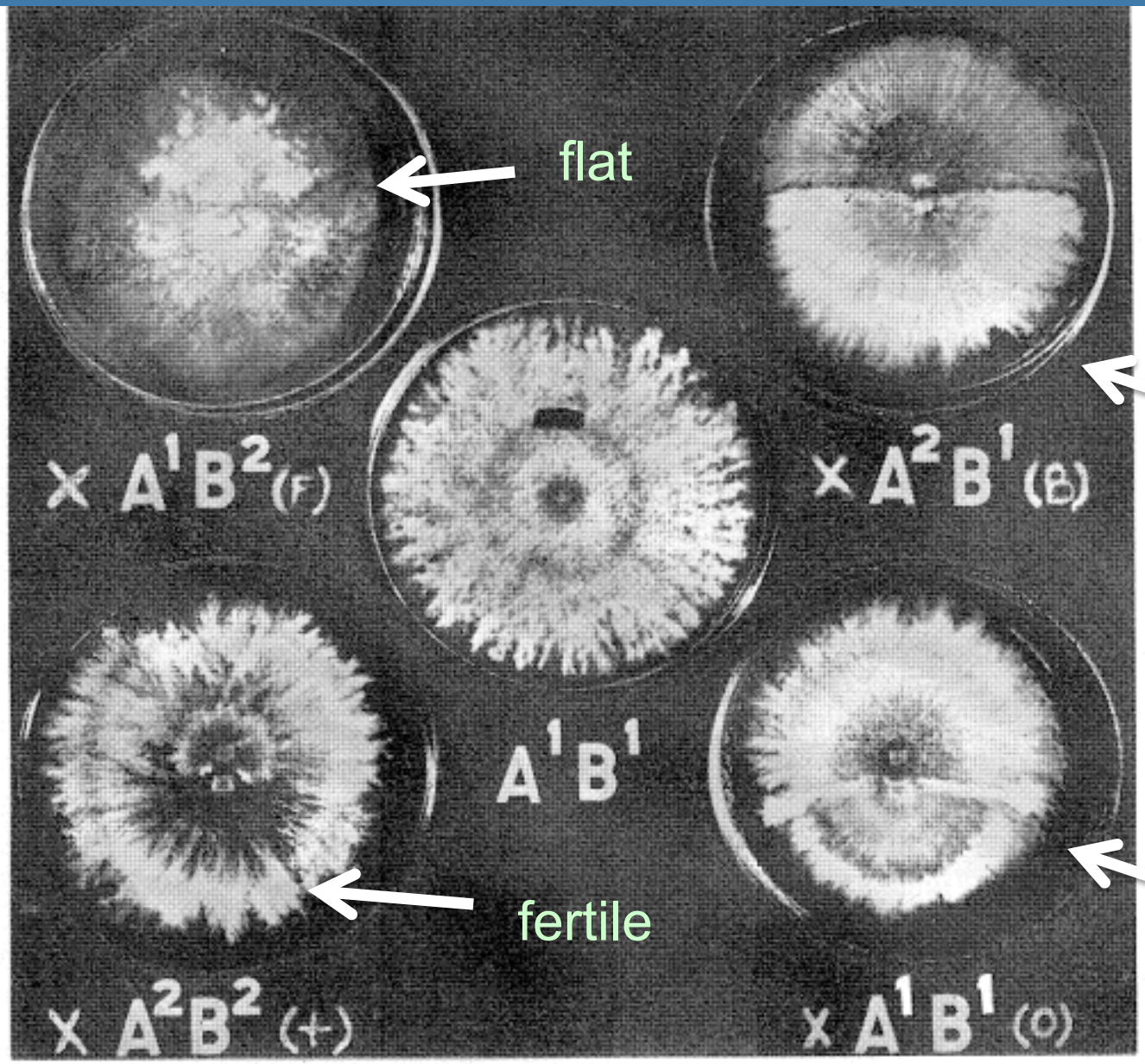


FIG. 1.—Mating reactions in *Schizophyllum*. A single monokaryon (A^1B^1) is shown in center. At four corners it is shown in matings with various other monokaryons. (F) = "flat," (B) = "barrage," (+) = dikaryon, (O) = overlap.

Mating reactions in *Schizophyllum commune*

barrage

overlap

Bifactorial Mating System

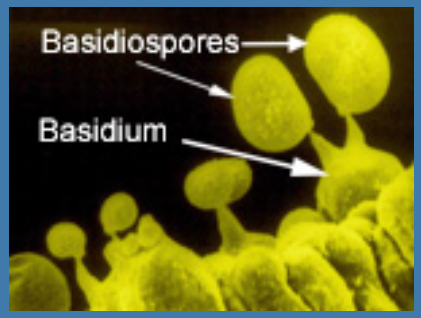
- Two genetic loci (A and B) located on separate chromosomes and segregating separately at meiosis
- Parental diploid genotype: A1B1 / A2B2
- Mating reactions of four possible isolates of a bifactorial fungus:

	A_1B_1	A_1B_2	A_2B_1	A_2B_2
A_1B_1	Overlap	Flat	Barrage	+ fertile
A_1B_2	Flat	Overlap	+ fertile	Barrage
A_2B_1	Barrage	+fertile	Overlap	Flat
A_2B_2	+fertile	Barrage	Flat	Overlap

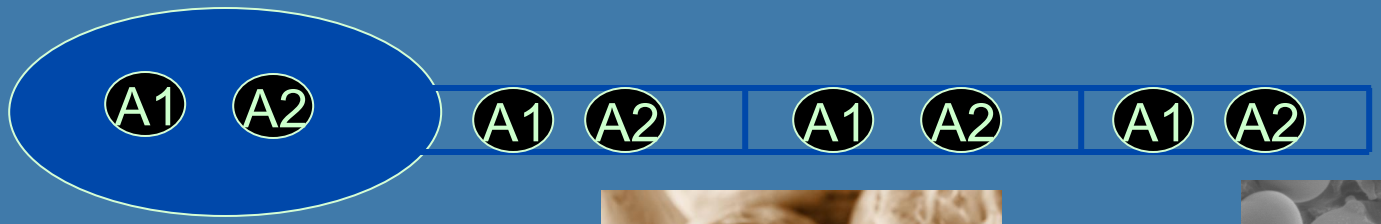
4/16, 25% of possible combinations are fertile

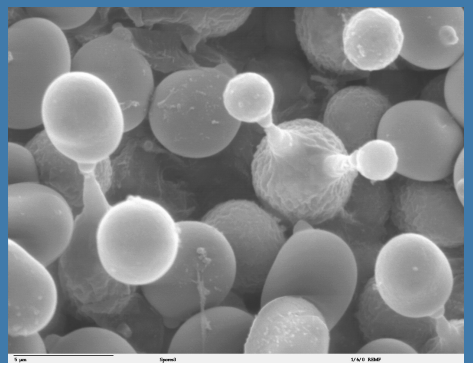
Secondary homothallic

-fungi that produce binucleate basidiospores
-contain two haploid nuclei with compatible mating type alleles
-basidiospore germinates directly into a dikaryon
-no true monokaryotic stage to life cycle
-superficially resembles a homothallic species



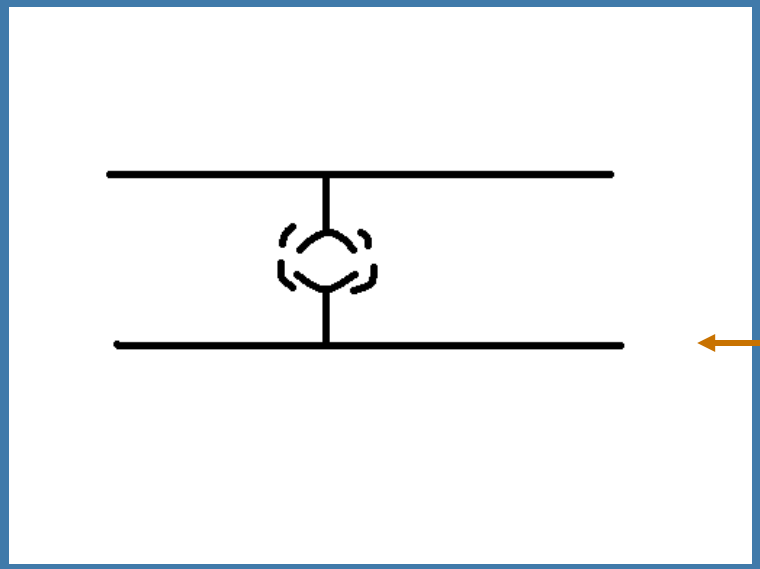
Agaricus bisporus, the supermarket mushroom is a secondary homothallic species

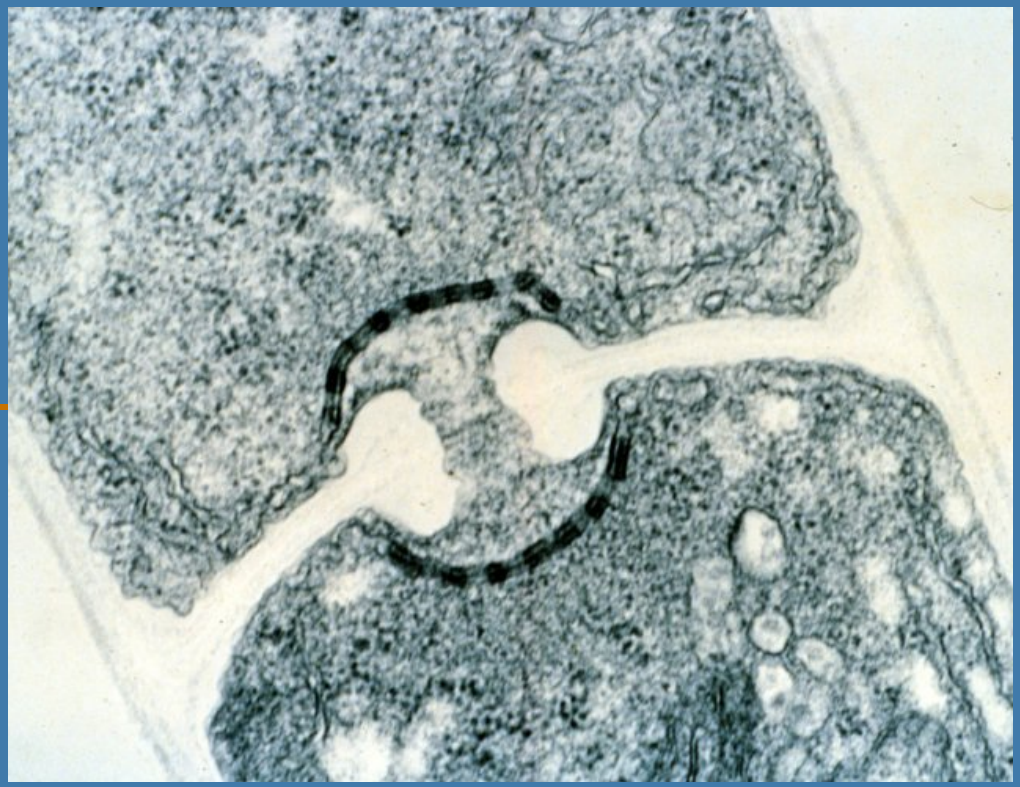


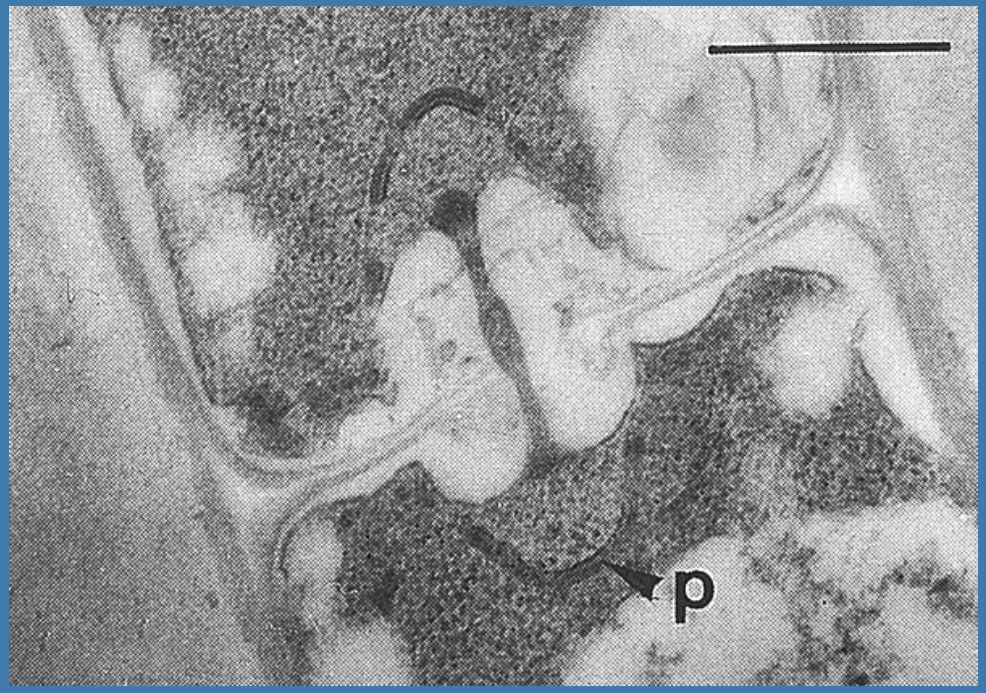


Septal pores--Basidiomycota

- Dolipore septa, septal pore caps or parenthosomes



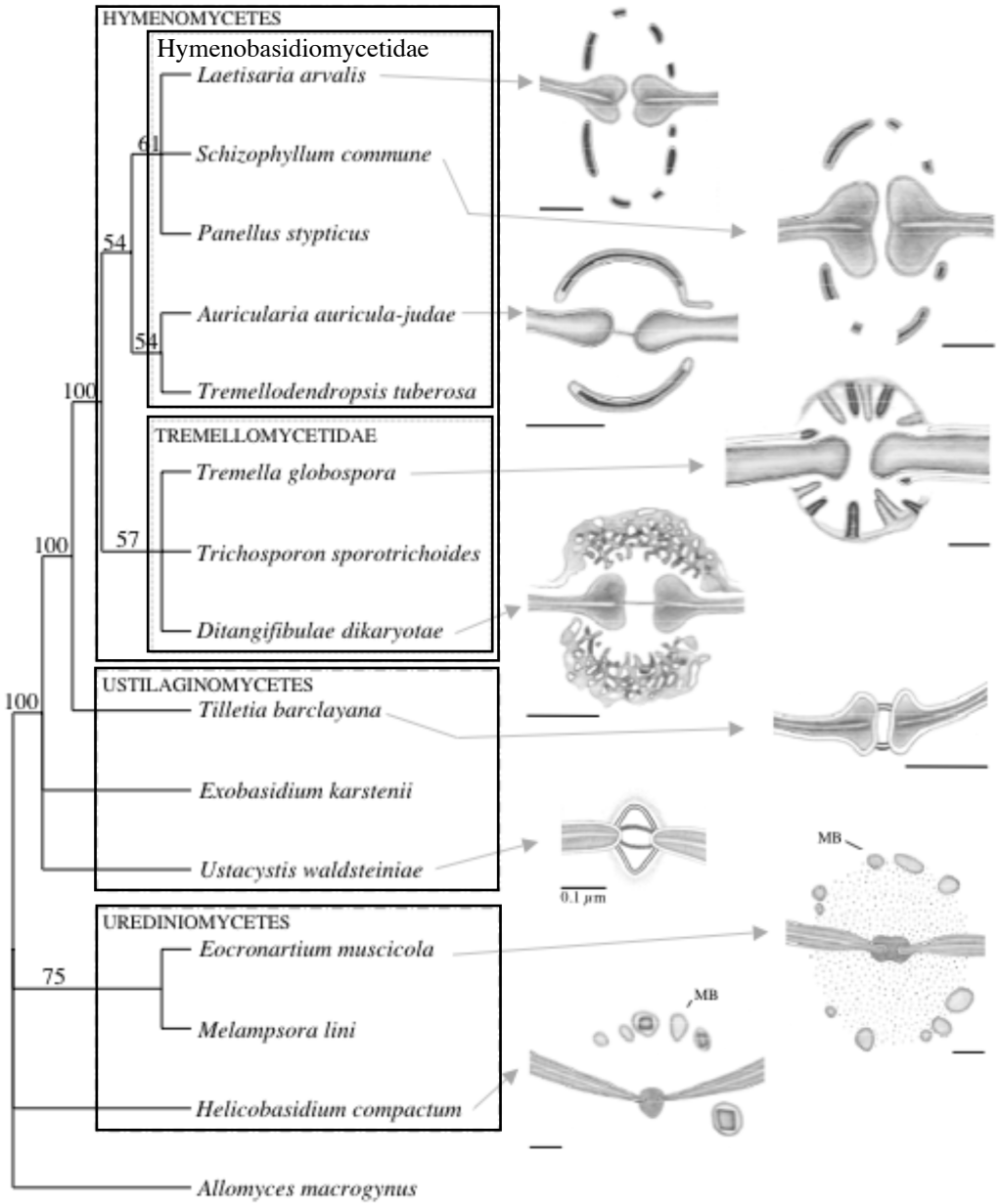




Basidiomycete dolipore septa showing septal pore cap or parenthosome

Three Classes of Basidiomycota

Agaricomycotina	dolipore septum holobasidia and phragmobasidia
Ustilaginomycotina	smut septum or "simple dolipore" phragmobasidia teliospores
Pucciniomycotina	simple septum phragmobasidia teliospores



Agaricomycotina

Hymenomycetes
- -dolipore septa
- -perforated and nonperforated septal pore cap

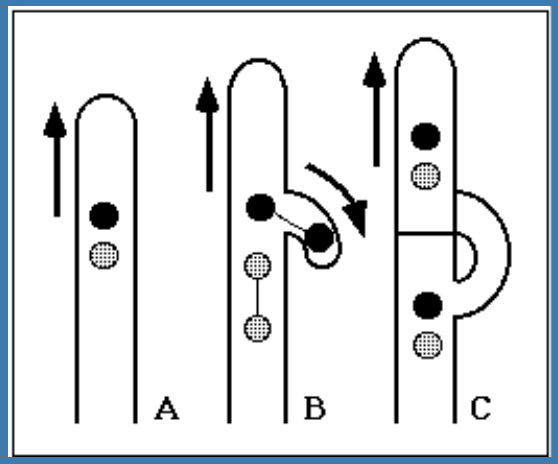
Ustaliginomycotina

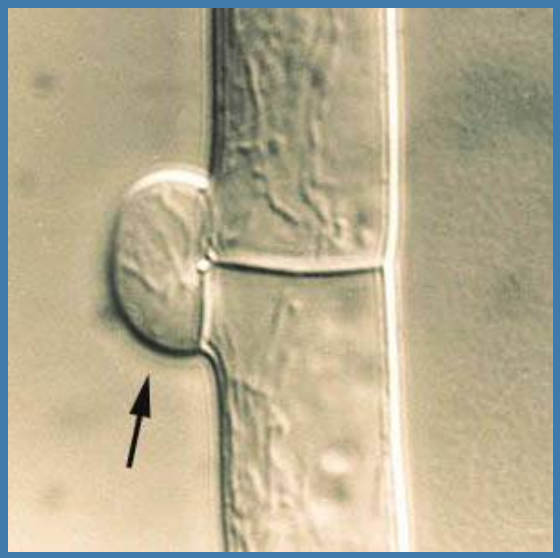
- -"smut" septa
- -no septal pore cap

Pucciniomycotina

- -simple septa, not dolipore
- -no septal pore cap
- -septal pore occlusions

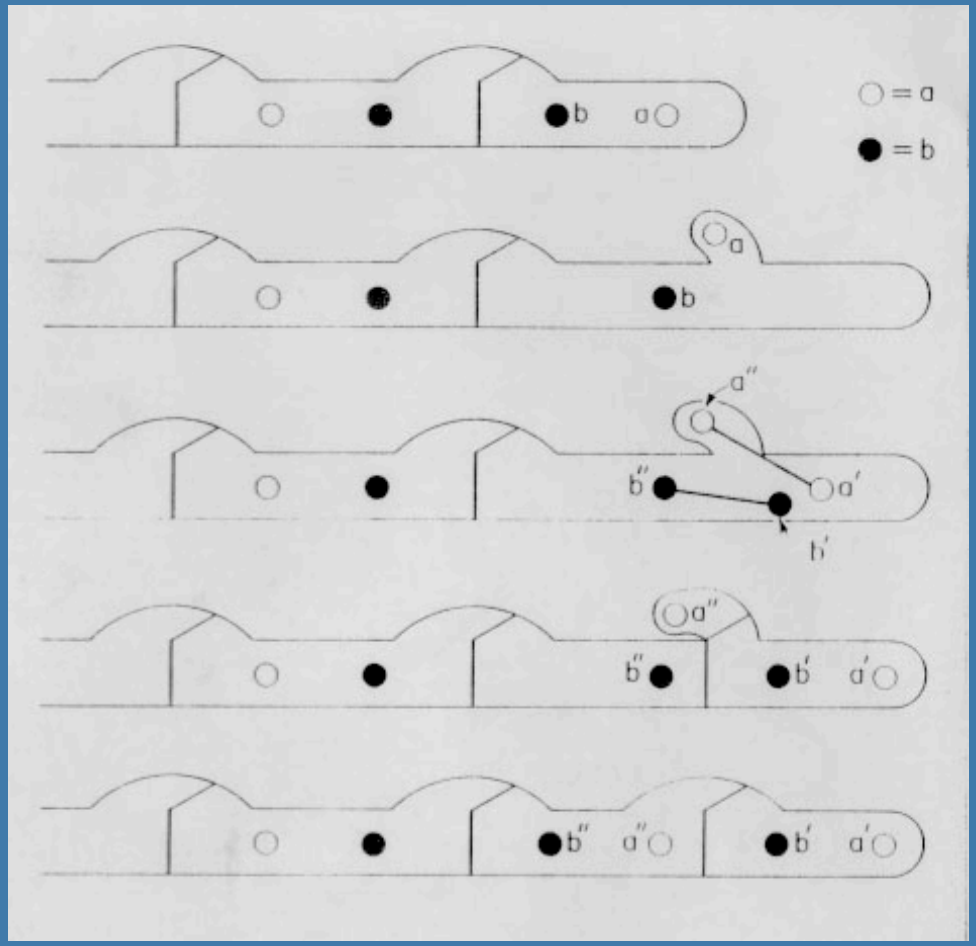
8. Clamp connections, secondary mycelium





Clamp connection -
Hyphal outgrowth which, at cell division, makes a connection between the resulting two cells by fusion of the distal cell with the proximal cell.

8. Clamp connections



A locus controls:

- Specific nuclear pairing
- Initiation of clamp
- Separation of clamp by septum

Compatibility at A locus only gives "barrage" reaction:

Nuclear pairing and initiation of clamp only

B locus controls:

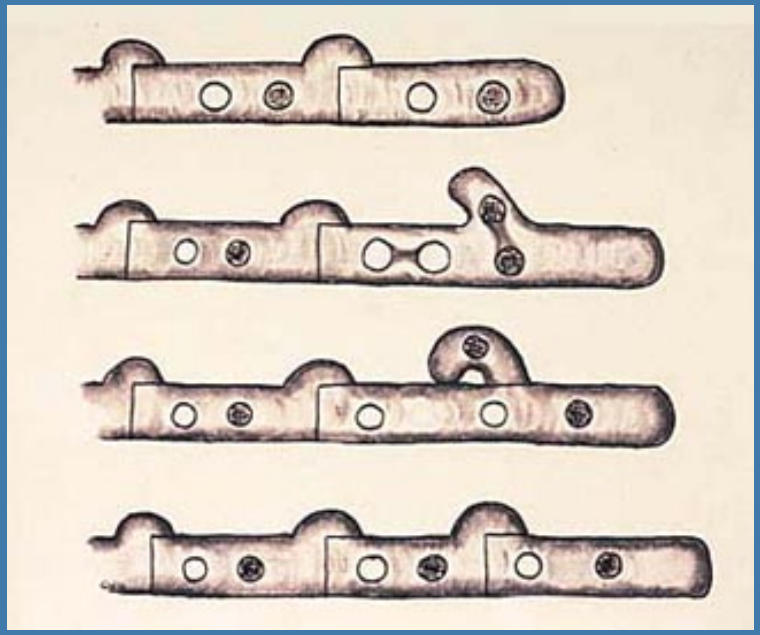
- Septal breakdown
- Nuclear migration

Compatibility at B locus only gives "flat" reaction:

Nuclear migration occurs, but no clamp initiation

9. Dikaryon

Dikaryon – Cells have two genetically distinct, sexually compatible, haploid nuclei



When a haploid monokaryotic mycelium (primary mycelium) meets another haploid mycelium of the same species, and they are sexually compatible (complementary mating types), the two mycelia fuse and each cell receives a nucleus from the other mycelium. This process is called dikaryotization. The resulting dikaryotic mycelium is called the dikaryophase or secondary mycelium

Basidiocarps

- **Shape**
  - **Resupinate—appressed to substrate, hymenium exposed**
  - **Pileate—upper portion sterile, hymenium on lower surface**
  - **Coraloid—hymenium covering entire basidiocarp**
- **Growth form**
  - **Annual**
  - **Perennial**
- **Texture**
  - **Soft/fleshy**
  - **Woody**
  - **Papery**
  - **Cartilaginous**

Orders of Agaricomycotina

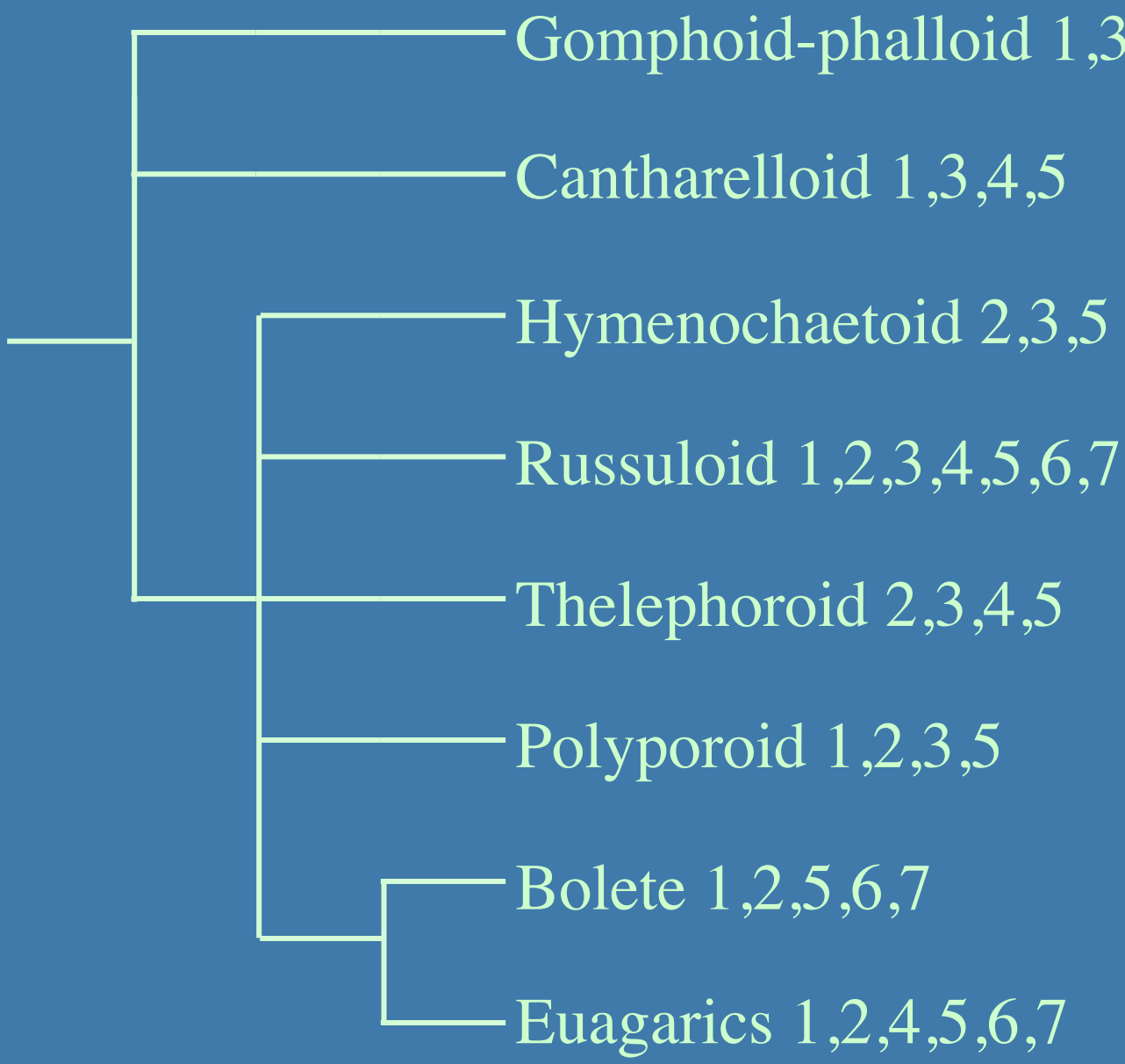
Basidia divided by septa:
"Jelly fungi"--Auriculariales, Ceratobasidiales, Dacrymecetales, Filobasidiales, Tremellales, Tulasnellales

Basidia not divided by septa (homobasidiomycetes):
Agarics--Agaricales, Boletales, Cantharellales, Phallales, Polyporales, Russulales, Thelephorales

"Aphyllophorales" Polyphyletic group of non gilled hymenomycetes usually including the Thelephoraceae, Clavariaceae, Hydnaceae, Polyporaceae

"Gasteromycetes" Polyphyletic group of homobasidiomycetes that do not have active spore discharge. Both epigeous and hypogeous

Homobasidiomycetes--holobasidia eight clades



Sporocarp/hymenium type

1 gills
2 poroid
3 toothed
4 club
5 crust
6 gasteromycete epigeous
7 truffle hypogeous

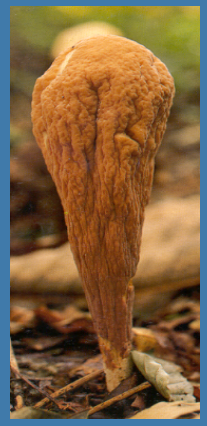
Sporocarp characters are not reliable indicators of phylogeny!

Gomphoid-phalloid clade

Gomphales

Ramaria

Gomphus

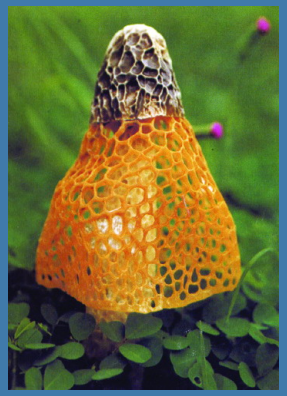


Clavariadelphis

Phallales

Phallus

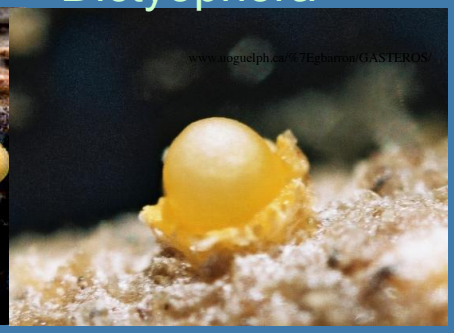
Hysterangium



Dictyophora

Geastraceae

Geastrum



Sphaerobolus

Cantharelloid clade

Hydnaceae

Cantharellaceae

Hydnum

Clavulina

Multiclavula

giechgroup.hp.infoseek.co.jp/kinoko/

Cantharellus

Craterellus

Tulasnellales

Botryobasidium

phragmobasidia

Hymenochaetoid clade

Coltricia

Hyphodontia

Thelephoroid clade

Thelephora

Sarcodon

Tomentella

Russuloid clade

Russula

Aleurodiscus

Auriscalpium

Gymnomyces

Bondarzewia

Polyporoid clade

Polyporus

Fomitopsis

Phanerochaete

Lentinus

Daedalea

Sparassis

Bolete clade

Boletus

Gomphidius

Rhizopogon

Scleroderma

Astreus

Serpula

Hygrophoropsis, a gilled mushroom, also belongs to the bolete clade

Euagaric clade

Agaricus

Cyathus

Tulostoma

Fistulina

Hydnangium

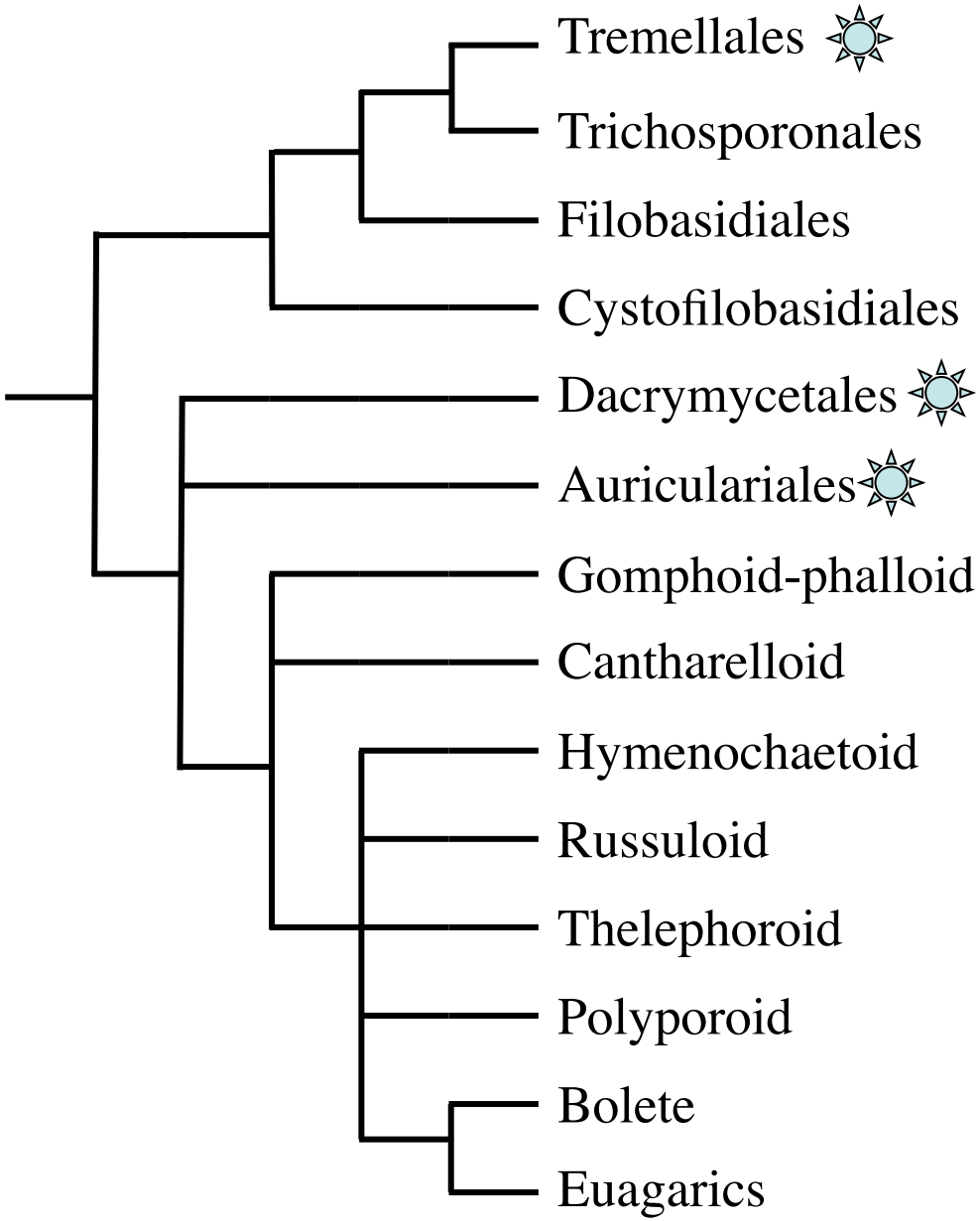
Lycoperdon

Mycena

Clavaria

Athelia

Hymenomycetes



"Jelly Fungi"

phragmobasidia

Tremella

Pseudohydnum

holobasidia

Dacrymyces

Auricularia

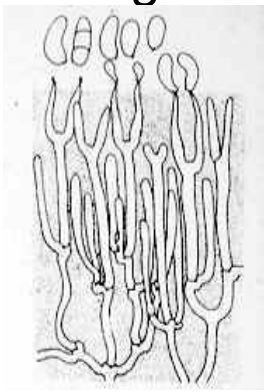
Basidiomycota

Holobasidiomycetes – nonseptate basidia

Hymenomycetes

Dacrymycetales –jelly fungi

- "tuning fork" basidia - aseptate, deeply forked, two sterigmata



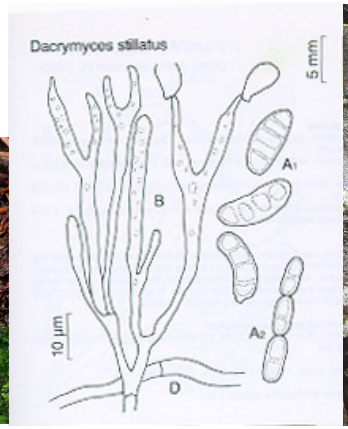
- Basidiospores become septate
- Formation of secondary basidiospores
- Basidiospores germinate directly or indirectly

- Cause brown rot of wood
- Basidiocarps of many species yellow, orange

Common Genera

Dacrymyces

– Cushion-shaped basidiocarps



Calocera

– Narrow, tapering basidiocarps, occasionally branched

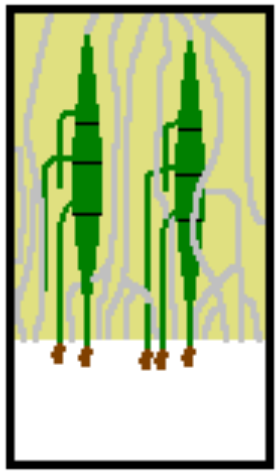
Calocera viscosa, Klebriger Hörnling © www.mykonet.ch

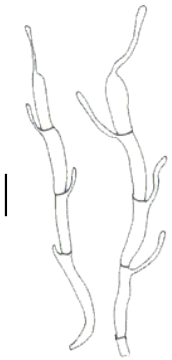
Guepiniopsis

– Small, stalked basidiocarps with cup-like head

Basidiomycota-Hymenomycetes
Phragmo/Heterobasidiomycetes
Tremellales – Jelly fungi
Auriculariales – Wood-ears

- Basidiocarps somewhat ear-shaped and grow on wood; gelatinous or rubbery
- Hymenial layer is smooth, semi-glossy, on the undersurface; basidia are embedded with ends of the sterigmata (and the spores) extending beyond the surface
- Phragmobasidia of two types (transversely or cruciately septate); sterigmata are hyphal-like; basidiospores become septate, may germinate indirectly
- Most members are saprotrophs, grow on dead wood





Common taxa

Auricularia

- Basidia transversely septate; sterigmata hyphal-like
- Common on decaying logs
- Cultivated, often sold dried; common in Asian/Chinese cuisine