LECTURE PRESENTATIONS

For CAMPBELL BIOLOGY, NINTH EDITION

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Chapter 31

Fungi

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Overview

- Fungi are diverse and widespread
- They are **essential for the well-being of most terrestrial ecosystems** because they **break down organic material and recycle vital nutrients**
- About 100,000 species of fungi have been described
- It is estimated there are actually 1.5 million species of fungi

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Figure 31.1

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Concept 31.1: Fungi are heterotrophs that feed by absorption

- Despite their diversity, fungi share key traits, most importantly **the way in which they derive nutrition**

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Nutrition and Ecology

- Fungi are **heterotrophs** and absorb nutrients from outside of their body
- Fungi use enzymes to break down a large variety of complex molecules into smaller organic compounds
- The versatility of these enzymes contributes to fungi's ecological success

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- Fungi exhibit diverse lifestyles
  - **Decomposers**
  - Parasites
  - Mutualists

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Body Structure

- The most common body structures are **multicellular filaments** and **single cells** (**yeasts**)
- Some species grow as either filaments or yeasts; others grow as both

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- The morphology of multicellular fungi enhances their ability to absorb nutrients
- Fungi consist of **mycelia**, networks of branched **hyphae** adapted for absorption
- A mycelium's structure maximizes its surface area-to-volume ratio
- Fungal cell walls contain **chitin**

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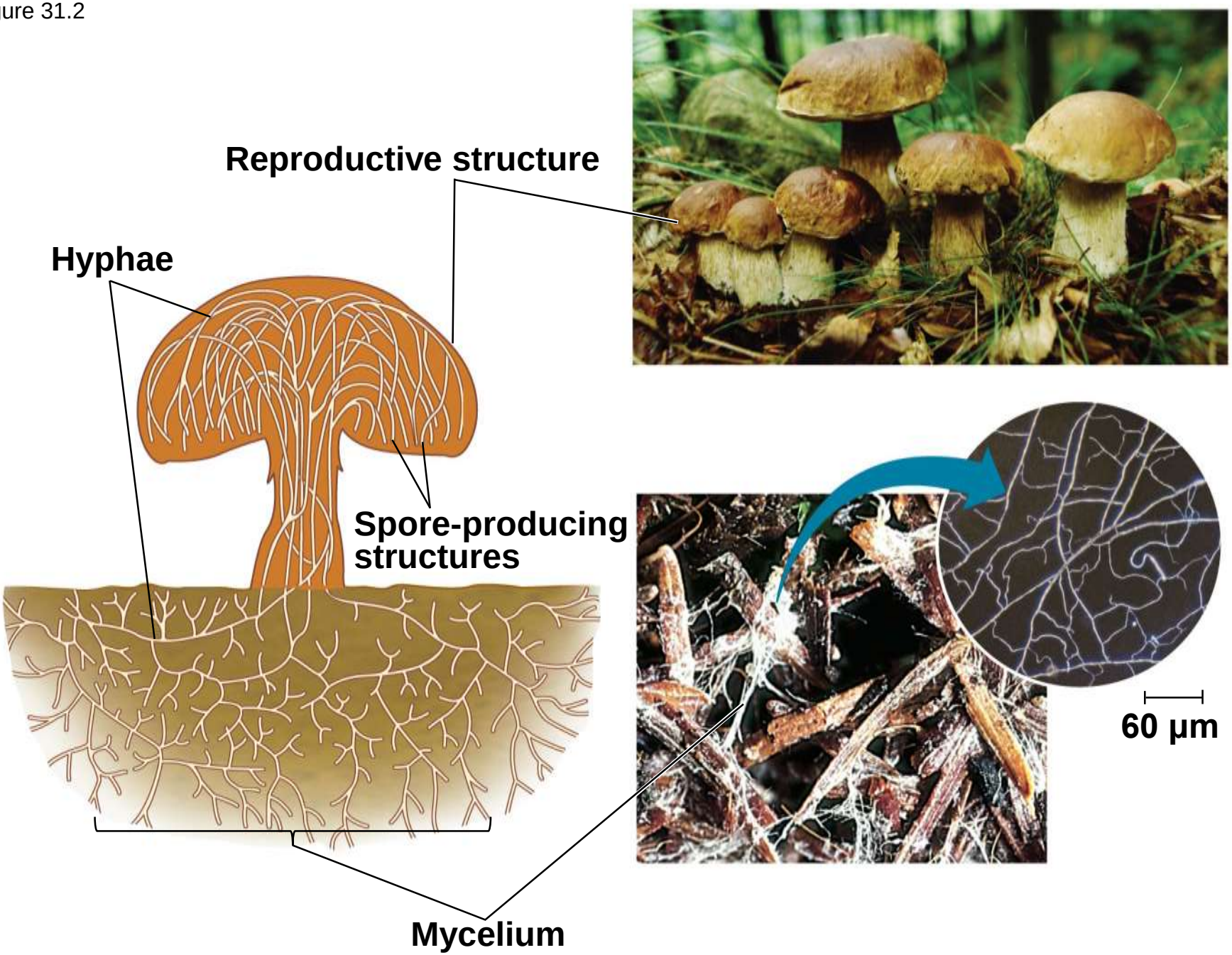
Figure 31.2



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- Most fungi have hyphae divided into cells by **septa**, with pores allowing cell-to-cell movement of organelles
- **Coenocytic fungi** lack septa and have a continuous cytoplasmic mass with hundreds or thousands of nuclei

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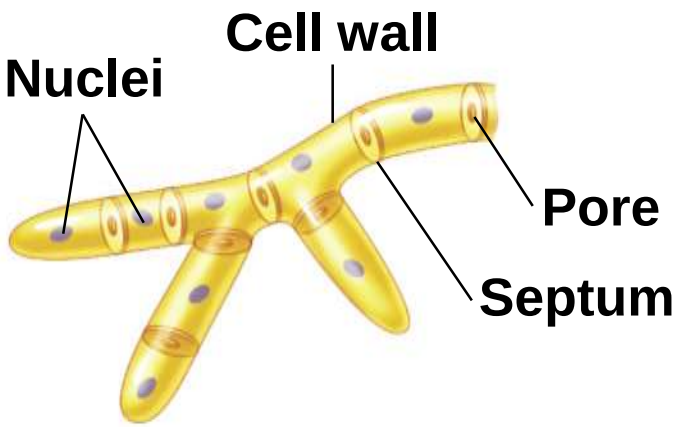
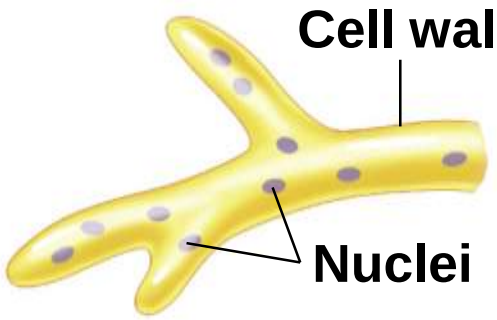
Figure 31.3



(a) Septate hypha



(b) Coenocytic hypha

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Specialized Hyphae in Mycorrhizal Fungi

- Some unique fungi have specialized hyphae called **haustoria** that allow them to penetrate the tissues of their host

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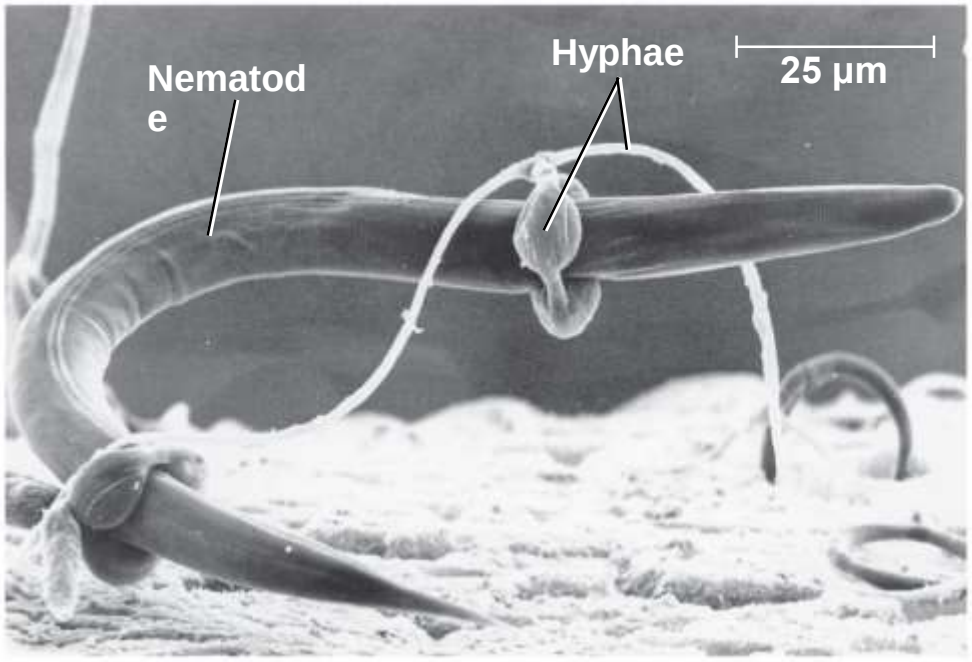
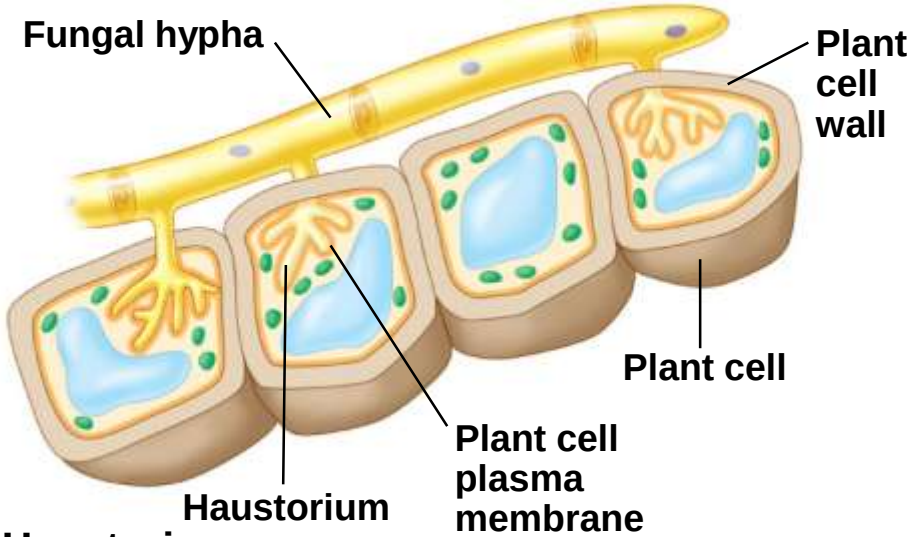
Figure 31.4



(a) Hyphae adapted for trapping and killing prey



(b) Haustoria

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- **Mycorrhizae** are mutually(متبادل) beneficial relationships between fungi and plant roots
- **Ectomycorrhizal fungi** form sheaths(أغلفة ،أغمدة) of hyphae **over a root** and also grow into the extracellular spaces of the root cortex(قشرة)
- **Arbuscular mycorrhizal fungi** extend hyphae through the cell walls of root cells and into tubes formed by invagination of the root cell membrane

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- Mycorrhizal fungi deliver phosphate ions and minerals to plants
- Most vascular plants have mycorrhizae

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Concept 31.2: Fungi produce spores through sexual or asexual life cycles

- Fungi propagate(تبث) themselves by producing vast numbers of spores, either sexually or asexually
- Fungi can produce spores from different types of life cycles

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Figure 31.5-1

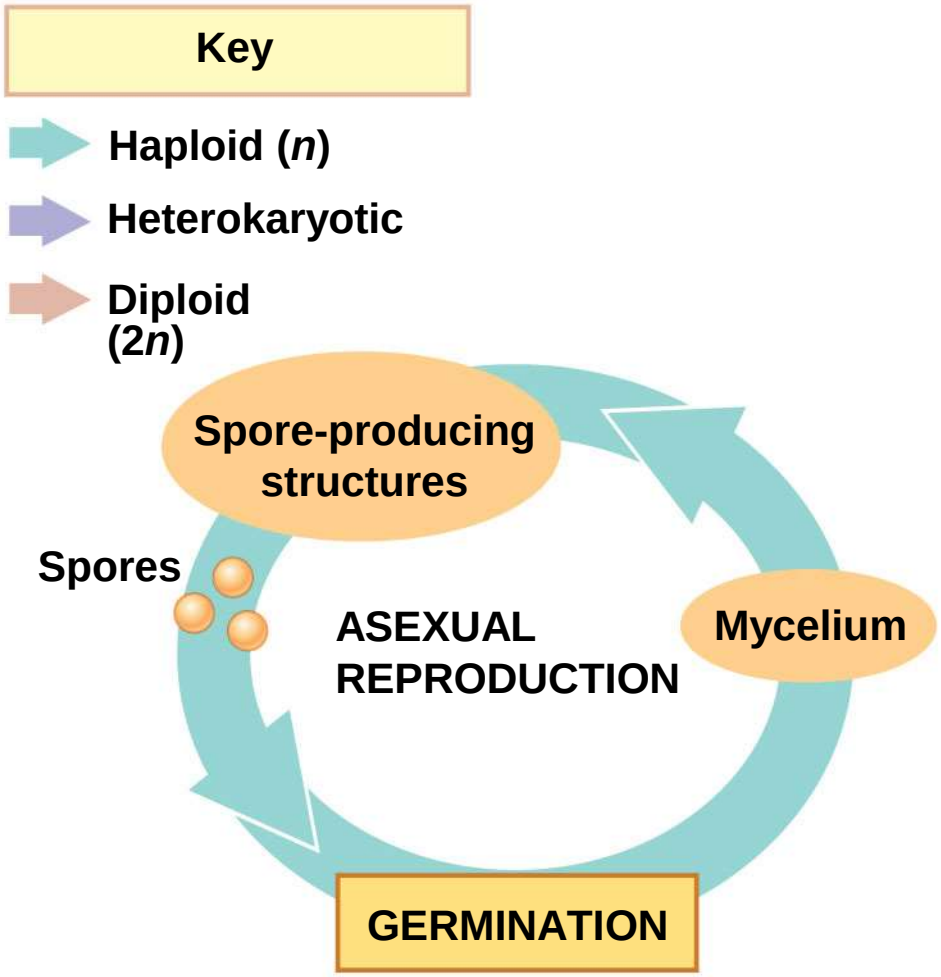

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Figure 31.5-2

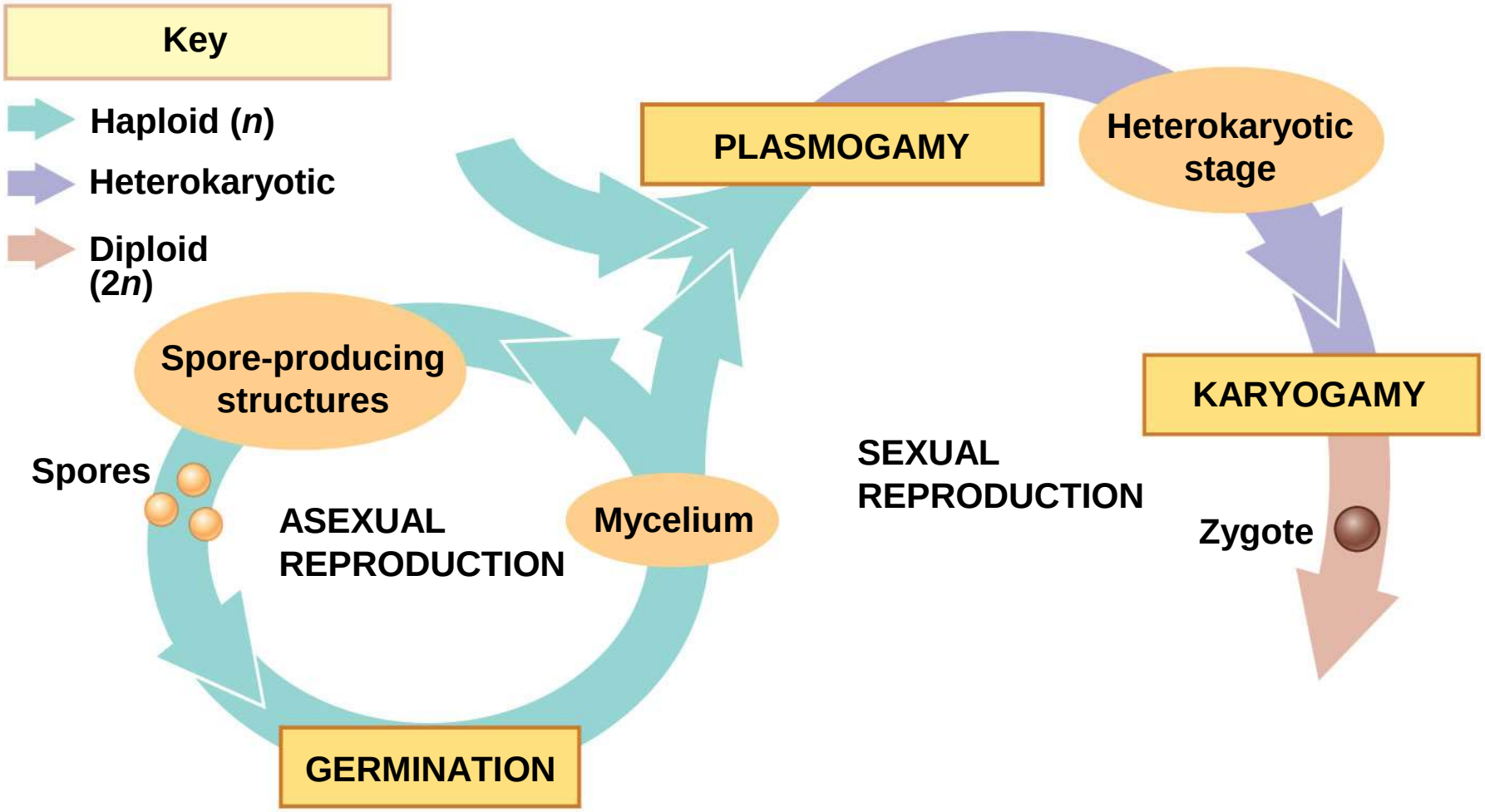

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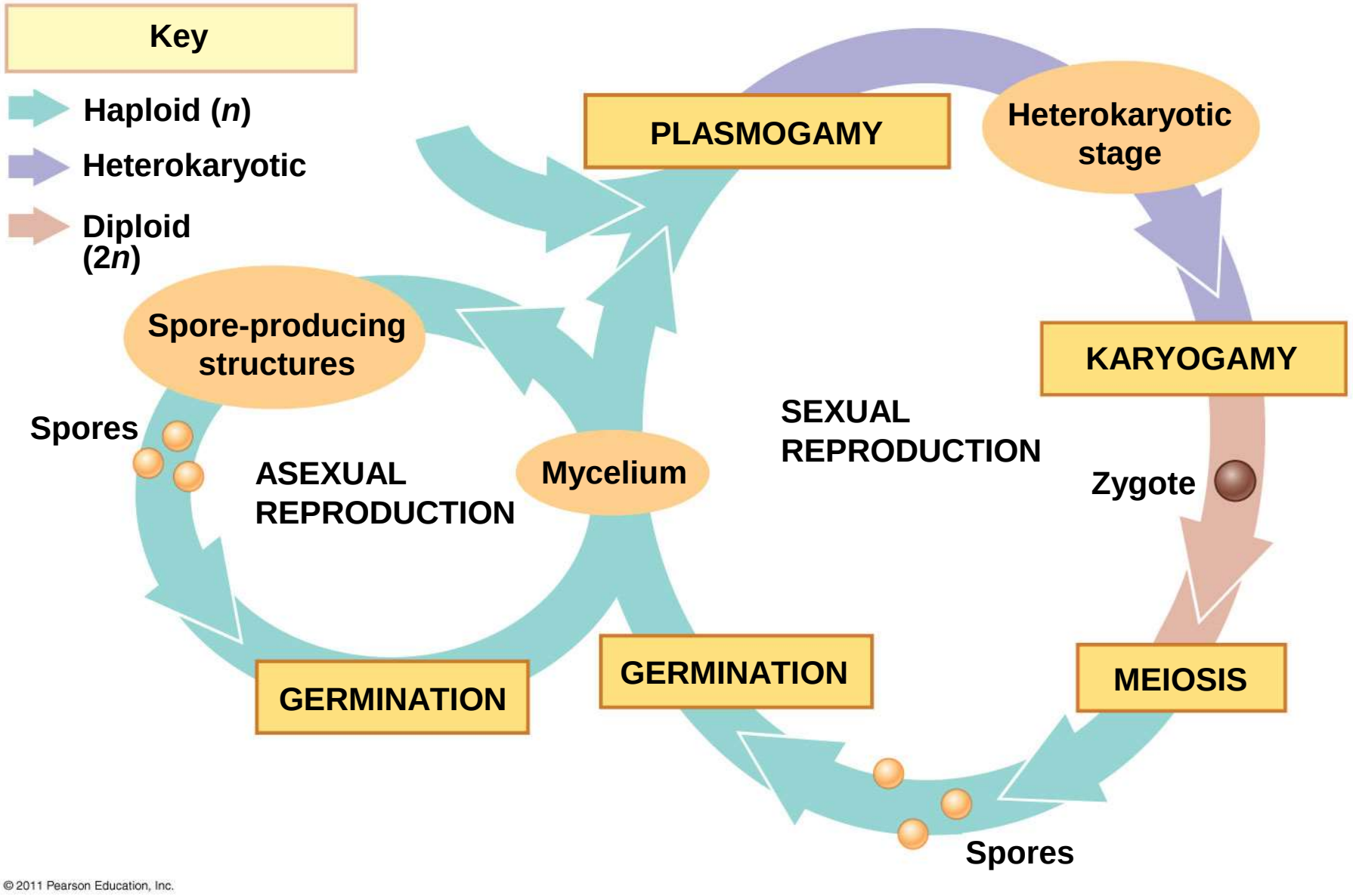
Figure 31.5-3



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Sexual Reproduction

- Fungal nuclei are **normally haploid**, with the exception of transient(عابر) diploid stages formed during the sexual life cycles
- Sexual reproduction requires the fusion of hyphae from different mating types
- Fungi use sexual signaling molecules called **pheromones** to communicate their mating type

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- **Plasmogamy** is the union of cytoplasm from two parent mycelia
- In most fungi, the haploid nuclei from each parent do not fuse right away; they coexist in the mycelium, called a **heterokaryon**
- In some fungi, the haploid nuclei pair off two to a cell; such a mycelium is said to be **dikaryotic**

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- Hours, days, or even centuries may pass before the occurrence of **karyogamy**, nuclear fusion
- During karyogamy, the haploid nuclei fuse, producing diploid cells
- The diploid phase is short-lived and undergoes meiosis, producing haploid spores
- The paired processes of karyogamy and meiosis produce genetic variation

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Asexual Reproduction

- In addition to sexual reproduction, many fungi can reproduce asexually
- **Molds** produce haploid spores by mitosis and form visible mycelia

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Figure 31.6

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- Other fungi that can reproduce asexually are yeasts, which are single cells
- Instead of producing spores, yeasts reproduce asexually by simple cell division and the pinching of ***"bud cells"*** from a parent cell

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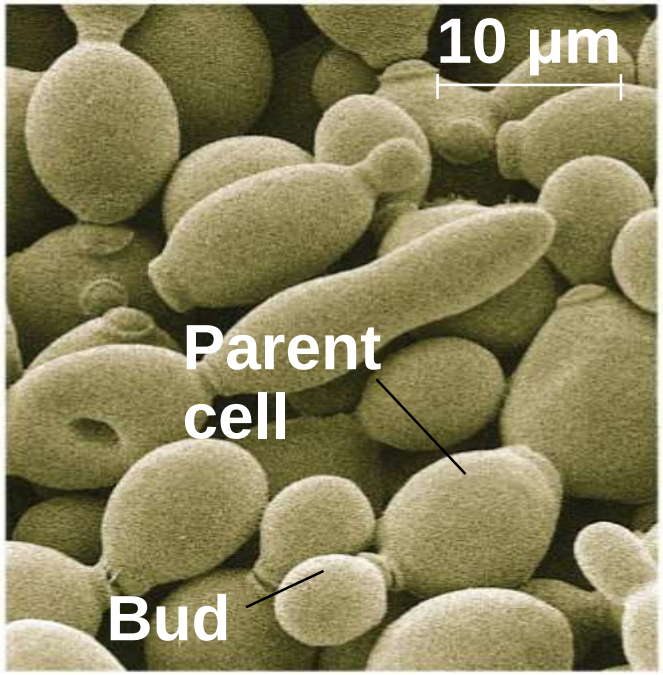
Figure 31.7



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- Many molds and yeasts have no known sexual stage
- ***Mycologists*** have traditionally called these **deuteromycetes**, or imperfect fungi
- This is not a sound taxonomic(التصنيفية) group; fungi are reclassified once their sexual stage is discovered

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Concept 31.3: The ancestor of fungi was an aquatic, single-celled, flagellated protist

- **Fungi and animals are more closely related** to each other than they are to plants or other eukaryotes

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The Move to Land

- Fungi were among the earliest colonizers of land and probably formed mutualistic(المنفعة المتبادلة) relationships with early land plants

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Concept 31.4: Fungi have radiated into (مشع في) a diverse set of lineages (الأنساب)

- Molecular analyses have helped clarify evolutionary relationships among fungal groups, although areas of uncertainty remain

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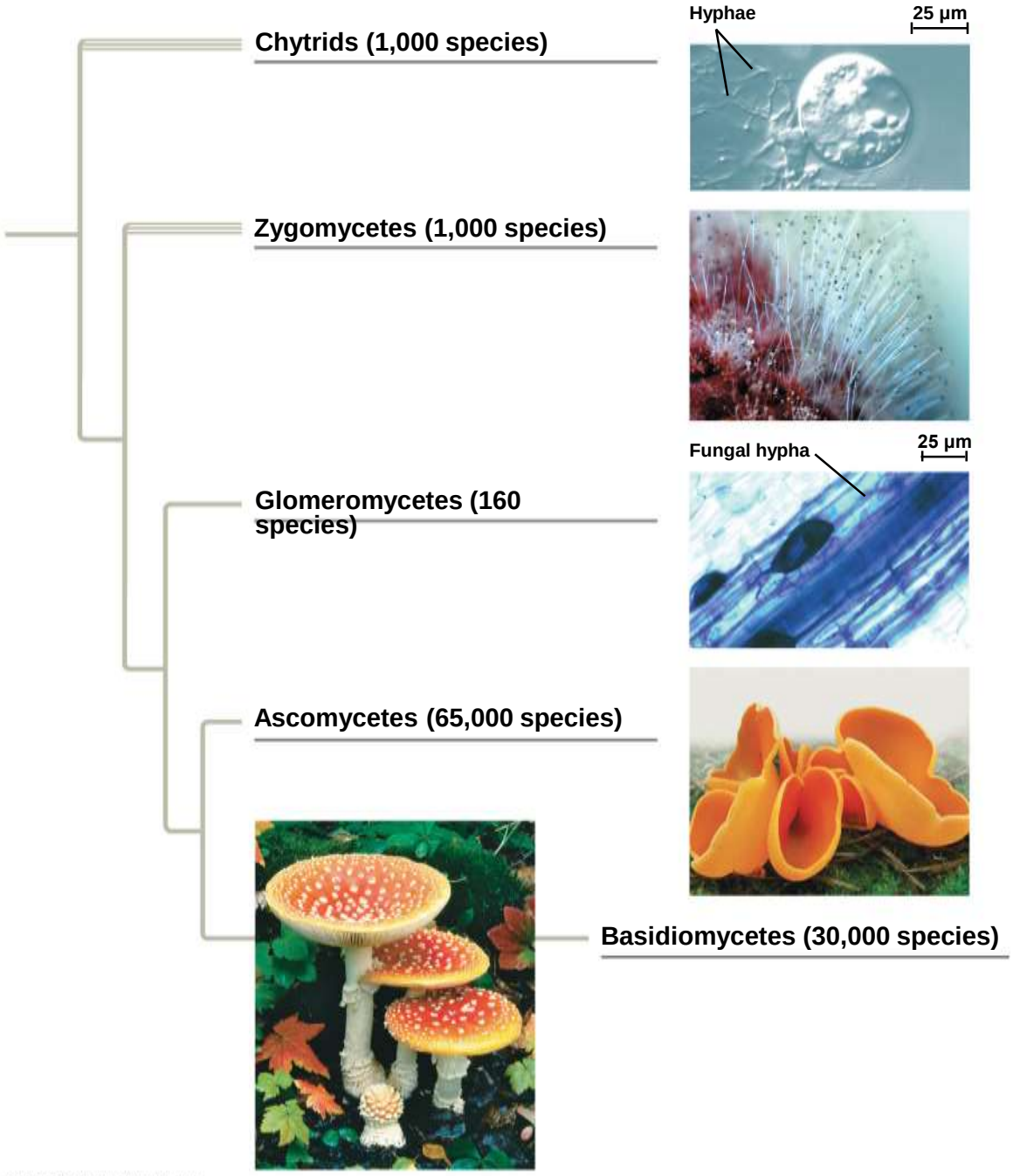
Figure 31.11



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Zygomycetes

- The **zygomycetes** (phylum Zygomycota) exhibit great diversity of life histories
- They include **fast-growing molds**, parasites, and commensal symbionts
- The life cycle of black bread mold (*Rhizopus stolonifer*) is fairly typical of the phylum
- Its hyphae are **coenocytic**
- Asexual **sporangia** produce haploid spores

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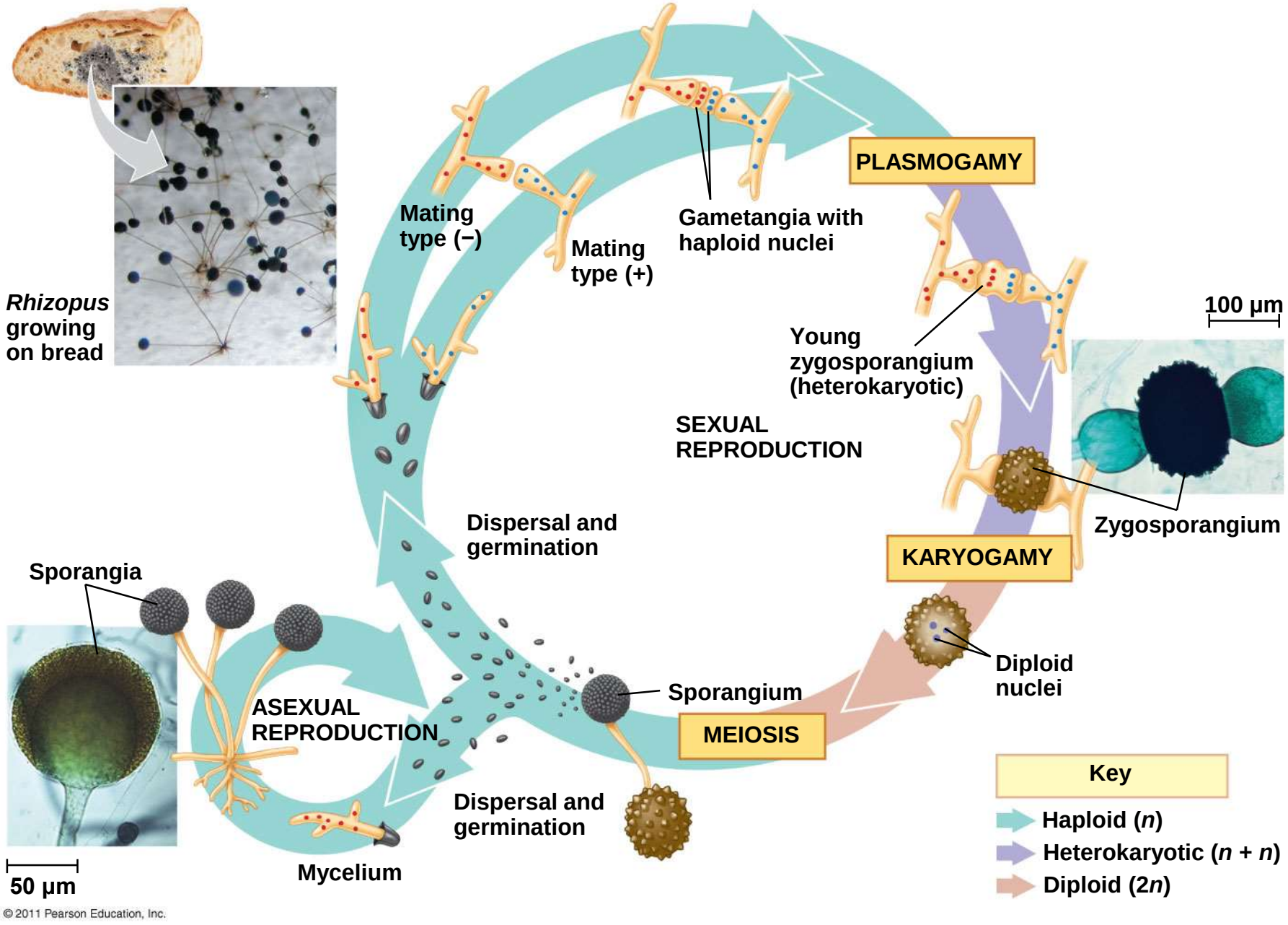
Figure 31.13



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- The zygomycetes are named for their sexually produced **zygosporangia**
- Zygosporangia are the site of **karyogamy** and then **meiosis**
- Zygosporangia, which are resistant to freezing and drying, can survive unfavorable conditions

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Glomeromycetes

- The **glomeromycetes** (phylum Glomeromycota) were once considered zygomycetes
- They are now classified in a separate clade
- Glomeromycetes form arbuscular mycorrhizae

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Figure 31.UN03

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Ascomycetes

- **Ascomycetes** (phylum Ascomycota) live in marine, freshwater, and terrestrial habitats
- Ascomycetes produce sexual spores in saclike **asci** contained in fruiting bodies called **ascocarps**
- Ascomycetes are commonly called **sac fungi**
- Ascomycetes vary in size and complexity

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- Ascomycetes include **plant pathogens, decomposers, and symbionts**
- Ascomycetes reproduce asexually by enormous numbers of asexual spores called **conidia**
- Conidia are not formed inside sporangia; they are produced asexually at the tips of specialized hyphae called conidiophores

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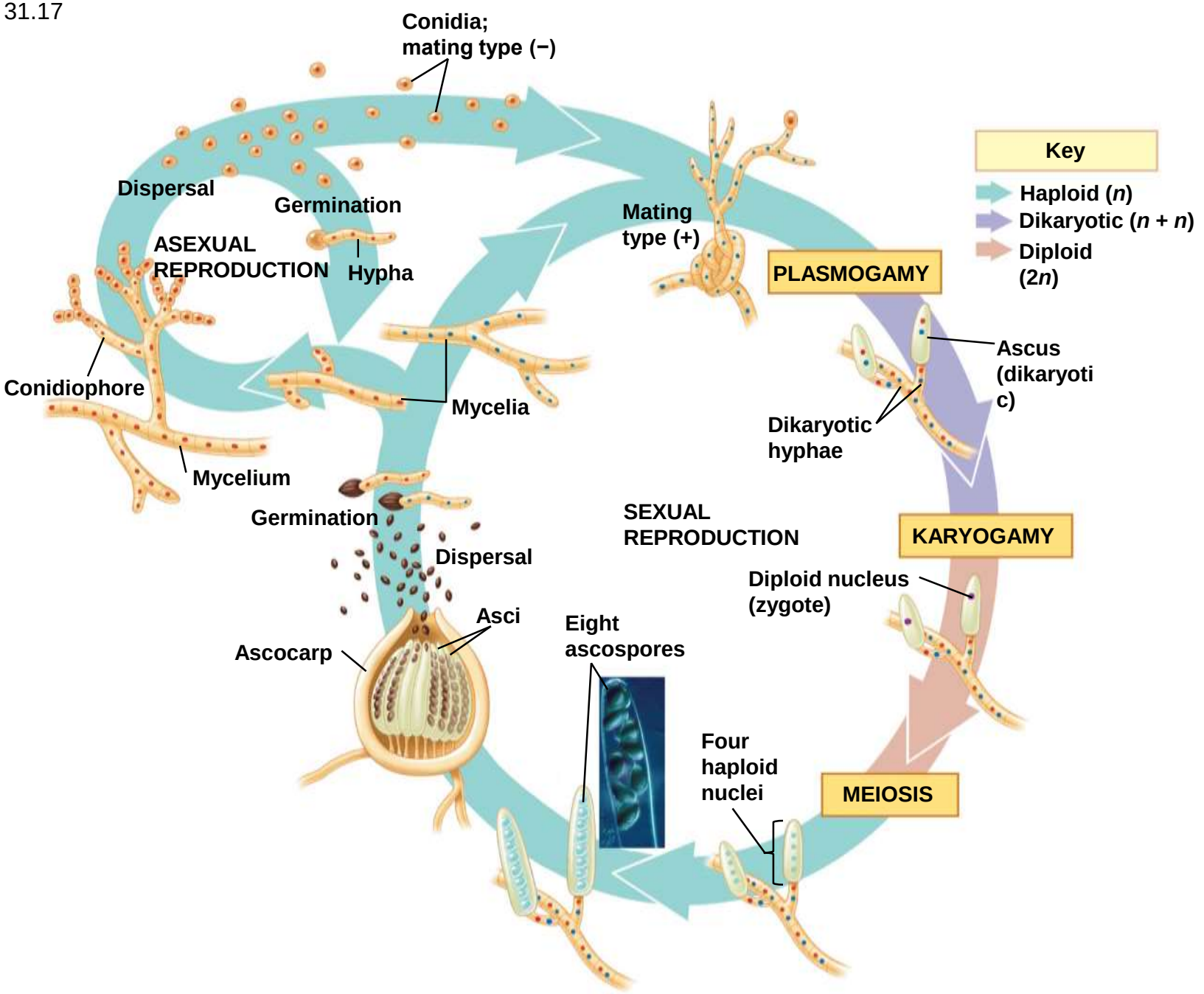
Figure 31.17



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Basidiomycetes

- **Basidomycetes** (phylum Basidiomycota) include mushrooms, puffballs, and shelf fungi, mycorrhizae, and plant parasites
- The phylum is defined by a clublike structure called a **basidium**, a transient diploid stage in the life cycle
- The basidiomycetes are also called club fungi
- Many basidiomycetes are decomposers of wood

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Figure 31.UN05

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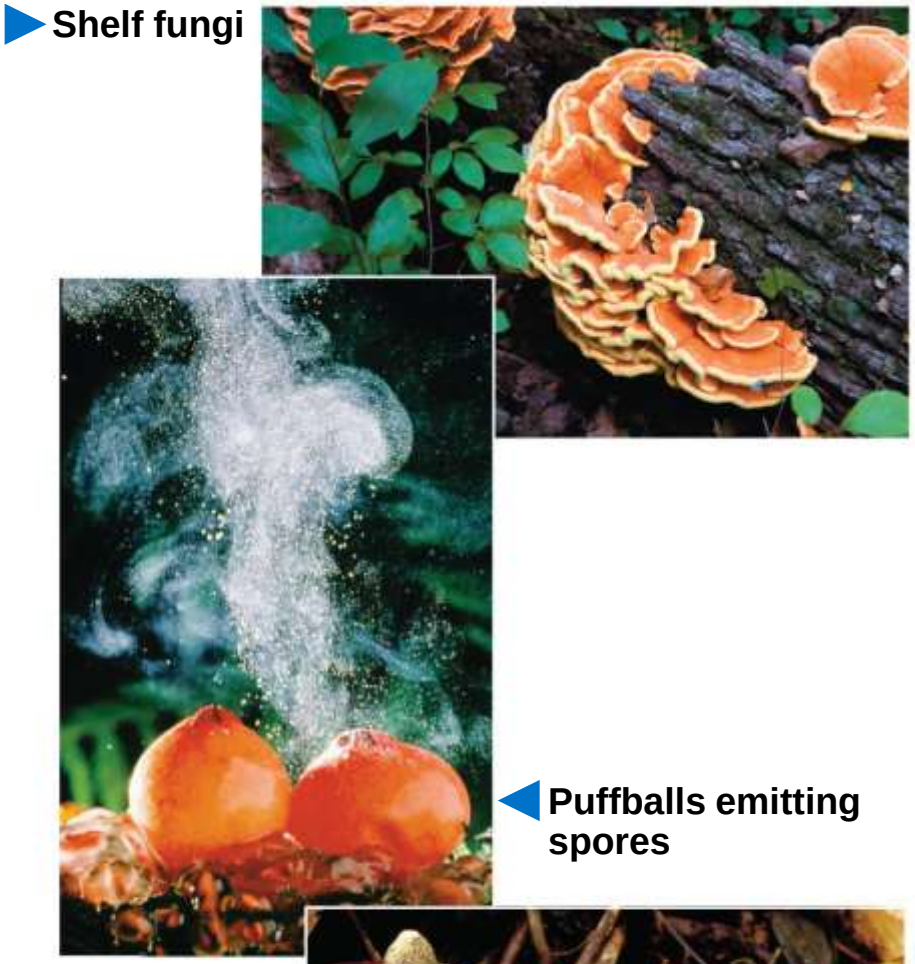
Figure 31.18



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- The life cycle of a basidiomycete usually includes a long-lived dikaryotic mycelium
- In response to environmental stimuli, the mycelium reproduces sexually by producing elaborate fruiting bodies call **basidiocarps**
- Mushrooms are examples of basidiocarps
- The numerous basidia in a basidiocarp are sources of sexual spores called basidiospores

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Figure 31.19

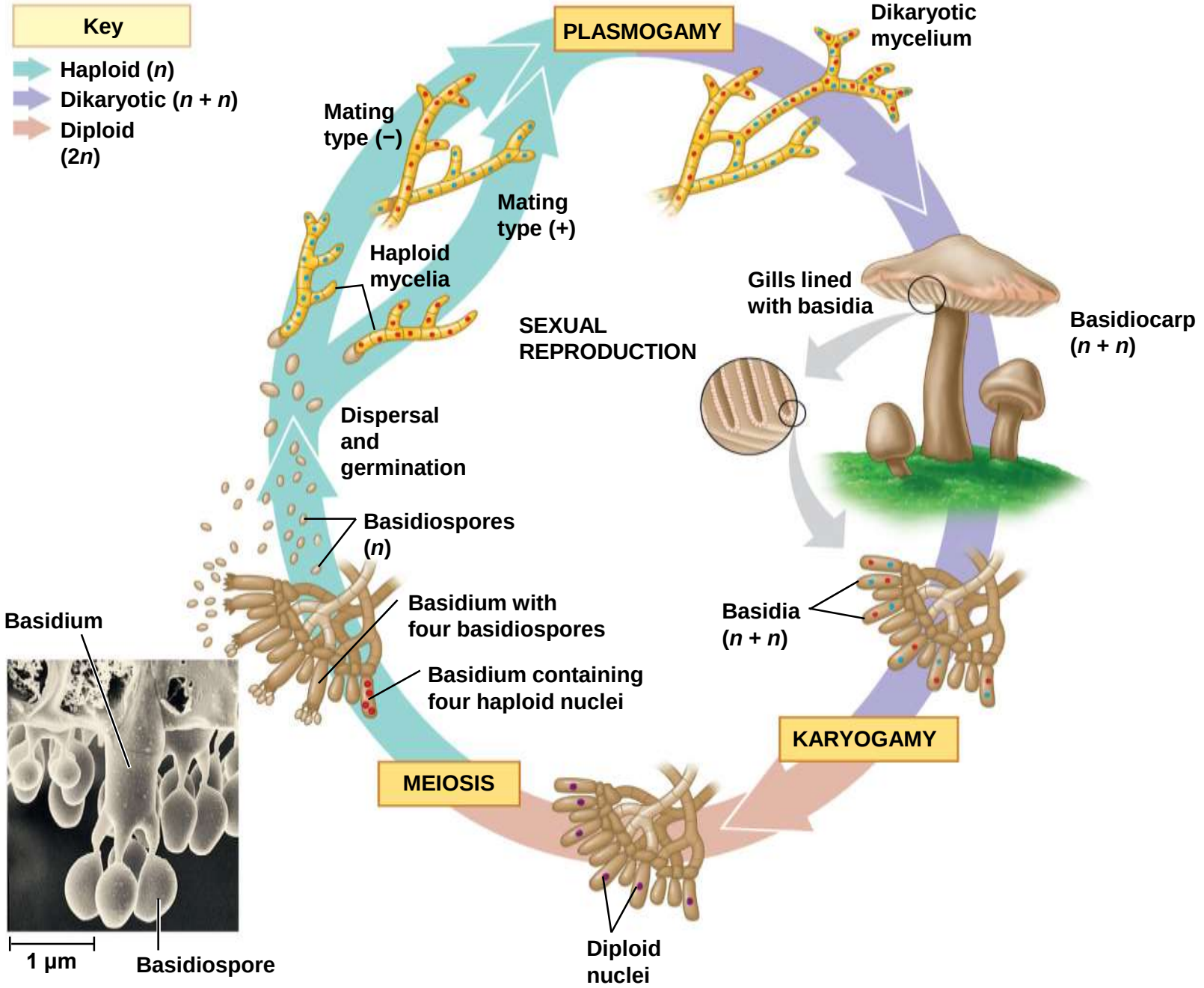

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Figure 31.20

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Concept 31.5: Fungi play key roles in nutrient cycling, ecological interactions, and human welfare

- Fungi interact with other organisms as decomposers, mutualists, and pathogens

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Fungi as Decomposers

- Fungi are efficient decomposers of organic material including cellulose and lignin
- They perform essential recycling of chemical elements between the living and nonliving world
- Fungi are also used in bioremediation(المعالجة البيولوجية) projects

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Fungi as Mutualists

- Fungi form mutualistic relationships with plants, algae, cyanobacteria, and animals
- All of these relationships have profound(عميقة) ecological effects

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Fungus-Plant Mutualisms

- Mycorrhizae are enormously important in natural ecosystems and agriculture
- Plants harbor harmless symbiotic **endophytes**, fungi that live inside leaves or other plant parts
- Endophytes **make toxins that deter herbivores and defend against pathogens**
- Most endophytes are ascomycetes

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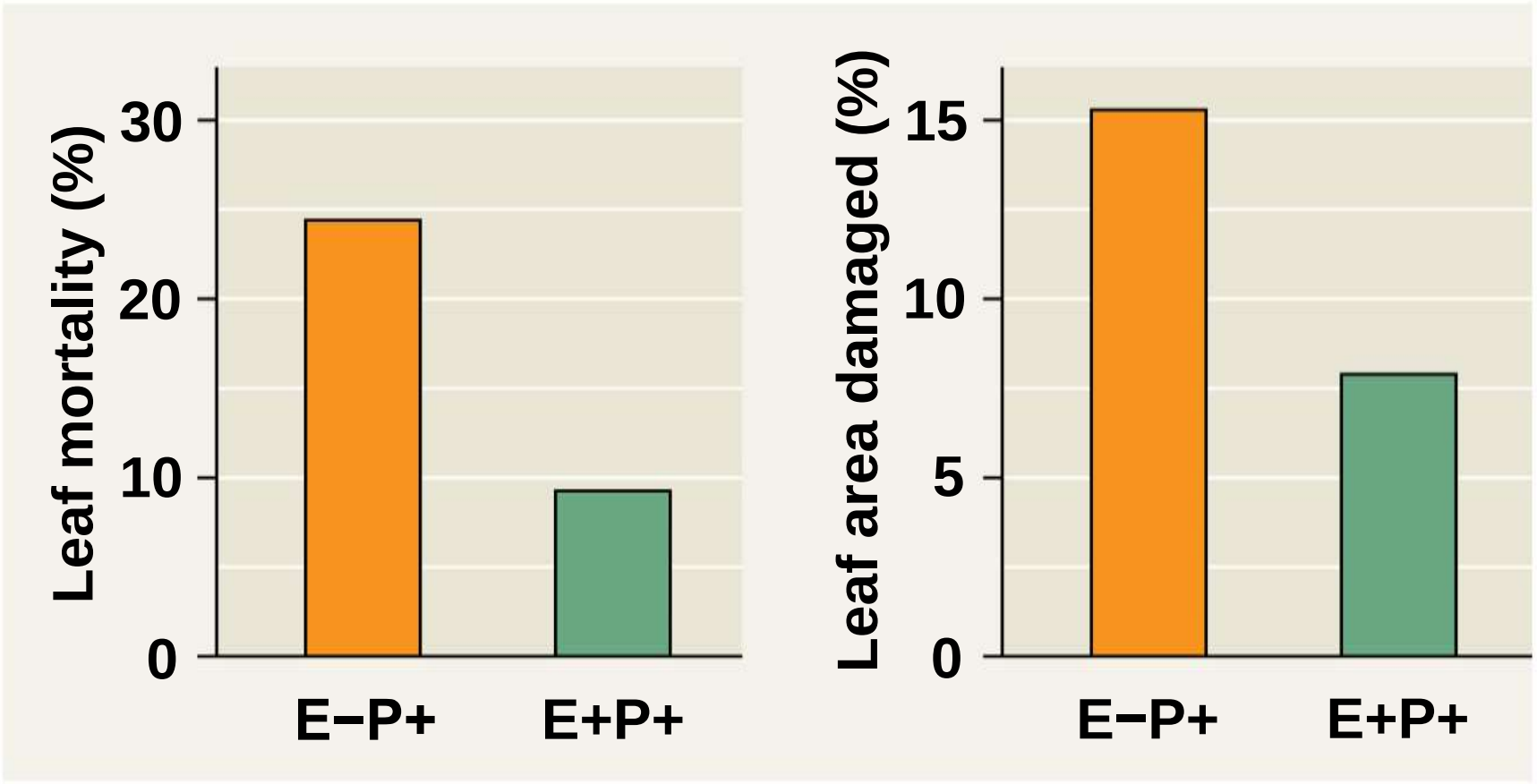
Figure 31.21

RESULTS

Endophyte not present; pathogen present (E−P+)

Both endophyte and pathogen present (E+P+)



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Fungus-Animal Symbioses

- Some fungi share their digestive services with animals
- **These fungi help break down plant material in the guts of cows and other grazing mammals**

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Lichens

- A **lichen** is a symbiotic association between a photosynthetic microorganism and a fungus
- Millions of photosynthetic cells are held in a mass of fungal hyphae
- The photosynthetic component is green algae of cyanobacteria
- The fungal component is most often an ascomycete

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Figure 31.23

A foliose (leaflike) lichen

Crustose (encrusting) lichens

A fruticose (shrublike) lichen

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- The symbioses are so complete that lichens are given scientific names
- Algae or cyanobacteria occupy an inner layer below the lichen surface

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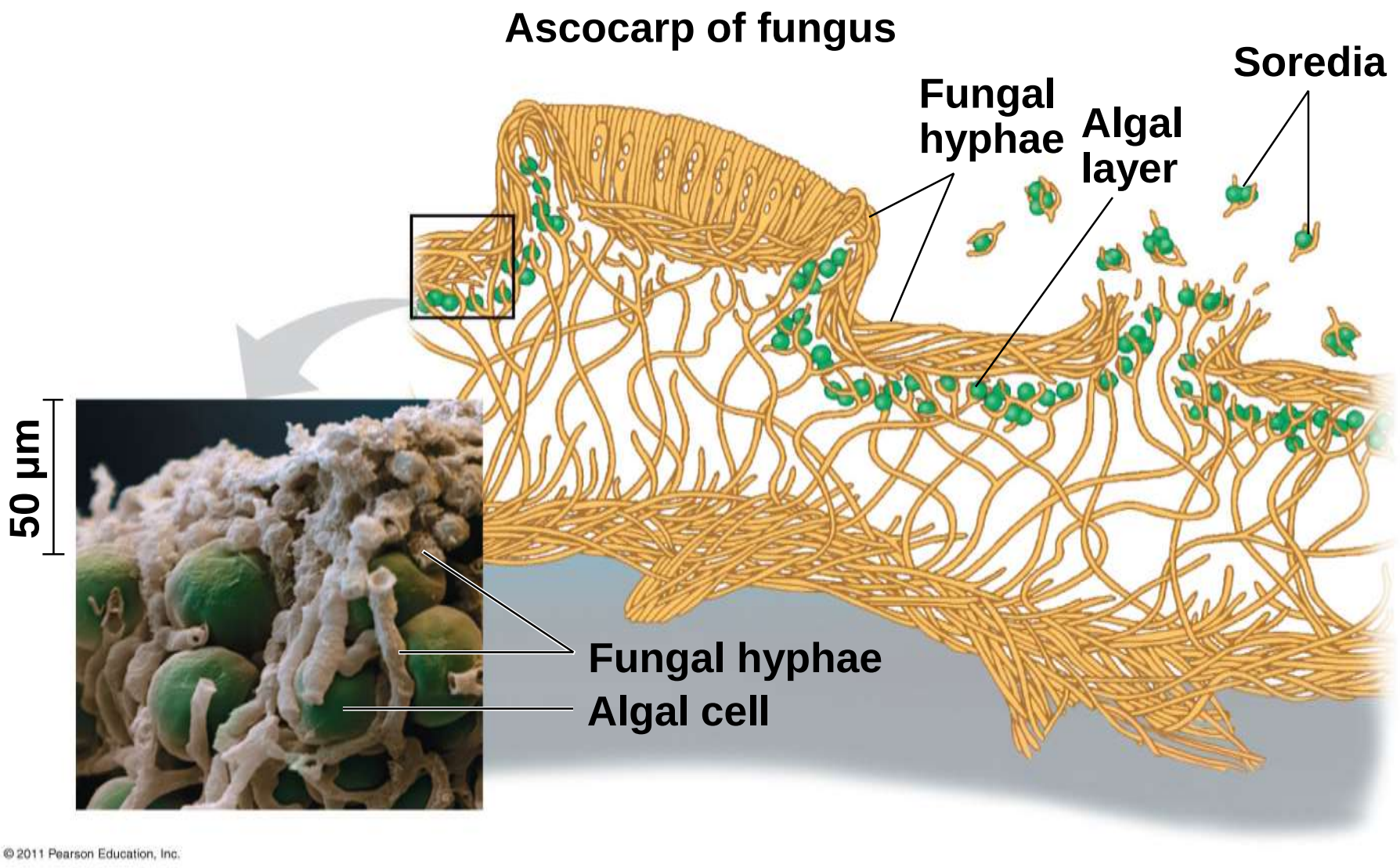
Figure 31.24



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- The algae provide carbon compounds, cyanobacteria also provide organic nitrogen, and fungi provide the environment for growth
- The fungi of lichens can reproduce sexually and asexually
- Asexual reproduction is by fragmentation or the formation of **soredia,** small clusters of hyphae with embedded algae

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- Lichens are important pioneers on new rock and soil surfaces
- Lichens may have helped the colonization of land by plants 550–600 million years ago
- Lichens are sensitive to pollution, and their death can be a warning that air quality is deteriorating(تدهور)

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Fungi as Pathogens

- About **30% of known fungal species are parasites or pathogens, mostly on or in plants**
- Each year, 10% to 50% of the world's fruit harvest is lost due to fungi
- **Some fungi that attack food crops are toxic to humans**

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Figure 31.25

(a) Corn smut on corn

(b) Tar spot fungus on maple leaves

(c) Ergots on rye

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- Ergot of rye is caused by an ascomycete, and produces toxins
- More than 40,000 people died from an epidemic of ergotism during the middle ages
- Ergotism is characterized by gangrene, nervous spasms(تشنجات), burning sensations, hallucinations(هلوسة), and temporary insanity(الجنون المؤقت)
- **Ergots contain lysergic acid, the raw material for LSD**

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- Animals are much less susceptible(سريع التأثر) to parasitic fungi than are plants
- The chytrid *Batrachochytrium dendrobatidis* might be the cause of the recent decline in amphibians worldwide

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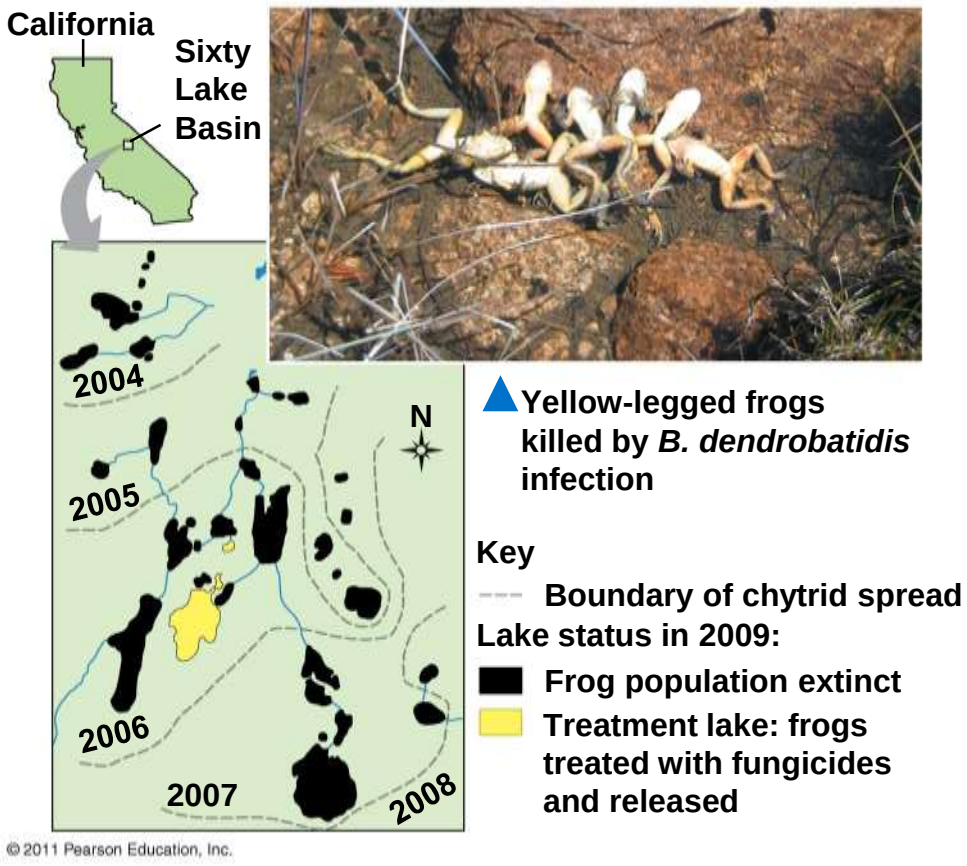
Figure 31.26



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- The general term for a fungal infection in animals is **mycosis**
- Ringworm and **athlete's foot** are examples a human mycoses
- Systemic mycoses spread through the body
  - For example, coccidioidomycosis produces tuberculosis-like symptoms
- Some mycoses are opportunistic
  - For example, *Candida albicans*, which causes yeast infections

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Practical Uses of Fungi

- Humans eat many fungi and use others to make cheeses, alcoholic beverages, and bread
- Some fungi **are used to produce antibiotics** for the treatment of bacterial infections
  - For example, the ascomycete *Penicillium*

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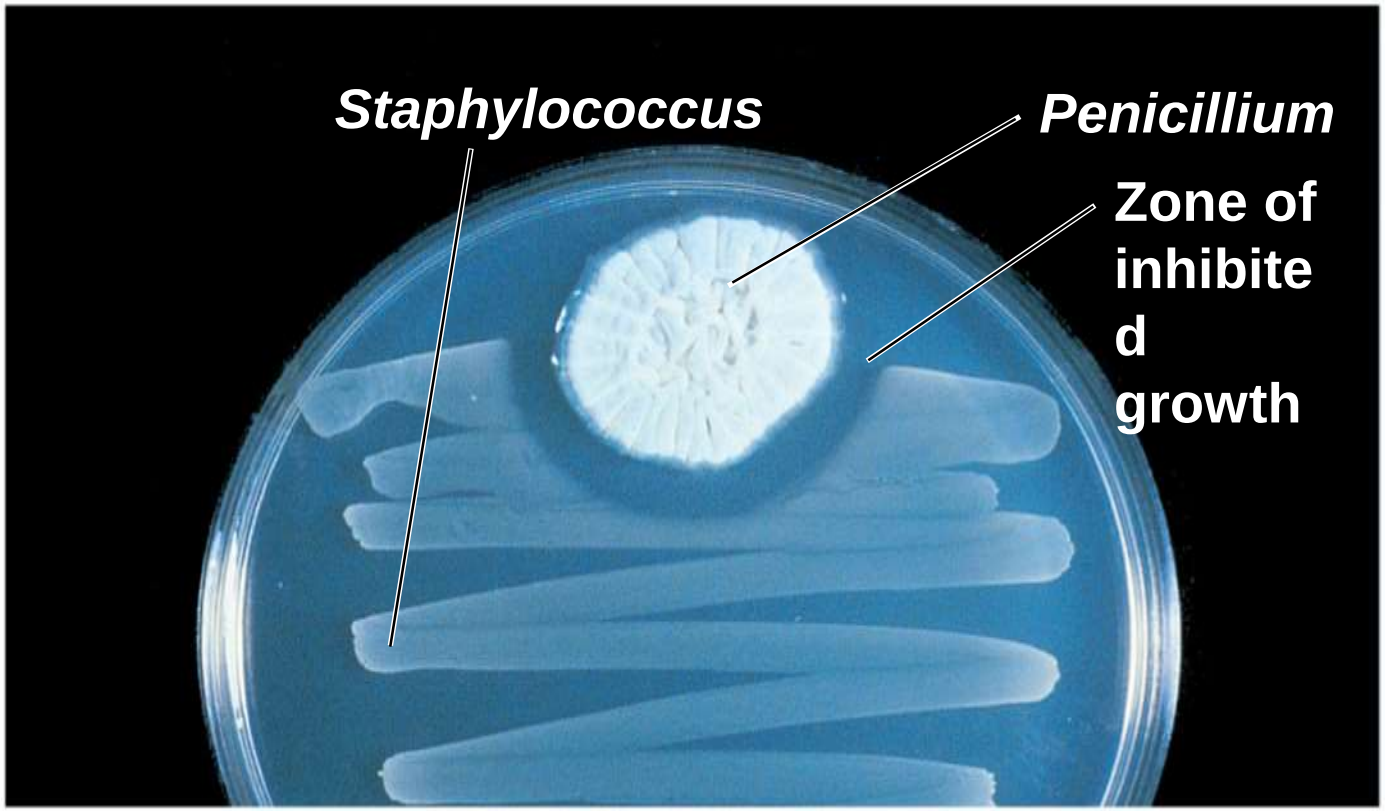
Figure 31.27



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- Genetic research on fungi is leading to applications in biotechnology
  - For example, scientists are using *Saccharomyces* to study homologs of the genes involved in Parkinson's and Huntington's diseases
  - For example, insulin-like growth factor can be produced in the fungus *Saccharomyces cerevisiae*

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