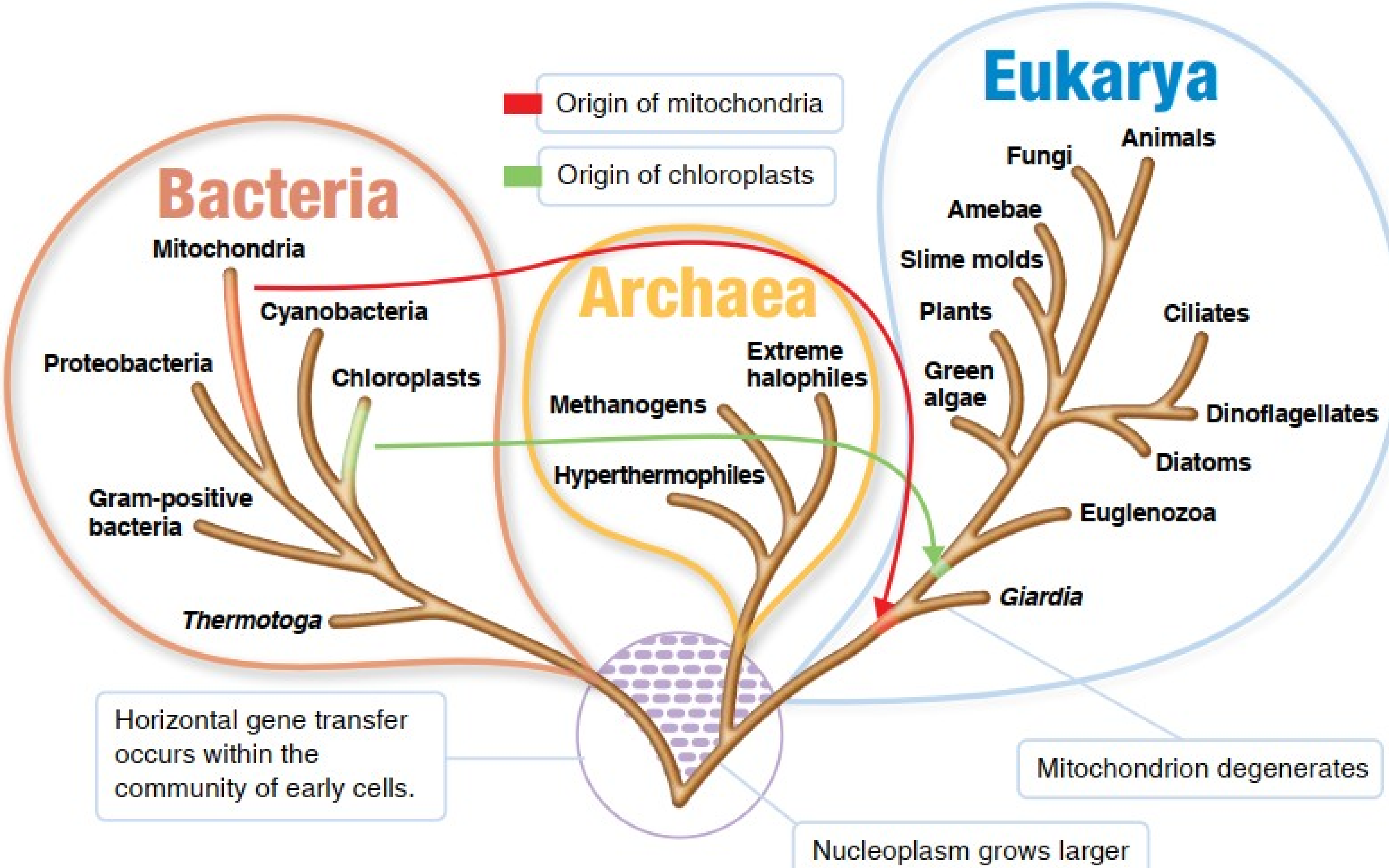
MOLDS



Origin of mitochondria
Origin of chloroplasts
Bacteria
Mitochondria
Cyanobacteria
Proteobacteria
Chloroplasts
Gram-positive bacteria
Thermotoga
Archaea
Extreme halophiles
Methanogens
Hyperthermophiles
Eukarya
Animals
Fungi
Amebae
Slime molds
Plants
Ciliates
Green algae
Dinoflagellates
Diatoms
Euglenozoa
Giardia
Horizontal gene transfer occurs within the community of early cells.
Mitochondrion degenerates
Nucleoplasm grows larger

Learning outcomes

1. Compare the cell morphology, cellular structures and function of the cellular structures among the molds, yeasts and bacteria.

2. Classify the molds.

3. List the types of asexual and sexual spores of molds and interpret the reproduction procedure of each spore type.

4. Compare and explain the ways of biomass quantification among molds, yeasts and bacteria.

Compare the cell morphology, cellular structures and function of the cellular structures among the molds, yeasts and bacteria.

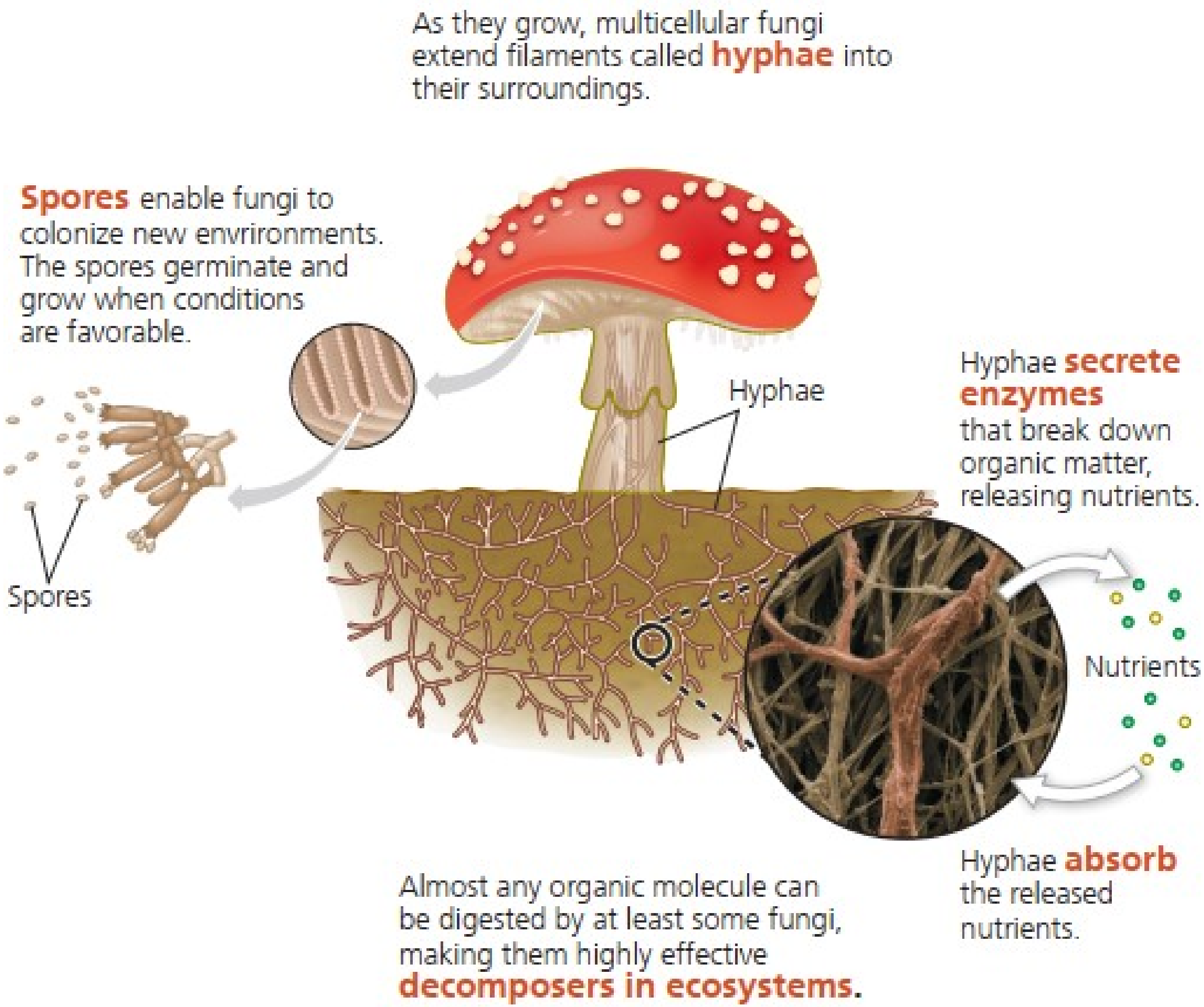
TABLE 12.1 Selected Features of Fungi and Bacteria Compared

	Fungi	Bacteria
Cell Type	Eukaryotic	Prokaryotic
Cell Membrane	Sterols present	Sterols absent, except in *Mycoplasma*
Cell Wall	Glucans; mannans; chitin (no peptidoglycan)	Peptidoglycan
Spores	Sexual and asexual reproductive spores	Endospores (not for reproduction); some asexual reproductive spores
Metabolism	Limited to heterotrophic; aerobic, facultatively anaerobic	Heterotrophic, autotrophic; aerobic, facultatively anaerobic, anaerobic

Morphological, structural and functional differences between yeast cells and filamentous fungal cells

	Molds	Yeasts
Morphology	?	?
Cell wall	?	?
Spore	?	?
Reproduction procedure	?	?
Metabolism	?	?

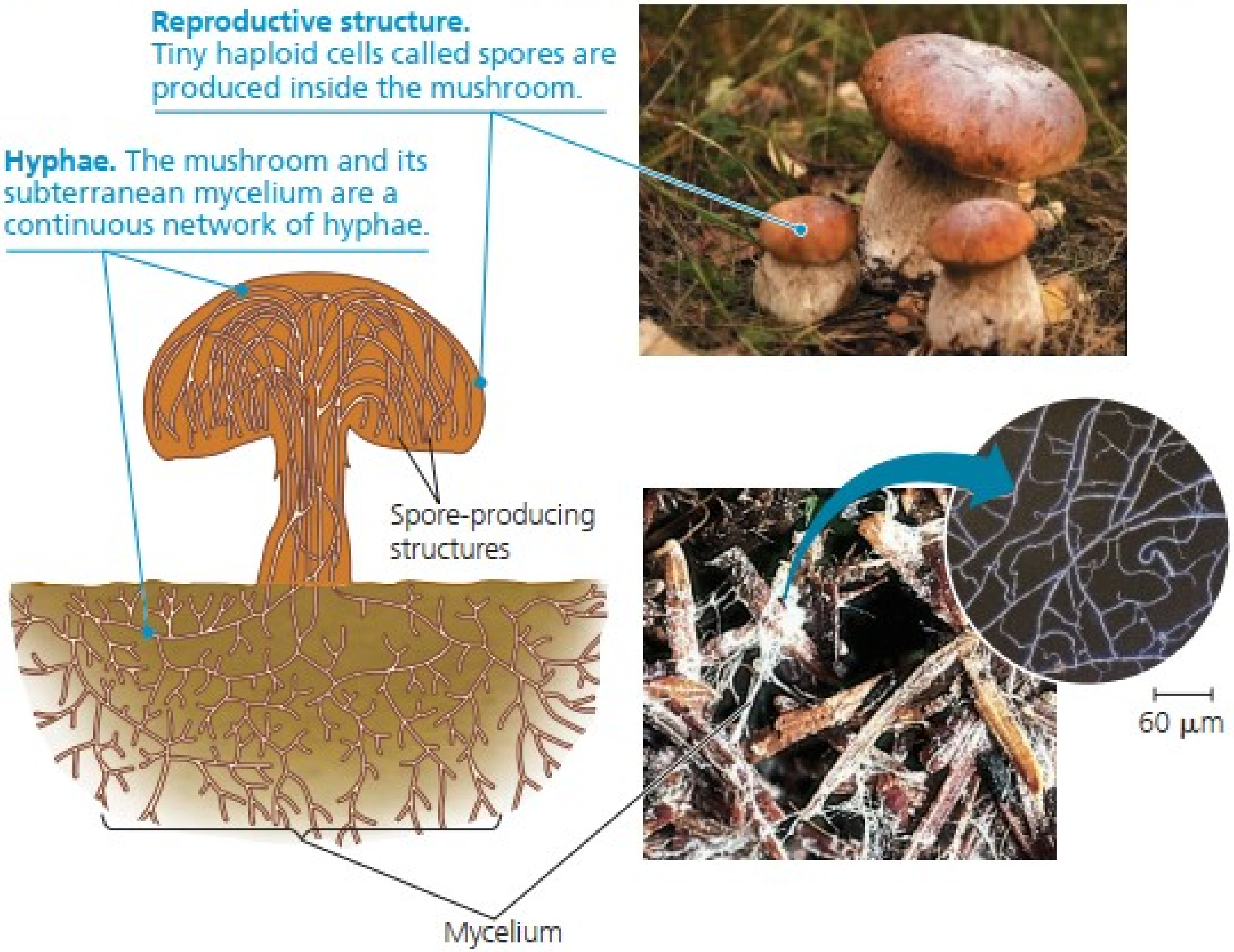
Morphology



As they grow, multicellular fungi extend filaments called hyphae into their surroundings.
Spores enable fungi to colonize new envrironments. The spores germinate and grow when conditions are favorable.
Spores
Hyphae
Hyphae secrete enzymes that break down organic matter, releasing nutrients.
Nutrients
Hyphae absorb the released nutrients.
Almost any organic molecule can be digested by at least some fungi, making them highly effective decomposers in ecosystems.

Morphology

▼ **Figure 31.2 Structure of a multicellular fungus.** The top photograph shows the sexual structures, in this case called mushrooms, of the penny bun fungus (*Boletus edulis*). The bottom photograph shows a mycelium growing on fallen conifer needles. The inset SEM shows hyphae.

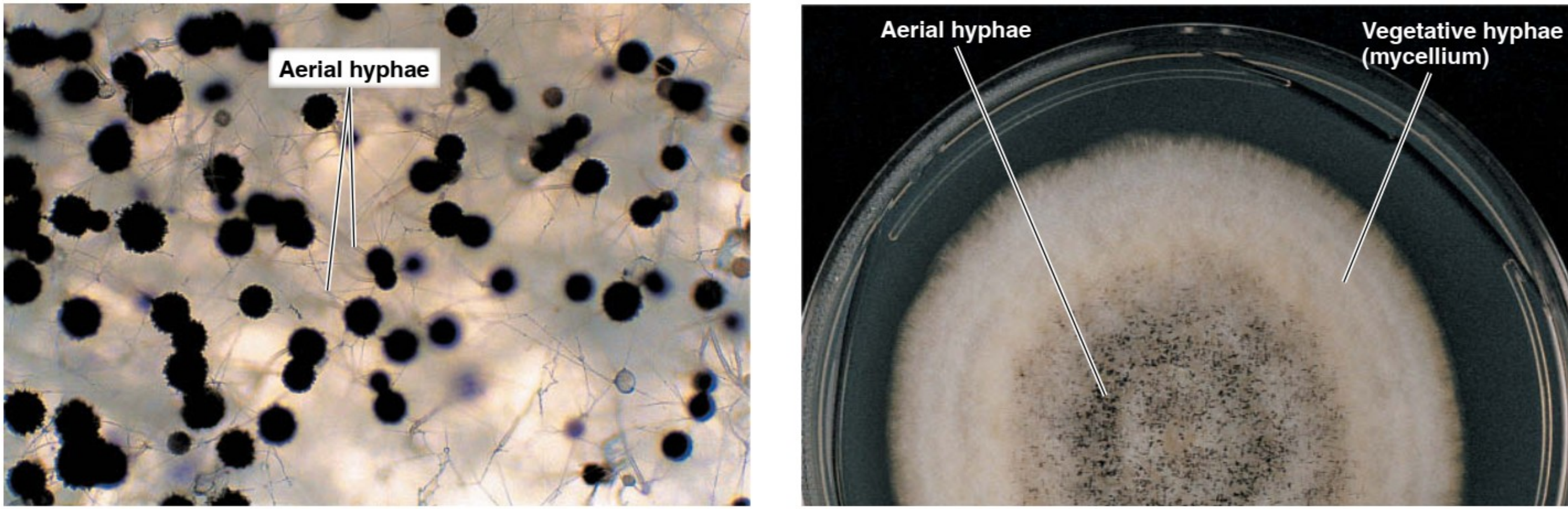


? *Although the mushrooms in the top photograph appear to be different individuals, could their DNA be identical? Explain.*

Morphology

Macroscopic view of a *Penicillin* colony.

Morphology

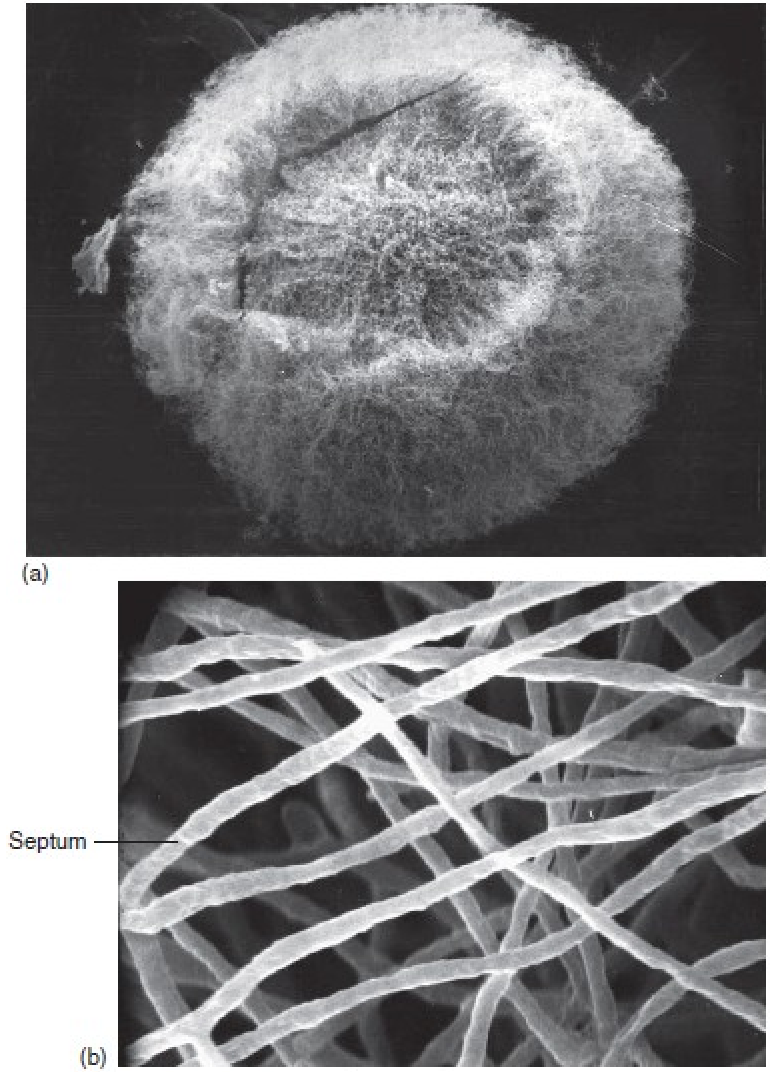


(a) *Aspergillus niger* LM 20 μm

(b) *A. niger* on agar

Figure 12.3 Aerial and vegetative hyphae. **(a)** A photomicrograph of aerial hyphae, showing reproductive spores. **(b)** A colony of *Aspergillus niger* grown on a glucose agar plate, showing both vegetative and aerial hyphae.

Morphology



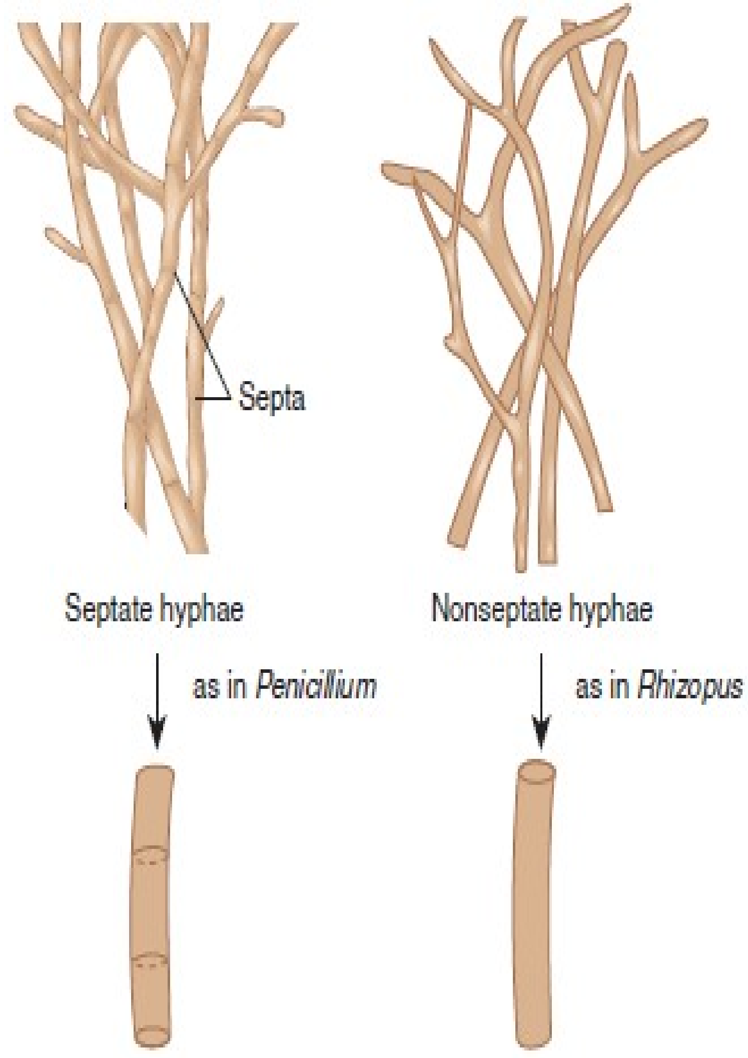
***Diplodia maydis*, a pathogenic fungus of corn plants.**
(a) Scanning electron micrograph showing a colony or mycelium (24×). **(b)** Close-up of hyphal structure (1,200×).

Structures

❖ Hyphae: cell tubes with a cell wall made of chitin that surrounds the plasma membrane and cytoplasm.

❖Hyphae contain cross-walls called septa (singular: septum), which divide them into distinct, uninucleate (one-nucleus) cell-like units.

❖ Mycelia: formed from the mycelium.



Basic structural types of hyphae.

Structures

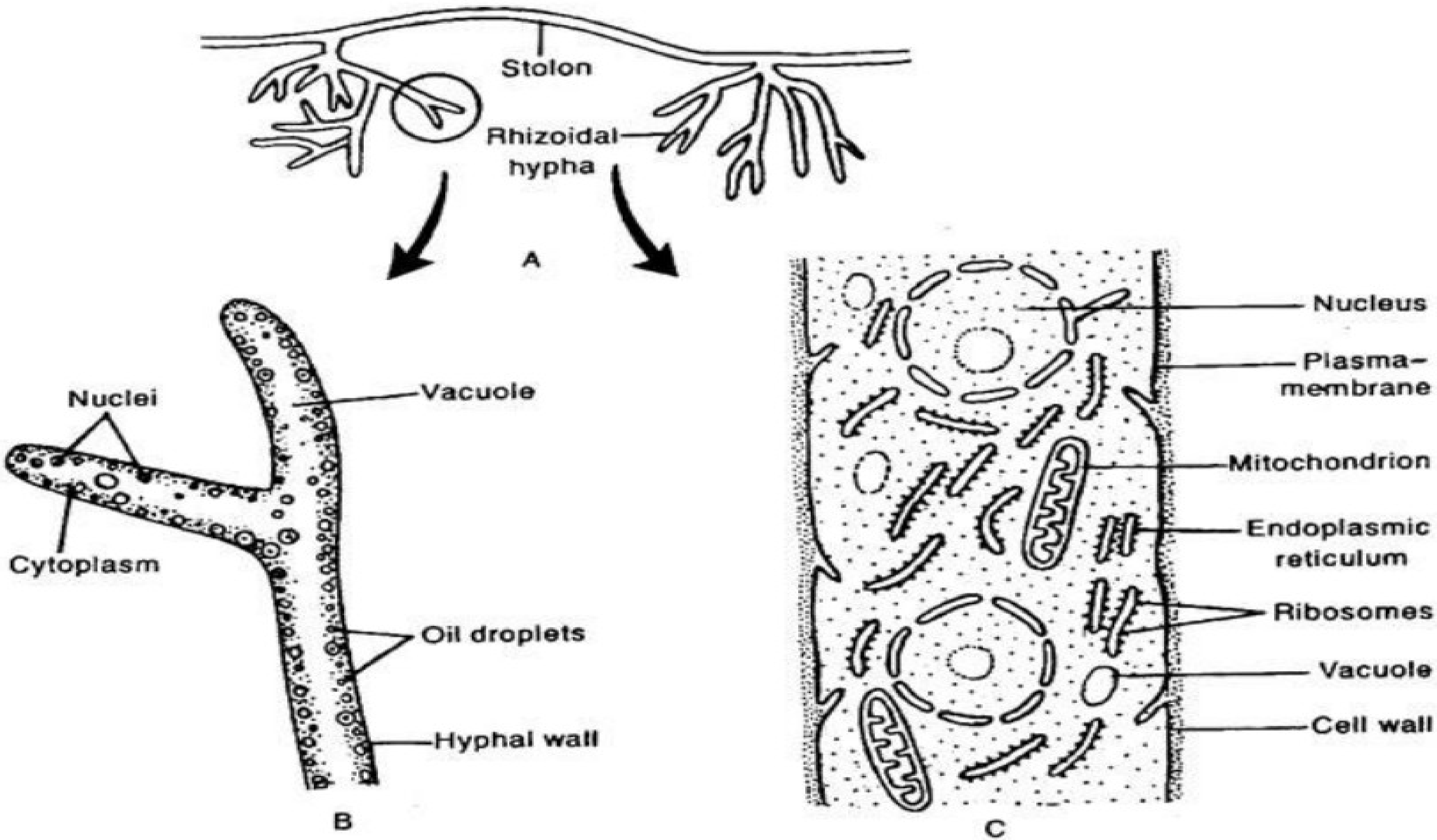


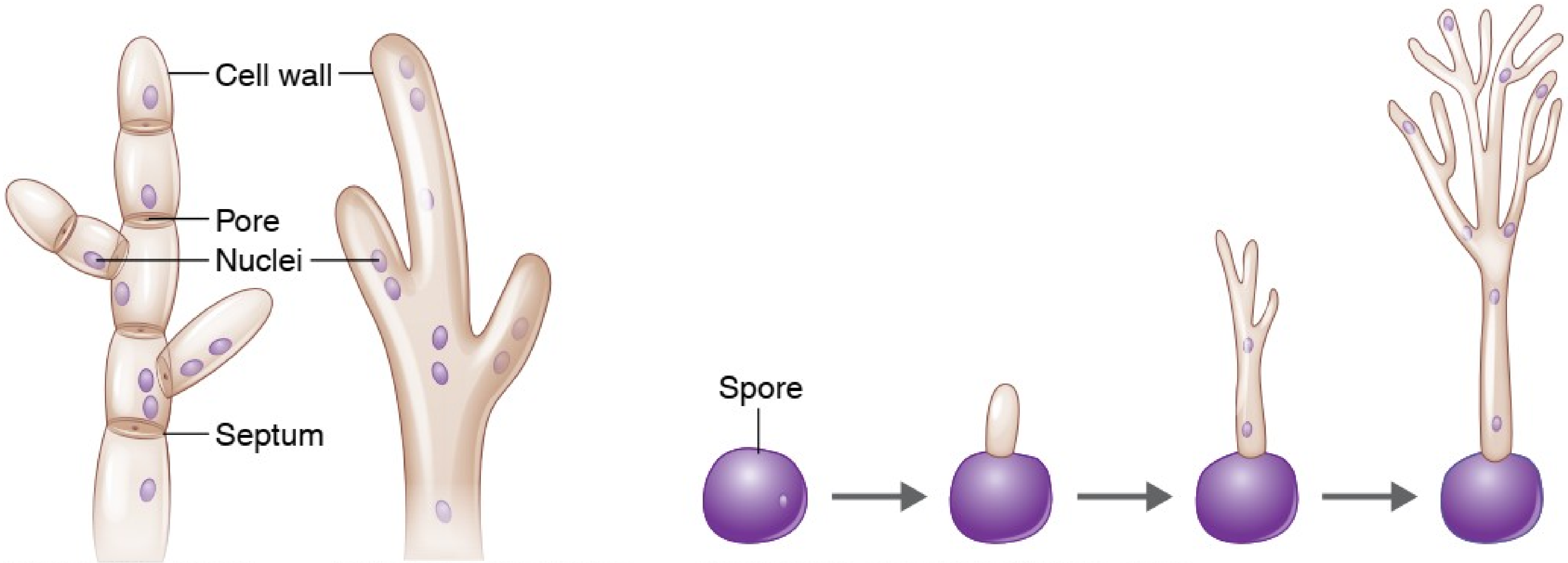
Fig. 4.25 : *Rhizopus stolonifer* : A. Vegetative mycelium, B. Portion of hypha under light microscope, C. Portion of hypha under electron microscope

Structures

- ❖ Hyphae grow by elongating at the tips.

- ❖ Each part of a hypha is capable of growth, and when a fragment breaks off, it can elongate to form a new hypha.

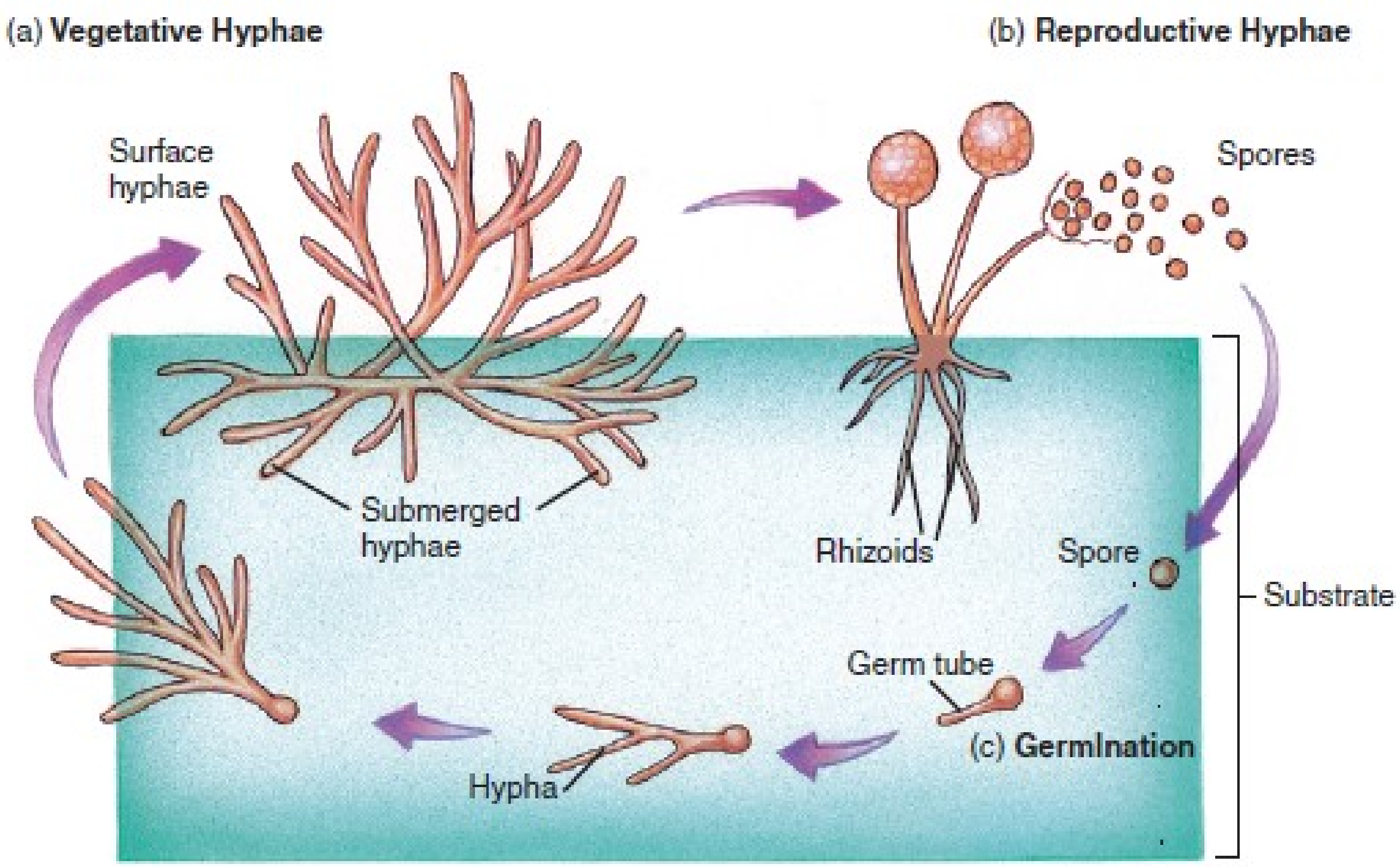
- ❖ Spores are reproductive structures in filamentous fungi.



(a) Septate hypha (b) Coenocytic hypha (c) Growth of a hypha from a spore

Structures

❖ **Vegetative hypha**: the portion of a hypha that obtains nutrients.
❖ **Aerial hypha** (or reproductive hypha): projects above the surface of the medium on which the fungus is growing. *Aerial hyphae often bear reproductive spores*.



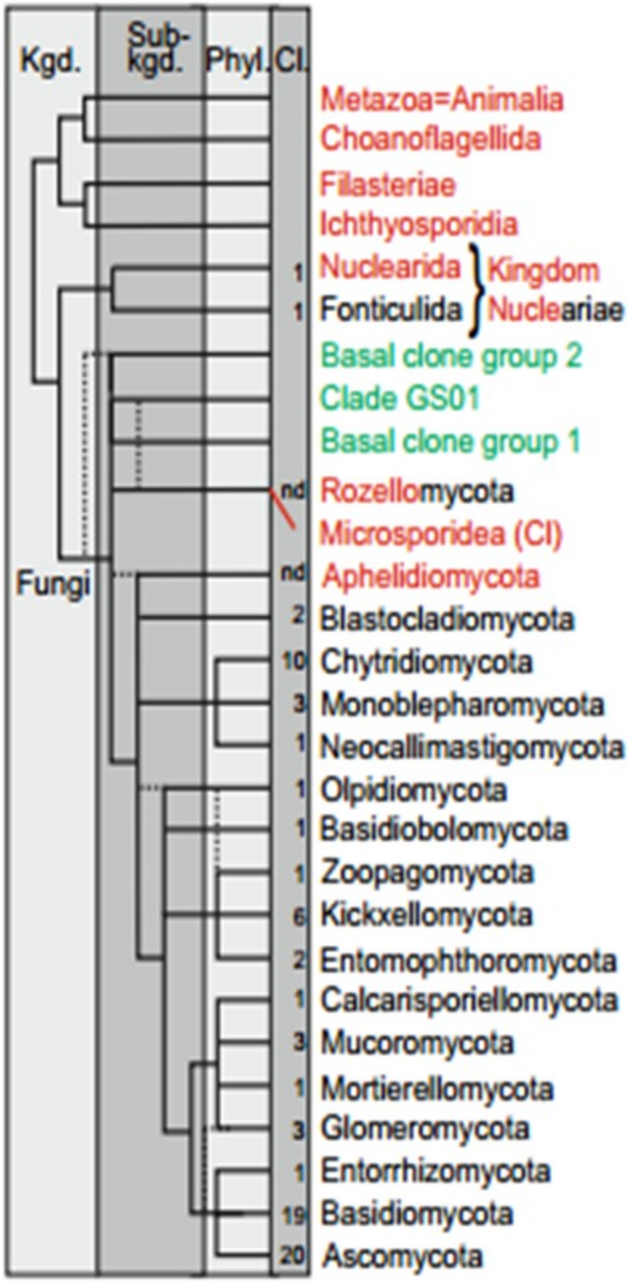
Classification

Molds are classified into different phyla based on their ways of sexual reproduction.

Classification

Updated phylum-level classification of fungi. Numbers behind branches indicate the number of classes included. Names in red indicate taxa traditionally considered under the Zoological nomenclature; names in green indicate unofficial names of undescribed major clades; names in blue indicate old classification and taxonomic super- and subranks. Names in brown depict names of taxa corresponding to subkingdom rank. Phylogenies are compiled from James et al. (2006a), Jiang et al. (2011), Parfrey et al. (2011); Cavalier-Smith et al. (2014); Lazarus and James (2015), Torruella et al. (2015), Spatafora et al. (2016) and Tedersoo et al. (2017). The numbers of classes are adapted from the proposed taxonomy (Online Resource 2). The ages of kingdoms and phyla exceed 1000 and 542 Ma, respectively (Table 1)

Tedersoo et al., 2018. High-level classification of the Fungi and a tool for evolutionary ecological analyses. Fungal Diversity, 90: 135-159.



Classification

Rhizopus stolonifer

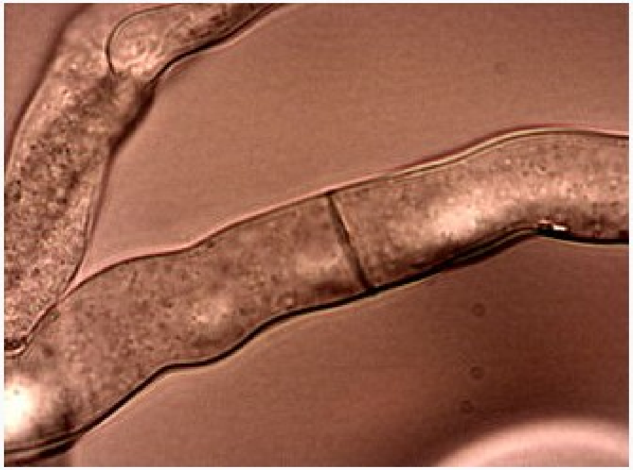
Scientific classification

Kingdom:	Fungi
Division:	Mucoromycota
Order:	Mucorales
Family:	Mucoraceae
Genus:	*Rhizopus*
Species:	***R. stolonifer***

https://en.wikipedia.org/wiki/Rhizopus_stolonifer

Classification

Neurospora crassa	



Scientific classification	
Kingdom:	Fungi
Division:	Ascomycota
Class:	Sordariomycetes
Order:	Sordariales
Family:	Sordariaceae
Genus:	*Neurospora*
Species:	***N. crassa***

https://en.wikipedia.org/wiki/Neurospora_crassa

Classification

Itajahya

Itajahya galericulata

Scientific classification

Kingdom:	Fungi
Division:	Basidiomycota
Class:	Agaricomycetes
Order:	Phallales
Family:	Phallaceae
Genus:	***Itajahya*** Møller (1895)

Type species

Itajahya galericulata
Møller (1895)

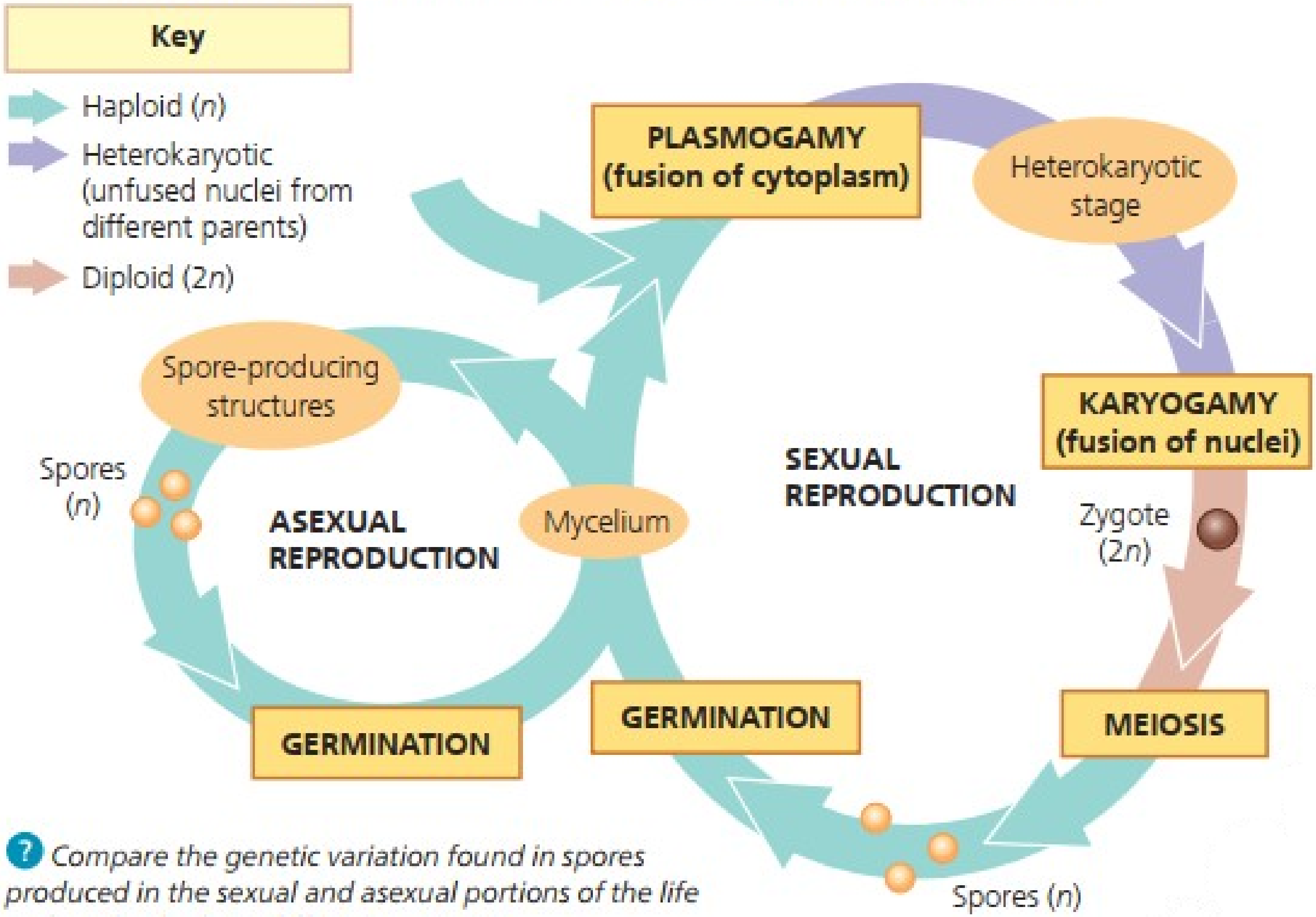
Species

Itajahya galericulata
Itajahya hornseyi
Itajahya rosea

https://en.wikipedia.org/wiki/Itajahya

Molds typically produce spores by asexual or sexual reproductive cycles or both.

▼ **Figure 31.5 Generalized life cycle of fungi.** Many fungi reproduce both sexually and asexually, as shown here; others, however, reproduce only sexually or asexually.



? *Compare the genetic variation found in spores produced in the sexual and asexual portions of the life cycle. Why do these differences occur?*

Reproduction

Molds can reproduce asexually or sexually, or both.

Asexual spores

- ✓ Sporangiospores
- ✓ Conidiospores
- ✓ Zoospores

Sexual spores

- ✓ Zygospores
- ✓ Basidiospores
- ✓ Ascospores

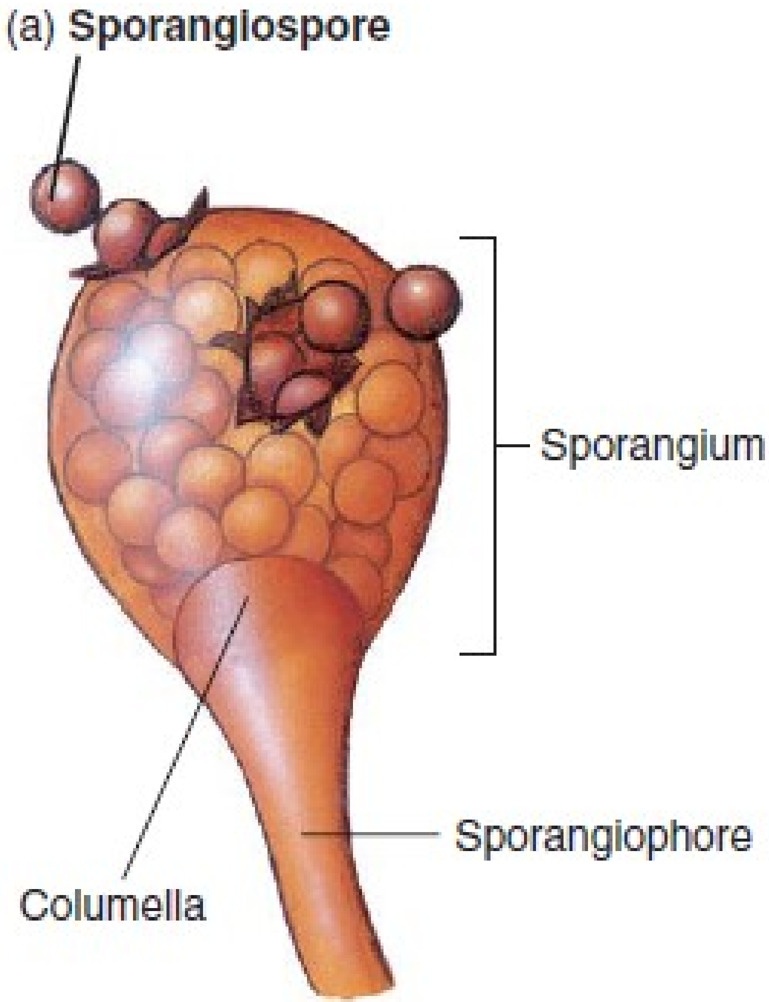
Asexual spores

Asexual spores are produced by an individual fungus through **mitosis** and subsequent cell division, including:

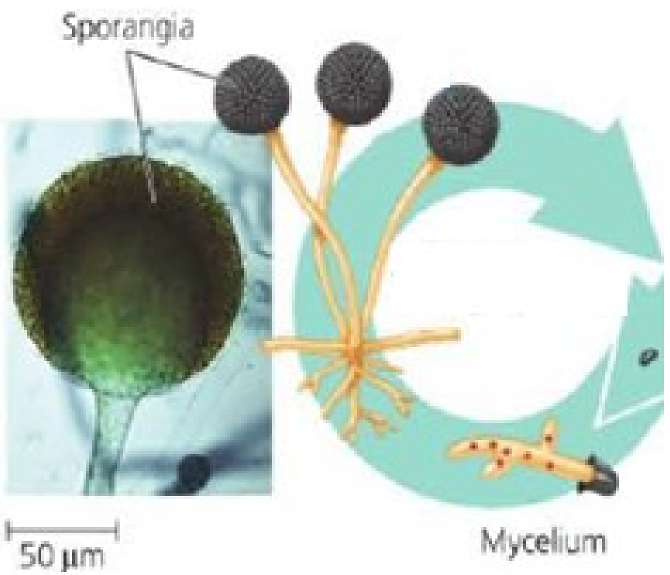
- Sporangiospores
- Conidiospores
- Zoospores

Asexual spores

1. Sporangiospores: formed within a **sporangium**, or **sac**, at the end of an aerial hypha called a *sporangiophore*.

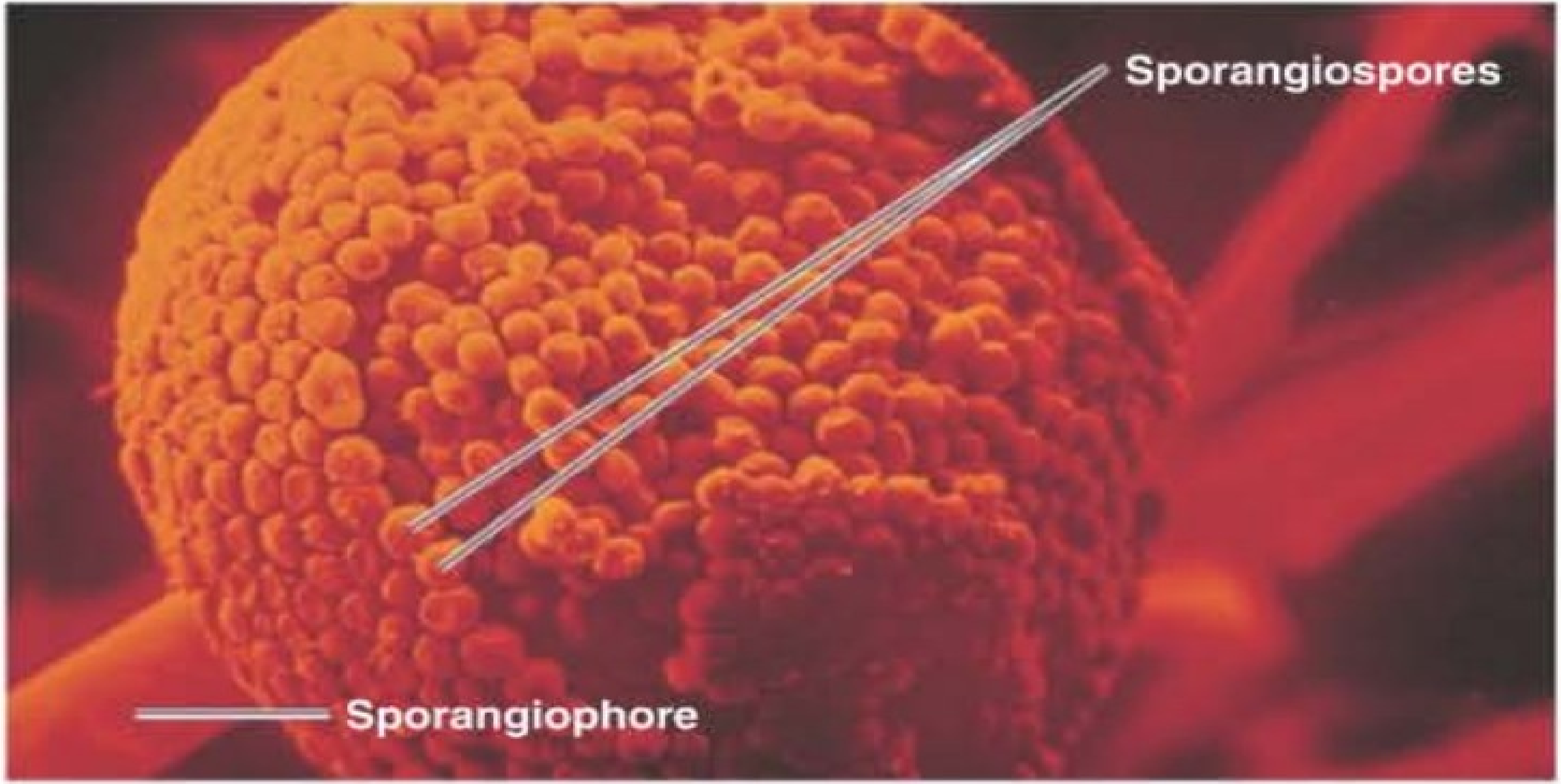


Absidia



Asexual spores

1. Sporangiospores: formed within a **sporangium**, or **sac**, at the end of an aerial hypha called a *sporangiophore*.



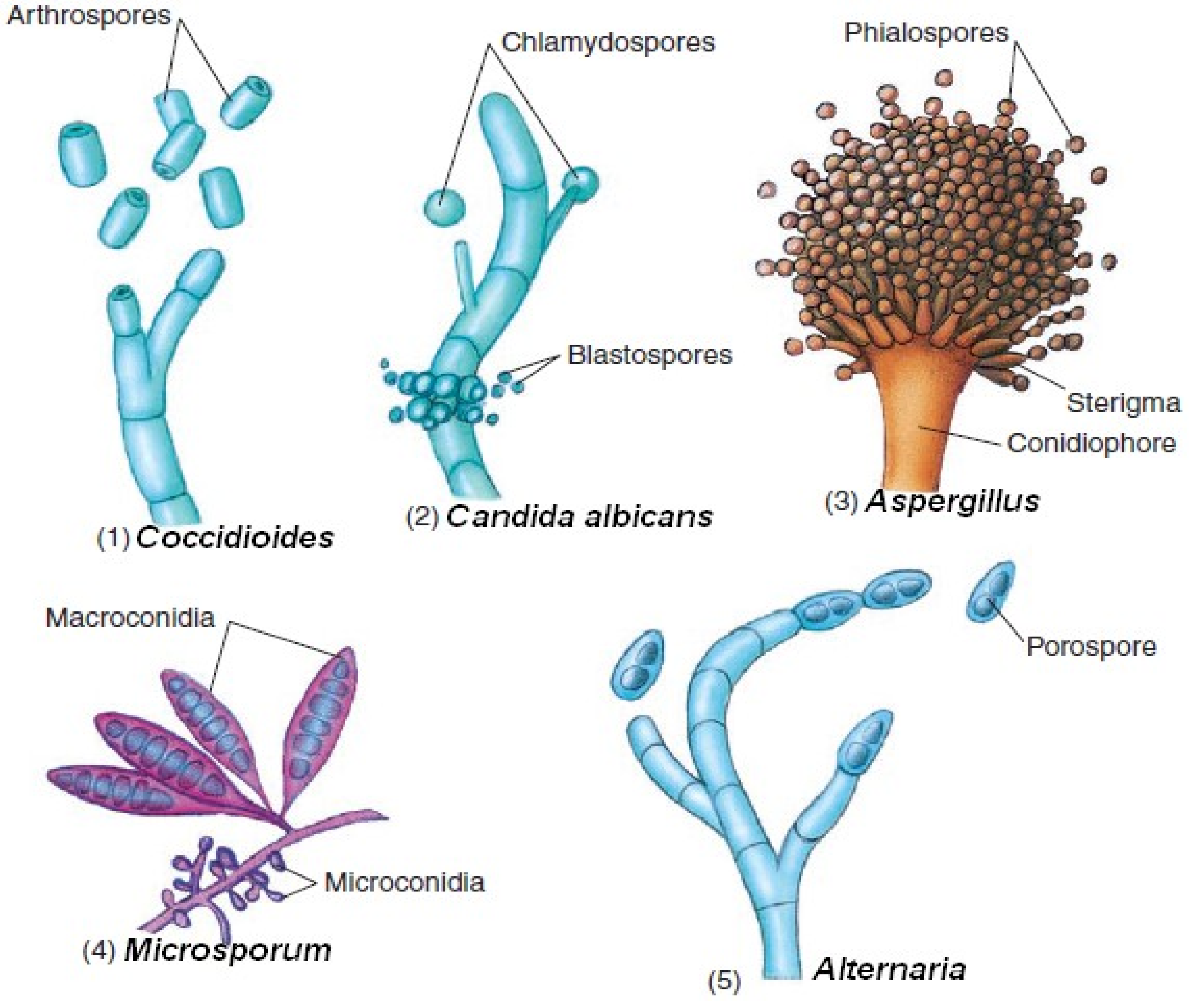
(e) Sporangiospores are formed within a sporangium (spore sac) of *Rhizopus*.

SEM

10 μm

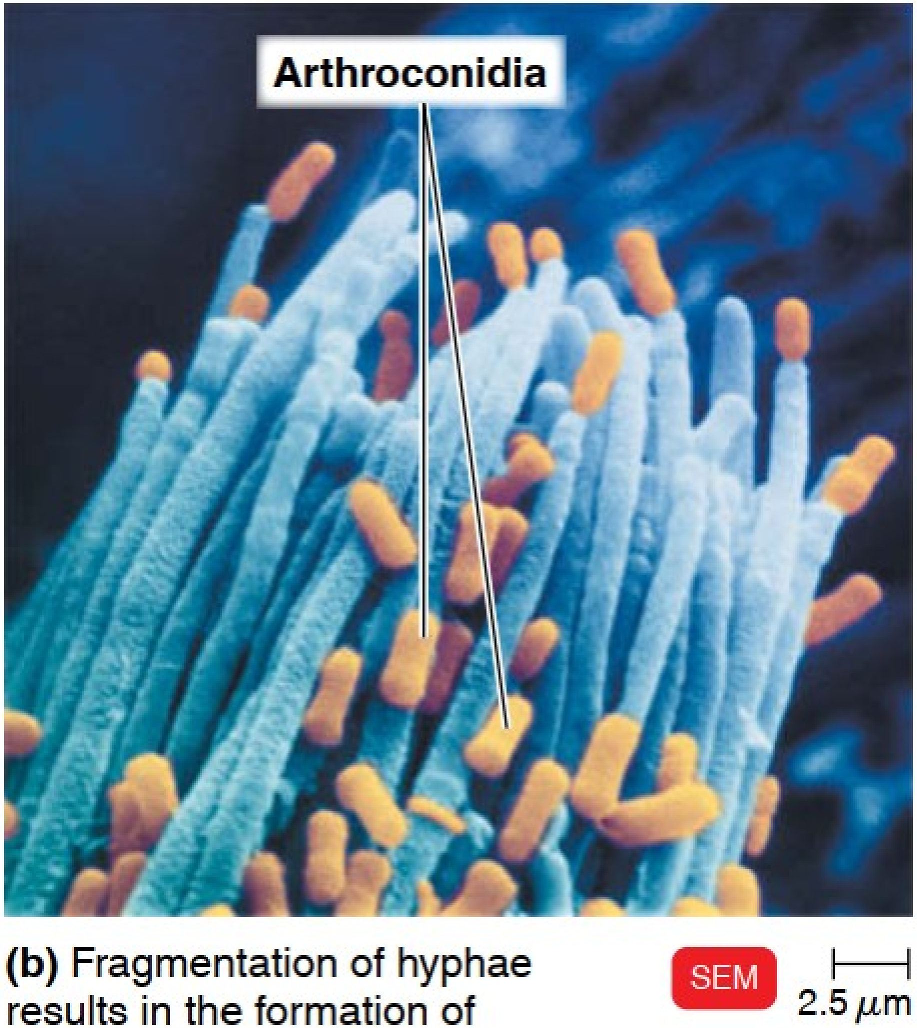
Asexual spores

2. Conidiospores: or **conidia**. A conidium is a *unicellular* or *multicellular* spore that is not enclosed in a **sac**.



Asexual spores

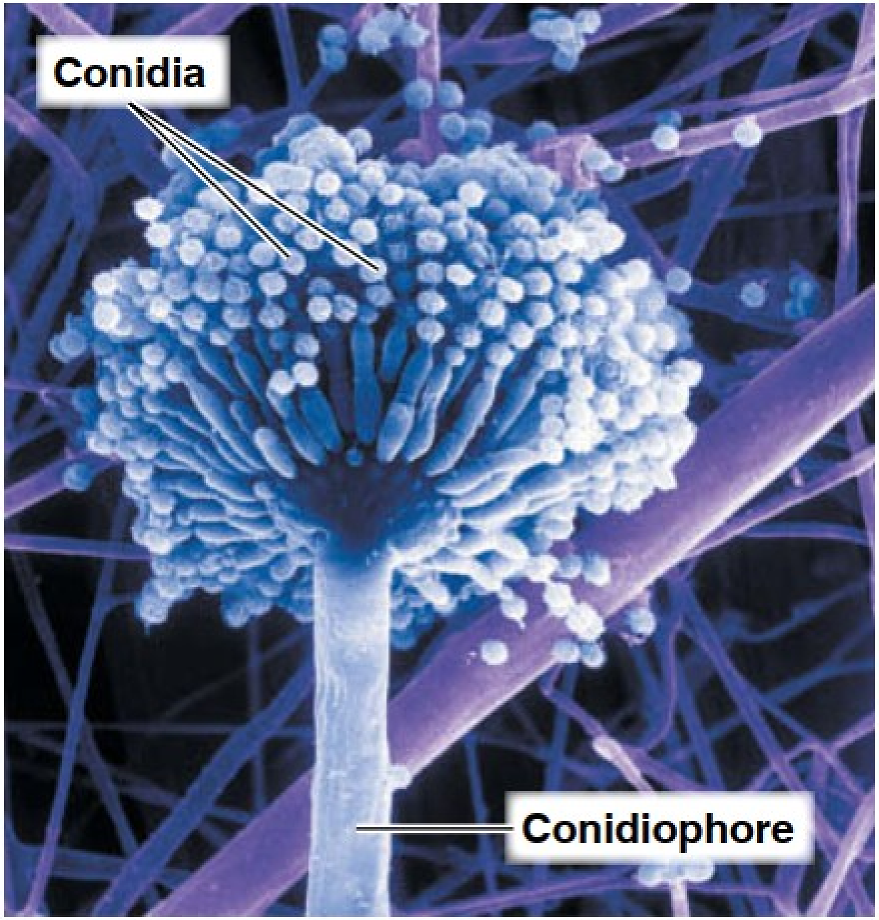
2. Conidiospores: or **conidia**. A conidium is a *unicellular* or *multicellular* spore that is not enclosed in a **sac**.



(b) Fragmentation of hyphae results in the formation of arthroconidia in *Ceratocystis ulmi*.

Asexual spores

2. Conidiospores: or **conidia**. A conidium is a *unicellular* or *multicellular* spore that is not enclosed in a **sac**.



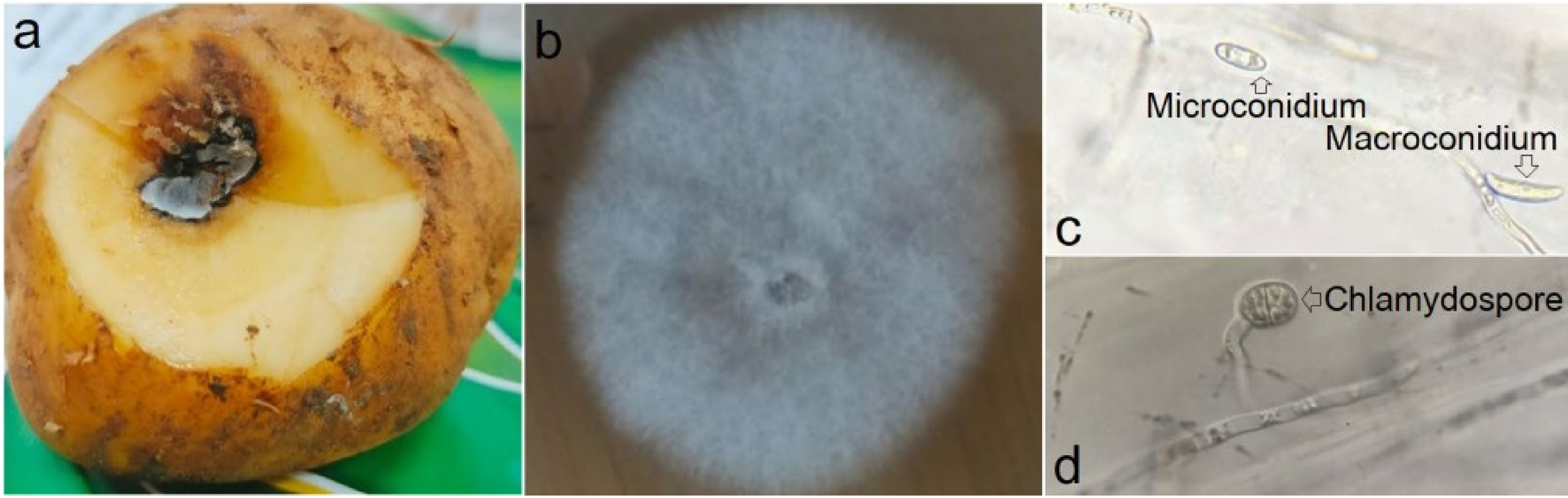
(a) Conidia are arranged in chains at the end of an *Aspergillus niger* conidiophore.

Asexual spores

2. Conidiospores: or **conidia**. A conidium is a *unicellular* or *multicellular* spore that is not enclosed in a **sac**.

Asexual spores

2. Conidiospores: or **conidia**. A conidium is a *unicellular* or *multicellular* spore that is not enclosed in a **sac**.



Asexual spores

3. Zoospore

Motile spores that use flagella for locomotion.

Zoosporangia of an *Allomyces* sp. sporophyte growing on agar.

Scientific classification	
Kingdom:	Fungi
Division:	Blastocladiomycota
Class:	Blastocladiomycetes
Order:	Blastocladiales
Family:	Blastocladiaceae
Genus:	***Allomyces*** E.J.Butler (1911)

Sexual spores

The sexual spores produced by fungi characterize the phyla.

Sexual spores

Sexual reproduction consists of three phases:

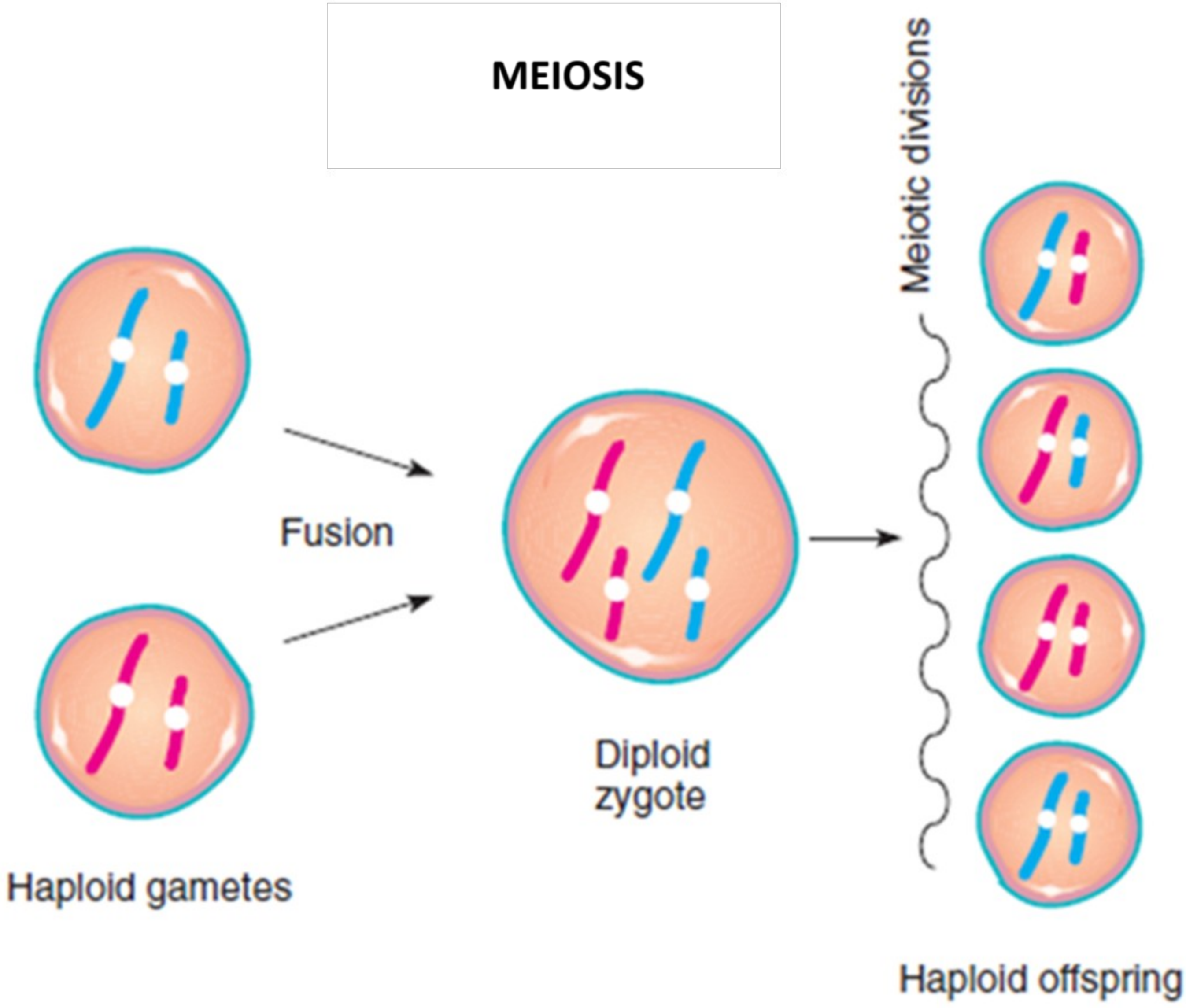
1. Plasmogamy: A haploid nucleus of a donor cell (+) penetrates the cytoplasm of a recipient cell (-).

2. Karyogamy: The (+) and (-) nuclei fuse to form a diploid zygote nucleus.

3. Meiosis: The diploid nucleus gives rise to haploid nuclei, some of which may be genetic recombinants.

Sexual spores

MEIOSIS



Sexual spores

1. Zygospores

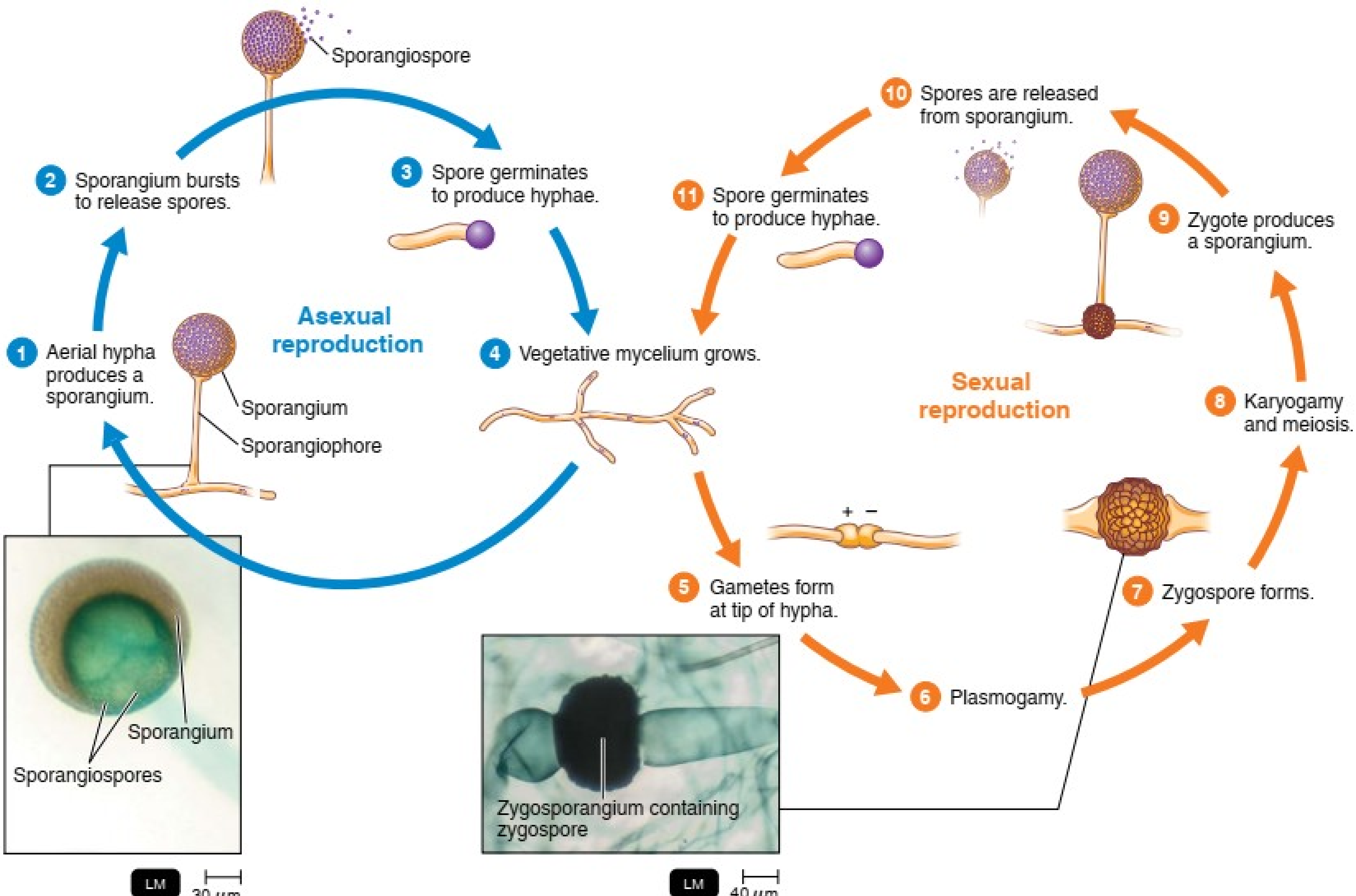
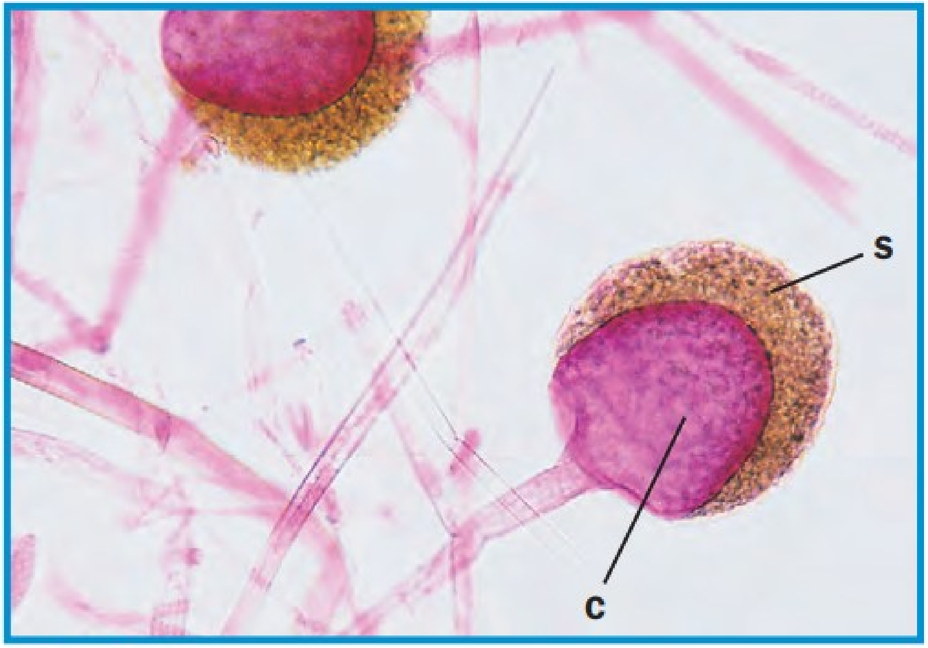


Figure 12.7 The life cycle of *Rhizopus*, a zygomycete. This fungus will reproduce asexually most of the time. Two opposite mating strains (designated + and –) are necessary for sexual reproduction.

Sexual spores

1. Zygospores



12-12 RHIZOPUS SPORANGIOPHORES (X264) ✦ The sporangium is found at the end of a long, unbranched, and nonseptate sporangiophore. The haploid asexual sporangiospores (**S**) cover the surface of the columella (**C**), which has a flattened base.

12-13 RHIZOPUS PROGAMETANGIA (X264) ✦ Progametangia from different hyphae are shown in the center of the field. Contact between the progametangia results in each forming a gamete.

Sexual spores

1. Zygospores

12-15 YOUNG *RHIZOPUS* ZYGOSPORE (X264) ✦ The zygospore forms when the cytoplasm from the two mating strains fuse (plasmogamy).

12-16 MATURE *RHIZOPUS* ZYGOSPORE (X264) ✦ Haploid nuclei from each strain fuse within the zygospore (**karyogamy**) to produce many diploid nuclei. Meiosis occurs to produce numerous haploid spores.

Zygomycetes

Mucor indicus

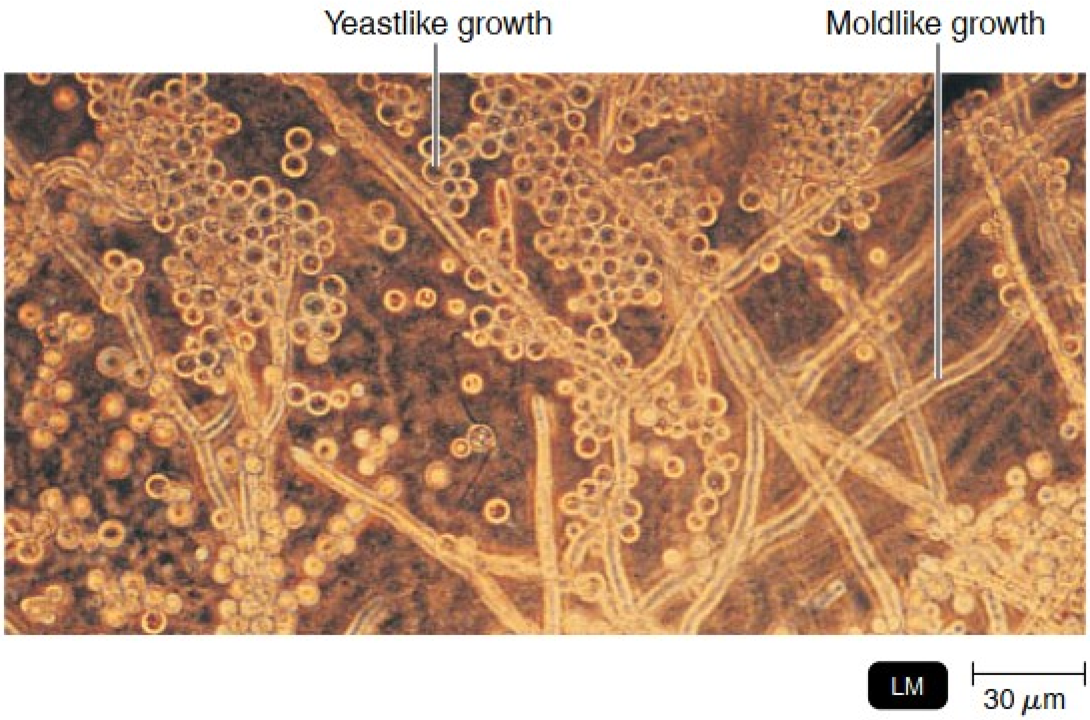


Figure 12.5 Fungal dimorphism. Dimorphism in the fungus *Mucor Indicus* depends on CO_2 concentration. On the agar surface, *Mucor* exhibits yeastlike growth, but in the agar where CO_2 from metabolism has accumulated, it is moldlike.

Sexual spores

2. Basidiospore

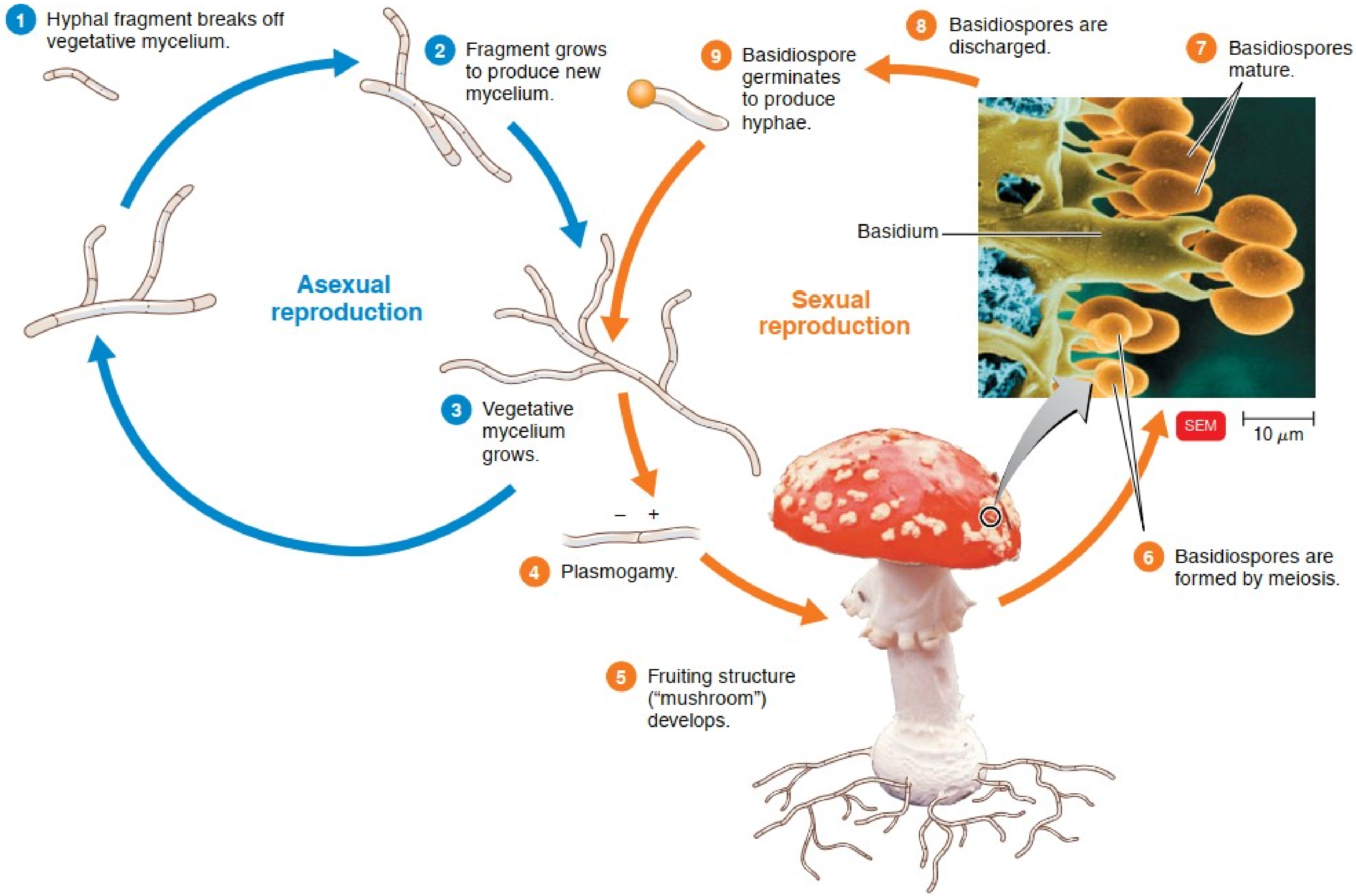


Figure 12.10 A generalized life cycle of a basidiomycete. Mushrooms appear after cells from two mating strains (+ and –) have fused.

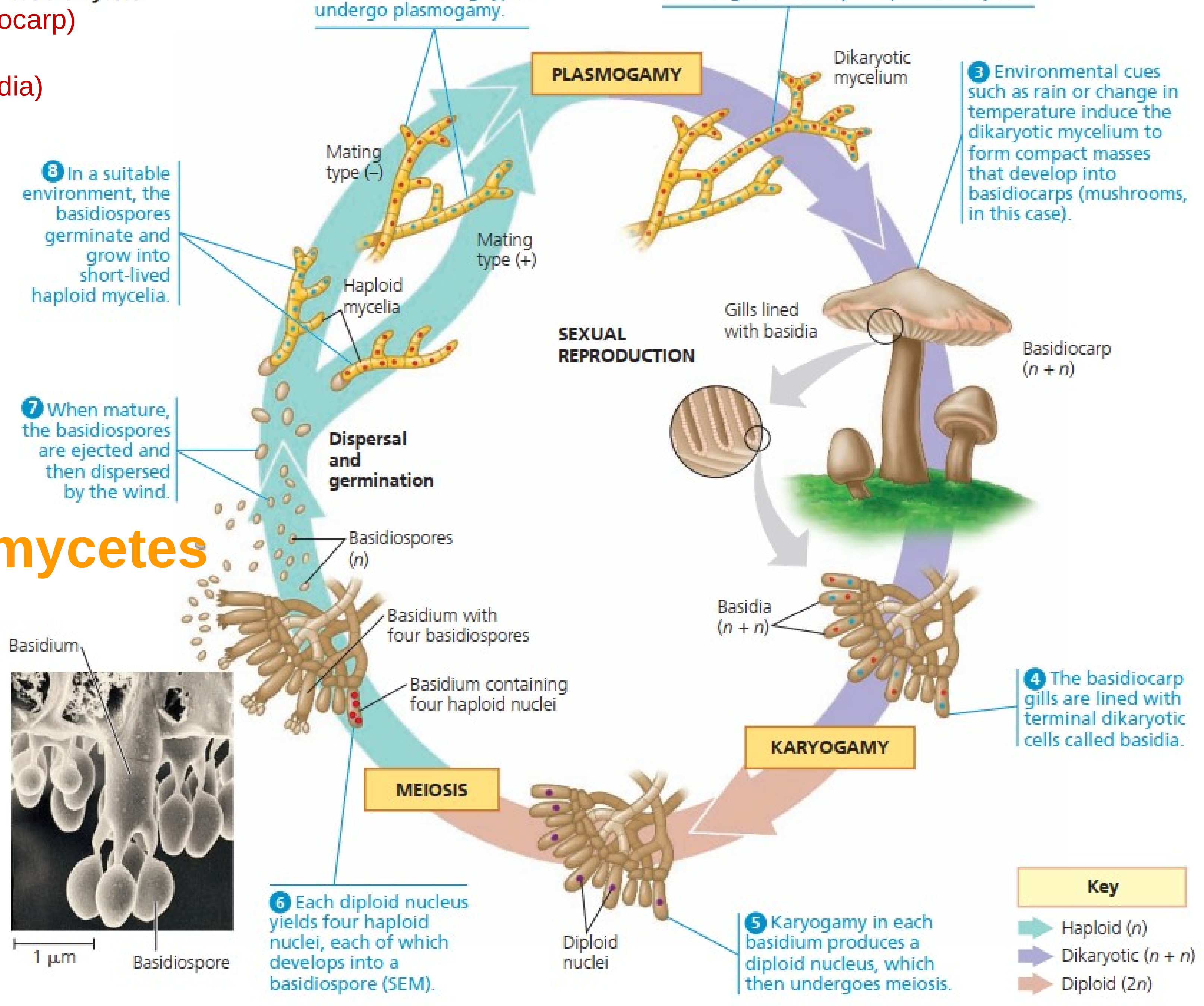
Q On what basis are fungi classified into phyla?

: 12.8

- Quả thể (basidiocarp)
- Phiến nấm (gill)
- Đảm nấm (basidia)
- Bào tử đảm (basidiospore)

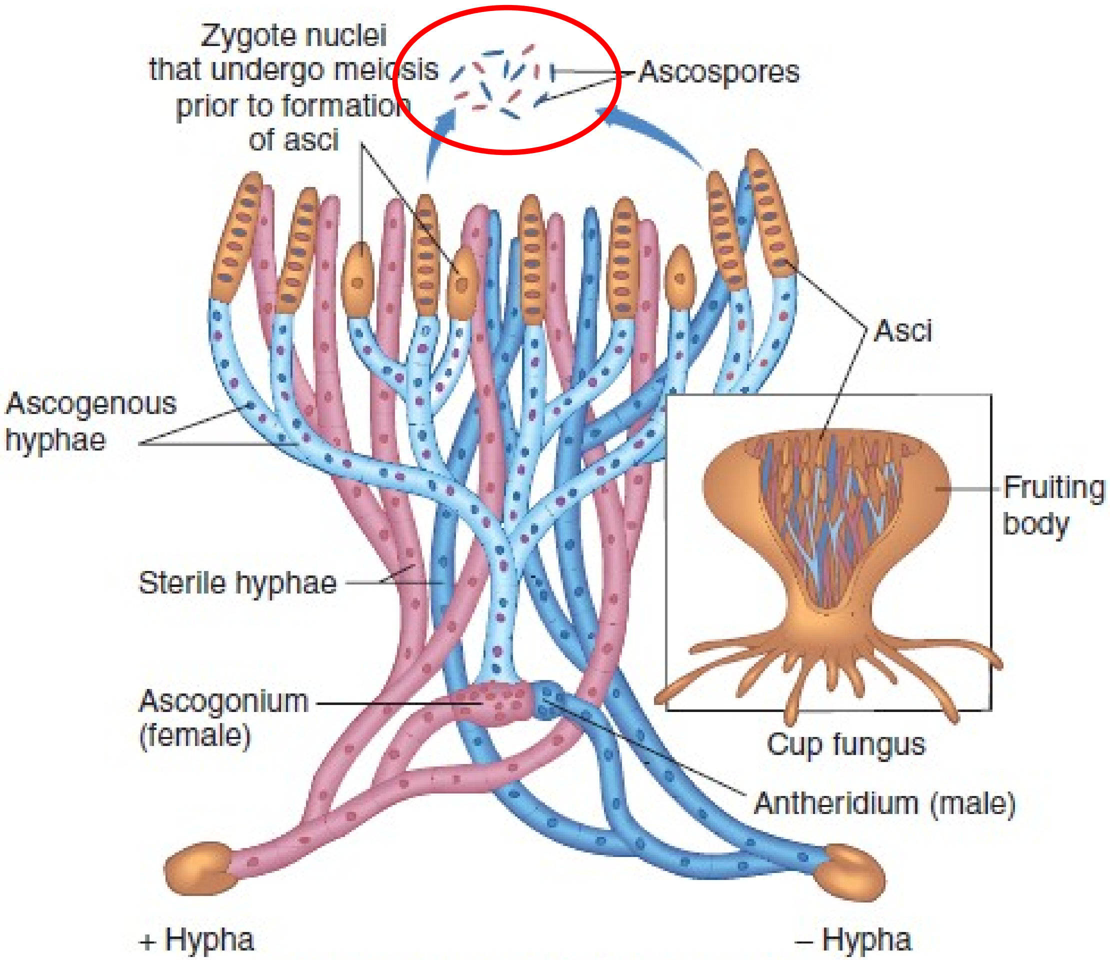
Basidiomycetes

▼ Figure 31.20 The life cycle of a mushroom-forming basidiomycete.



Sexual spores

3. Ascospores



Production of ascospores in a cup fungus. Inset shows the cup-shaped fruiting body that houses the asci.

Sexual spores

3. Ascospores

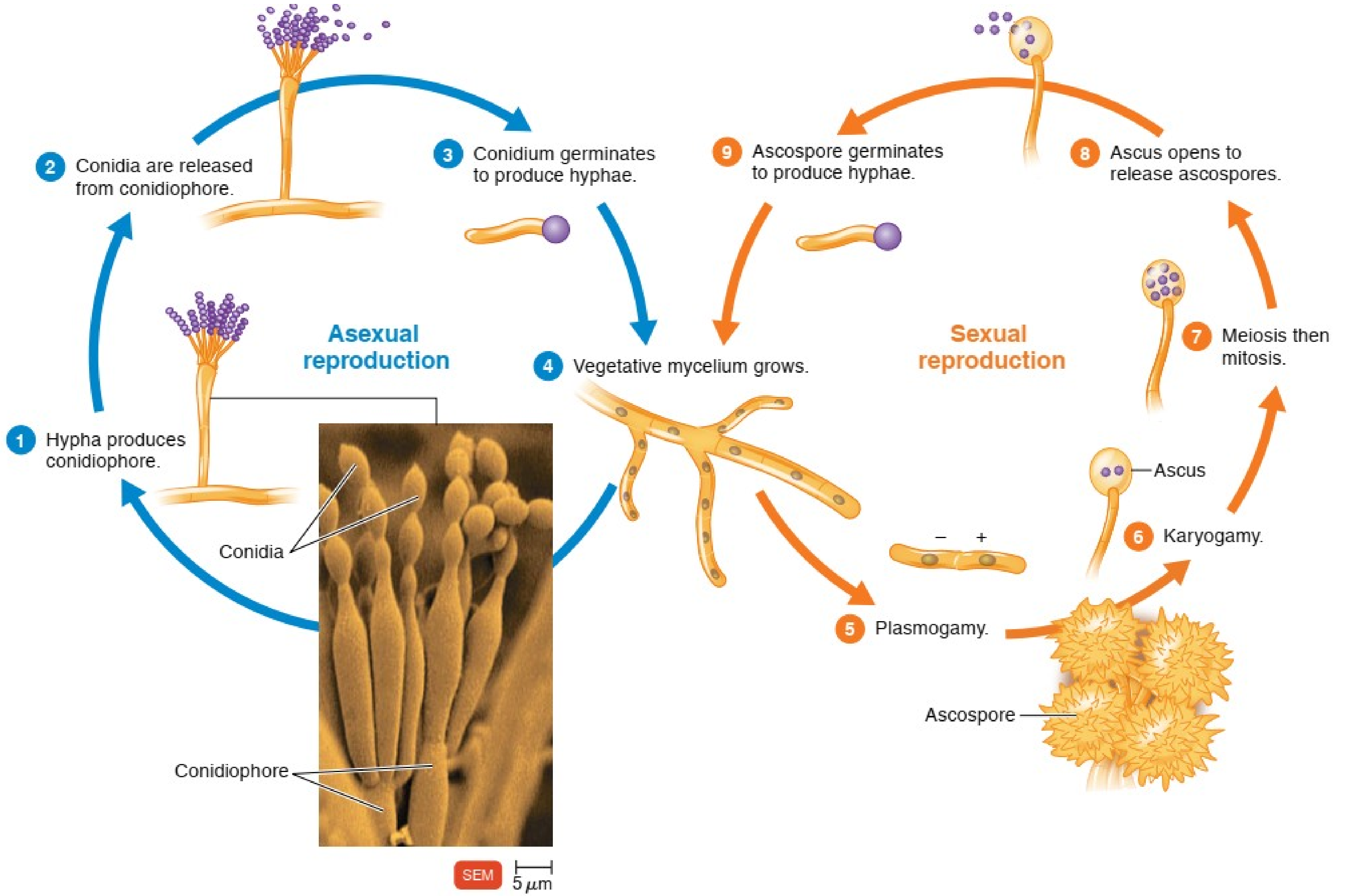
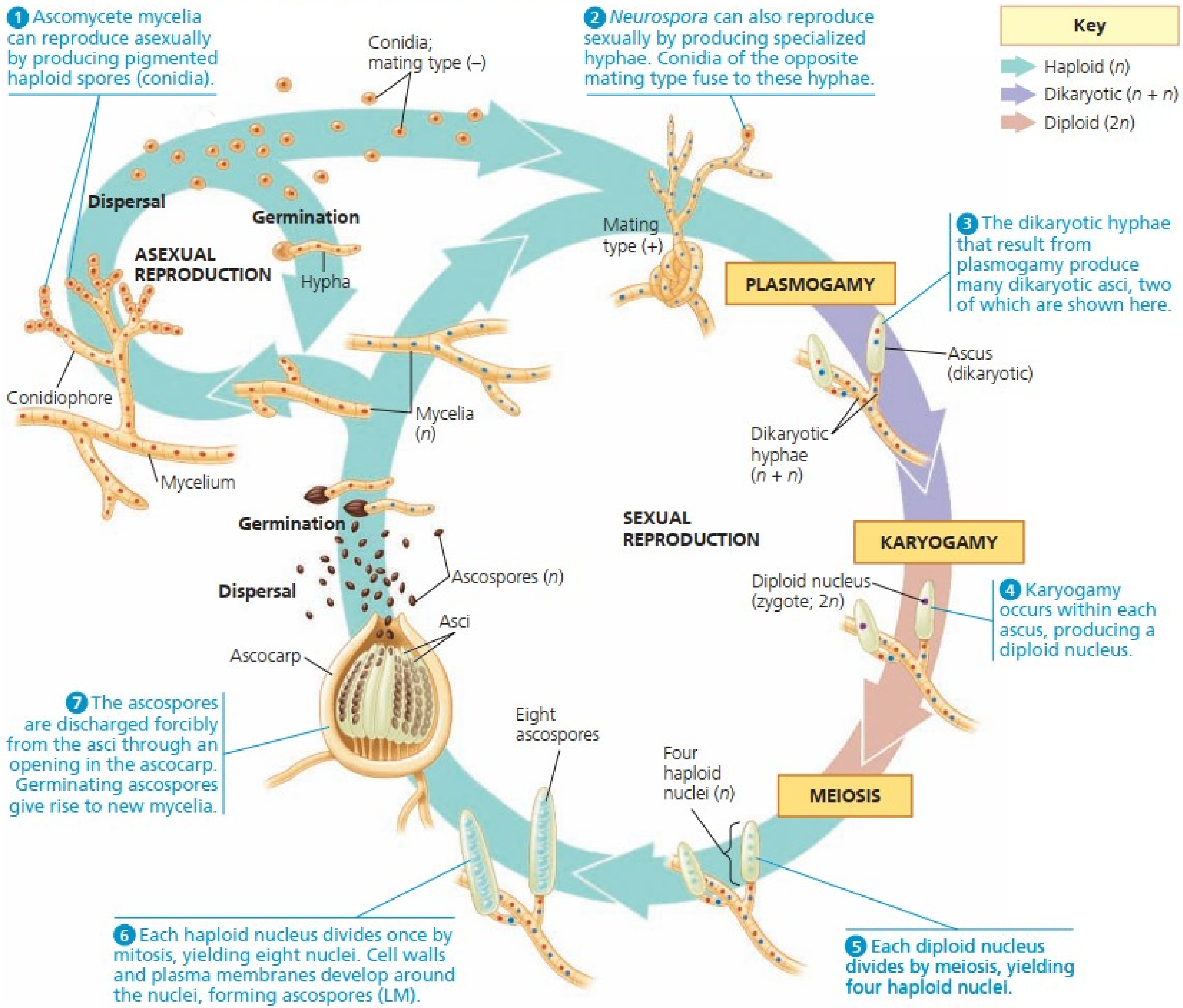
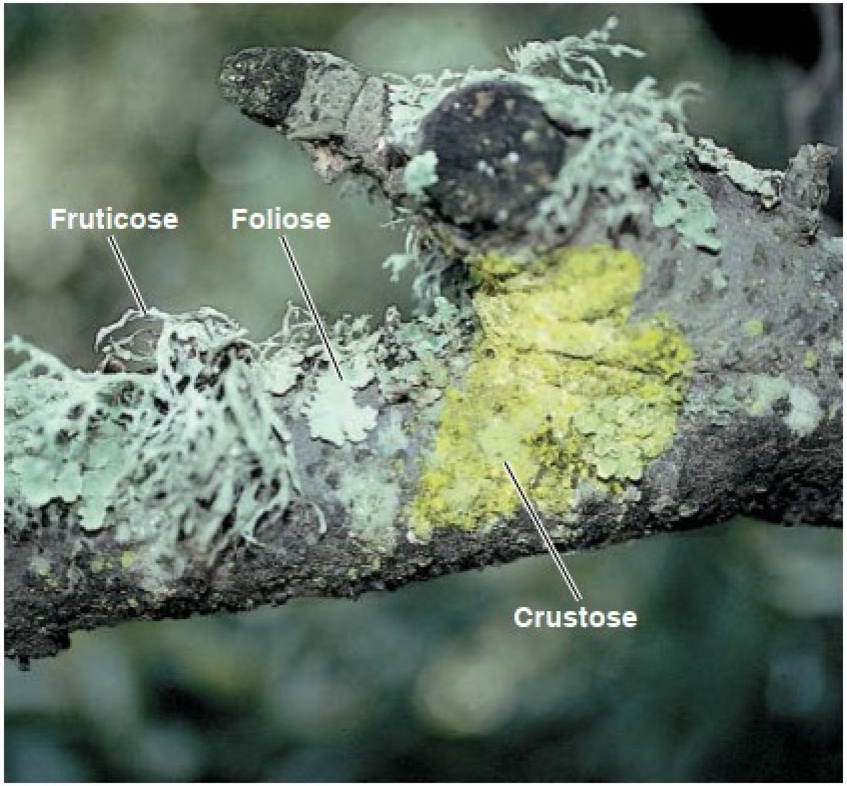


Figure 12.9 The life cycle of *Talaromyces*, an ascomycete. Occasionally, when two opposite mating cells from two different strains (+ and –) fuse, sexual reproduction occurs.

▼ **Figure 31.18 The life cycle of *Neurospora crassa*, an ascomycete.** *Neurospora* is a bread mold and research organism that also grows in the wild on burned vegetation.



Lichens



(a) Three types of lichens

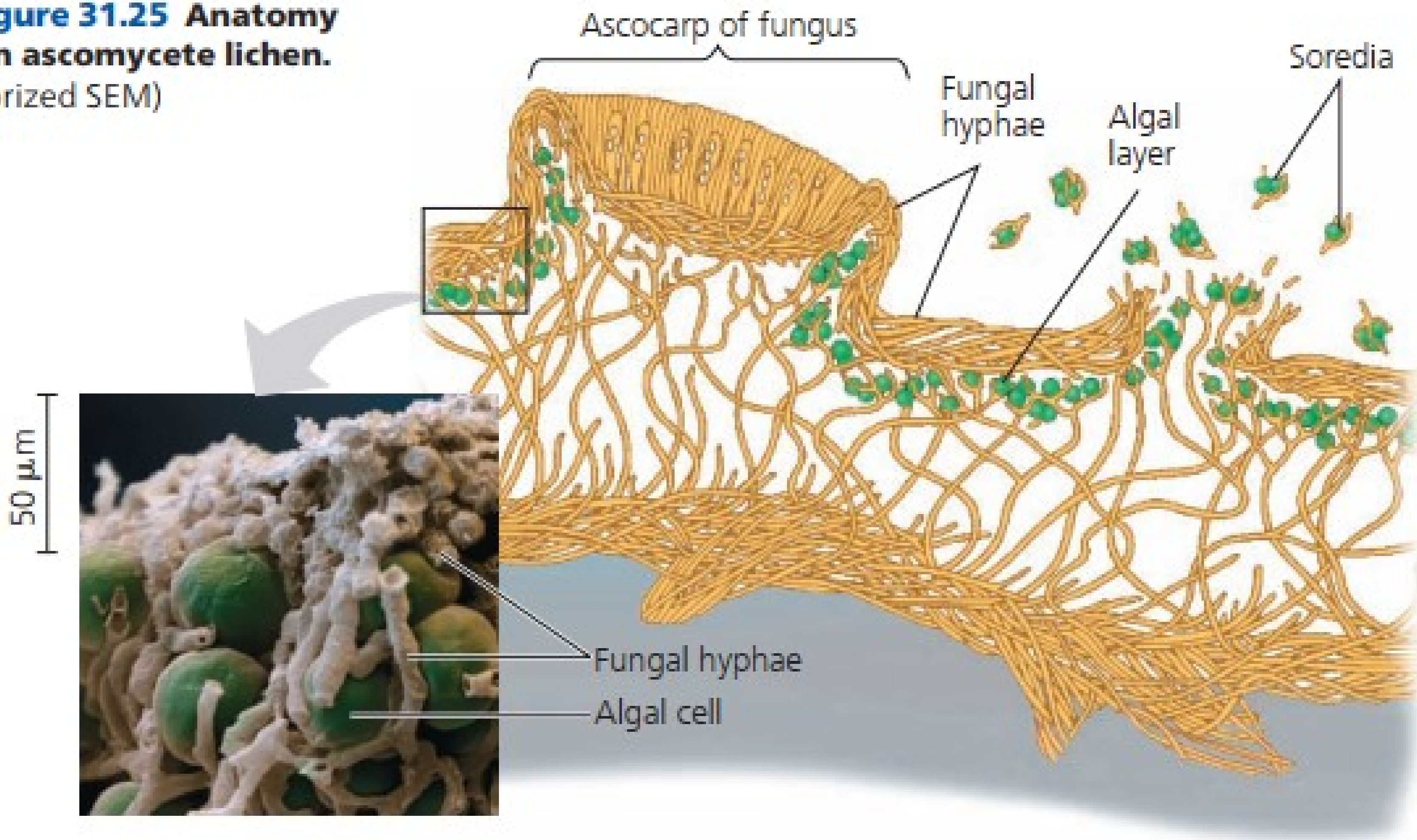
2 cm

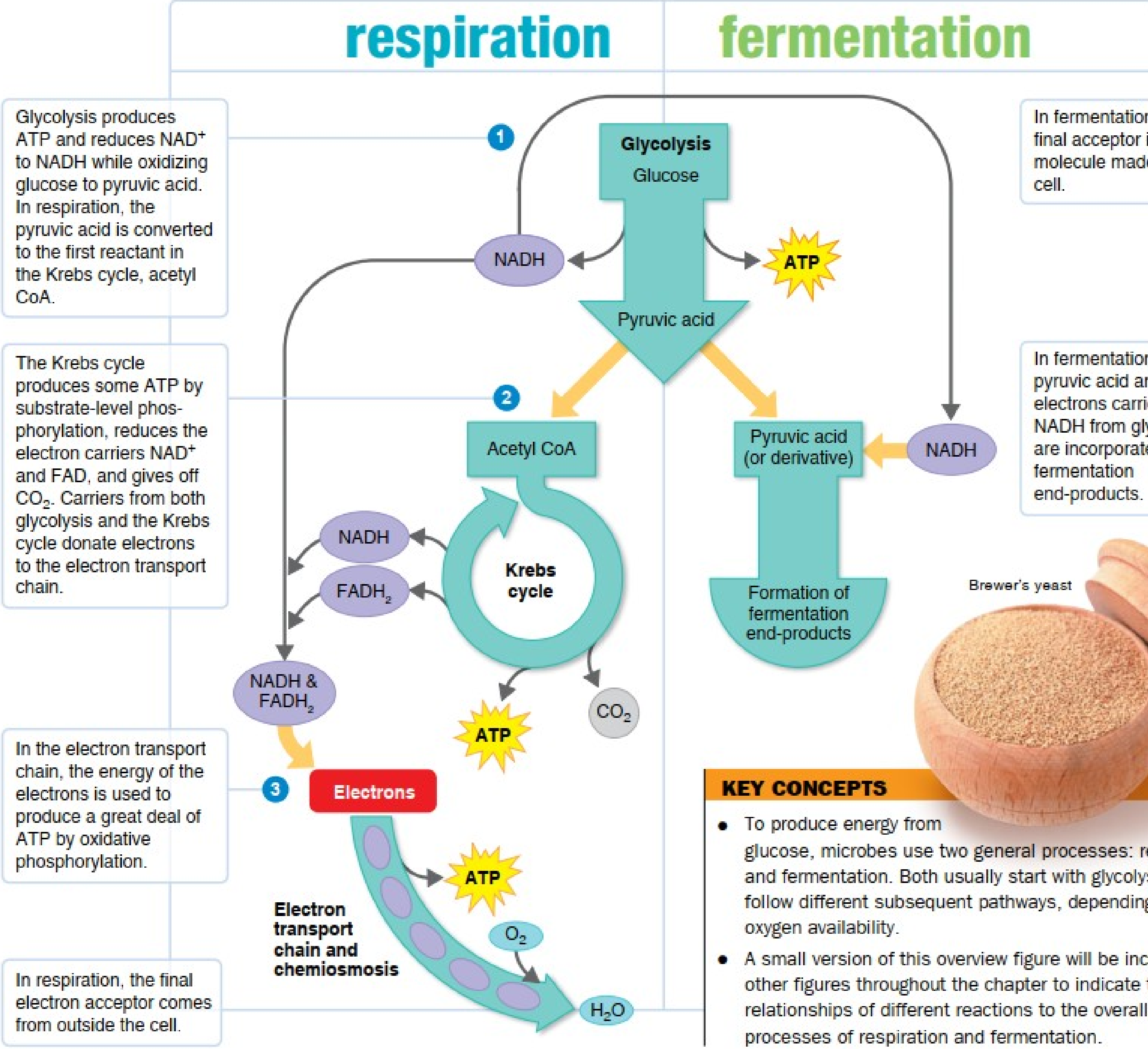
Lichens

Figure 31.24 Variation in lichen growth forms.

Lichens

▶ **Figure 31.25 Anatomy of an ascomycete lichen.** (colorized SEM)





KEY CONCEPTS

- To produce energy from glucose, microbes use two general processes: respiration and fermentation. Both usually start with glycolysis but follow different subsequent pathways, depending on oxygen availability.
- A small version of this overview figure will be included in other figures throughout the chapter to indicate the relationships of different reactions to the overall processes of respiration and fermentation.

Compare and explain the ways of biomass quantification among molds, yeasts and bacteria.

Molds:

- Spore quantification
- Biomass quantification