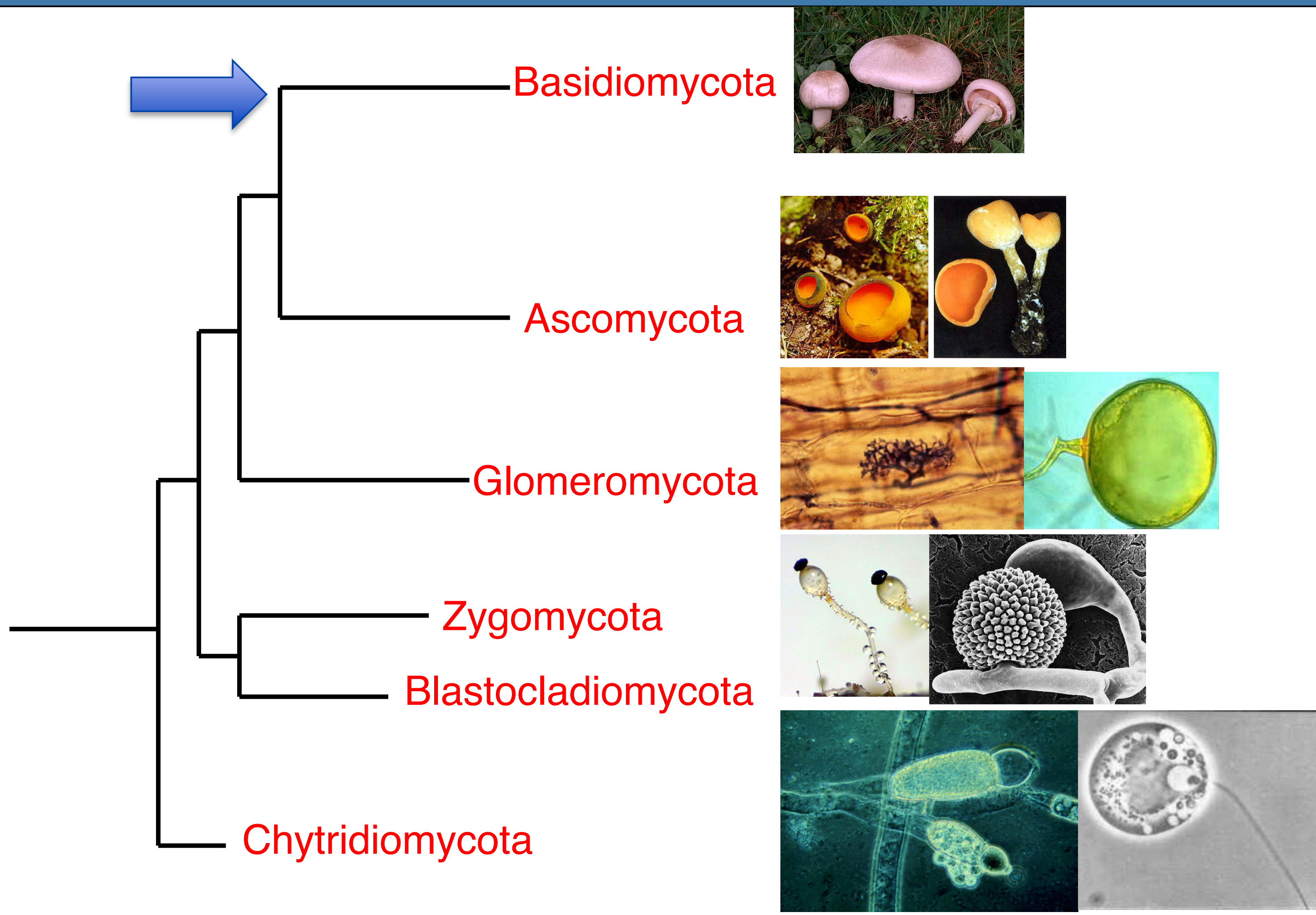
3. Basidiomycota: Life cycle and mating systems

Phyla of Fungi



Basidiomycota ~31,500 species

Diverse ecologies:

- Saprobes/decomposers/wood decay
- Plant parasites/pathogens
- Animal and human pathogens
- Insect parasites/symbionts
- Mycorrhizal plant symbionts
- Nematode trappers/predators

Diversity in structures

- Yeast (single cell) and filamentous forms
- Mushrooms, clubs, corals, stinkhorns, puffballs
- Perennial conks (polypores)
- Resupinate crusts (on decaying wood)
- Jelly fungi
- Truffles (hypogeous)
- Plant galls

Phylum Basidiomycota

- basidiomycetes— common name for this phylum and no longer carries any formal taxonomic significance
- Basidiomycota (phylum) characterized by having meiospores called basidiospores that are formed on specialized cells, basidia (sing. basidium), the site of meiosis

- Three subphyla recognized

Current name (subphyla)	Names used in Webster (classes)
– Agaricomycotina	(Homobasidiomycetes)
– Ustilaginomycotina	(Ustilaginomycetes
– Pucciniomycotina	(Urediniomycetes)

Terminations of taxon names indicate rank

3 Major Clades - Subphyla - of the Basidiomycota

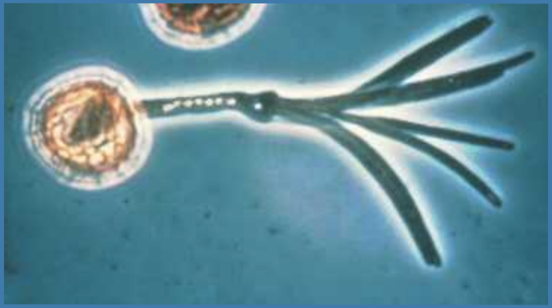
Agaricomycotina
mushrooms, polypores, jelly fungi, corals, chanterelles, crusts, puffballs, stinkhorns

Ustilaginomycotina
smuts, *Exobasidium*, *Malassezia*

Pucciniomycotina
rusts, *Septobasidium*

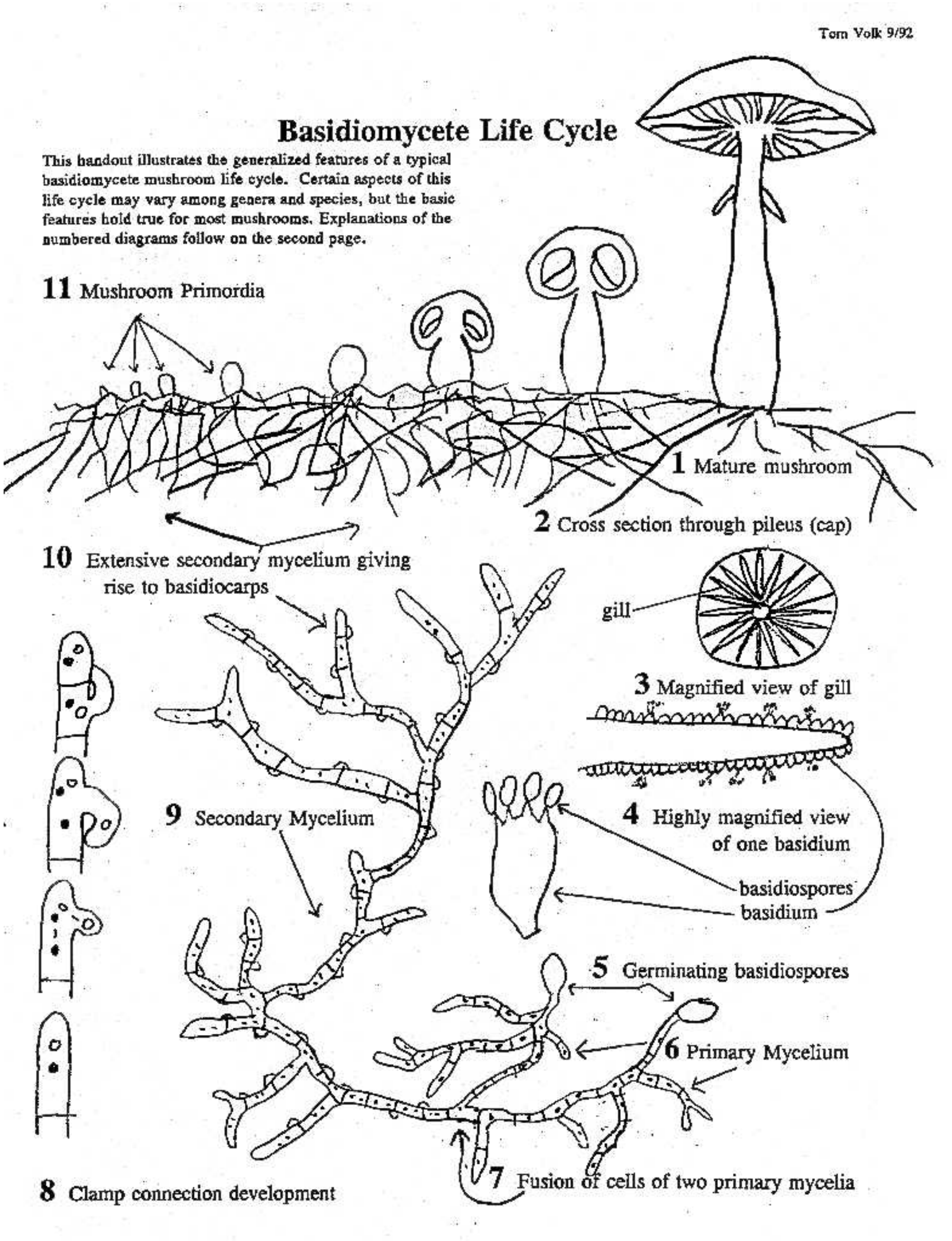
Three Subphyla of Basidiomycota

Agaricomycotina (Hombasidiomycetes)
Agaricales, Boletales, Russulales, Cantharellales - mushrooms
Gomphales, Phallales - coral, club fungi, stinkhorns
Hymenochaetales, Polyporales - polypores
Auriculariales, Dacrymycetales & Tremellales - jelly fungi
Geastrales – earth stars



Ustilaginomycotina (Ustilaginomycetes)
Ustilaginomycetes (smuts) - plant pathogens
Exobasidiomycetes –*Exobasidium* - plant pathogens
Malassezia – mammalian skin yeasts

Pucciniomycotina (Urediniomycetes)
Pucciniomycetes, Pucciniales (=Uredinales, rusts)
- plant pathogens
Septobasidiales (crusts) - insect parasites
Microbotryomycetes – plant pathogens



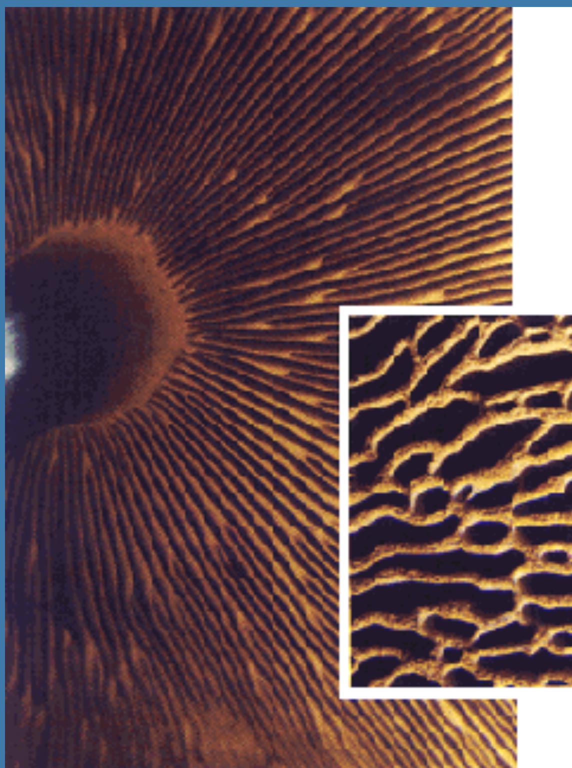
Major stages of Agaricomycete life cycle

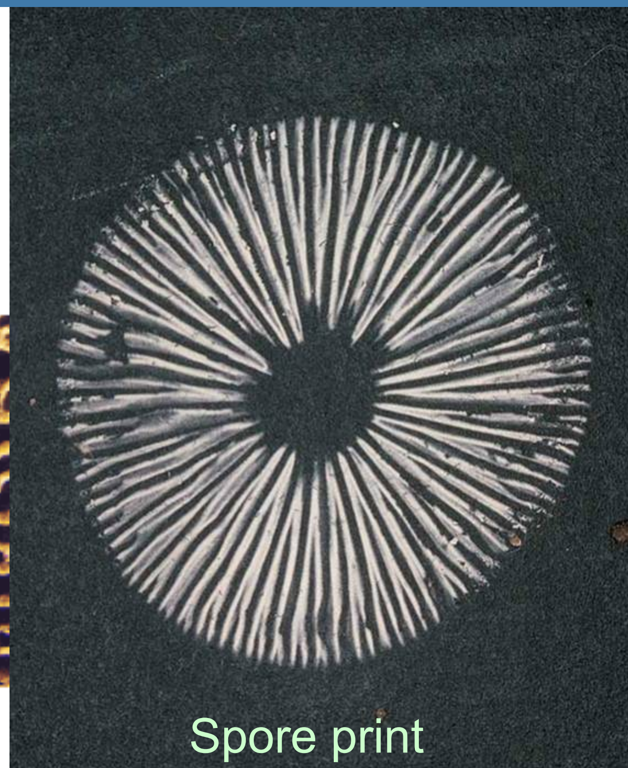
1) <u>Sporocarp</u>
2) Gilled Hymenophore
3) Hymenium
4) Basidium
5) Basidiospore
6) Monokaryon
7) Fusion of monokaryons
8) Clamp connections
9) Dikaryon
10) Mycelium
11) Sporocarp primordia

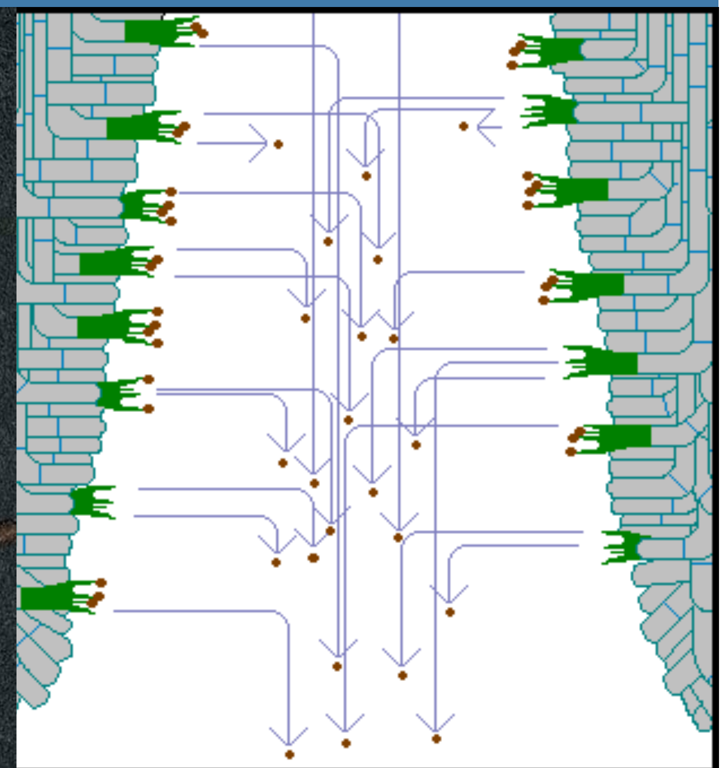
1. Sporocarp

Sporocarp – general term for macroscopic fungal reproductive structure, “fruiting body”
Basidiocarp – term for sporocarp of the basidiomycetes
Basidiome(ata) - formal term used to designate basidiomycete sporocarp(s)
Hymenophore – a basidiocarp with a <u>hymenium</u> (layer of fertile cells)

2. Gilled hymenophore







Gills increase surface area for spore production up to 20 times that of a flat surface

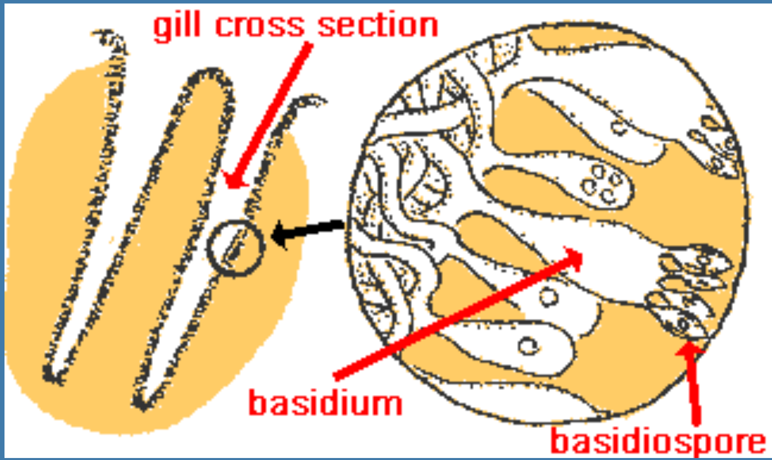
Spacing of lamellae in gilled sporocarps varies by species
May have ony primary lamellae, or additional levels, secondary, tertiary

3. Hymenium

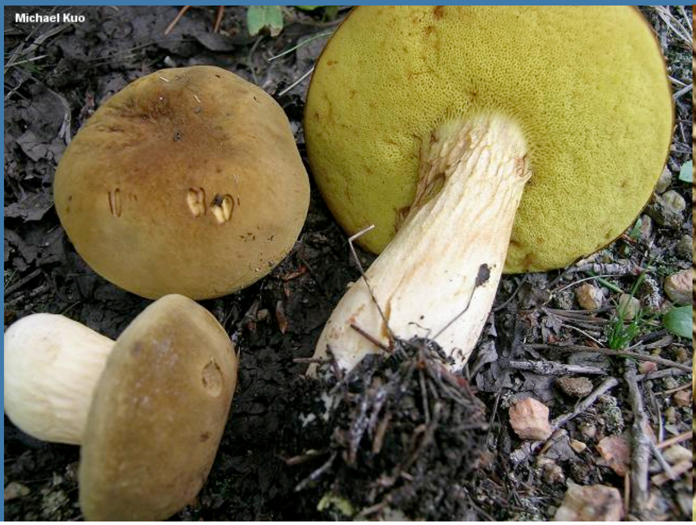
The tissue layer that contains the reproductive cells (basidia) and sterile supporting cells (cystidia).

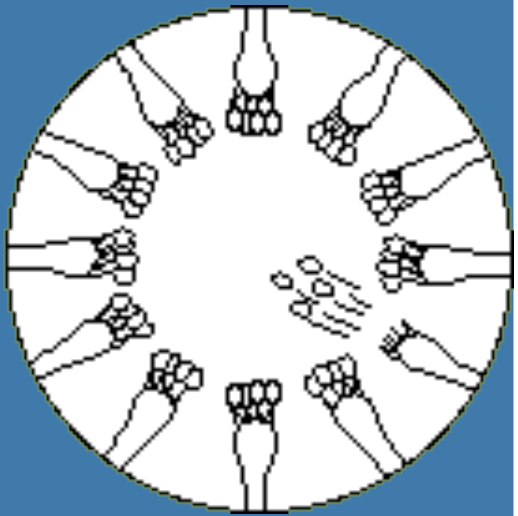
Gill





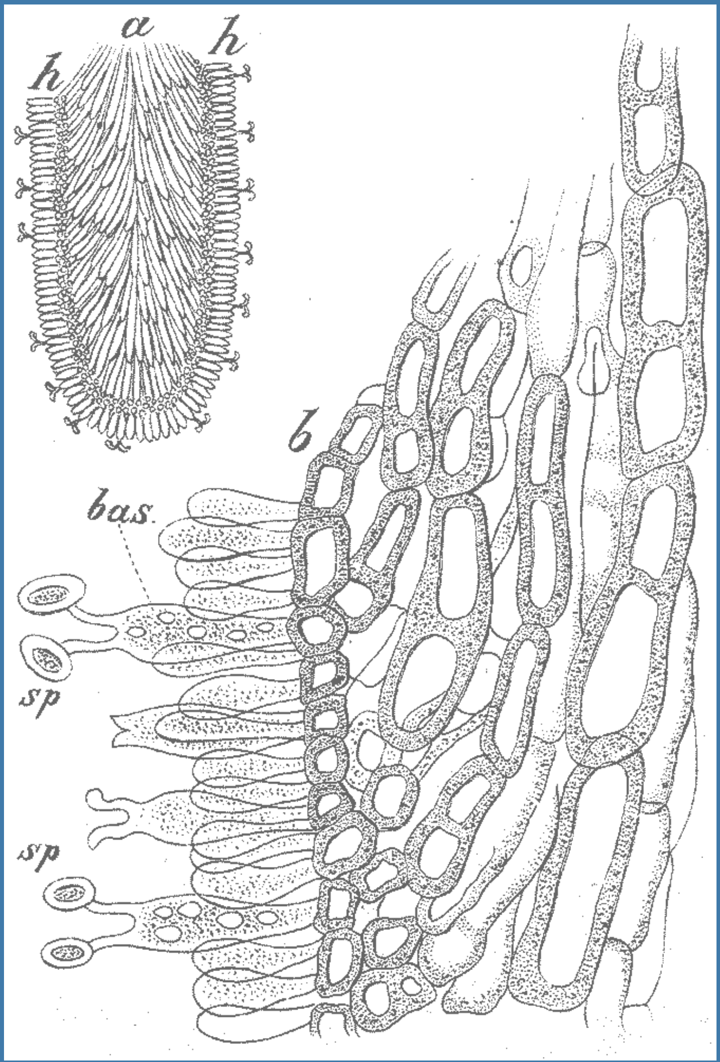
Pore



Hymenium

- Term for the organized tissue layer that produces basidiospores
- Basidia
- Basidioles
  - Cells resembling basidia that have not produced basidiospores
- Cystidia
  - Larger than other hymenial elements
  - Variety of shapes—taxonomically useful
  - Function not known



Hymenium/hymenophore

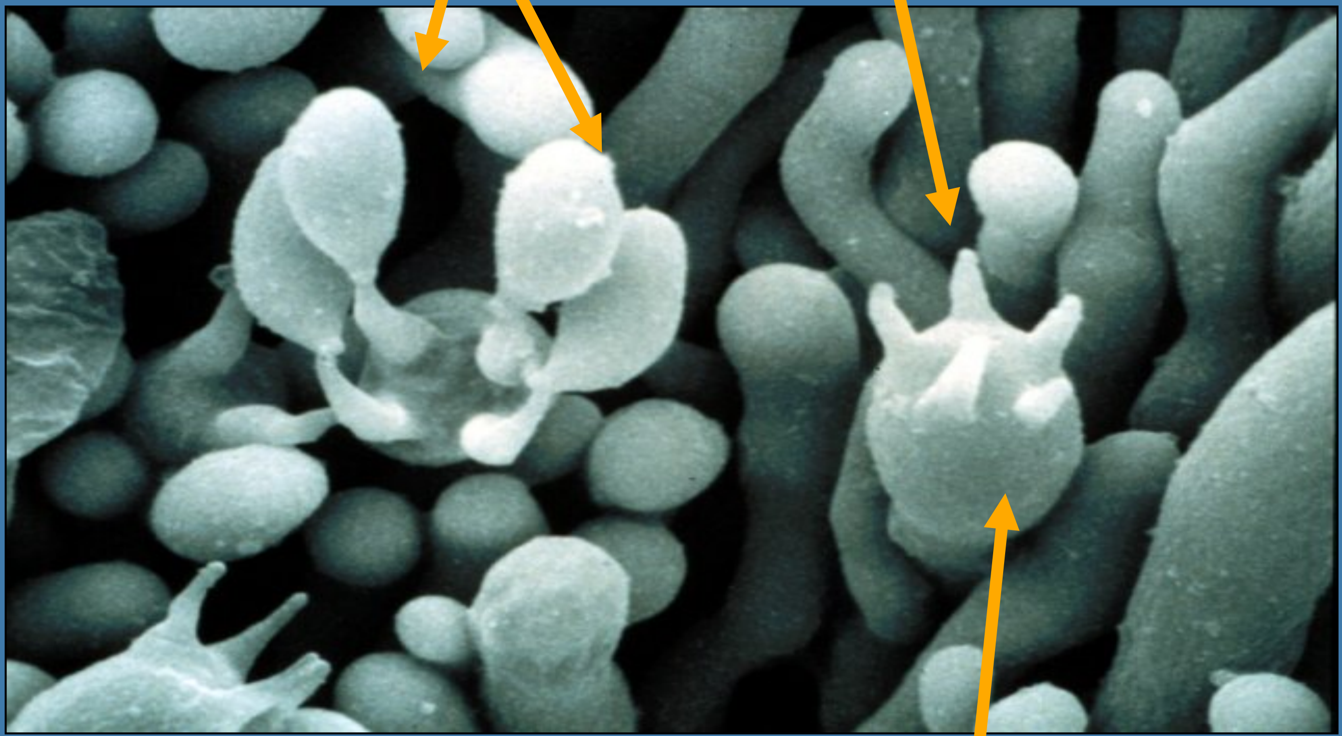
- Polypores—hymenium lining pores or tubes
- Chanterelles—hymenium on gill-like folds
- Toothed fungi—hymenium on small spines
- Coral fungi—erect basidiocarps, hymenium covering surface
- Corticioid fungi (resupinate)—smooth or wrinkled hymenium
- Agarics—hymenium on “gills” or lamellae
- “Jelly fungi” smooth or wrinkled hymenium



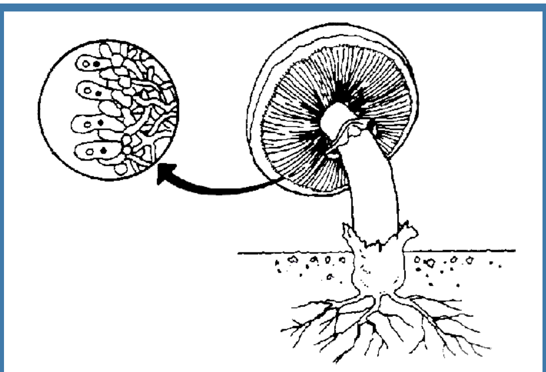




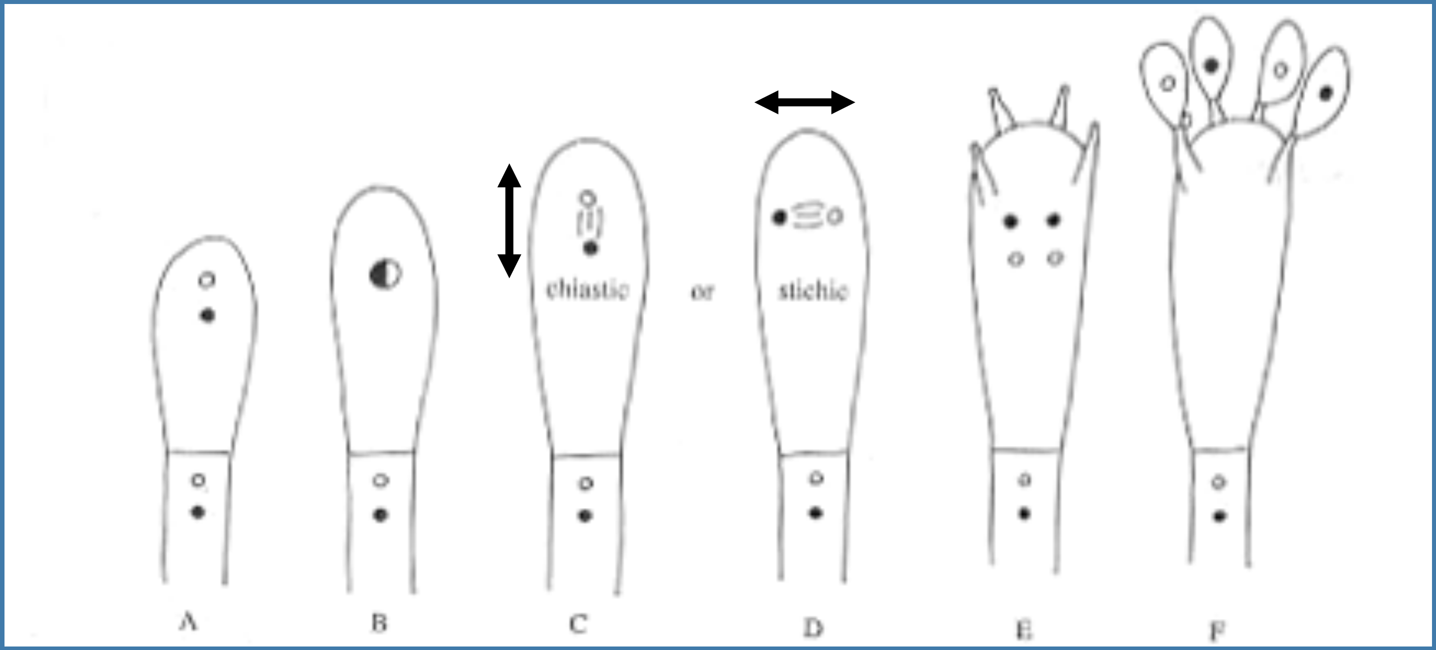

4. Basidium



4. Basidium

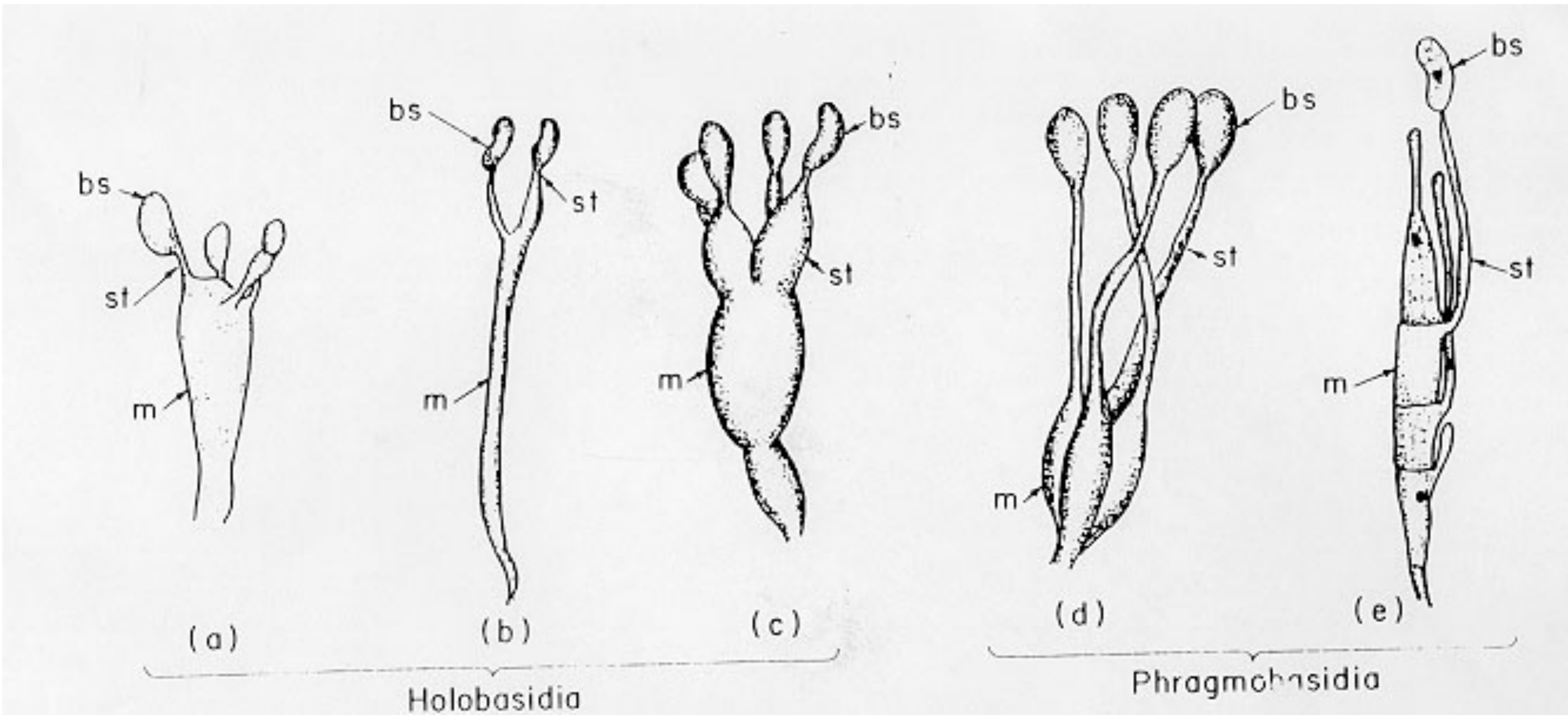


- Defining structure of the Basidiomycota
- Site of meiosis; products are basidiospores
- Usually located in specialized regions or tissues (hymenium)



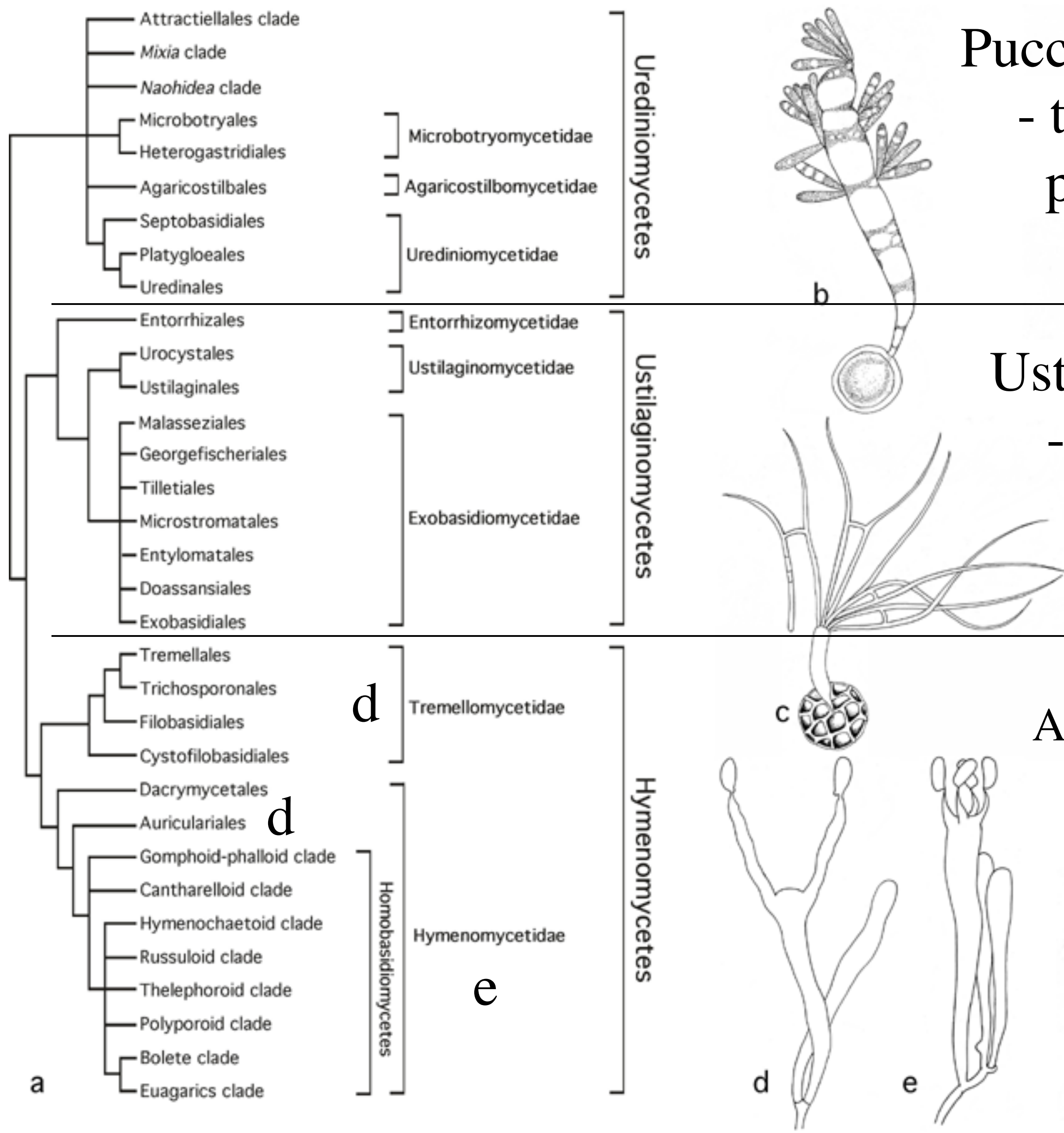
dikaryon karyogamy Meiosis I Meiosis II Migration of haploid nuclei into basidiospores

Types of basidia



Holobasidia: basidium not divided by septa

Phragmobasidia:
Basidium divided by one or more septa, transverse or cruciate

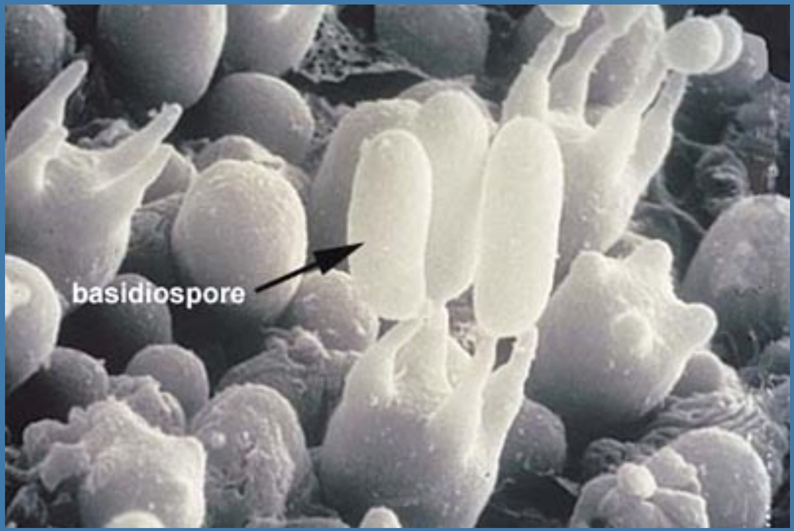


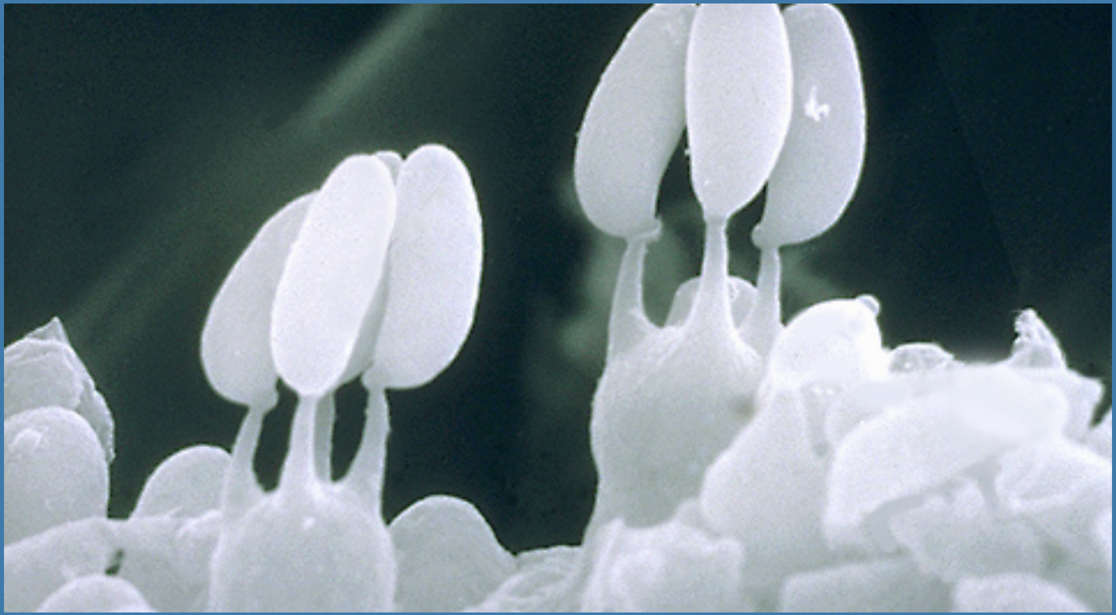
Pucciniomycetes (e.g. rusts)
- teliospore with
  phragmobasidium (b)

Ustilaginomycetes
- teliospore with
  phragmobasidium (c)

Agaricomycetes
- phragmobasidium (d)
  in ‘jelly fungi’--
  Tremellomycetes
- holobasidium (e)
  in Homobasidiomycetes

5. Basidiospore



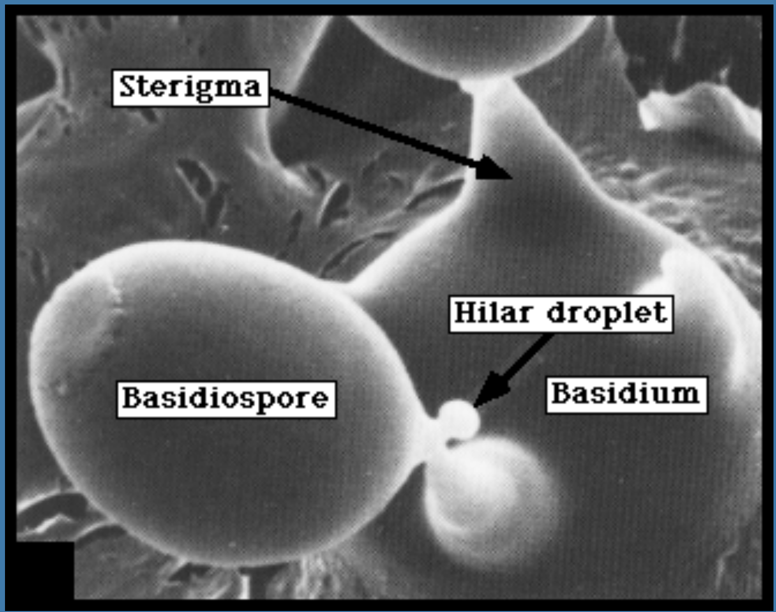


Note that basidiospores are attached asymmetrically

5. Basidiospore

Dissemination: “surface tension catapult”

1. hygroscopic substances secreted near hilar appendix, cause water condensation, hydrophobic wall region keeps drops apart
2. fusion of Buller’s drop and adaxial drop causes rapid displacement of the center of mass of the spore
3. this exerts a force that is opposed by the sterigma
4. the spore is projected away from the sterigma



Buller’ s Drop

A. H. Reginald Buller

Researches on Fungi 1909

Studied spore liberation, genetics and pretty much everything about fungi,
and wrote scientific limericks

There was a young lady named Bright
Whose speed was far faster than light;
She set out one day,
In a relative way
And returned on the previous night.

To her friends said the Bright one in chatter,
"I have learned something new about matter:
My speed was so great,
Much increased was my weight,
Yet I failed to become any fatter!"

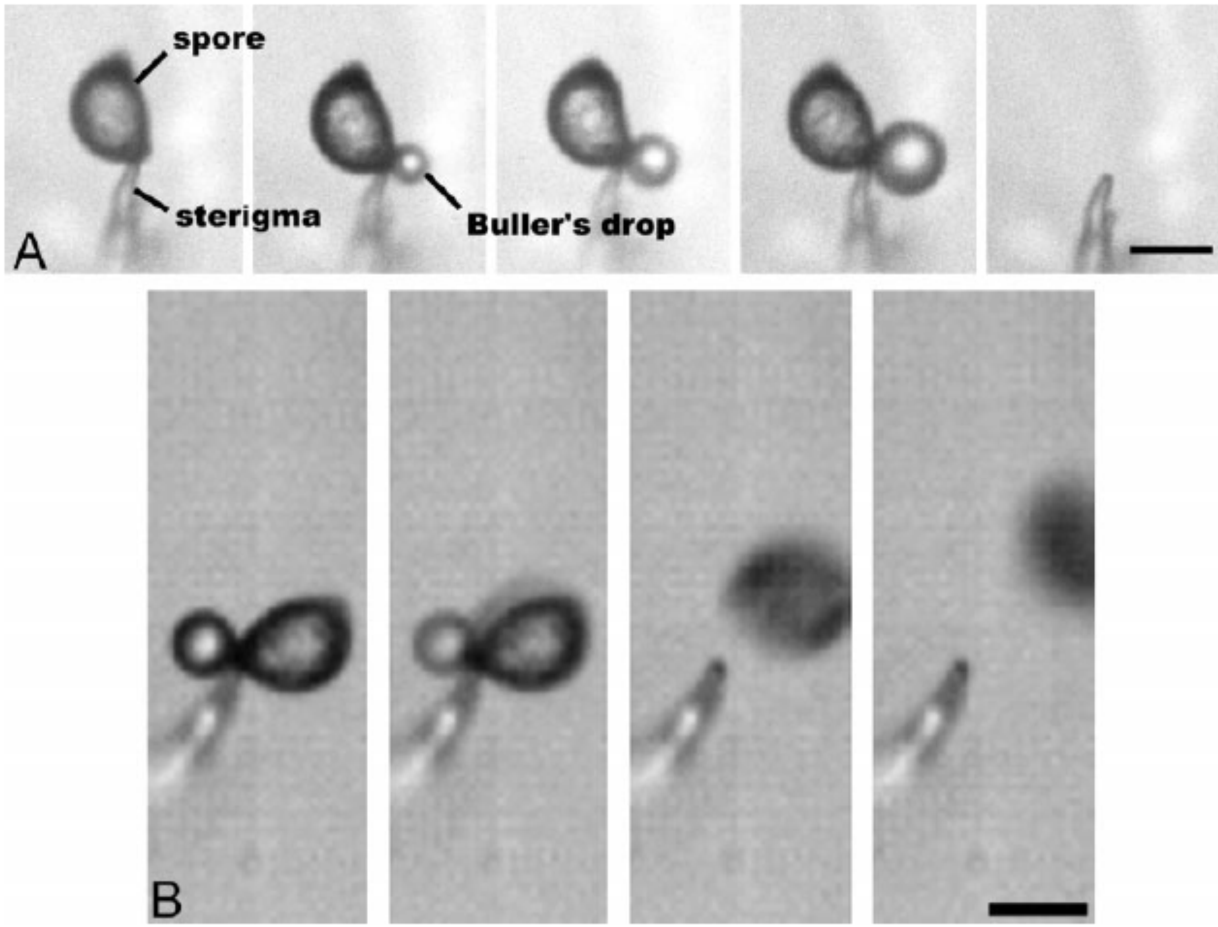
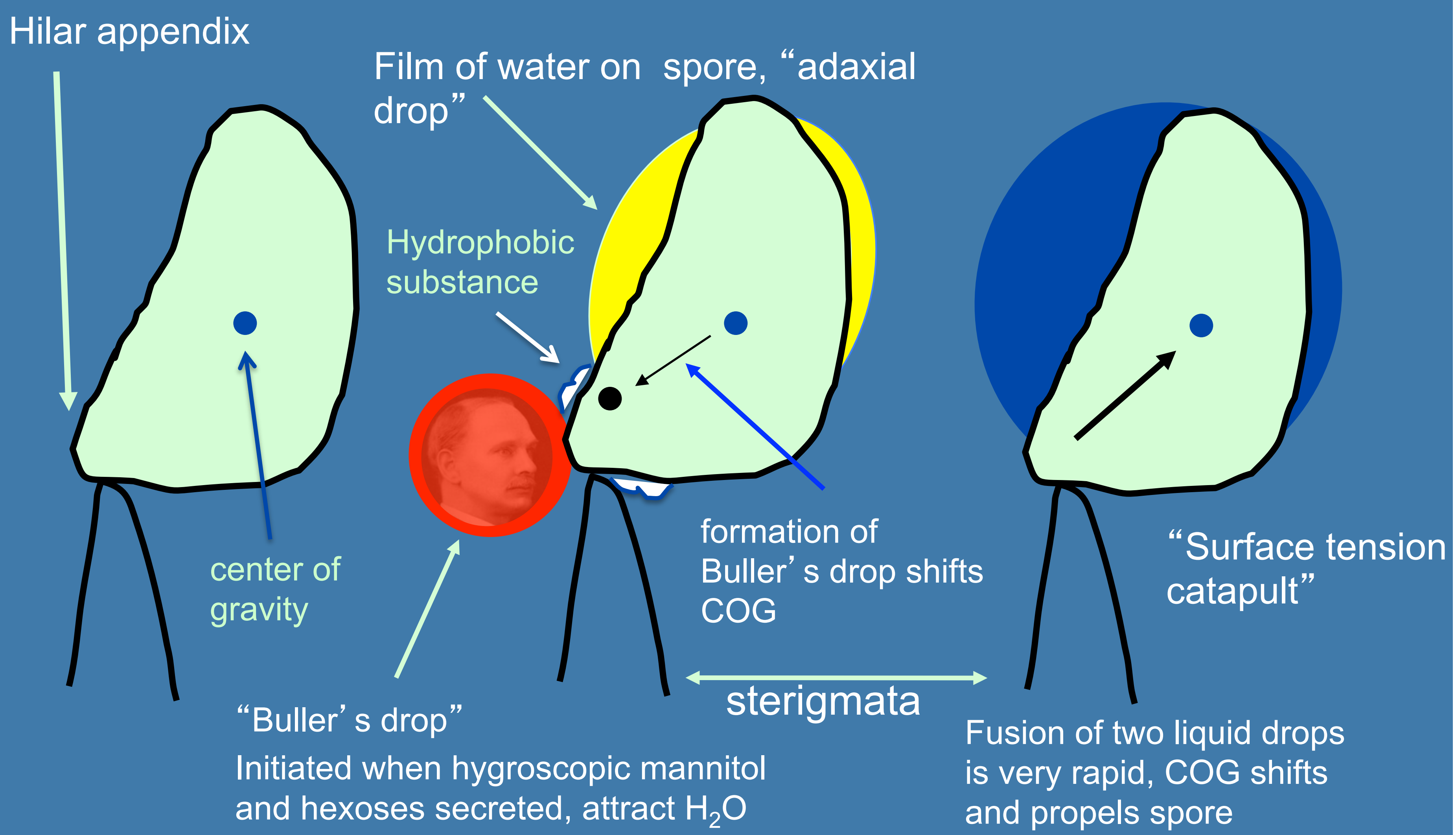
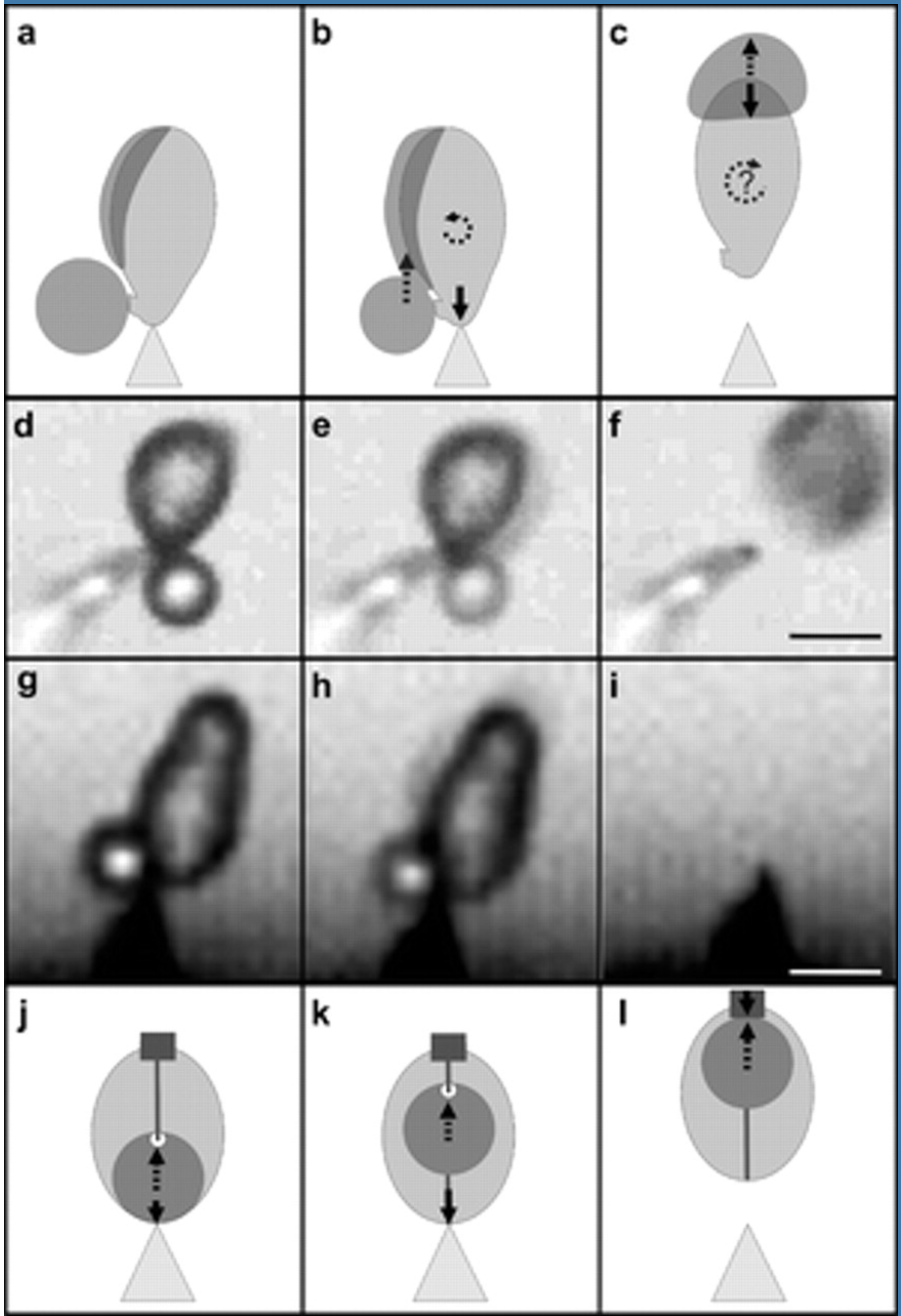


FIG. 1. a. Mechanism of ballistospore discharge in *I. perplexans* as captured using conventional still photomicroscopy. Successive images separated by 10 s show the growth of Buller's drop and simultaneous disappearance of drop and spore from sterigma in final frame (scale bar 10 μm). Photographs courtesy of John Webster. b, Images of Buller's drop and the ballistospore using ultra high speed video. Successive images separated by 10 μs (scale bar 10 μm).

5. Basidiospore

Mechanism of propulsion: Buller's drop & surface tension

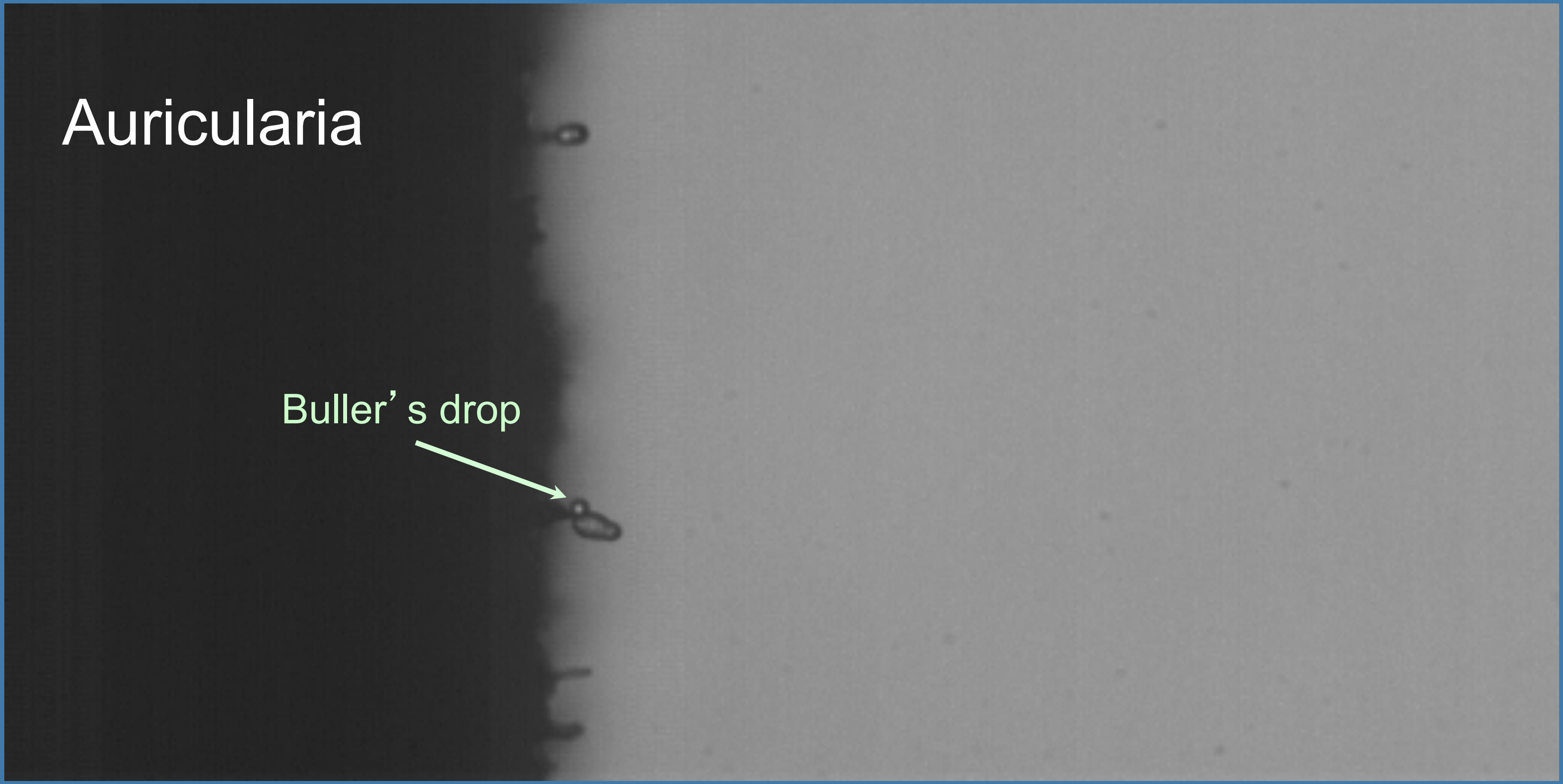




a: Buller's drop contains energy in the form of surface tension forces.
b: When Buller's drop touches the fluid on the side of the spore (the adaxial drop), the merging fluid flows rapidly toward the distal end of the spore
c: The collapsed drop and spore launch from the sterigma.
d–e: An oblique view of the spore and Buller's drop of *I. perplexans* (10 μs between each frame, scale bar 10 μm).
g–l; A lateral view of *A. auricularia* during ballistospore launch (50 μs between each frame, scale bar 10 μm).
j: the drop begins to collapse and surface tension energy is released.
l: surface tension forces cause the drop to stop abruptly and prevent the fluid from flying off of the spore. The abrupt deceleration delivers a directed and substantial force to the spore, and causes the spore and drop to eject away from the sterigma. The increasing drop momentum during its directed distal movement is critical for directing the spore away from the sterigma, and for delivering sufficient force for spore release.

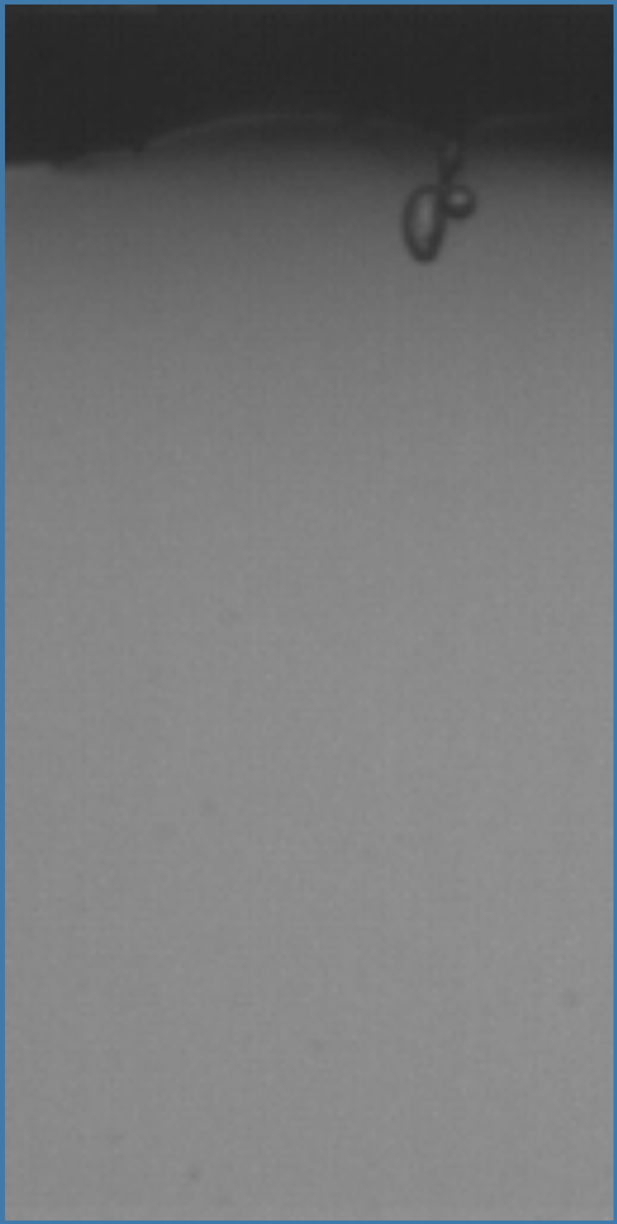
From: Pringle et al. 2005 Mycologia 97: 866-871

Basidiospore Release



From: Pringle et al. 2005 Mycologia 97: 866-871

High speed video micrographs of basidiospore release



From: Pringle et al. 2005 Mycologia 97: 866-871

How far and how fast can basidiospores travel?

Aleurodiscus species have the largest known basidiospores. *A. amorphus* spores are ~25 x 20 µm, *A. gigasporus* spores are up to 34 x 28µm.

Volume of a *A. gigasporus* spore would be 1.4×10^{-14} m^3

At a density of 1.2×10^3 kg per m^3, these spores would have a mass of about 17ng

Xerula radicata has the largest known spores of a gilled mushroom, 17 x 14 µm.

see Fischer et al 2010, Fungal Biology 114:669-675

How far and how fast can basidiospores travel?

Tectella patellaris has the smallest known basidiospores of a gilled basidiomycete, 3.7 x 0.7. *Hyphodontia latitans* has 3.5 – 5 x 0.5 – 0.8 µm spores.

At a volume of 0.5×10^{-19} m^3 these spores would have a mass of 0.6 pg (~10,000 times less than *A. gigasporus*).

How far and how fast can basidiospores travel?

Fischer et al. (Fungal Biology 114:669-675) used high speed video to measure the velocity of basidiospore discharge by large and small-spored species. To estimate distance traveled, drag force, air viscosity, spore radius and mass are the parameters needed.

Species	Spore size (µm)	Spore volume	Buller's drop radius (µm)	Est. spore mass (g)	velocity (m per sec)	range (mm), spore lengths
Aleurodiscus gigasporus	34 x 28	1.4×10^{-14}	8.3	1.9×10^{-8}	0.53	1.83, 54
Xerula radicata	17 x 14	1.6×10^{-15}	3.7	2.2×10^{-9}	0.70	0.58, 35
Trametes versicolor	5 x 2	1.4×10^{-18}	0.6	8.5×10^{-12}	0.68	0.01, 3
Hyphodontia latitans	4 x 0.6	1.4×10^{-19}	0.3	6.2×10^{-13}	1.05	0.004, 1

“Hymenomycetes” vs. “Gasteromycetes”

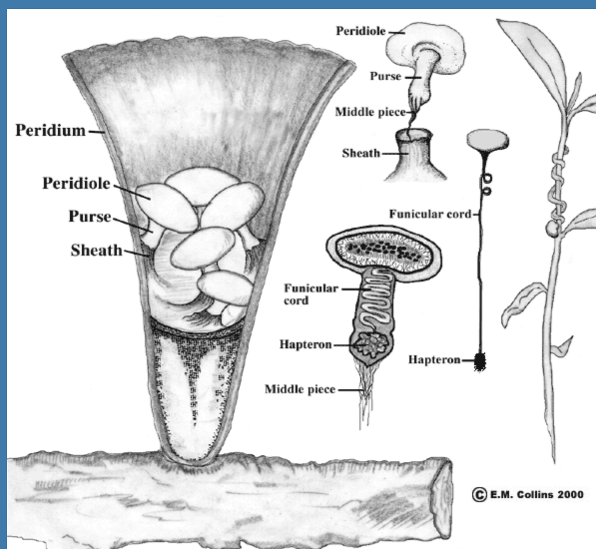
As used informally, both are polyphyletic.

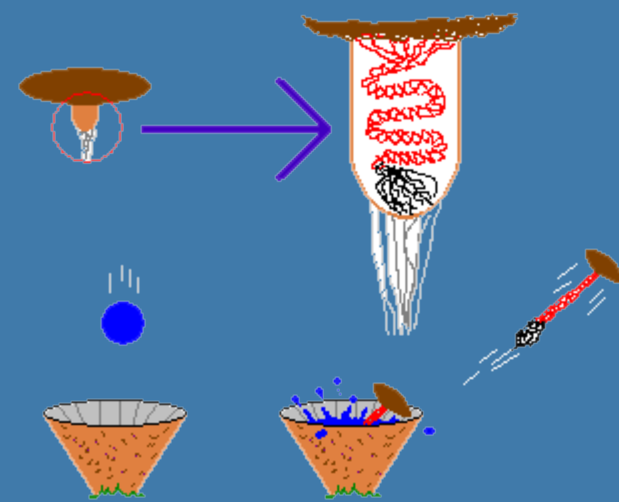
Hymenomycetes: general term for taxa having holobasidia and a definite hymenium that remains intact during sporulation
Hymenium exposed, gills, pores etc
Basidiospores actively discharged ballistospores

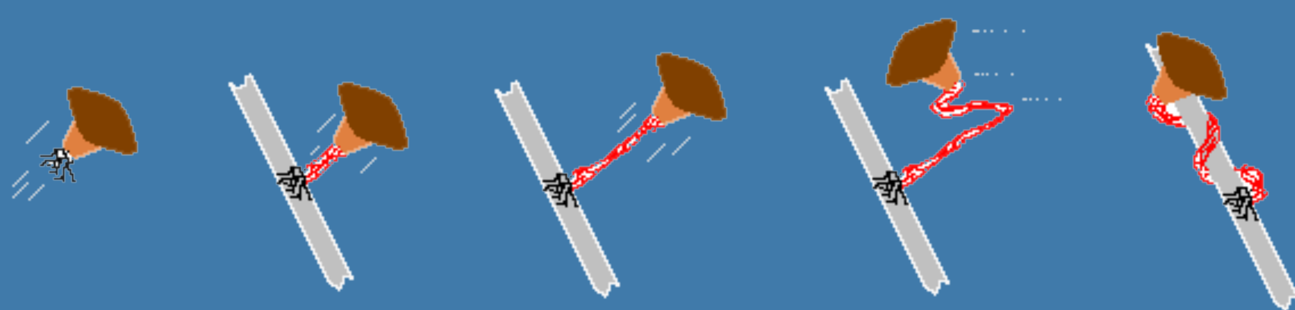
Gasteromycetes: No distinct hymenium present at time of basidiospore release
Closed basidiocarps
Basidiospores passively discharged
Included in Class Agaricomycotina

5. Basidiospore

Dissemination: Passive (rain drop)
Bird's nest fungus





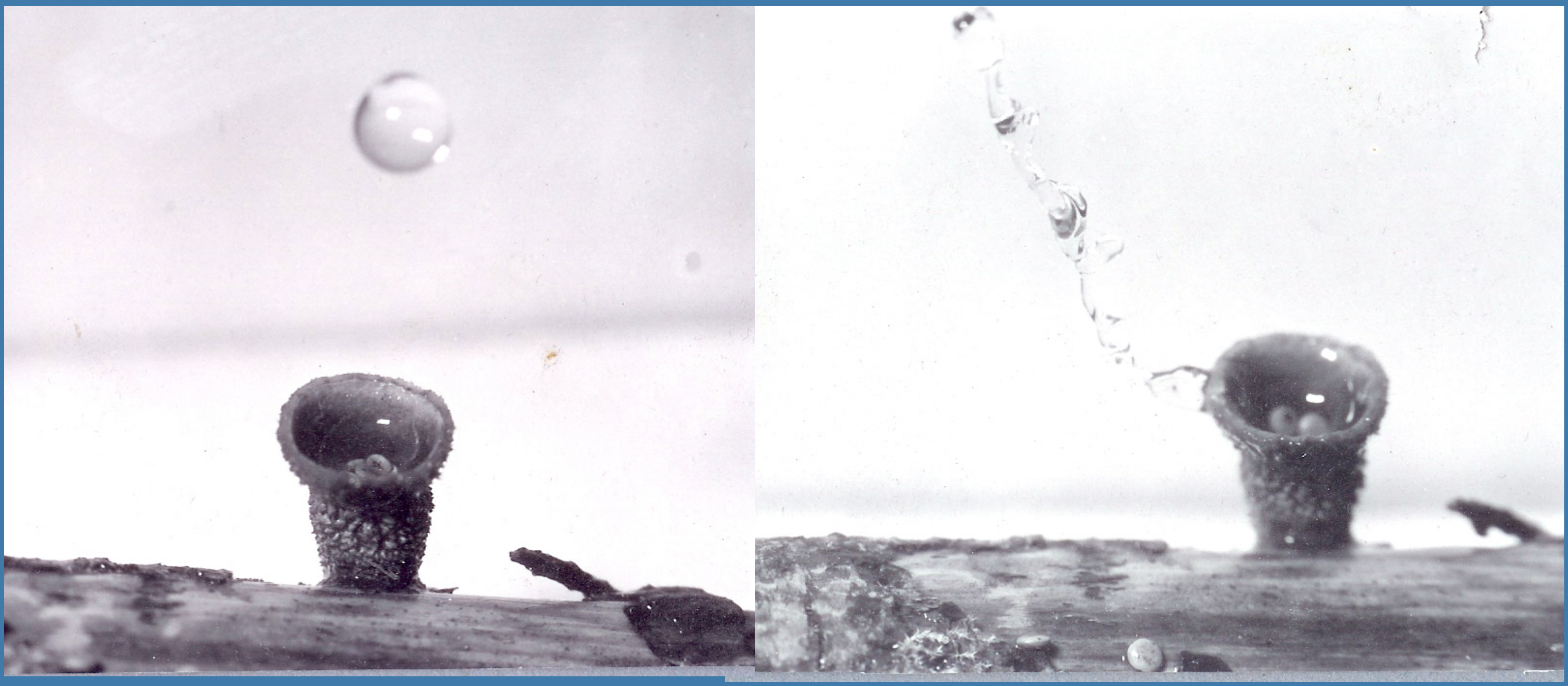


Common taxa

Crucibulum

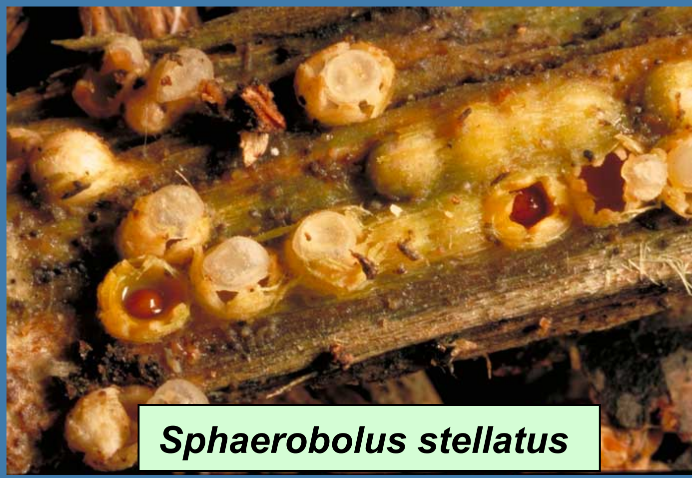
– Cup-shaped, dull white peridioles, funiculus

Expulsion of peridiole by a water drop

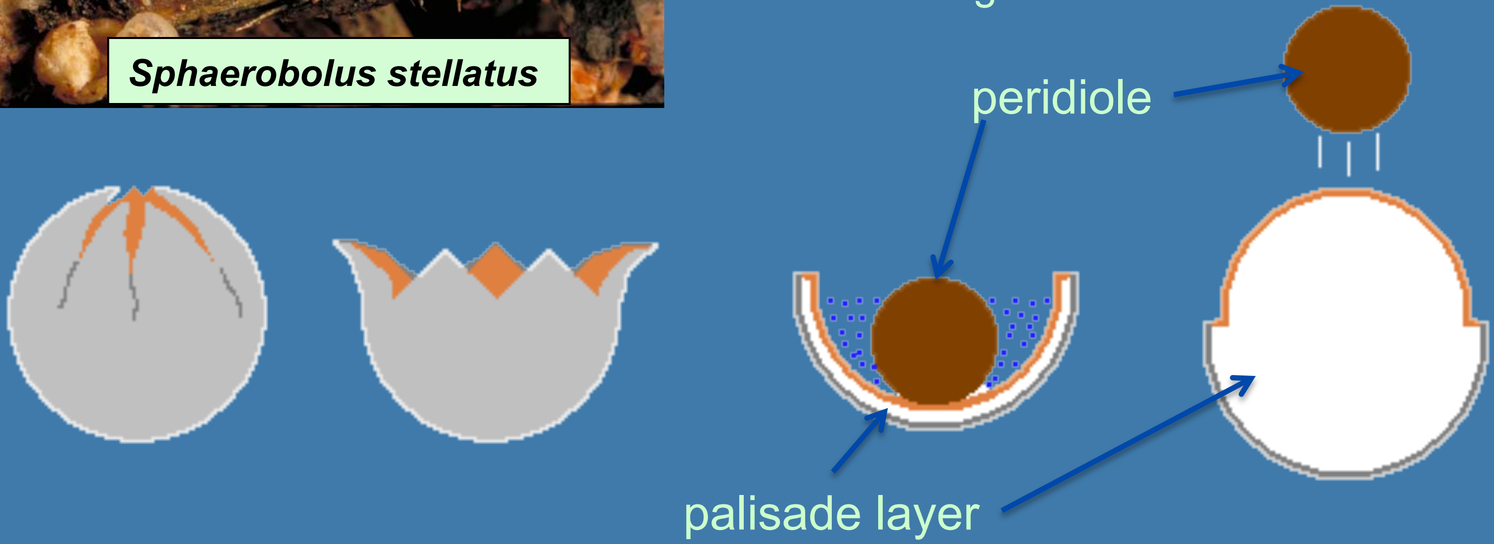


5. Basidiospore

Dissemination: Active
Cannon ball fungus, *Sphaerobolus*

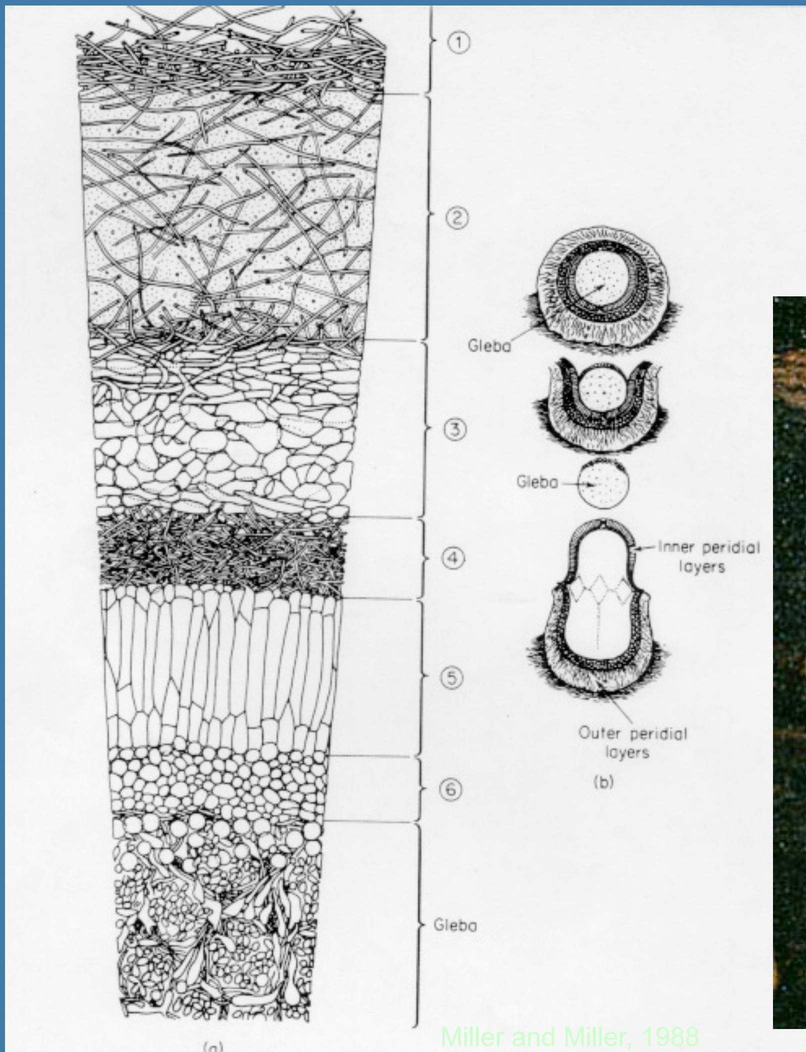


Conversion of glycogen to glucose in palisade layer cells causes increase in osmotic pressure. Movement of H_2O into the palisade results in increased turgor pressure and explosive expulsion of peridiole as the inner cup truns inside out. Peridiole is sticky and adheres to vegetation.



Sphaerobolus

– Cannon-ball fungus; one peridiole, forcibly discharged by evagination of endoperidium



Miller and Miller, 1988

MykoWeb

Other gasteromycetes such as *Lycoperdon* passively disperse basidiospores when a water drop strikes the thin persistent peridium

Mycelium

- Three types of mycelia occur in the basidiomycete life cycle:
  - **Primary mycelium (monokaryon)**
    - **Germinated basidiospore**
  - **Secondary mycelium (dikaryon)**
    - **Anastomosis of compatible mating type monokaryons**
    - **Characterized by clamp connections in many taxa**
  - **Tertiary mycelium**
    - **organized, specialized tissues that make up the basidiocarp**