

Fungal physiology and identification

Topics (just the very basics):

- Fungal nutrition and metabolism
- Fungal development
- Mushroom mechanics
- Active dispersal
- Mushroom identification

Fungi are biochemistry champions

Can metabolize the widest range
of carbon sources of any
organisms on Earth

Termites "eat wood" ... yeah but
fungi do the digesting

Cows "eat grass" ... that's cute.
Fungi do most of the work.

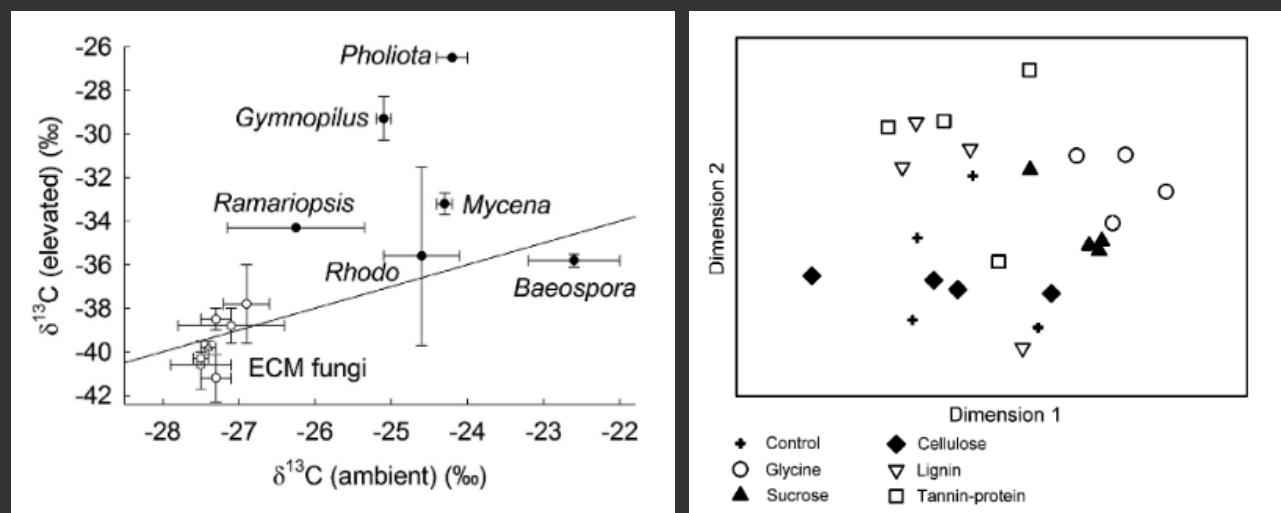
Different fungi have different
strategies for getting carbon

Fungal Taxa Target Different Carbon Sources in Forest Soil

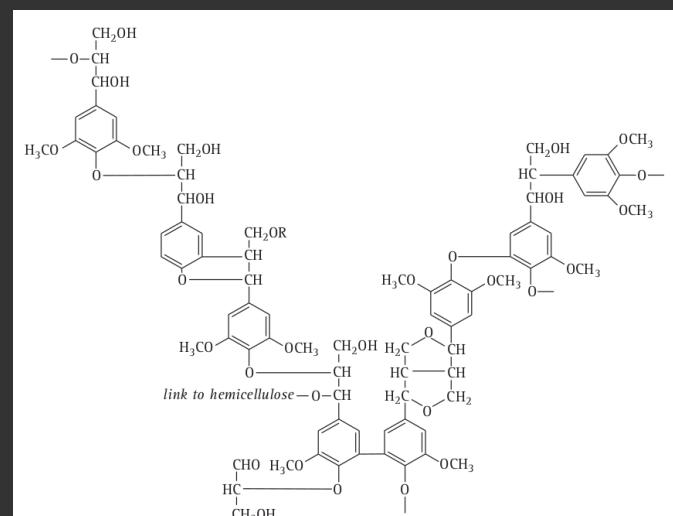
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Fair game C sources include:
cellulose, hemicellulose, pectins, chitin,
starch, glycogen, simple sugars,
lignin, and even proteins



Angiosperm lignin. Good luck digesting that

Fungal trophic modes:

- animal pathogens
- arbuscular mycorrhizal
- ectomycorrhizal
- ericoidmycorrhizal
- foliar endophytes
- lichenicolous
- lichenized
- mycoparasites
- plant pathogens
- saprotophorts



FunGuild website

Three main categories are reasonable:

Saprotoph (eats dead stuff)

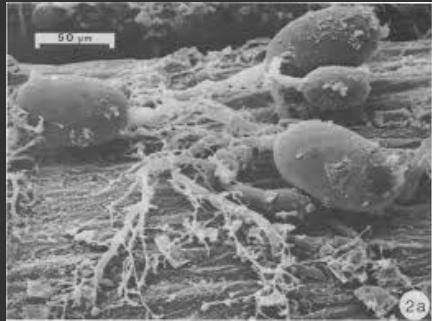
Biotroph (needs host alive)

Necrotroph (pathogen, kills host then eats corpse as saprotoph)

Necrotrophs	Biotrophs
Opportunistic, unspecialised ('non-obligate') pathogens	Specialised ('obligate') pathogens
Host cells killed rapidly	Cause little damage to the host plant; host cells not killed rapidly, but can induce hypersensitive cell death in incompatible interactions
Entry unspecialised via wounds or natural openings	Entry specialised e.g. direct (mechanical) entry (powdery mildews) or through natural openings (rusts)
Secret copious cell-wall-degrading (lytic) enzymes and toxins	Few if any lytic enzymes or toxins are produced
Appressoria/haustoria not normally produced	Possess appressoria or haustoria
Seldom systemic	Often systemic
Usually attack weak, young or damaged plants	Plants of all ages and vigour attacked
Wide host range	Narrow host range
Easy to culture axenically	Not easily cultured axenically
Survive as competitive saprotophorts	Frequently survive on host or as dormant propagules
Controlled by quantitative resistance genes (example is <i>Septoria nodorum</i> blotch caused by <i>Stagonospora nodorum</i>)	Controlled by specific (gene-for-gene) resistance genes (for example, tomato leaf mould, the rusts, powdery and downy mildews)
Growth within host is intercellular and intracellular through dead cells	Growth within host is intercellular
Controlled by jasmonate- and ethylene-dependent host-defence pathways	Controlled by salicylate-dependent host-defence pathways

Saprotrophs

Definitely, the majority of fungi fall into this category. They break down and recycle dead material.



Rumen fungi on grass blade



Living on sand



Dung fungi



Fallen leaves

Ever see a log that looks like either of these?



"White rot" (dissolve lignin first)

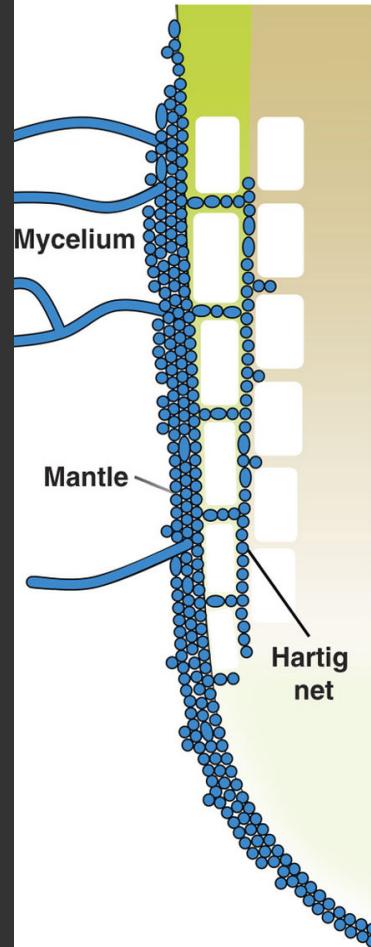


"Brown rot" (leave lignin behind)

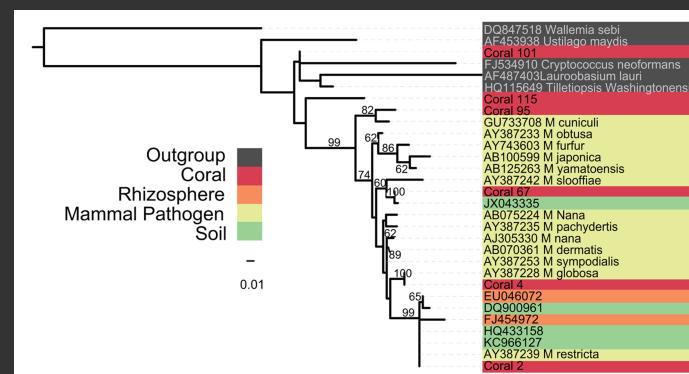
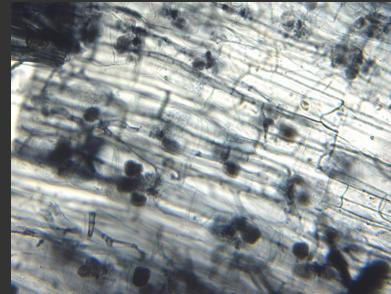
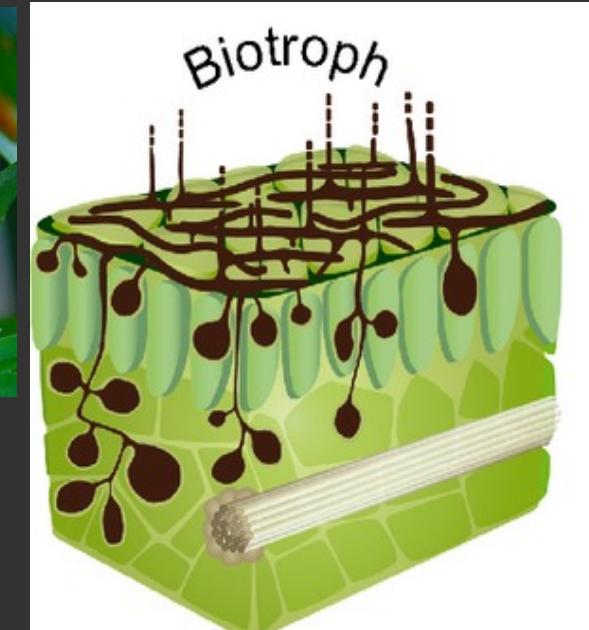
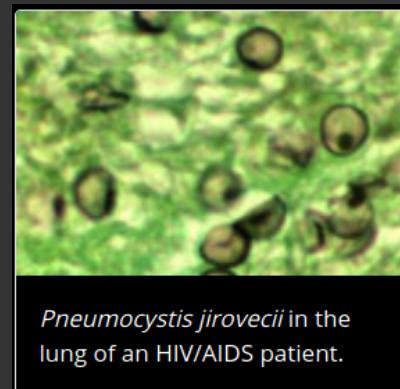
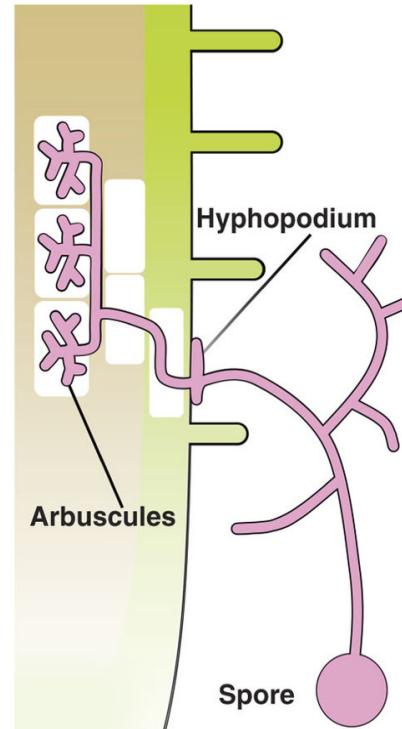
Biotrophs

Can't grow without living host....often, other way around too.

Ectomycorrhiza



Arbuscular mycorrhiza



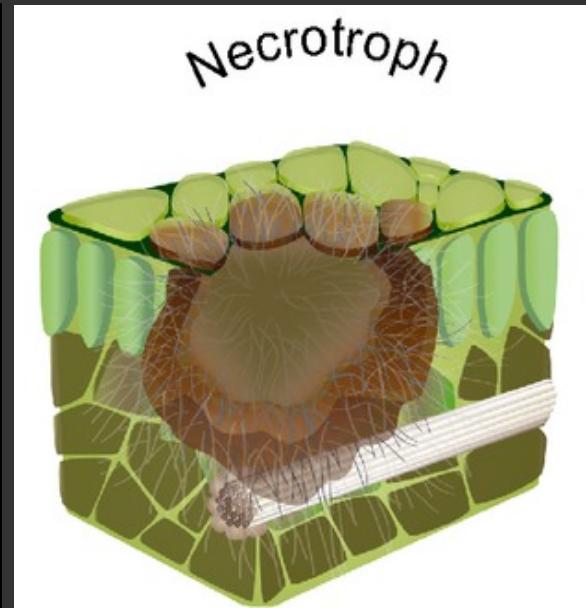
From dandruff to deep sea vents, an ecologically hyper-diverse fungus

UH Manoa scientist tracks Malassezia-like fungi to global reaches



Necrotrophs

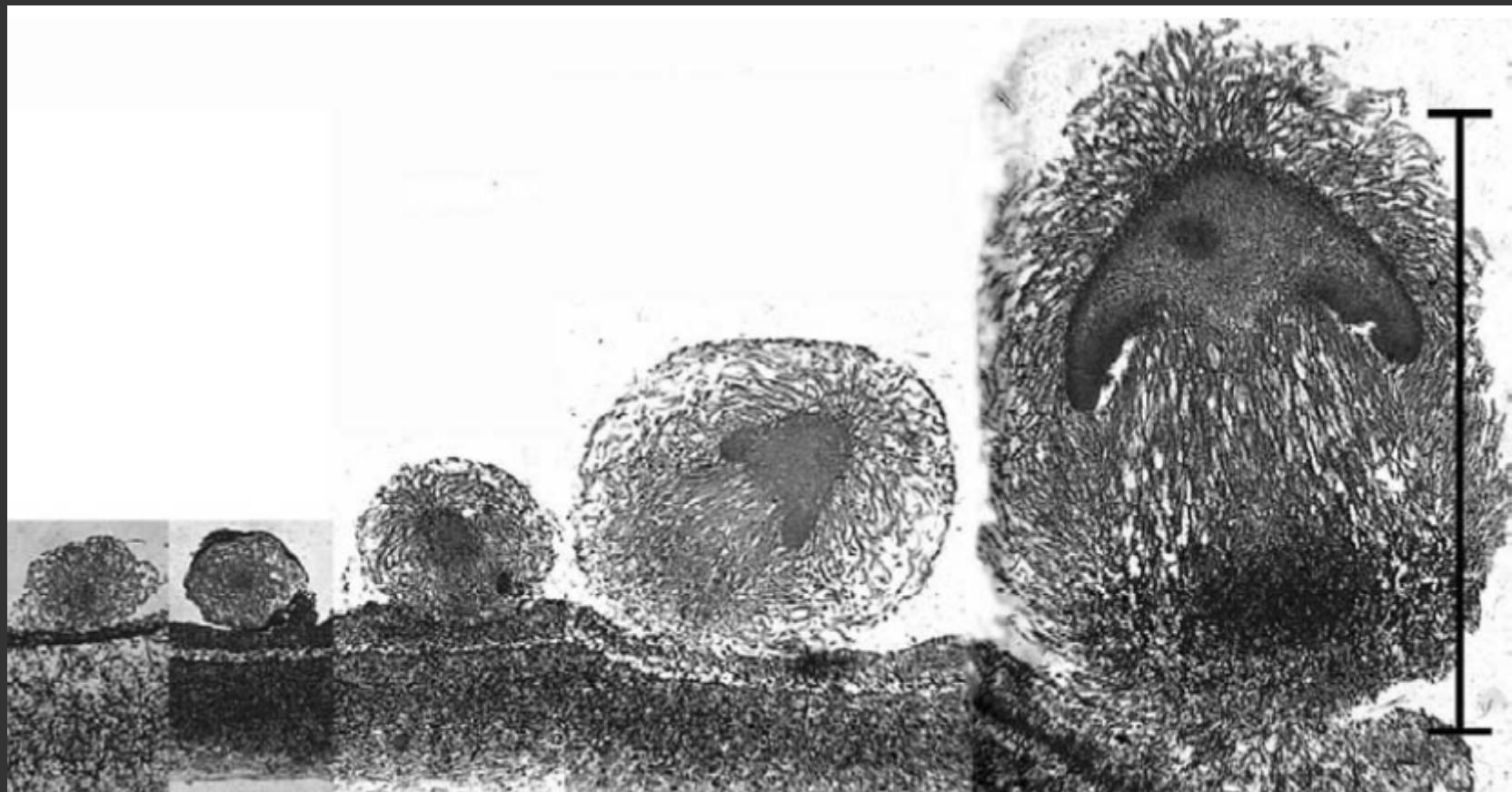
Kill their host pretty quickly, and then feast on the corpse.



Fungal development

Name of the game is mycelial differentiation

Different from animal developmental biology. Fungal "organs" are actually appendages of the mycelium, not individual units. Similar to clonal corals. Fungi do multicellularity very differently than animals.



"It's hyphae all the way down..."

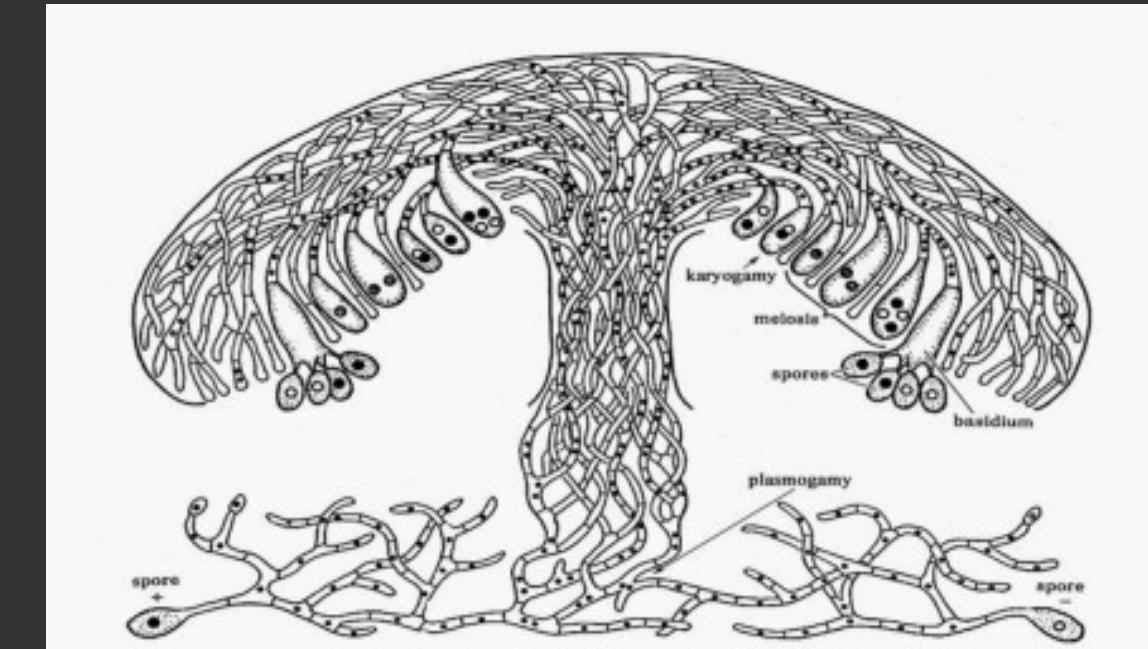


Fig. 21.29. Diagram of section through a mushroom. The entire stalk and cap are composed of hyphae tightly packed together. Spores are produced by basidia on the lower surface of the cap. [From L. W. Sharp, *Fundamentals of Cytology*, McGraw-Hill Book Co., 1943. Used by permission.]

Kenton 1967



Hydraulics and cell inflation



Erupting mushrooms lift driveway

A couple were left baffled when their driveway started to erupt only to find it was caused by a crop of mushrooms.

David and Carolyn Phillips of Reading, Berkshire, said they could not believe their eyes when the tarmac outside their home started lifting last week.

They thought the hump must have been caused by a tree root but when they called in an expert he was baffled.

It was only when Mr Phillips decided to cut away the top of the lump that he found the crop of mushrooms.



Mr Phillips said a clump of mushrooms "popped out" when he broke the hump

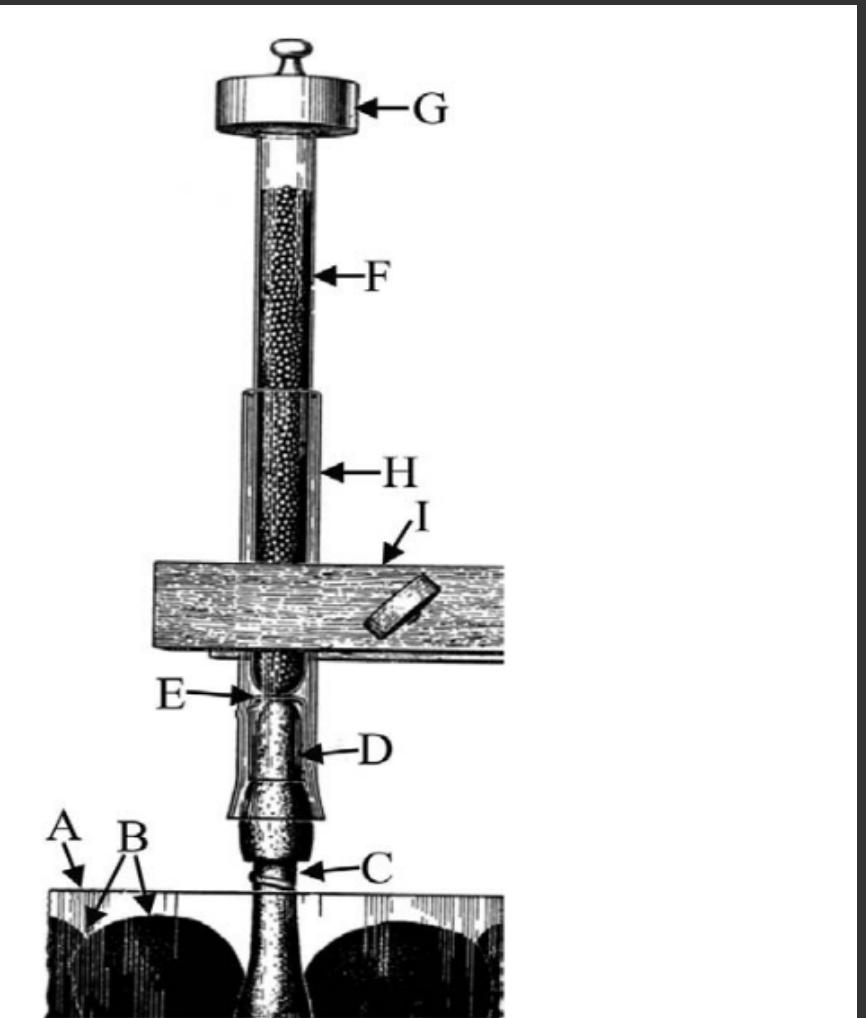
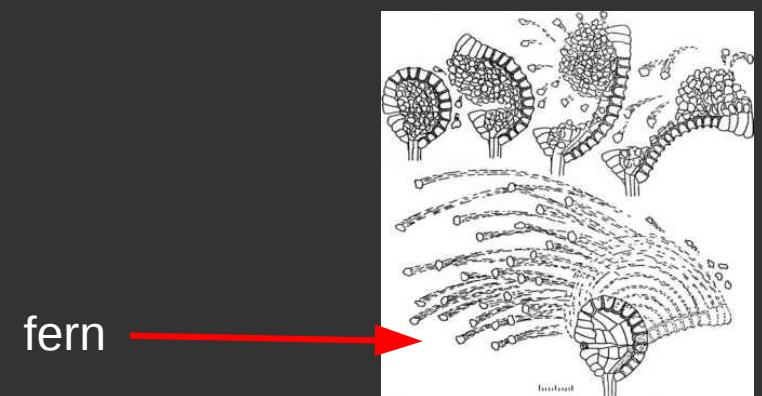
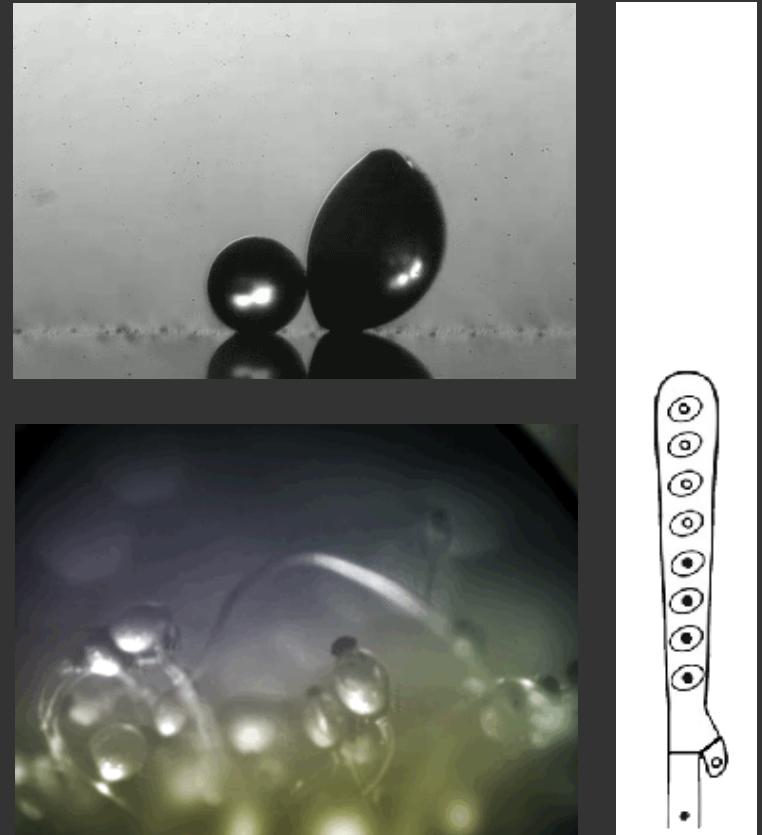
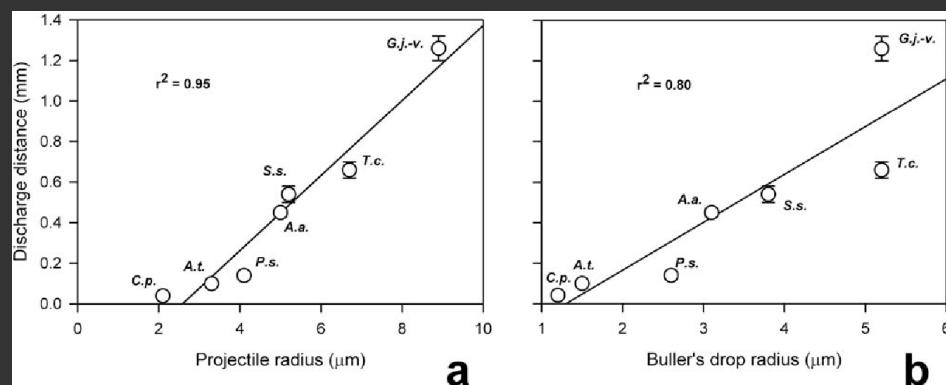
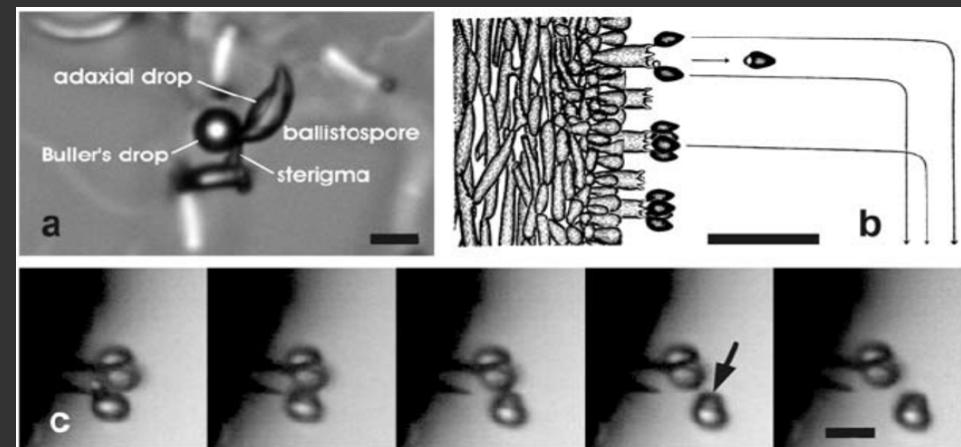
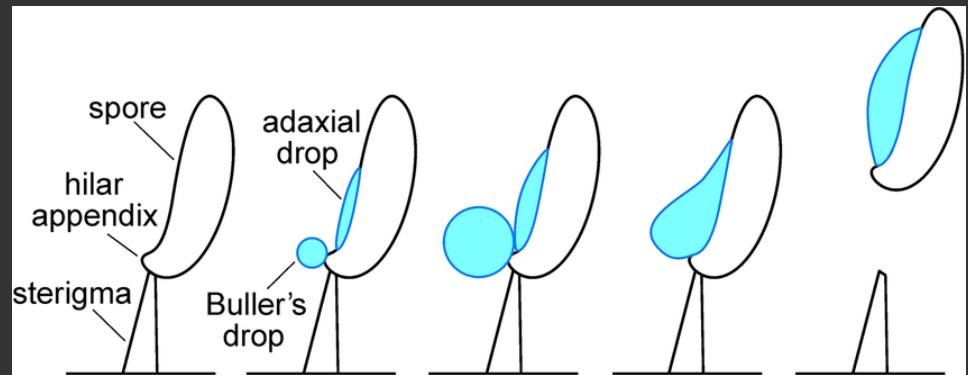
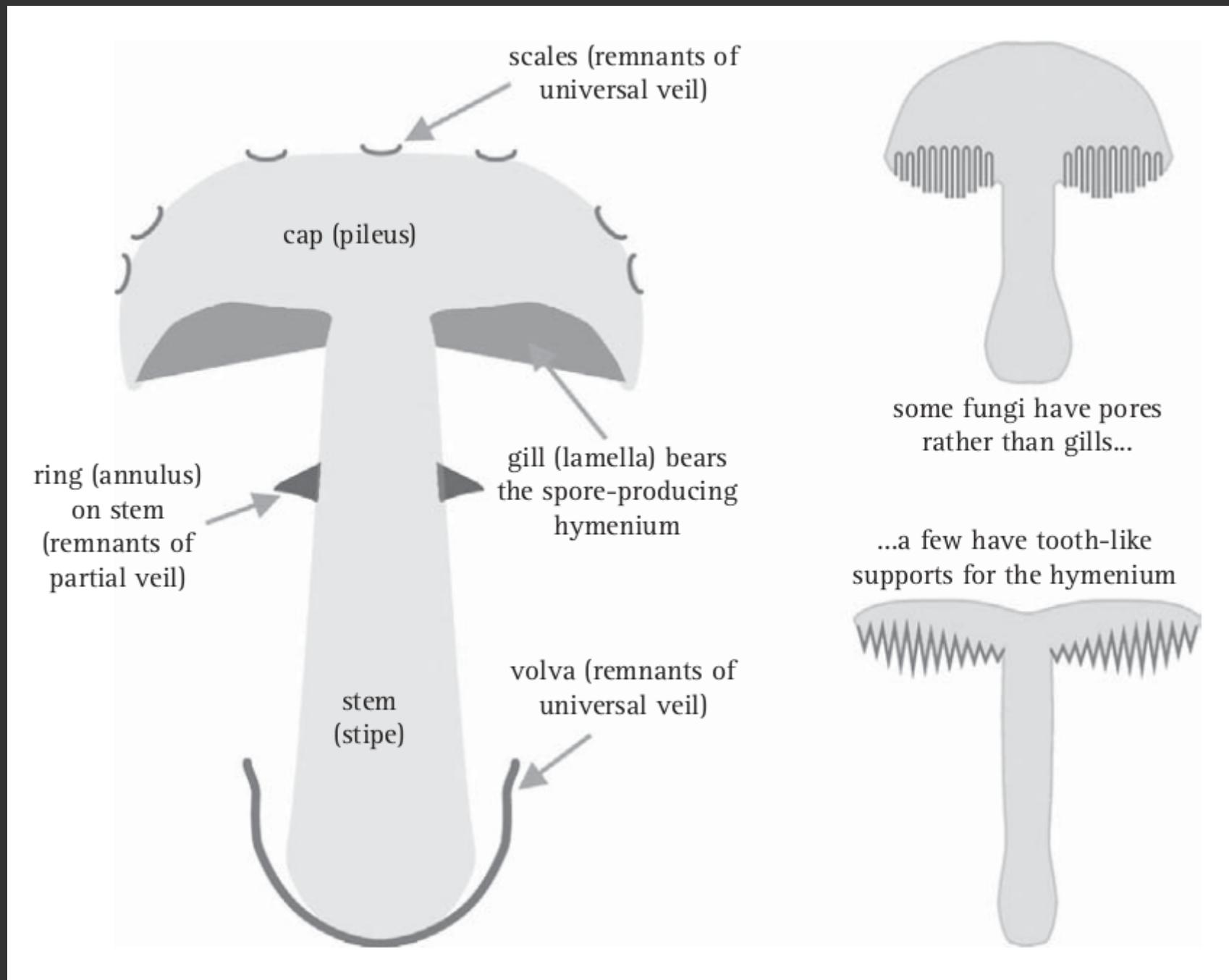


Fig. 13.2 Diagram of an experimental rig (original appears as Fig. 67 in Buller, 1931) to test the ability of fruit bodies of *Coprinus sterquilinus* to lift quantities of lead shot. The *Coprinus* fruit body (C) had grown on some balls of horse dung (B) incubated in a glass dish (A) in the laboratory. A glass tube (H) was placed over the fruit body to stabilise it with clamp (I) and then the fruit body cap (D) was covered with a small glass beaker (E) and then loaded with a test tube containing lead shot (F) to a total weight of 150 g. The fruit body grew a further millimetre in 2 h after this and even the addition of a further 50 g weight (G) did not decrease the rate of growth. Only when the overall loading was increased to 300 g did the fruit body stem (C) bend and break.

Active spore dispersal: fungal mechanisms fling spore into environment environmentally sensitive



To identify a mushroom properly, you need a lot of characters:
anatomical morphology, ecology, spore shape and color, etc.



Lots of features...lots of jargon

Body form / overall Shape

Cap shape, color, and texture

Stem shape, color, and texture

Flesh color and texture

Spore surface type (gills, teeth/tubes or pores)

Spore surface color

Color changes due to touch

Gill attachment

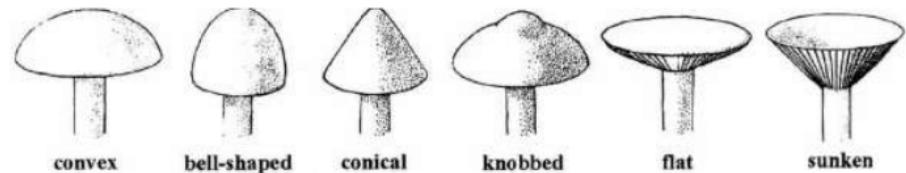
Presence or absence of a ring/anulus on the stem

Presence or absence of a volva

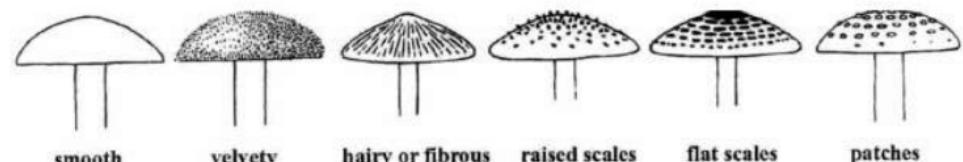
Spore color (may require making a spore print)

Caps

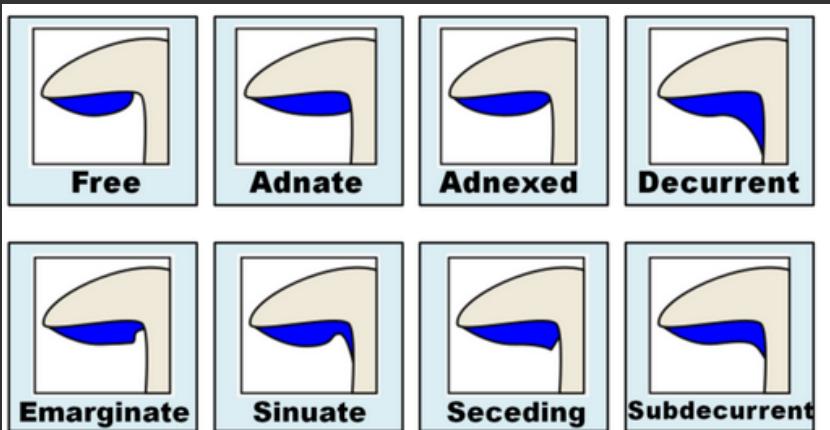
Mushroom cap shapes



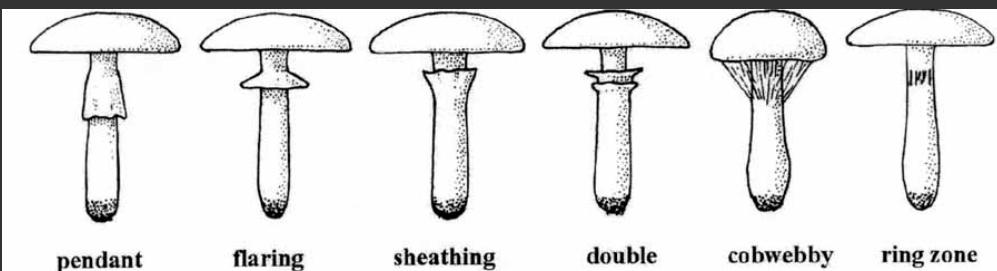
Mushroom cap surfaces



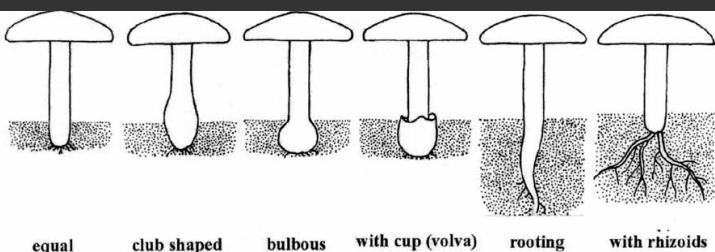
Gills



Veil



Stipe

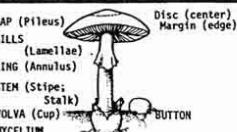


These are the traits you need to pay attention to when identifying a mushroom morphologically.

The "easy" guide! ([this file](#) is available in hi-res on the website)

EASY GUIDE TO MUSHROOMS DESCRIPTIONS

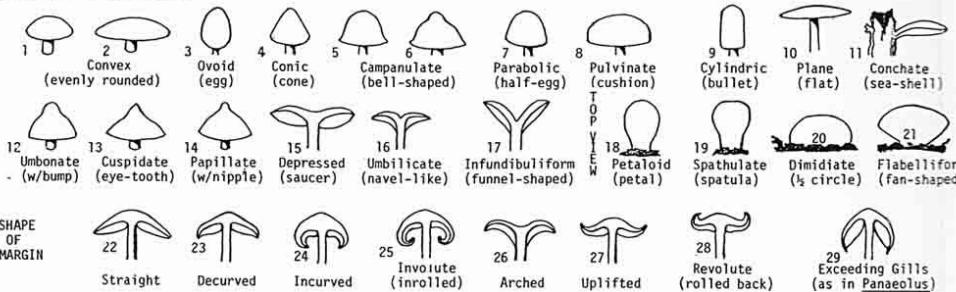
Terms on this side are arranged in the order of mushroom descriptions used by most field guides. Thus it is easy to check a description or make notes on a collection of your own. These terms, plus many others, are arranged in alphabetical order on the reverse side.



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E. 2830 Marine Dr.
Post Falls, Idaho 83854
Illustrated by Cindy Davis

I. CAP
A. SIZE: Several mature caps, smallest to largest, are measured for breadth at widest point; also height (only when taller than wide); then range of sizes is given.

B. SHAPE (YOUNG & OLD):



C. COLOR: First should come general color terms, then exact terms from a color book, if possible, for (1) young and old, (2) disc & margin, (3) background if different from fibrils, (4) changes on bruising, (5) wet & dry if hygrophanous.

D. SURFACE FEATURES:



E. CAP MARGIN:



F. CONTEXT (FLESH): 1. Color: moist or dry; under cuticle (if different)

2. Thickness: at disc and at margin

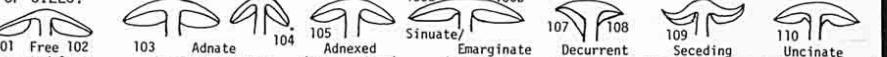
3. Texture: soft, spongy, firm, compact, rigid, brittle, corky, etc.

4. Latex color, changing after exposure?: taste, abundance

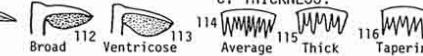
G. ODOR: None; Fruity; Lemony; Anise (licorice); Farinaceous (like fresh meal); Pungent; Nauseous; Nitrous; Earthy; Spermatic; & Raphanoid (like radishes); Green corn; Almond Extract (benzaldehyde); etc.

TASTE: (immediate or later?): Mild; Bitter; Acrid (=puckery? astringent)/Peppery; Agreeable; Farinaceous (like fresh meal); etc.

A. ATTACHMENT OF GILLS:



B. BREADTH:



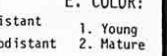
C. THICKNESS:



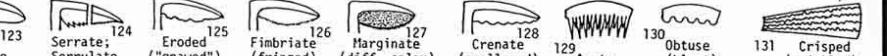
D. SPACING:



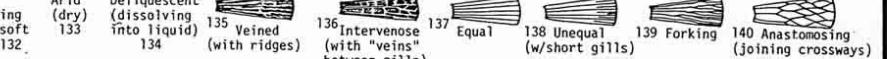
E. COLOR:



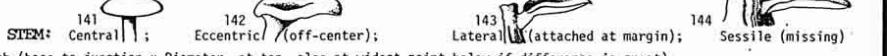
F. EDGES:



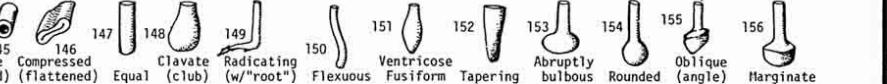
G. MISC.



A. LOCATION OF STEM:



C. SHAPES



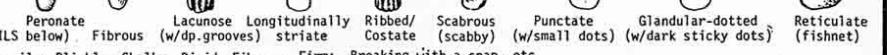
BULBS & VOLVAS



D. COLOR & CHANGES:



E. SURFACE:



F. TEXTURE:

Fragile; Pliable; Chalky; Rigid; Fibrous; Firm; Breaking with a snap, etc.

G. INTERIOR:

Solid; Hollow; Tubular; Cavernous; Stuffed with pith (describe)

IV. PARTIAL (INNER) VEIL & REMAINS

A. COLOR

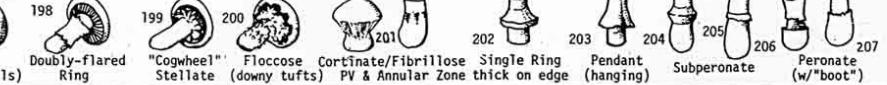
Membranous (skin-like); Cortinate (cobwebby); Fibrillose (thready); Gelatinous (slimy)--See RINGS below.

C. FATE:

Disappearing? Leaving fragments on cap? Ring (annulus)? Annular zone? Describe as below.

D. RING (ANNULUS):

Describe appearance, size, position (superior, median, inferior), persistence.



V. UNIVERSAL (OUTER) VEIL & REMAINS

A. DESCRIPTION: (1) Texture; (2) Method of rupturing; (3) Fate: disappearing? remnants where?

B. VOLVA: (1) Absent or present; (2) Size; (3) Shape, see above; (4) Color; (5) Texture

VI. MYCELIUM, RHIZOMORPHS, ETC.

Describe color and texture, etc.

VII. HABIT,

HABITAT,

PLANT ASSOC. & LOCATION

- Single, solitary
- Scattered (1-2 ft. apart)
- Gregarious (growing in a group)
- Caespitose (clustered, not joined)
- Connate (fused at base)
- Imbricate (overlapping)
- In troops or rings
- Terrestrial (on soil)--bare, burned, disturbed?
- Lignicolous (on wood)--what kind of tree?
- Humicolous (on humus, duff)--conifer, other?
- Coprophilous (on dung)--what kind?
- In grassy area--lawn, pasture, etc.?
- In forest--conifer, hardwood, mixed?
- Miscellaneous--moss, cones, needles, what?
- With what kinds of tree or other plants?
- Where? What mountain, creek, etc.? What county?

Typical mushroom guidebook description:

FUSED CORK HYDNUM *Phellodon confluens*

Pl. 8

Medium-sized, *velvety*, pale yellowish to brown caps on *short stalks*; often fused to form large, irregular masses. **Cap:** Pale grayish yellowish gray, becoming dull brown to dark brown where *velvety surface is worn away* on older parts. Margin usually white, becoming gray to dark brown when bruised. Flesh of cap two-layered, with a soft, cottony upper layer, colored like the surface, and a firm, dark, two-zoned lower layer. **Odor** disagreeable; taste mild to disagreeable.* Spines short, extending down upper stalk; nearly-white to buff at first, becoming buff to violet-gray and later brown. **Technical notes:** Cap 4–7 cm across, united in masses up to 13 cm (5 in.) across. Stalk to 2.5 cm long. Flesh turns darker in KOH when fresh; turns oliveaceous in FeSO₄. No clamps. Spores minutely roughened, hyaline, subglobose; 4–5 × 3–4 µm.

Fruiting: Solitary or clustered; on soil in forested areas. Midwest to eastern N. America and Pacific Northwest.

Edibility: Unpalatable.

Similar species: Cap colors (usually darker with age) and shorter spines distinguish Fused Cork Hydnum from Dusky Cork Hydnum (*P. niger*, below), which often has fused caps but otherwise resembles *P. confluens* only slightly (see Pl. 10). Dusky Cork Hydnum has *black* flesh.

Remarks: Color of Fused Cork Hydnum varies greatly with moisture changes.



All images are this same species



What are some problems with identifying mushrooms using a guidebook?

Assignments

1. Read Kiss *et al.*, 2019 [[Link](#)]
2. You will have a Canvas quiz on the assigned readings and will also have to participate in a Slack discussion about them.
3. Exam 1 is due by the end of the week. On Canvas.
4. Find 5 macrofungi, take proper photos and collection notes. Assignment on Canvas.