Unit 5 · Fungi and Lichens

STUDY NOTES

WHAT NEB'S GRADE 11 EXAM ASKS

- **CDC's grid (2077):** Floral Diversity (Units 4–10 together): 18 of 75 marks; with Ecology and Vegetation a combined 26, at least 3 MCQs, 2 short and 1 long from them
- **The paper:** 11 MCQs × 1 · 8 short × 5 · 3 long × 8; 3 hours; 1 mark per expected point
- **CDC's model paper:** long (8): why sexual reproduction matters in fungi; sexual reproduction of **yeast** with diagrams (2 + 2 × 3)
- **MCQ (1 mark)**
  - club fungi; yeast's nutrient (B vitamins); reserve food (glycogen)
  - perfect stage; not an asexual spore; *Mucor* in the ecosystem
  - columella; chlamydospores; labels of a drawing
  - mycobiont, phycobiont; fruticose lichen
- **Short and long (in parts)**
  - define mycelium, hyphae, ascus, coenocytic hyphae
  - haplobiontic vs diplobiontic yeast
  - why Deuteromycetes = Fungi Imperfecti
  - vegetative structure of *Mucor*; mushroom structure, with labeled diagrams
  - ecological role of fungi; spoiling of fruit and how to reduce it
  - edible vs poisonous mushrooms
  - lichens: characters; dual organisms; fungi vs lichens; bioindicators; economic importance

Key terms

Fungi: eukaryotic, no chlorophyll, feed by **absorbing**; yeasts, molds, mushrooms; older books: non-green thallophytes.

Mycology (*mykes*, fungus): study of fungi.

Hypha (pl. hyphae): fine branching thread of wall and cytoplasm, grows at its tip; ~2–10 μm across.

Mycelium: the whole network of hyphae.

Coenocytic (aseptate) hypha: no cross walls; many nuclei in one cytoplasm (*Mucor*).

Septate hypha: cross walls (**septa**), each with a **pore**; one or few nuclei a compartment.

Ascus: sac-like cell in which ascospores form.

Basidium: club-shaped cell bearing four basidiospores outside.

Perfect stage: the sexual stage of a fungus.

Dikaryotic: two nuclei a cell, one from each parent.

Pseudomycelium: temporary chain of budding yeast cells.

Mycorrhiza: fungus living with plant roots.

Lichen: fungus + alga so close they look like one organism: **dual** (composite) organism.

Mycobiont: the lichen's fungus; **phycobiont**: its green alga (or cyanobacterium, **cyanobiont**).

General features of fungi

- in soil, air, water, on food, wood, leather, paper; like **warm and damp**
- wall of **chitin** (+ glucans); food stored as **glycogen** and oil, not starch
- **heterotrophic**: enzymes poured out, products absorbed
  - **saprophytes**: dead matter (most molds, mushrooms)
  - **parasites**: *Fusarium* (wilt), rusts, smuts
  - **symbionts**: lichens, mycorrhiza
- reproduction
  - **vegetative**: fragmentation; budding (yeast)
  - **asexual**: spores, no fusion
  - **sexual**: fusion of nuclei, then meiosis

Why a kingdom of their own

- no chlorophyll; heterotrophic
- absorb food digested outside
- walls of **chitin**, not cellulose
- store **glycogen**, not starch
- mycelium, never roots, stems, leaves
- DNA: closer to **animals** than to plants

Classification (four classes)

	Phycomycetes (algal fungi)	Ascomycetes (sac fungi)	Basidiomycetes (club fungi)	Deutero (Fungi Imperfe
hyphae	**aseptate, coenocytic**	**septate** (yeast unicellular)	septate, **dolipore**	septate, b
asexual	sporangium: aplanospores (land), zoospores (water)	**conidia** on conidiophores	usually none (rusts, smuts have)	**conidia**
sexual spore	oospore or zygospore	**ascospores** (8, or 4) in **ascus**	4 **basidiospores** on **basidium**	none kno
other	water, damp wood, parasites; 1–2 flagella	no motile stage; **ascocarp**	primary (monokaryotic) and secondary (**dikaryotic**) mycelium	"waiting
e.g.	*Albugo*, *Phytophthora*, *Mucor*, *Rhizopus*	yeast, *Penicillium*, *Aspergillus*, *Claviceps*, *Neurospora*, morels	*Agaricus*, *Ustilago*, *Puccinia*, *Polyporus*	*Alternari Trichoder Cladospo Fusarium*

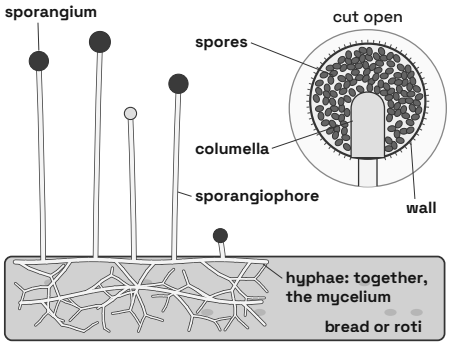
Phycomycetes: two subclasses

Oomycetes	Zygomycetes
generally parasites	generally saprophytes
motile **biflagellate zoospores**	**non-motile** spores; oidia, chlamydospores
gametangial contact: antheridium passes nucleus to oogonium	**gametangial copulation** (conjugation): two gametangia fuse
thick-walled **oospore**	thick-walled resting **zygospore**
Albugo, *Plasmopara*, *Phytophthora*	*Rhizopus*, *Mucor*

- oomycetes (water molds) not true fungi: **cellulose** walls, diploid, related to brown algae; *Phytophthora infestans*: late blight of potato (Irish famine 1845–1849)
- Basidiomycetes: primary mycelium from a **basidiospore**, short-lived; two of opposite mating types fuse → secondary, long-lived, makes fruiting bodies; basidium: two nuclei fuse → 4 basidiospores
- **Deuteromycetes = Fungi Imperfecti**: only the asexual stage known; perfect (sexual) stage not found; when found → Ascomycetes (most) or Basidiomycetes; DNA: *Trichoderma*, *Fusarium* are ascomycetes; one fungus, one name (2013)
- **yarsagumba** (*Ophiocordyceps sinensis*): ascomycete of high pastures (3,000–5,000 m); infects ghost-moth caterpillars; fruiting body from the head

Mucor (pin mold)

- Mycota → Zygomycota → Zygomycetes → Mucorales → Mucoraceae → *Mucor*
- saprophyte: bread, jam, cheese, pickles, leather, dung, humus
- "black bread mold" is *Rhizopus stolonifer*: has **stolons**, **rhizoids**, sporangiophores in clusters; *Mucor* has **none**, sporangiophores one by one



Mucor on bread: prostrate and submerged hyphae; aerial sporangiophores with sporangia.

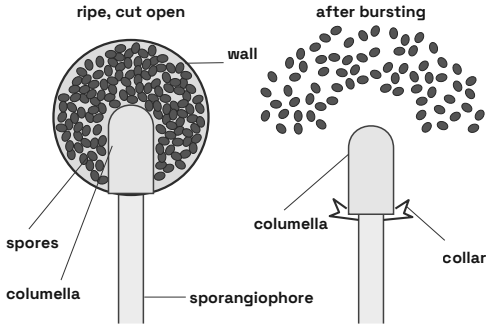
Mycelium: branched, **coenocytic** hyphae of three kinds

- **submerged**: inside the substratum; **absorb food**, fix the mold
- **prostrate**: spread over the surface; fix it
- **aerial** (**sporangiophores**): upright, bear sporangia; asexual reproduction

Vegetative: **fragmentation** in bad conditions

Asexual

- **sporangiospores** (usual, good conditions): tip swells → **sporangium**; outer fertile **sporangium proper** + inner sterile dome, **columella**; nuclei divide by mitosis → many multinucleate spores; columella swells, wall bursts, spores blow away
- **chlamydospores** (bad conditions): cytoplasm gathers **inside hyphae**, rounds off, stores food, **thick wall**; resting spores
- **oidia**: in **sugary liquid**, hyphae septate, cells round off, separate; bud like yeast; fermentation



Sporangium cut open: wall, spores, columella; after bursting, bare columella with collar.

Sexual: conjugation (bad conditions)

- mostly **heterothallic**: **+ strain** and **− strain** (look alike)

1. ◦ and − hyphae put out **progametangia**
2. septum → basal **suspensor** + terminal **gametangium**
3. wall between dissolves; contents fuse → **zygote**; nuclei fuse in + and − pairs → many diploid nuclei
4. thick, warty, dark wall → **zygospore**, between two suspensors; rests for months
5. one diploid nucleus left → **meiosis** → 4; three degenerate; fourth divides many times
6. outer wall bursts → **promycelium** (germ tube)
7. tip → **germ sporangium** → haploid **germ spores** → new mycelia

Activity 2.2: damp bread sealed in a bag, warm, dark → in 3–6 days white cottony hyphae with **dark pin-heads**; keep bag shut (spores bring on asthma, allergies)

Yeast

- Mycota → Ascomycota → Saccharomycetes (Hemiascomycetes) → Saccharomycetales → Saccharomycetaceae → *Saccharomyces*
- saprophytes on sugar: fruit, sugarcane juice, nectar, milk products; *Candida albicans*: thrush
- **unicellular**, oval or round, 5–10 μm

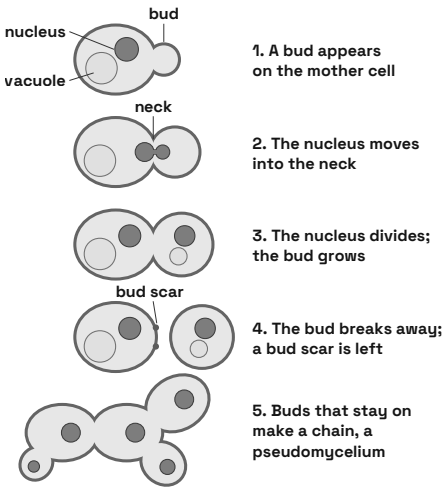
Cell

- thin **wall**: glucans, mannoproteins, a little chitin
- **cell membrane**
- **cytoplasm**: mitochondria, ER, Golgi, ribosomes; **glycogen**, oil
- one large **vacuole** in the **tonoplast** (old name "nuclear vacuole")
- one **nucleus** beside the vacuole, with nucleolus

Vegetative (good conditions)

- **budding** (commonest): bud at one end; nucleus divides, one passes into the bud; vacuole breaks up; wall across the neck; bud separates → **bud scar**; fast budding → **pseudomycelium**
- nucleus divides by **closed mitosis** (envelope stays), not amitosis

- **fission** (*Schizosaccharomyces*): cell lengthens, nucleus divides, cross wall → two cells



Budding: bud grows, nucleus divides through the neck, wall forms, bud breaks away (bud scar).

Sexual (bad conditions): no sex organs; two cells of **opposite mating types** fuse (**conjugation**) → diploid cell → **ascus** → meiosis → haploid **ascospores**

	Haplobiontic	Diplobiontic	Haplodiplobiontic
species	*Schizosaccharomyces octosporus*	*Saccharomycodes ludwigii*	*Saccharomyces cerevisiae*
main phase	**haploid**	**diploid**	both **equal**
steps	haploid cells → **conjugation tube** → zygote = **ascus** → meiosis (4) + mitosis → **8 ascospores** → haploid cells	diploid cell = ascus → meiosis → **4 ascospores**; they **conjugate in pairs inside the ascus** → germ tube → **sprout mycelium** → diploid cells	haploid cells fuse → zygote **buds** diploid cells → each = ascus → meiosis → **4 ascospores** → bud haploid cells
only…	zygote is the only **diploid** cell	ascospores are the only **haploid** cells	both phases bud for generations

- sex in fungi comes in **unfavorable** conditions; its meiosis gives new gene combinations (variation, Unit 3)
- baker's yeast: first eukaryote genome read (1996; ~12 million base pairs, ~6,000 genes)

Mushroom

- saprophytic **basidiomycete**: humus, dung, rotting logs, meadows; rainy season
- **mycelium**: branched hyphae in soil or wood; lives for years
- **basidiocarp** (fruiting body)
  - **stipe**: stalk
  - **pileus**: cap
  - **button** stage covered by **velum** (veil) → torn → **annulus** (ring) on stipe
  - **gills** (lamellae) under the pileus: **basidia** with 4 **basidiospores** each, among sterile **paraphyses**

Said of poisonous	Said of edible
green or purple when cut	no color change
bad smell	pleasant smell
bitter	pleasant taste
no worms	may have worms
gills attached to stalk	gills on cap, free of stalk
annulus usually absent	annulus usually present
Amanita phalloides, *Pholiotina rugosa*, *Cortinarius rubellus*	*Agaricus bisporus*, *Pleurotus ostreatus*, *Volvariella volvacea*

- learn for the exam; **never** use in the forest: **death cap** breaks almost every rule; cooking doesn't destroy its poison; only an expert, or farmed mushrooms

Economic importance of fungi

Useful

1. **medicines**
   - **penicillin** (*Penicillium chrysogenum*; Fleming 1928; Florey, Chain; Nobel 1945); claviformin
   - **cyclosporin** (transplants); **statins**
   - **B vitamins** (yeast); **riboflavin** B_2 (*Eremothecium ashbyii*); β-**carotene** (*Blakeslea trispora*); steroids
2. **food**: mushrooms (protein, vitamins, minerals, little fat); oyster (*Pleurotus*, कन्ने च्याउ), button (*Agaricus bisporus*), morels (गुच्छी च्याउ)

3. **industry**
   - alcohol (*Saccharomyces*); **murcha** (*Mucor*, *Rhizopus* + yeasts) → jaand, chhyang, raksi
   - bread
   - cheese (*P. roqueforti*, *P. camemberti*)
   - enzymes: amylase, cellulase, invertase
   - acids: **citric** (*Aspergillus niger*), fumaric, lactic, oxalic
4. **soil fertility**: *Fusarium*, *Chaetomium*, *Aspergillus* decompose litter; white-rot fungi digest lignin; minerals returned
5. **mycorrhiza**: hyphae take water, **phosphate** for the root; get sugar; sal, pine
6. **gibberellin**: *Gibberella fujikuroi*, "foolish seedling" (bakanae) of rice; Kurosawa 1926
7. **biological control**: *Beauveria bassiana* kills insects; *Trichoderma* attacks root-rot fungi

Harmful

1. **plant diseases**
   - late blight of potato, tomato: *Phytophthora infestans*
   - blast of rice: *Magnaporthe oryzae*
   - rust of wheat: *Puccinia*
   - red rot of sugarcane: *Colletotrichum falcatum*
   - wart of potato: *Synchytrium endobioticum*
   - damping off: *Pythium*
   - club root of cabbage: *Plasmodiophora brassicae*
2. **rotting of food**: *Penicillium* (green, blue molds of oranges, apples), *A. niger* (black mold), *A. flavus* (**aflatoxins**: liver damage, cancer)
3. **human, animal diseases**: **ringworm**, **athlete's foot** (*Trichophyton*, *Microsporum*), thrush (*Candida*), lungs (*Aspergillus*), fish (*Saprolegnia*)
4. **clothes** rot when damp (natural fibers more)
5. **paper, wood**: *Polyporus* rots timber
6. **mushroom poisoning**: vomiting, liver failure, death

- **refrigerator**: at 2–5 °C molds' enzymes work slowly → slows spoiling, doesn't kill
- strawberries (gray mold *Botrytis*, *Rhizopus*): keep **cold** and **dry**, sort out moldy ones, handle gently in ventilated boxes, sell quickly, clean shelves, extra CO_2

Lichens

- fungus makes most of the **thallus**: shape, color, shelter, water, minerals, CO_2; alga: **photosynthesis**, food shared
- neither grows so alone → **dual organisms**
- **lichenology**; **Erik Acharius** (1757–1819) father of lichenology; **Theophrastus** first described them

Characters

1. dual: alga (or cyanobacterium) + fungus, symbiosis
2. moist, cool places: bark, leaves, logs, bare rock, walls; dry out and revive
3. grow **very slowly** (mm a year); live hundreds of years
4. thallus irregular, colored by the fungus's pigments, acids
   - **crustose**: crust, embedded, can't be lifted (*Graphis*, *Lecanora*)
   - **foliose**: flat, leaf-like lobes (*Physcia*, *Parmelia*, *Xanthoria*)
   - **fruticose**: shrubby or hanging, attached at base (*Usnea*, *Cladonia*)
5. very sensitive to air pollution: **indicators**
6. reproduce by fragments, **soredia** (fungus + alga packets); fungus's own spores

- in no Whittaker kingdom: **two** organisms from different kingdoms; named and classed by the **fungus** (mostly Ascomycetes)

Fungi	Lichens
one organism	two: fungus + alga
heterotrophic	food from the alga's photosynthesis
hyphae, mycelium	thallus: crustose, foliose, fruticose
warm, damp, organic matter	bare rock, bark; slow, long-lived

Useful

1. **food**: mites, snails; reindeer moss (*Cladonia rangiferina*); *Parmotrema* in garam masala
2. **medicine**: folk (*Lobaria pulmonaria*, *Xanthoria* for jaundice; no good evidence); **usnic acid** (*Usnea*) antibiotic
3. **pioneers** on bare rock: hold dust, water; acids crumble rock → first **soil** → mosses, grasses
4. **bioindicators**: sensitive to SO_2; absorb through surface, can't get rid of poisons, long-lived; shrubby go first, then leafy, crusts last
5. **industry**: dyes (orchil), **litmus** (*Roccella*), perfume (oakmoss, *Evernia prunastri*), cosmetics, alcohol

- झ्याउ trade in Nepal (*Parmelia*): banned 2011, allowed 2023

Harmful

1. spoil plaster of walls
2. dry lichens help **forest fires** spread
3. acids **etch glass, marble**, statues
4. on coffee, tea, rubber leaves: shade, early leaf fall

COMMON MISTAKES

✗ *Mucor* is the black bread mold
✓ that is *Rhizopus* (stolons, rhizoids); *Mucor* has neither.

✗ Chlamydospores form in sporangia
✓ **inside the hyphae**, in bad conditions.

✗ Columella forms spores
✓ it is **sterile**; spores form in the sporangium proper.

✗ Yeast's nucleus divides amitotically
✓ **closed mitosis**.

✗ Fungi store starch
✓ **glycogen** and oil.

✗ Basidiospores form inside the basidium
✓ **outside**; ascospores inside the ascus.

✗ Vitamin B_{12} from a fungus
✓ only bacteria and archaea make it; *Eremothecium* makes B_2.

✗ The edible/poisonous table is safe to use
✓ no simple test works; the death cap passes it.

✗ Lichen = one organism in a kingdom
✓ **two** organisms; named by the fungus.