

Biology

A group of penguins is shown swimming underwater. The water is a deep blue-green color. The penguins are in various positions, some swimming towards the camera and others away. Their bodies are sleek and dark, with some showing lighter patches on their chests. Bubbles are visible around them, suggesting they are breathing or moving through the water.

Concepts and Applications | 9e
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Chapter 22

Fungi

22.1 What Is a Fungus?

- Fungus: eukaryote that secretes digestive enzymes onto its food, then absorbs the resulting breakdown products
 - Most are decomposers that feed on organic wastes and remains
 - Some live on or in other living organisms
 - Example: parasitic fungi

Absorptive Feeders (cont'd.)

- Fungal digestive enzymes can break down many sturdy structural proteins that animal digestive enzymes cannot
 - Cellulose
 - Lignin
 - Keratin

Filamentous Structure

- Yeast: fungus that lives as a single cell
- Multicelled fungi live as a mesh of threadlike filaments collectively called a *mycelium*
- Each filament in the mycelium is a *hypha*
 - Hypha: consists of haploid, walled cells attached end to end

Filamentous Structure (cont'd.)



Filamentous Structure (cont'd.)

- Fungal cell walls contain chitin
- Some fungal groups contain porous cross-walls between cells of a hypha
 - Allows materials (e.g., nutrients and water) to flow between adjacent cells

Spore Producers

- Fungi disperse by releasing microscopic spores
 - A fungal spore is typically one or more haploid (n) cells enclosed within a thick coat
 - When the spore germinates (becomes active), it grows into a new haploid mycelium

Spore Producers (cont'd.)

- Fungi produce spores both asexually and sexually
 - During asexual reproduction, multicelled fungi form spores by mitosis at the tips of specialized hyphae

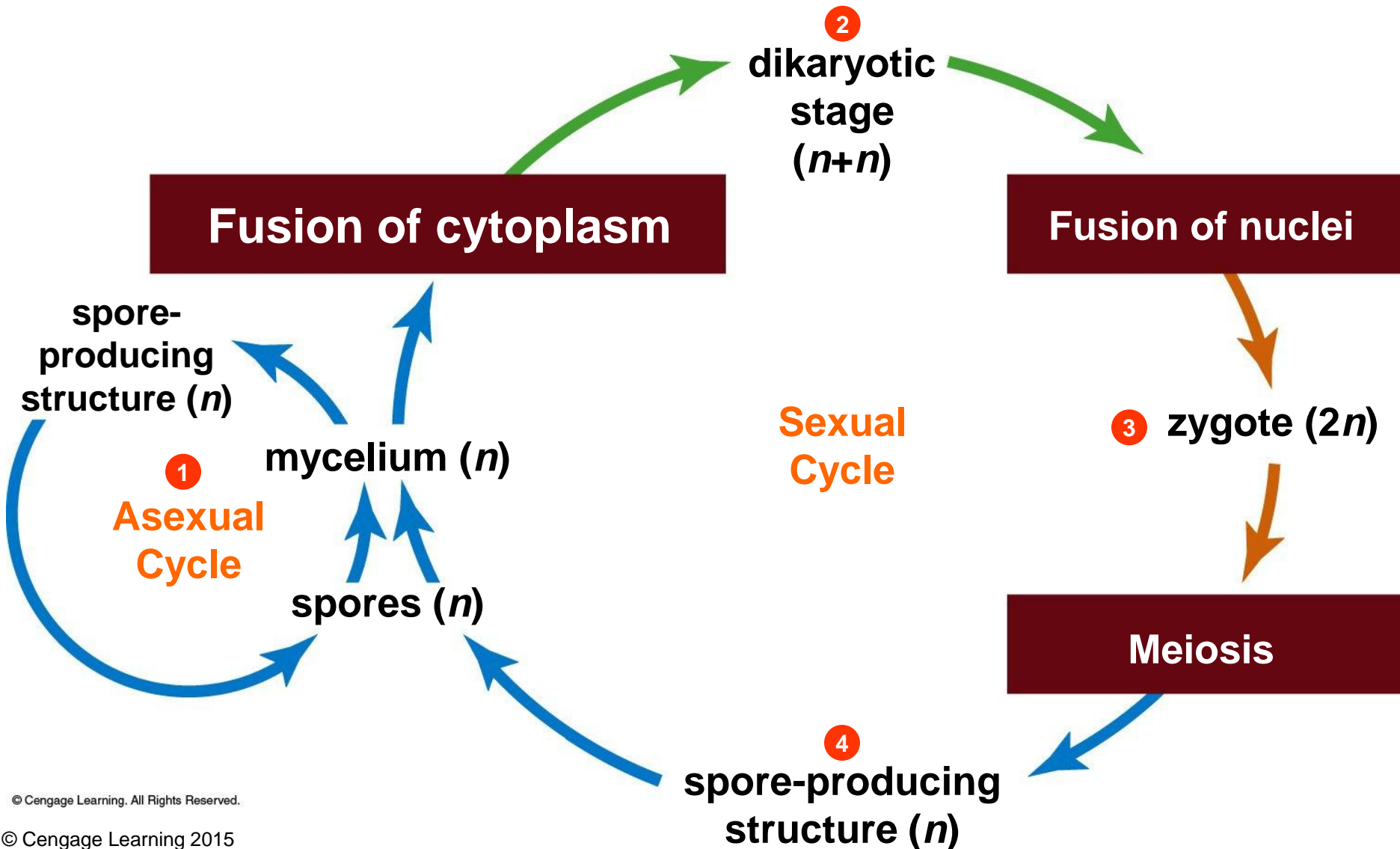
Spore Producers (cont'd.)

- Sexual reproduction:
 - Two haploid hyphae meet and cells at their tips fuse
 - This cytoplasmic fusion produces a dikaryotic cell
 - Dikaryotic: cell that has two genetically distinct nuclei ($n + n$)

Spore Producers (cont'd.)

- Sexual reproduction (cont'd.):
 - A diploid fungal zygote forms when the two nuclei inside a dikaryotic cell fuse
 - Zygote then undergoes meiosis, producing a structure that produces haploid spores
 - These spores germinate, releasing cells that divide by mitosis to form a new haploid mycelium

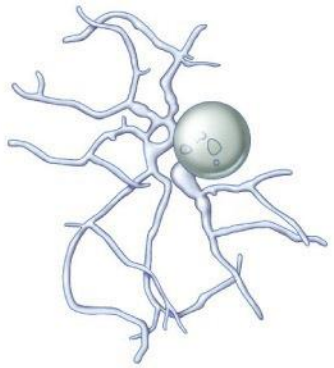
Spore Producers (cont'd.)



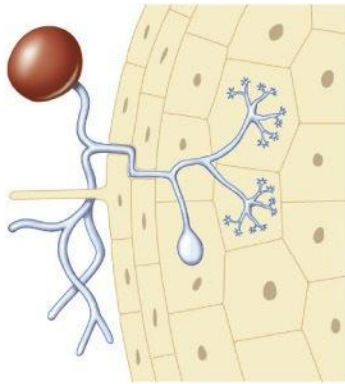
Five Major Subgroups

- The five major fungal subgroups
 - Chytrids
 - Glomeromycetes
 - Zygomycota
 - Ascomycota
 - Basidiomycota

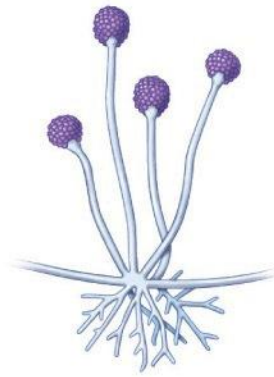
Five Major Subgroups (cont'd.)



chytrids



glomeromycetes



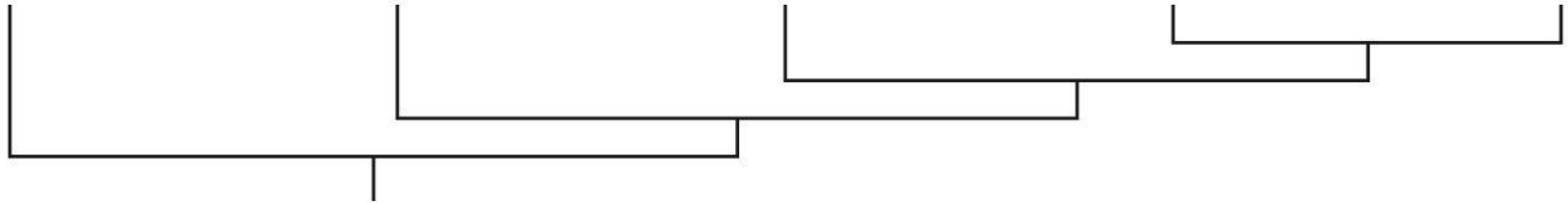
zygote fungi



sac fungi



club fungi



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Chytrids

- Chytrids are the oldest fungal lineages
- Only living fungi that make flagellated spores
- Most are aquatic decomposers
 - Some live in the gut of herbivores where they help their host digest cellulose
- Others are parasites of plants or animals

Glomeromycetes

- Glomeromycetes are soil fungi
- Partners with plant roots
- Contain fungal hyphae that grow inside the cell walls of root cells

Zygoter Fungi

- Most zygoter fungi are molds that live in damp places
- Molds grow as a mass of hyphae and reproduce asexually (as long as food is plentiful)
- During sexual reproduction, zygoter fungi produce a thick-walled structure called a zygospore

Sac Fungi

- Sac fungi contain cross-walls between cells of their hyphae
- Reproduce sexually by producing spores in sac-shaped structures
- Most diverse fungal group:
 - Yeasts, molds, parasites, species that aide in the production of lichens, and species that form large fruiting bodies

Club Fungi

- Club fungi contain cross-walls between cells of their hyphae
- Reproduce sexually by producing spores in club-shaped structures
- Most familiar mushrooms are the fruiting bodies of club fungi
- Includes some parasites

22.2 How Do Life Cycles Differ Among Fungal Groups?

- The black bread mold (*Rhizopus stolonifera*) has a life cycle typical of zygote fungi
 - When food is plentiful, it grows as a haploid mycelium and produces spores by mitosis

How Do Life Cycles Differ Among Fungal Groups? (cont'd.)

- Life cycle of black mold (cont'd.)
 - When the food supply dwindles, lack of food and of a sexual partner leads to the formation of special side branches (gametangia)
 - Many haploid nuclei from within a hypha can flow into each gametangium
 - When the two gametangia come into contact, their walls break down, and their cytoplasm fuses

How Do Life Cycles Differ Among Fungal Groups? (cont'd.)

- Life cycle of black mold (cont'd.):
 - Immature zygospores contain multiple nuclei from each parent form
 - The haploid nuclei of the zygospores fuse, forming diploid nuclei
 - When the zygospore germinates, a hypha emerges and cells at its tip undergo meiosis to produce haploid spores

ANIMATION: Rhizopus

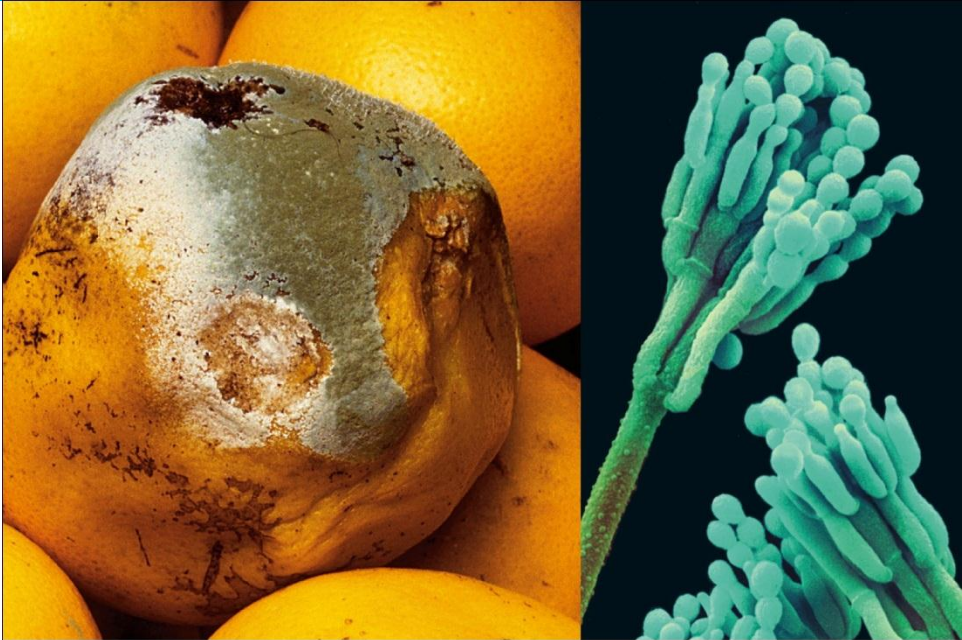
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How Do Life Cycles Differ Among Fungal Groups? (cont'd.)

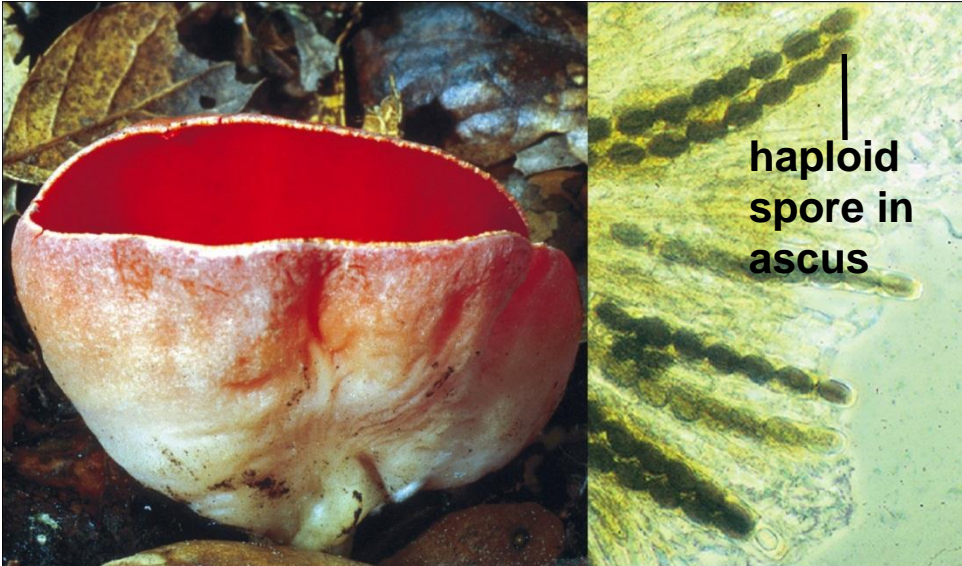
- Life cycle of sac fungi yeasts:
 - Yeasts usually reproduce asexually by budding
- Life cycle of sac fungi molds:
 - Asexual mold reproduction occurs via the mitotic production of spores by hyphae
 - Sexual reproduction of mold (and other sac fungi) occurs via the formation of spores in a sac-shaped structure called an ascus

How Do Life Cycles Differ Among Fungal Groups? (cont'd.)



A

left, © Photo by Scott Bauer/USDA; right, © Dennis Kunkel Microscopy, Inc.



B

left, © Michael Wood/mykob.com.; right, © North Carolina State University, Dept. of Plant Pathology

How Do Life Cycles Differ Among Fungal Groups? (cont'd.)

- Club fungi sexual reproduction:
 - Form spores by meiosis in club-shaped cells called basidia
 - These cells form on a fruiting body (a basidiocarp) composed of dikaryotic hyphae

How Do Life Cycles Differ Among Fungal Groups? (cont'd.)

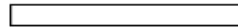
- Club fungi sexual reproduction (cont'd.):
 - When hyphae of two mushroom-forming club fungi meet, they fuse and form a dikaryotic mycelium
 - Embryonic mushrooms form on the mycelium
 - When it rains, hyphae soak up water, and these tiny mushrooms expand and break through the soil surface

How Do Life Cycles Differ Among Fungal Groups? (cont'd.)

- Club fungi sexual reproduction (cont'd.):
 - The underside of a mushroom's cap has thin tissue sheets (gills) fringed with club-shaped, dikaryotic cells
 - Fusion of the nuclei in a dikaryotic cell forms a diploid zygote
 - The zygote undergoes meiosis, forming four haploid spores
 - After dispersal, these spores germinate

ANIMATION: Club fungus life cycle

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22.3 What Ecological Roles Do Fungi Play?

- Fungi provide an important ecological service
 - They break down complex compounds in organic wastes and remains
 - When digestive enzymes are secreted onto these materials, some soluble nutrients escape into nearby soil or water
 - Plants and other producers can then take up these substances to meet their own needs

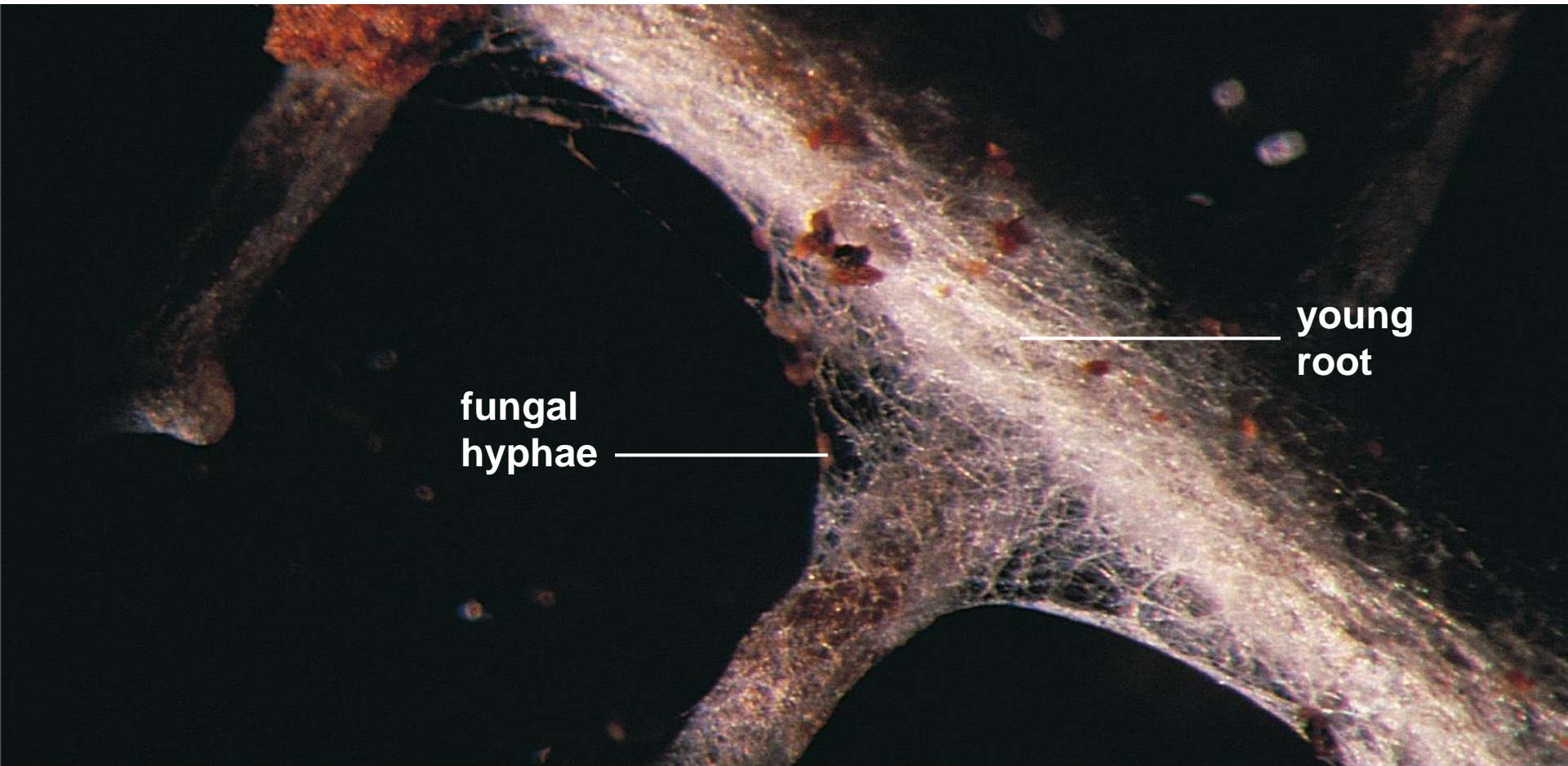
Beneficial Partners

- Many fungi take part in *mutualism*
 - Mutualism: interspecific interaction that benefits both participants

Beneficial Partners (cont'd.)

- Mycorrhiza: partnership between a soil fungus and the root of a vascular plant
 - Hyphae enter root cells and branch between the cell wall and plasma membrane
 - These hyphae functionally increase the absorptive surface area of their plant partner
 - The fungus shares water and nutrients taken up by its hyphae with root cells
 - In return, the plant supplies the fungus with sugar

Beneficial Partners (cont'd.)



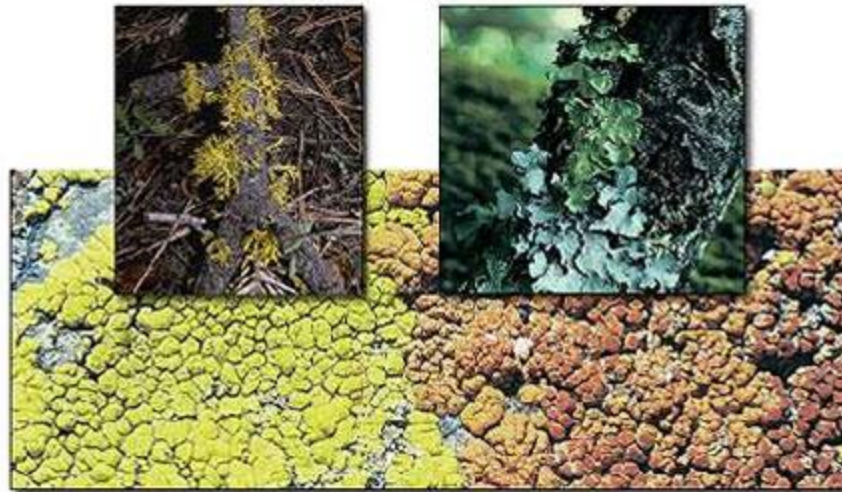
young
root

fungal
hyphae

Beneficial Partners (cont'd.)

- A lichen is a composite organism that consists of a sac fungus and either cyanobacteria or green algae
 - The fungus makes up the bulk of a lichen's mass
 - Hyphae surround the photosynthetic cells, which provide the fungus with sugars or fixed nitrogen

ANIMATION: Lichens



Pause Animation



Start Animation



Beneficial Partners (cont'd.)

- Lichens play an important ecological role by colonizing places too hostile for most organisms, such as exposed rocks
 - Lichens break down rock and produce soil by releasing acids and by holding water that freezes and thaws

Beneficial Partners (cont'd.)

- Fungal partners also enhance the nutrition of some animals
 - Chytrid fungi who live in the stomachs of grazing animals break down otherwise indigestible cellulose
 - Fungal partners of some ants and termites serve as an external digestive system

Parasites and Pathogens

- Powdery mildews (sac fungi) and rusts and smuts (club fungi) are parasites that grow only in living plants
 - Hyphae grow into cells of stems and leaves, removing photosynthetically produced sugars
 - Loss of nutrients ensues: stunts the plant, prevents seed production, and may eventually kill plant

Parasites and Pathogens (cont'd.)

- Some pathogenic fungi produce toxins that kill plant tissues, then feed on the resulting remains
 - Club fungus *Armillaria* causes root rot by infecting trees and woody shrubs
 - Once an infected tree dies, the fungus decomposes the stumps and logs left behind

Parasites and Pathogens (cont'd.)

- Animal fungal infections:
 - Animals that do not maintain a high body temperature are most vulnerable to fungal infections
 - Hundreds of fungal species infect insects, sometimes turning their hosts into “zombies”

Parasites and Pathogens (cont'd.)



Tamara Kavalou/National Geographic Creative.

Parasites and Pathogens (cont'd.)

- Most human fungal infections involve body surfaces
 - Infected areas become raised, red, and itchy
 - Examples:
 - “Athlete’s foot”
 - Fungal vaginitis
 - “Ringworms” (skin rash)

22.4 How Do We Use Fungi?

- Many fungal fruiting bodies serve as human food
 - Button mushrooms, shiitake mushrooms, and oyster mushrooms are easily cultivated
 - Edible mycorrhizal fungi: chanterelles, porcini mushrooms, morels, and truffles are typically gathered from the wild
- Each year thousands of people become ill after eating poisonous mushrooms

How Do We Use Fungi? (cont'd.)

- Truffles form underground near their host trees
 - When mature, they produce an odor similar to that of an amorous male wild pig
 - Female wild pigs detect the scent and root through the soil and, following consumption, disperse truffle spores in their feces

How Do We Use Fungi? (cont'd.)

- Fermentation by fungi helps us make a variety of products
 - *Aspergillus*: helps make soy sauce
 - *Penicillium*: produces the tangy blue veins in cheeses
 - *Saccharomyces cerevisiae*: baker's yeast

How Do We Use Fungi? (cont'd.)



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How Do We Use Fungi? (cont'd.)

- Geneticists and biotechnologists make use of yeasts
 - Yeasts grow readily in laboratories and are eukaryotes like us
 - Checkpoint genes that regulate the eukaryotic cell cycle were first discovered in *S. cerevisiae*
 - Some yeasts are used to produce proteins that serve as vaccines or other medicines

How Do We Use Fungi? (cont'd.)

- Some naturally occurring fungal–derived compounds have medicinal or psychoactive properties
 - Penicillin: antibiotic
 - Cyclosporin: immune suppressant
 - Ergotamine: migraine reliever or hallucinogen
 - Psilocybin (magic mushrooms): hallucinogen
 - Cordycepin: increases testosterone or anticancer drug

22.5 Application: Spread of Fungal Pathogens

- The dispersal of fungal pathogens by global trade and travel can have devastating effects on ecosystems
 - Plant-infecting sac fungus native to China eliminated all mature American chestnut trees

Application: Spread of Fungal Pathogens (cont'd.)

- Today, human-facilitated spread of a fungal pathogen is among the foremost causes of an amphibian extinction crisis
 - Some amphibians infected with the chytrid fungus referred to as Bd eventually die of dehydration
 - Bd was first introduced from African clawed frogs that were traded internationally

Application: Spread of Fungal Pathogens (cont'd.)



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