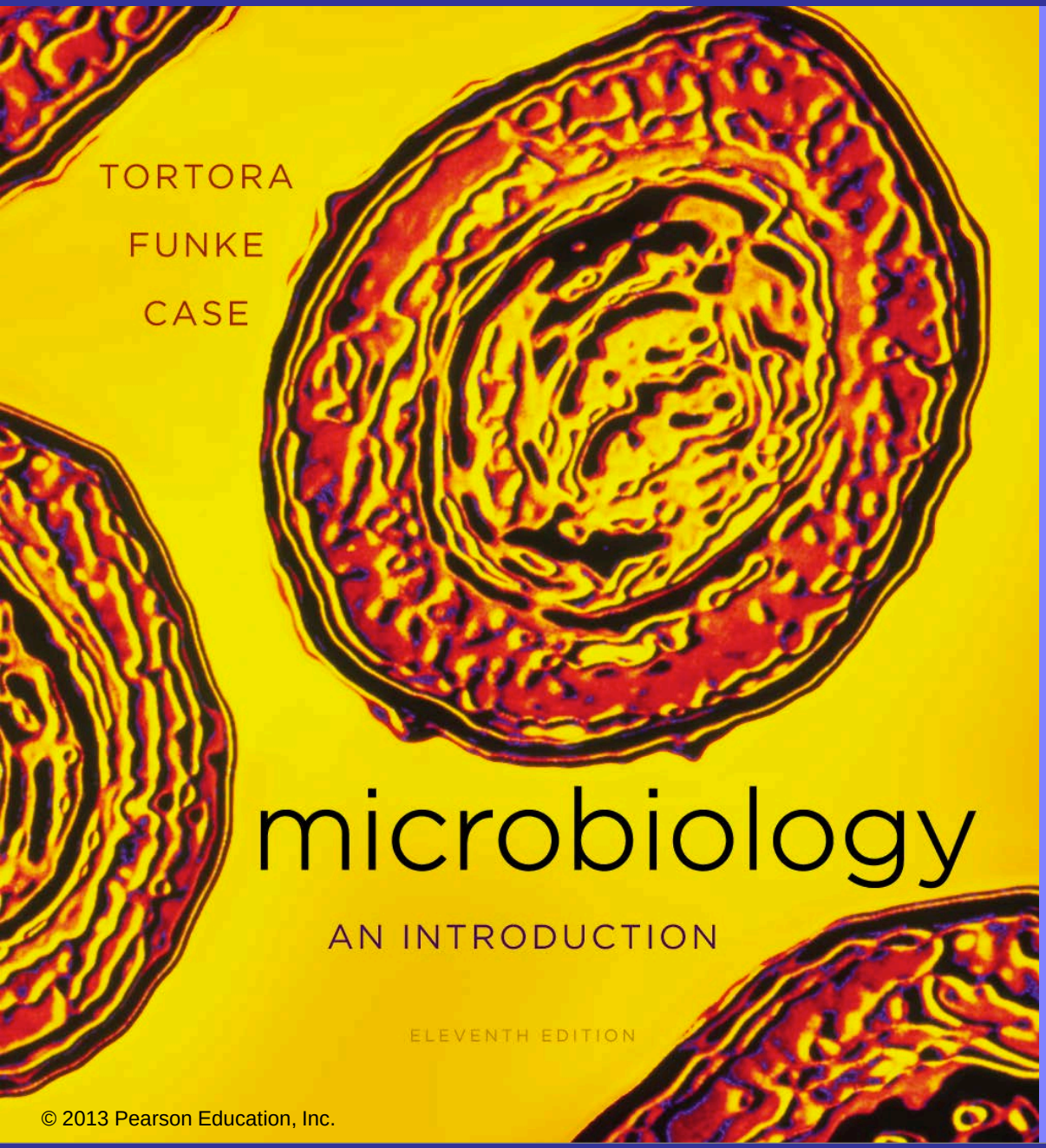
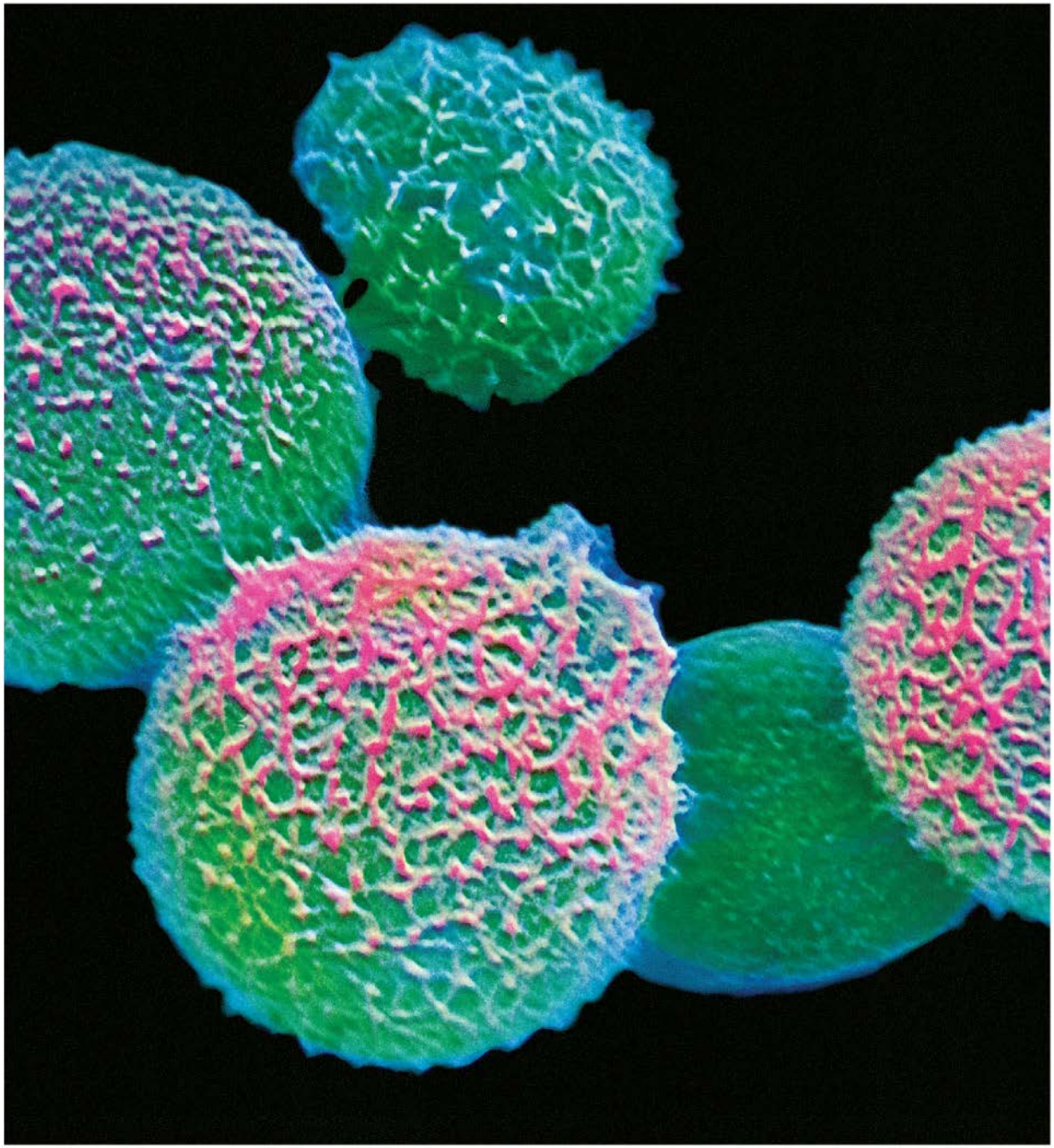


Chapter 12

The Eukaryotes: Fungi, Algae, Protozoa, and Helminths

Lectures prepared by Christine L. Case



Fungi

Learning Objectives

12-1 List the defining characteristics of fungi.

12-2 Differentiate asexual from sexual reproduction, and describe each of these processes in fungi.

12-3 List the defining characteristics of the four phyla of fungi described in this chapter.

12-4 Identify two beneficial and two harmful effects of fungi.

Fungi

Kingdom	Fungi
Nutritional Type	Chemoheterotroph
Multicellularity	All, except yeasts
Cellular Arrangement	Unicellular, filamentous, fleshy
Food Acquisition Method	Absorptive
Characteristic Features	Sexual and asexual spores

Mycology: the study of fungi

Table 12.1 Selected Features of Fungi and Bacteria Compared.

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

Vegetative Growth

- Molds
  - The fungal **thallus** consists of **hyphae**; a mass of hyphae is a **mycelium**
- Unicellular fungi
  - **Fission yeasts** divide symmetrically
  - **Budding yeasts** divide asymmetrically
- Dimorphism
  - Pathogenic **dimorphic fungi** are yeastlike at 37°C and moldlike at 25°C

Figure 12.2 Characteristics of fungal hyphae.

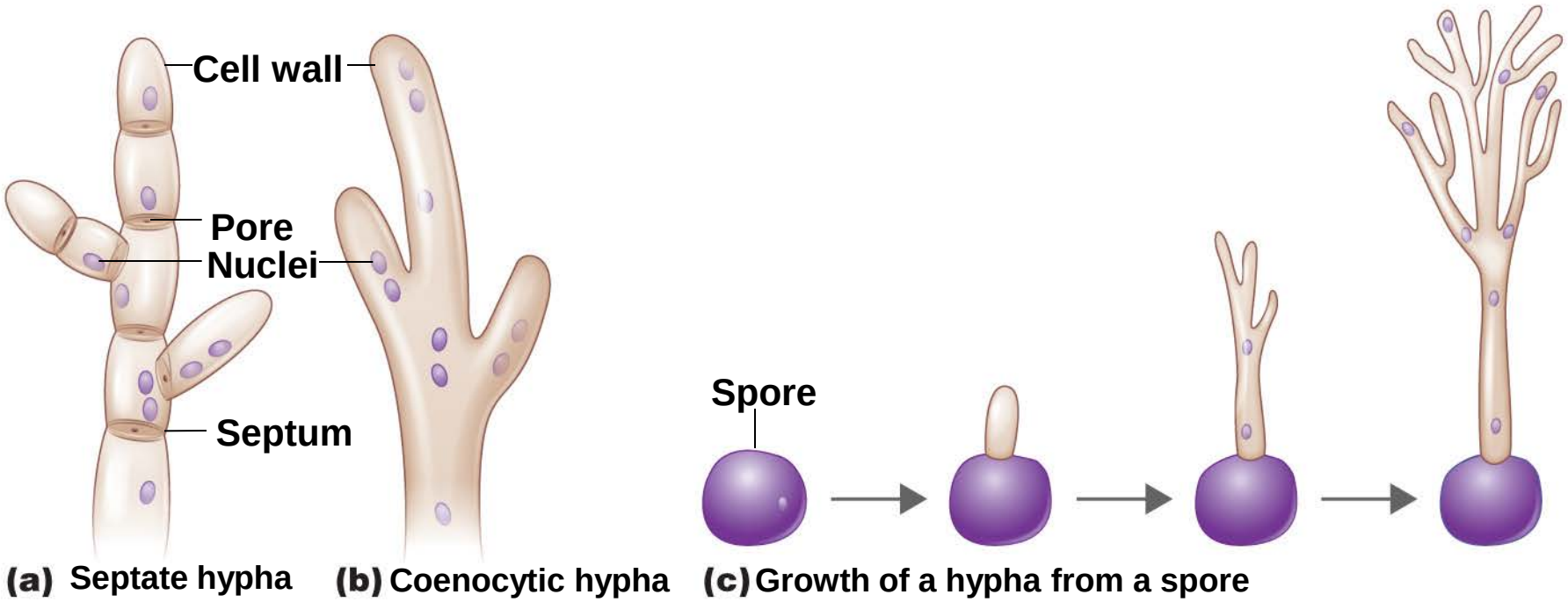


Figure 12.3a Aerial and vegetative hyphae.

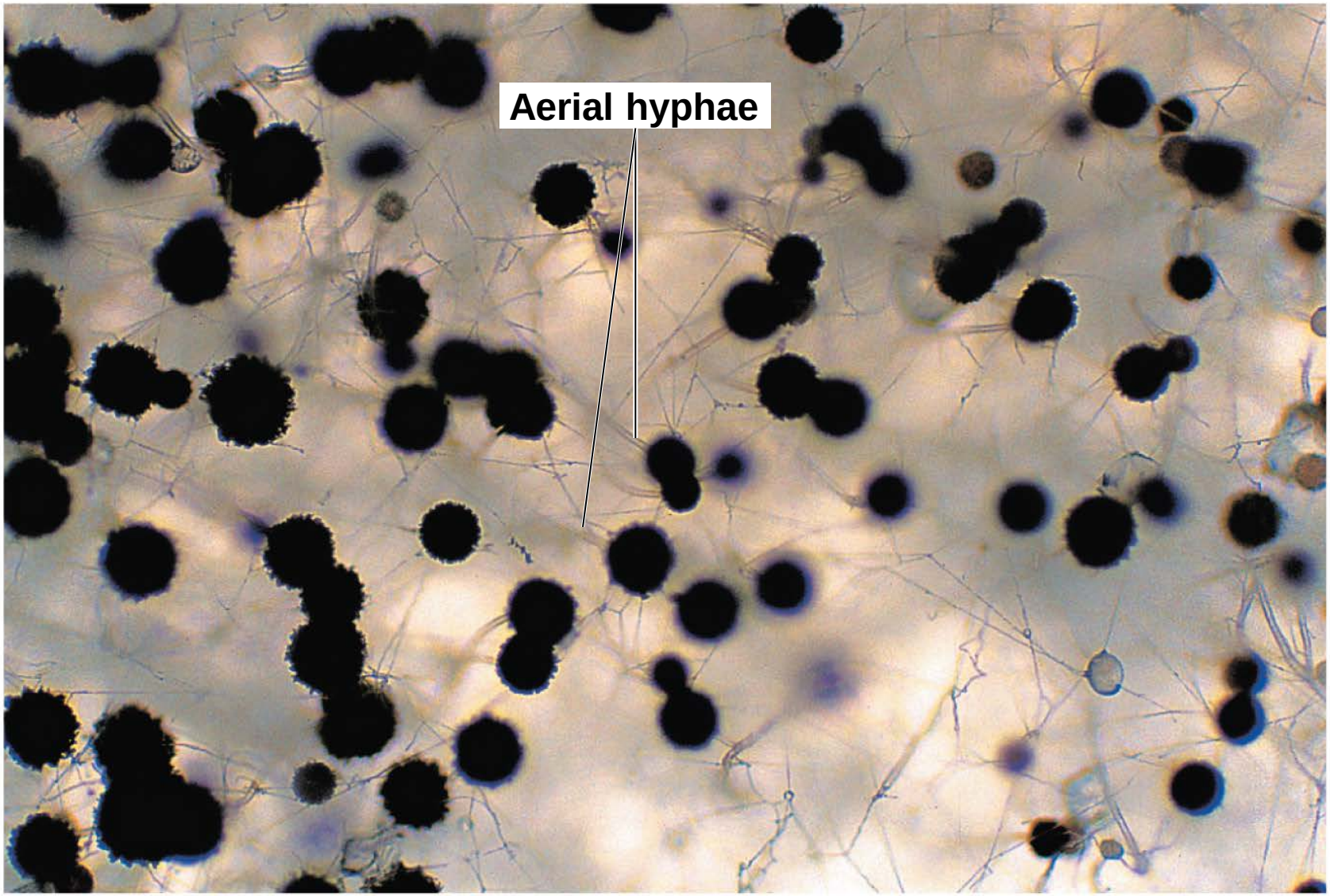


Figure 12.4 A budding yeast.

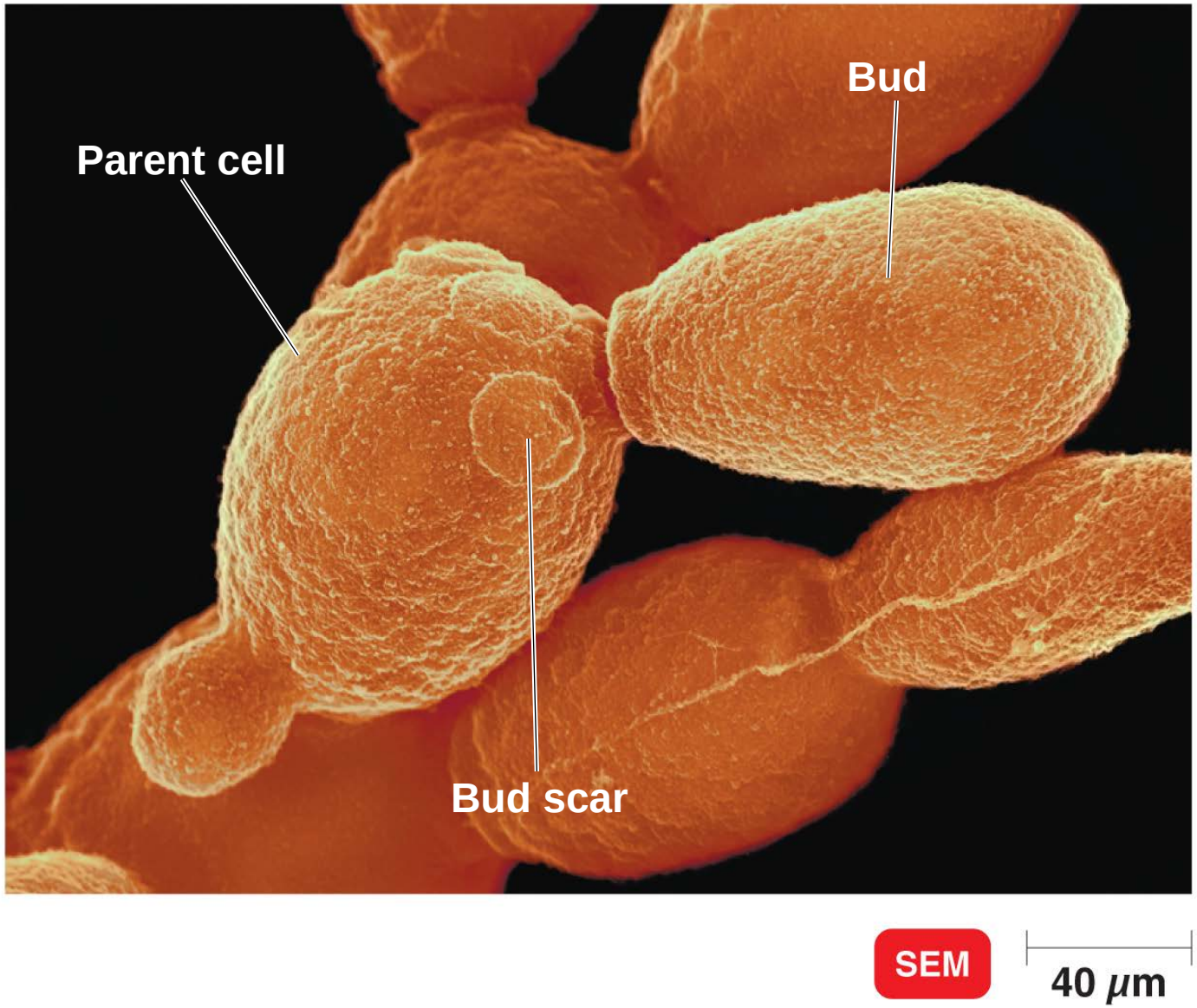


Figure 12.5 Fungal dimorphism.

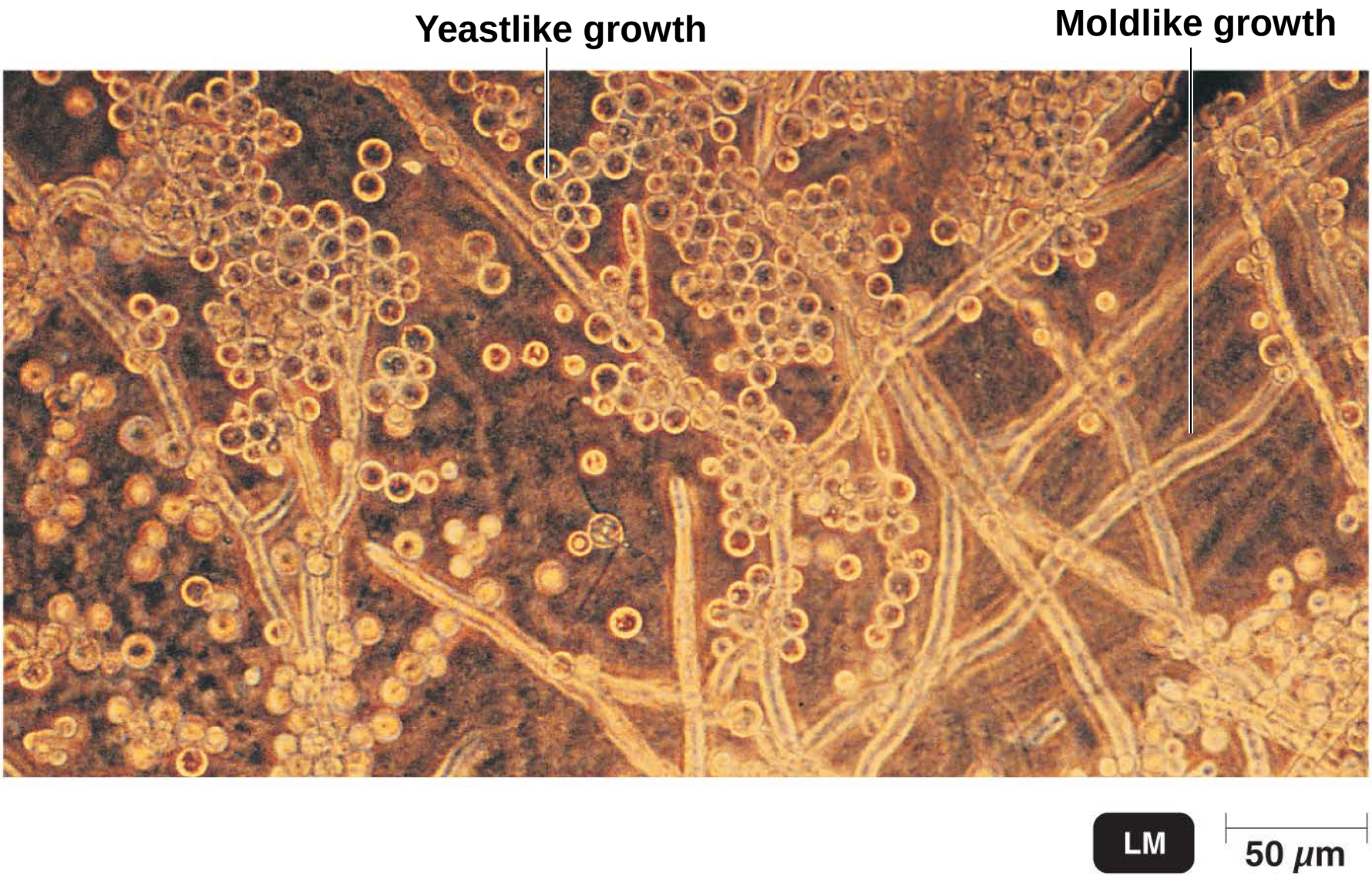


Figure 12.6a Representative asexual spores.

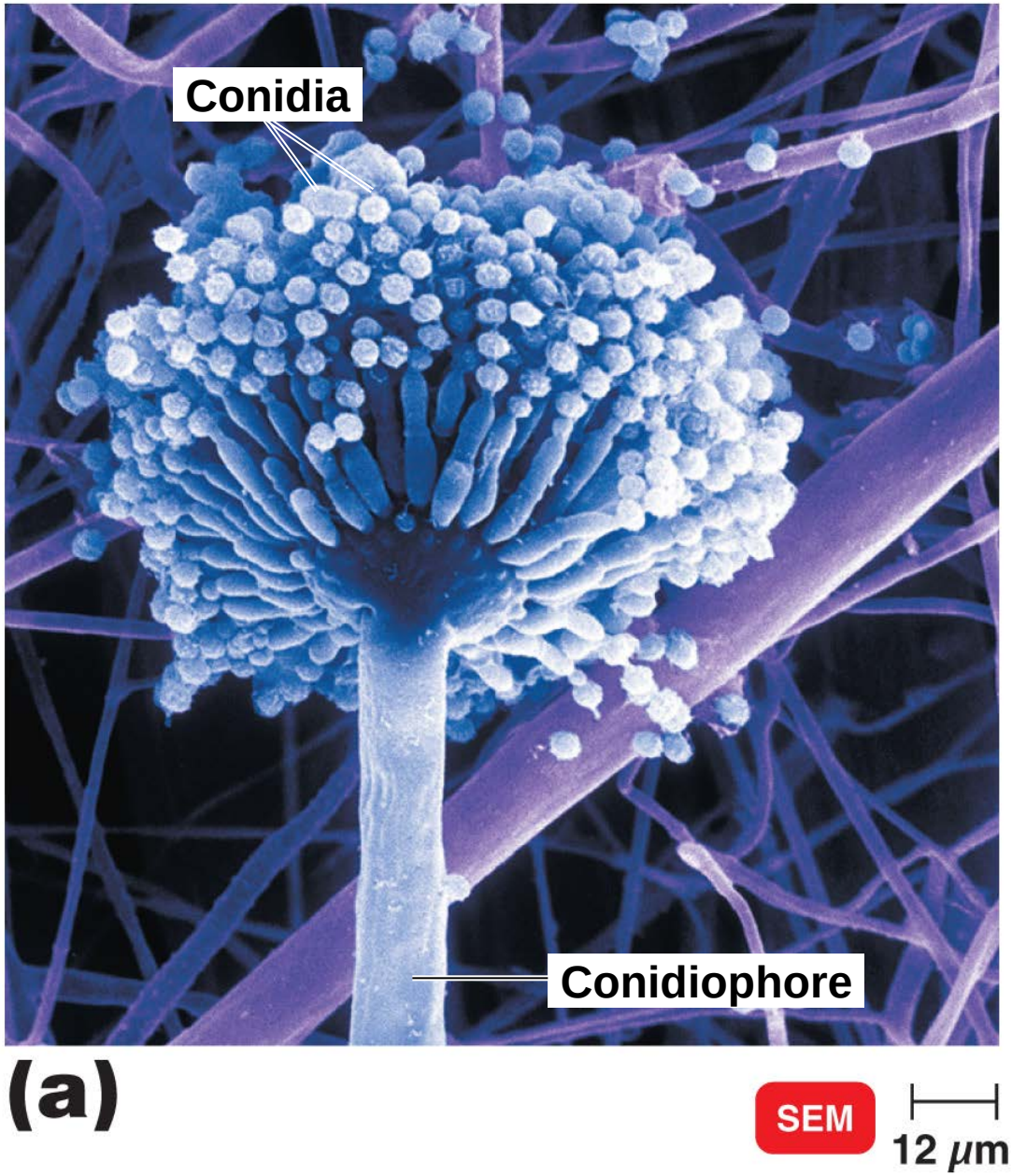


Figure 12.6b Representative asexual spores.

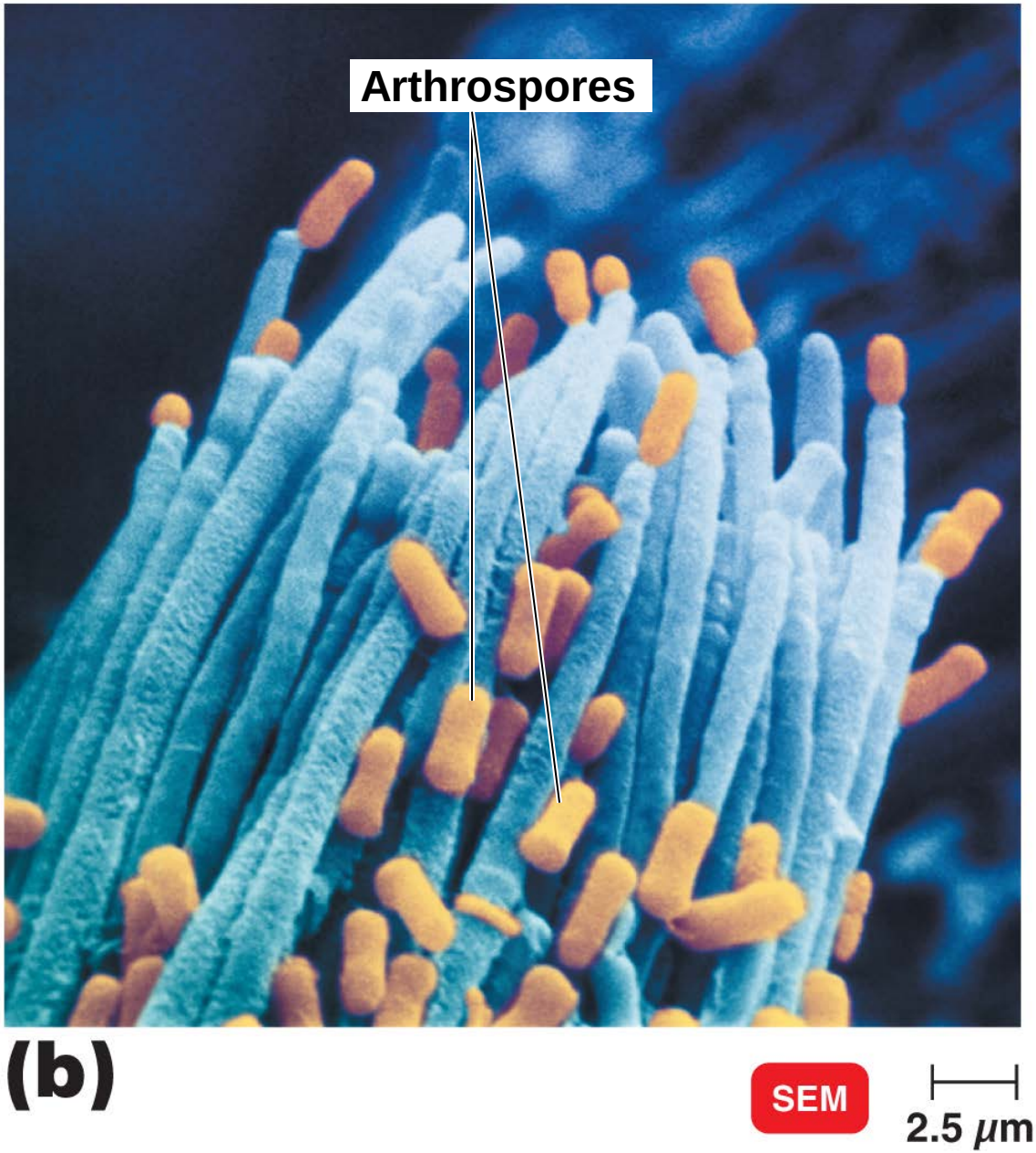


Figure 12.6c Representative asexual spores.

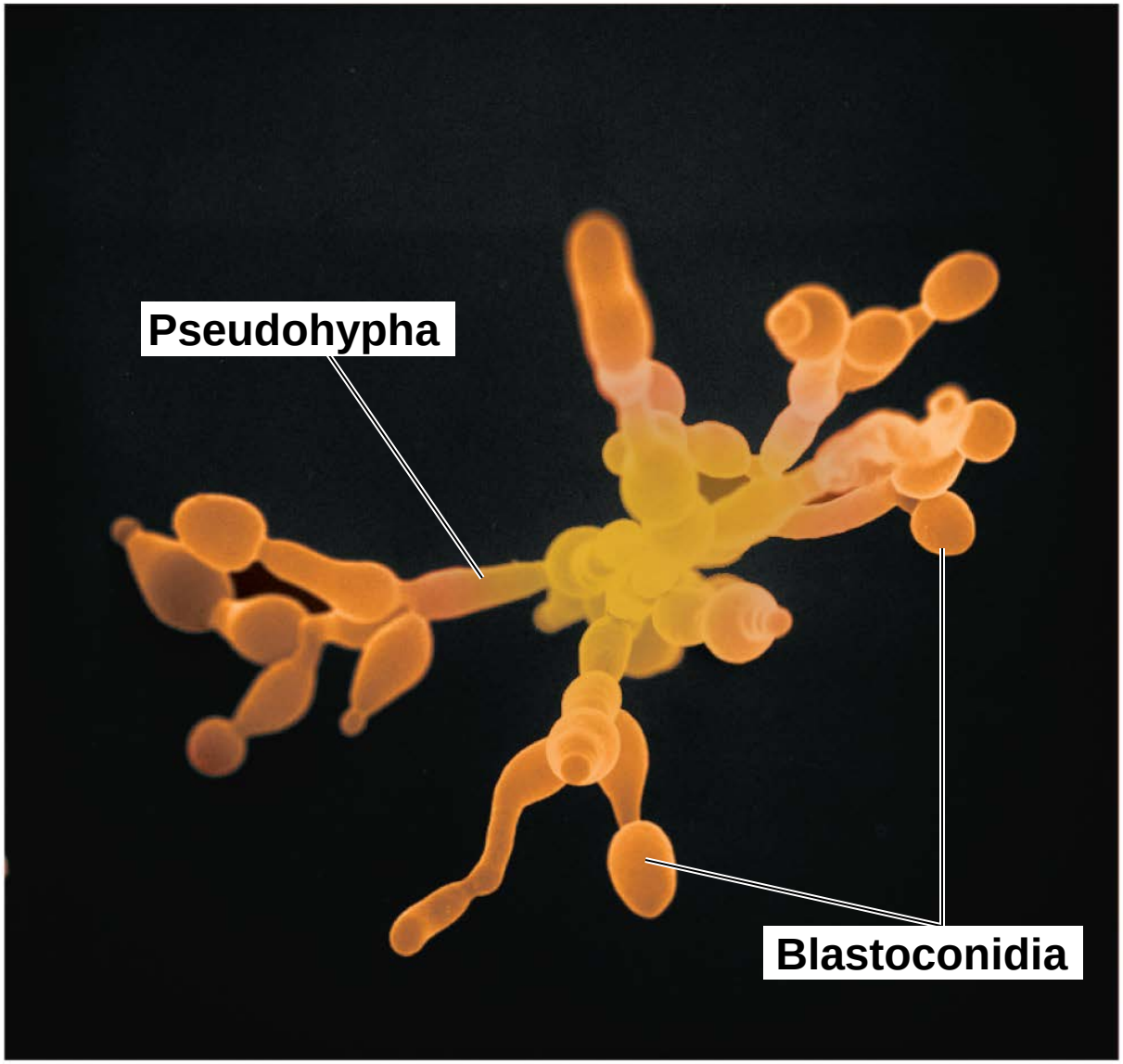


Figure 12.6d Representative asexual spores.

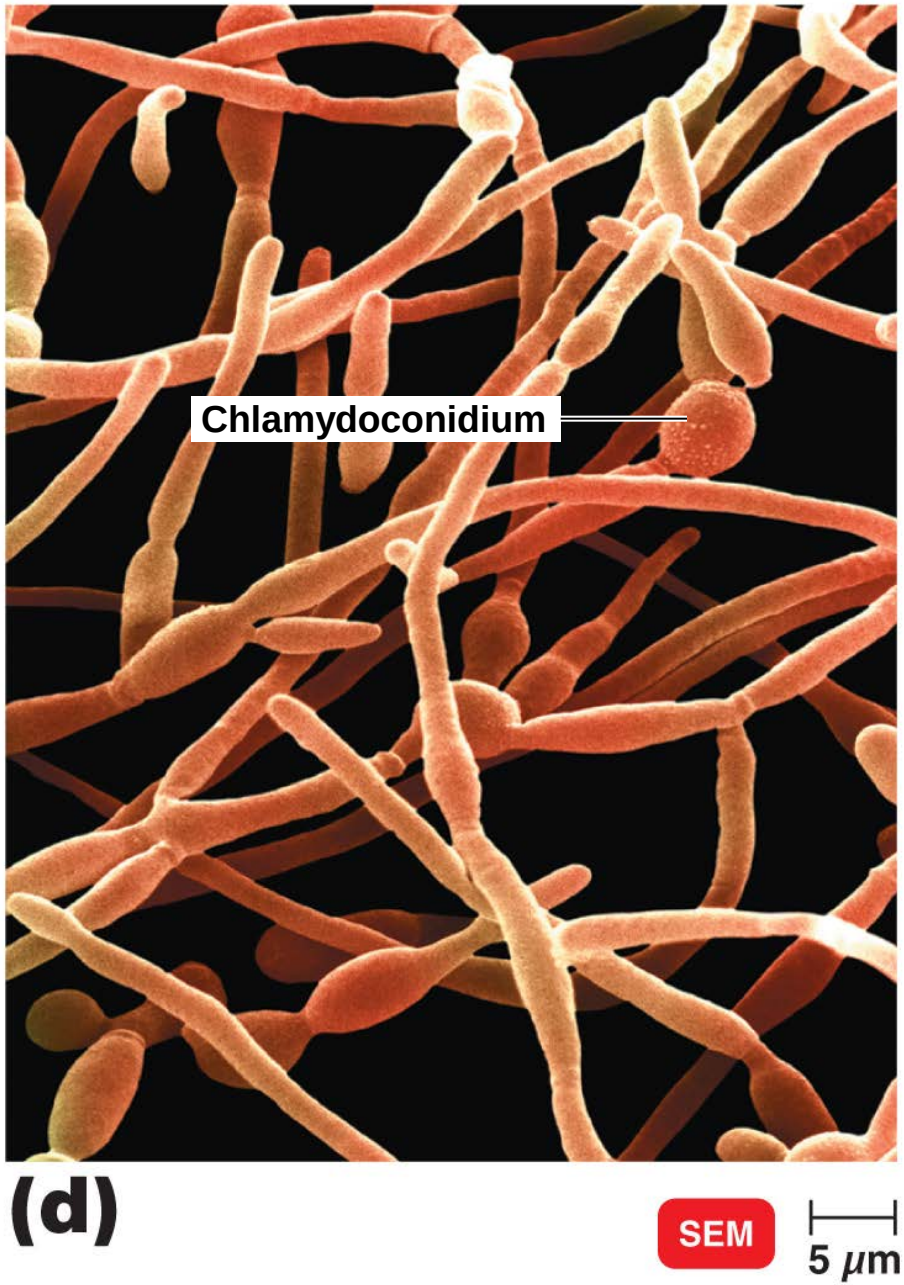
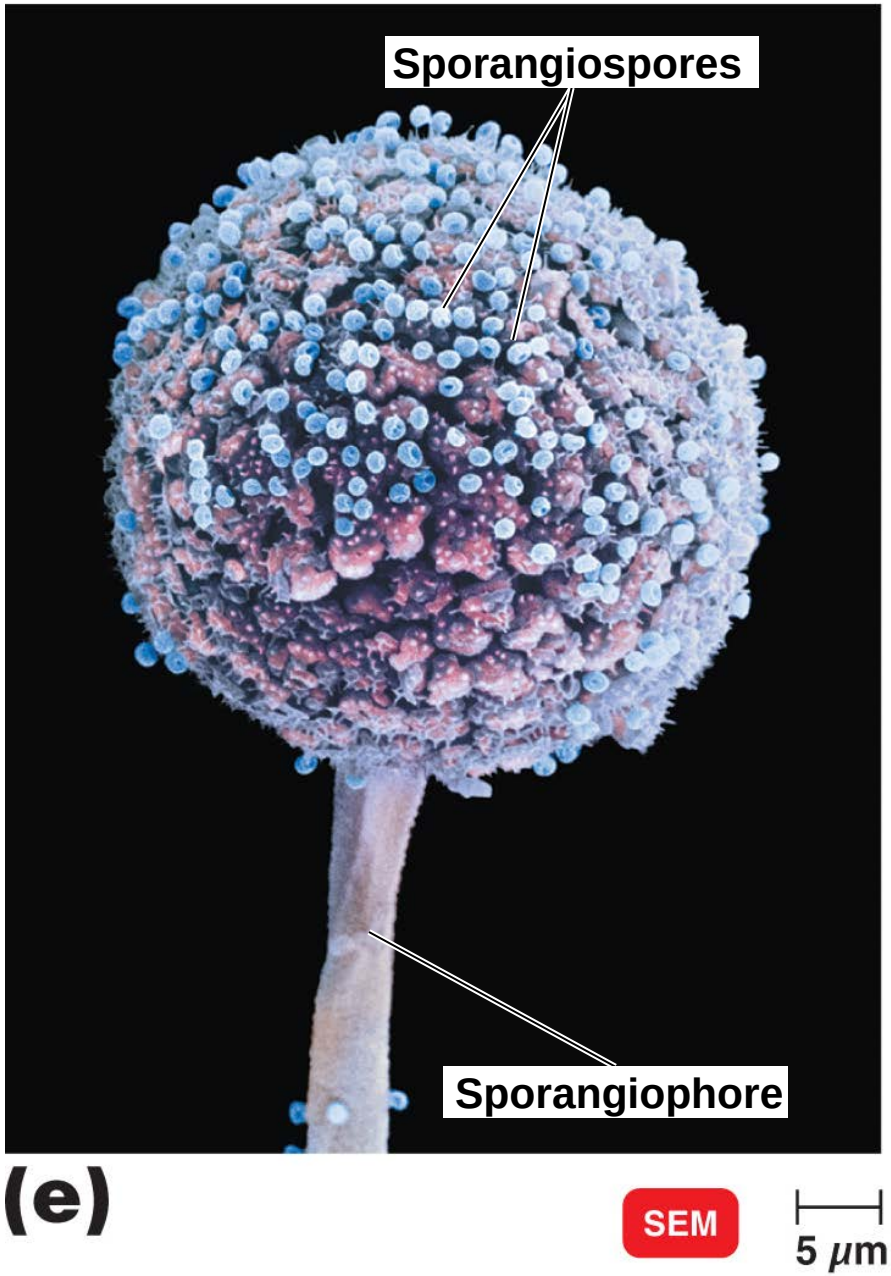


Figure 12.6e Representative asexual spores.



Sexual Reproduction

- Three phases:
  - **Plasmogamy**: haploid donor cell nucleus (+) penetrates cytoplasm of recipient cell (−)
  - **Karyogamy**: + and − nuclei fuse
  - **Meiosis**: diploid nucleus produces haploid nuclei (sexual spores)

Sexual Spores

- **Zygospore**: fusion of haploid cells produces one zygospore
- **Ascospore**: formed in a sac (ascus)
- **Basidiospore**: formed externally on a pedestal (basidium)

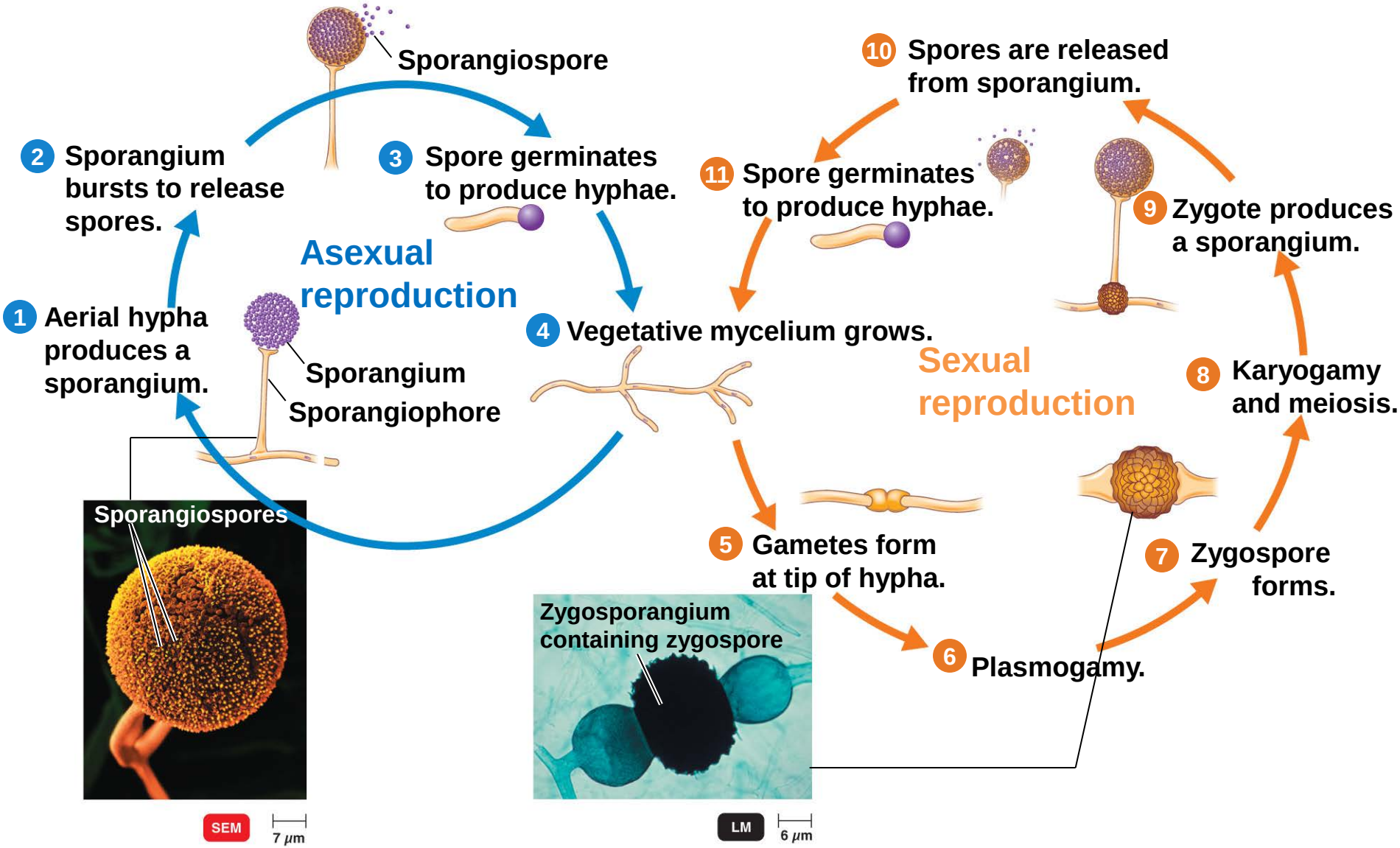
Medically Important Phyla of Fungi

- Zygomycota
- Microsporidia
- Ascomycota
  - Anamorphs
- Basidiomycota

Zygomycota

- Conjugation fungi
- Coenocytic
- Produce sporangiospores and zygospores
  - *Rhizopus, Mucor* (opportunistic, systemic mycoses)

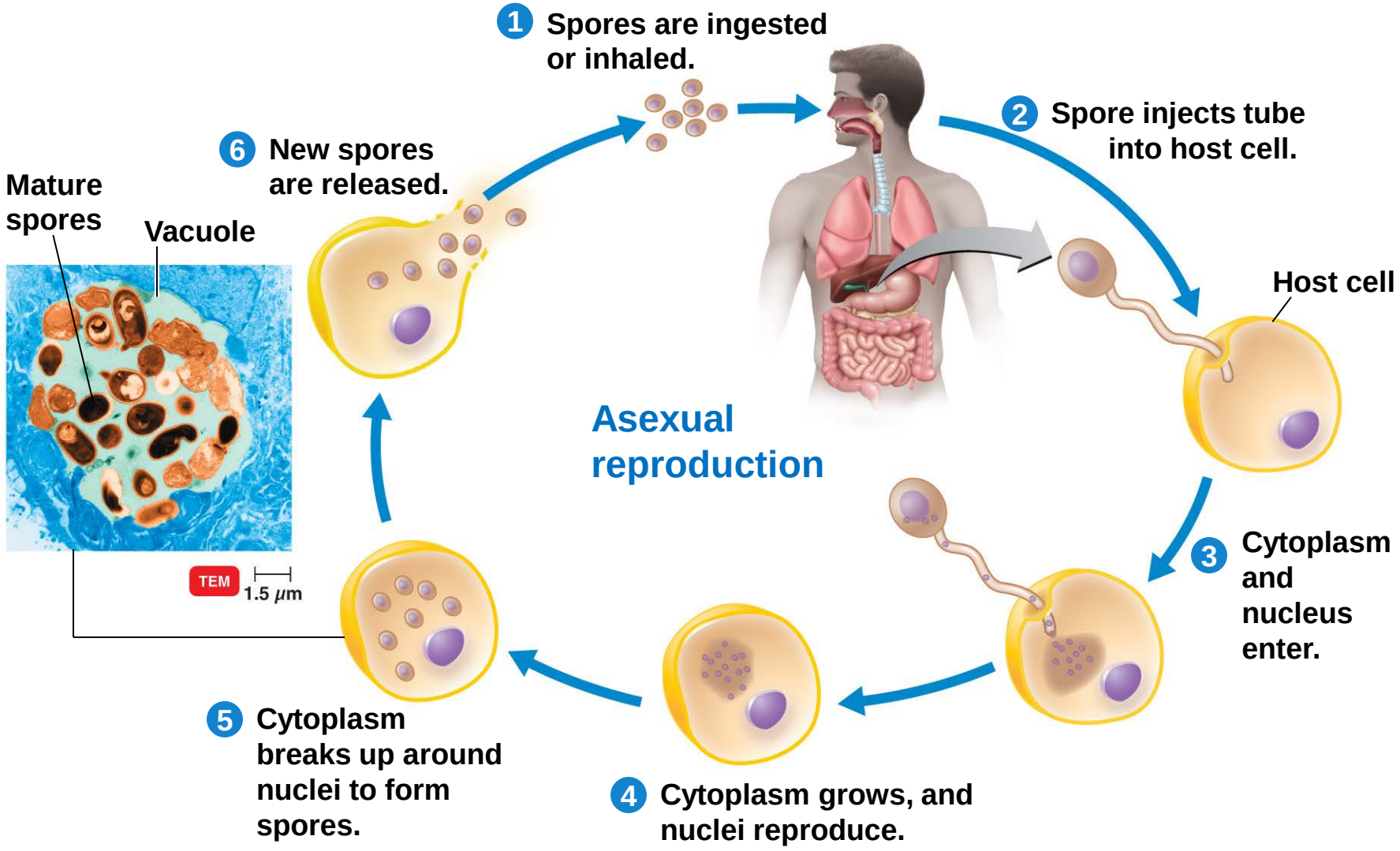
Figure 12.7 The life cycle of *Rhizopus*, a zygomycete.



Microsporidia

- No hyphae
- No mitochondria
- Intracellular parasites
  - *Encephalitozoon intestinalis*

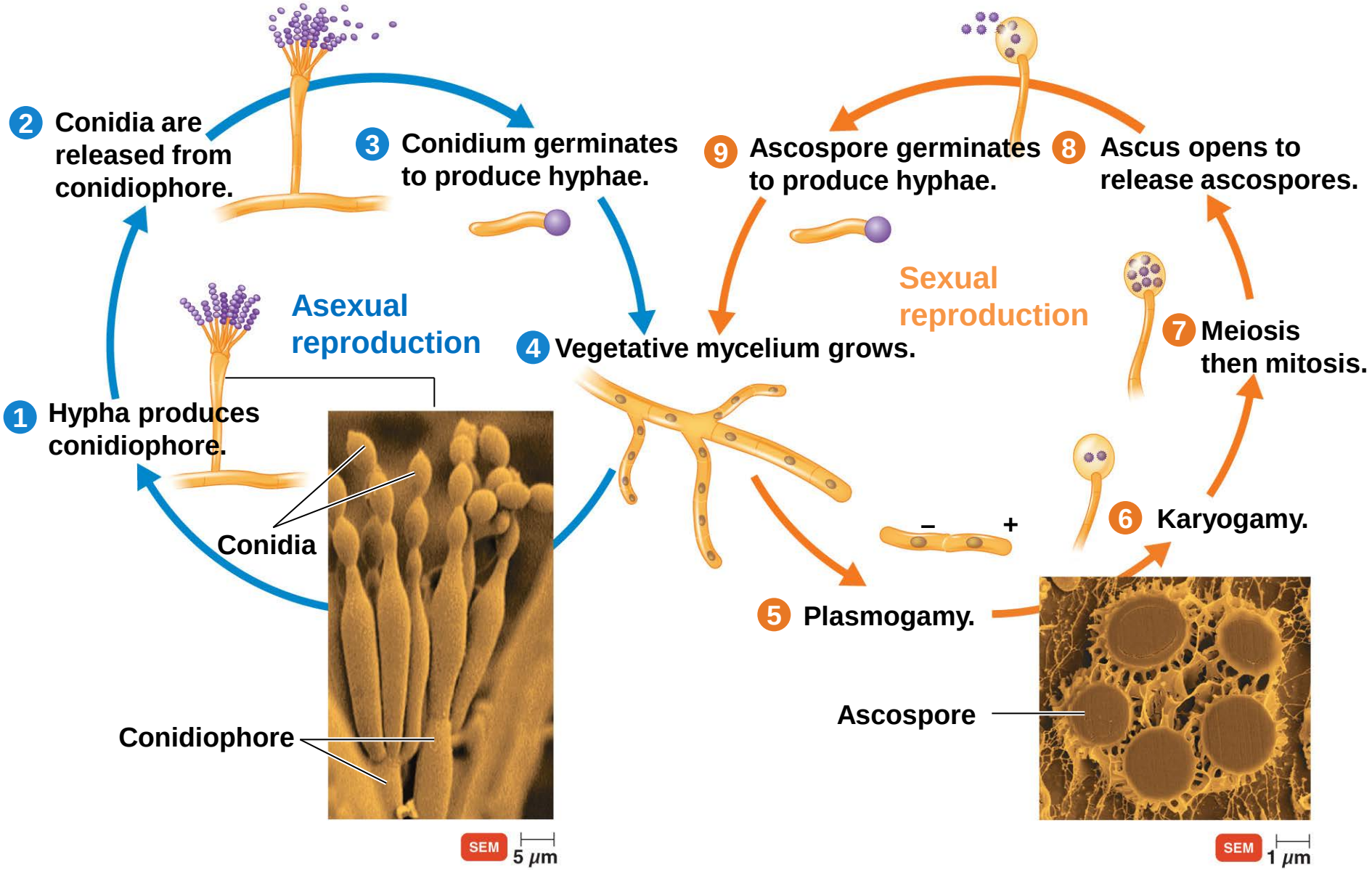
Figure 12.8 The life cycle of *Encephalitozoon*, a microsporidian.



Ascomycota

- Sac fungi
- Septate
- Teleomorphic fungi
  - Produce sexual and asexual spores
- Ascospores and frequently conidiospores
  - *Aspergillus* (opportunistic, systemic mycosis)
  - *Blastomyces dermatitidis, Histoplasma capsulatum* (systemic mycoses)
  - *Microsporum, Trichophyton* (cutaneous mycoses)

Figure 12.9 The life cycle of *Talaromyces*, an ascomycete.



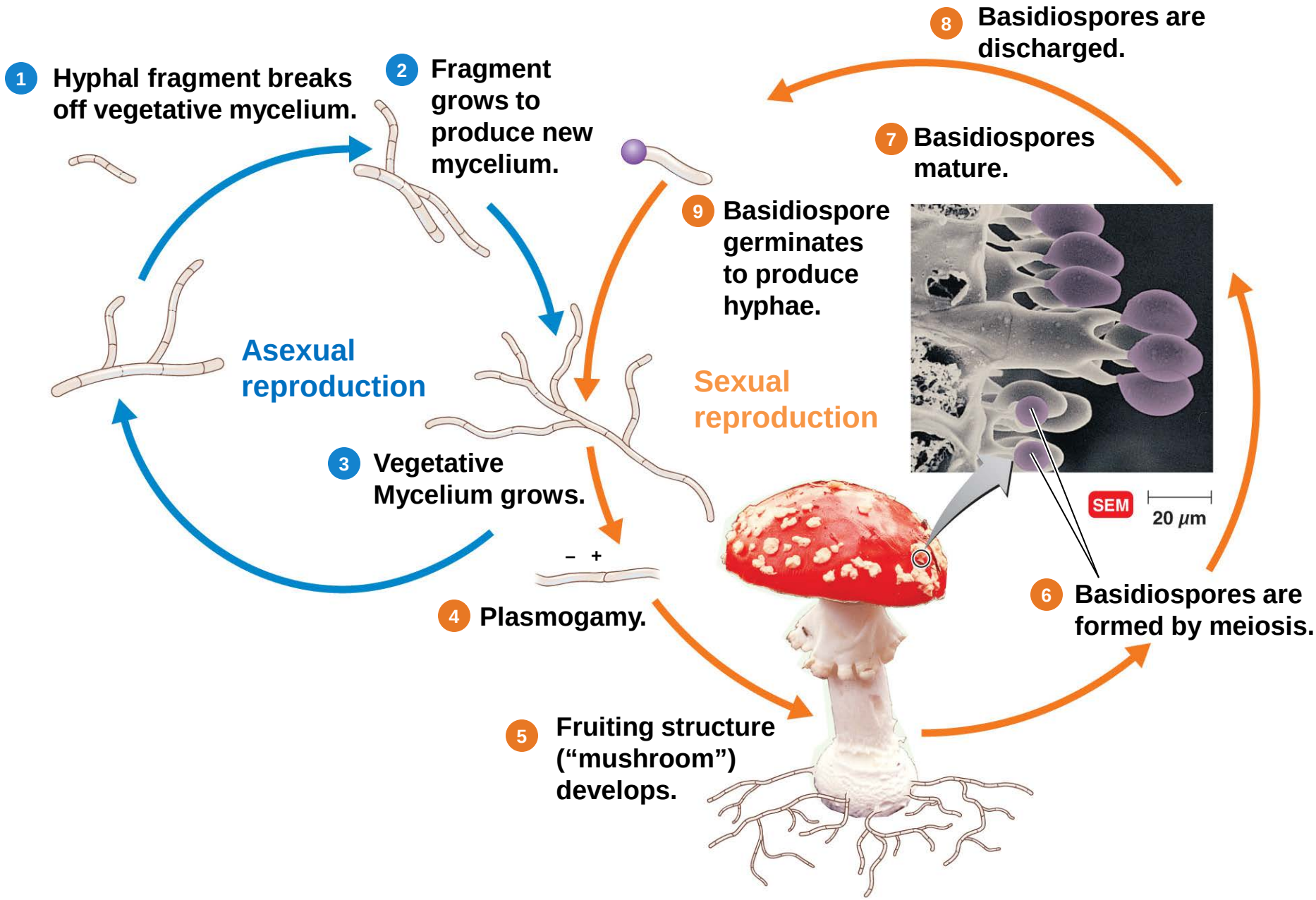
Anamorphs

- Produce asexual spores only
  - rRNA sequencing places most in Ascomycota; a few are Basidiomycota
  - *Penicillium*
  - *Sporothrix* (subcutaneous mycosis)
  - *Stachybotrys, Coccidioides, Pneumocystis* (systemic mycoses)
  - *Candida albicans* (cutaneous mycoses)

Basidiomycota

- Club fungi
- Septate
- Produce basidiospores and sometimes conidiospores
  - *Cryptococcus neoformans* (systemic mycosis)

Figure 12.10 A generalized life cycle of a basidiomycete.



Economic Effects of Fungi

- *Saccharomyces cerevisiae*: bread, wine, HBV vaccine
- *Trichoderma*: cellulase
- *Taxomyces*: taxol
- *Entomophaga*: biocontrol
- *Coniothyrium minitans*: kills fungi
- *Paecilomyces*: kills termites

Fungal Diseases (Mycoses)

- **Systemic mycoses**: deep within body
- **Subcutaneous mycoses**: beneath the skin
- **Cutaneous mycoses**: affect hair, skin, and nails
- **Superficial mycoses**: localized, e.g., hair shafts
- **Opportunistic mycoses**: caused by normal microbiota or environmental fungi

Check Your Understanding

- ✓ Assume you isolated a single-celled organism that has a cell wall. How would you determine that it is a fungus and not a bacterium? 12-1
- ✓ Contrast the mechanism of conidiospore and ascospore formation. 12-2
- ✓ List the asexual and sexual spores made by Zygomycetes, Ascomycetes, and Basidiomycetes. 12-3
- ✓ Why are microsporidia classified as fungi? 12-4
- ✓ Are yeasts beneficial or harmful? 12-4

Lichens

Learning Objectives

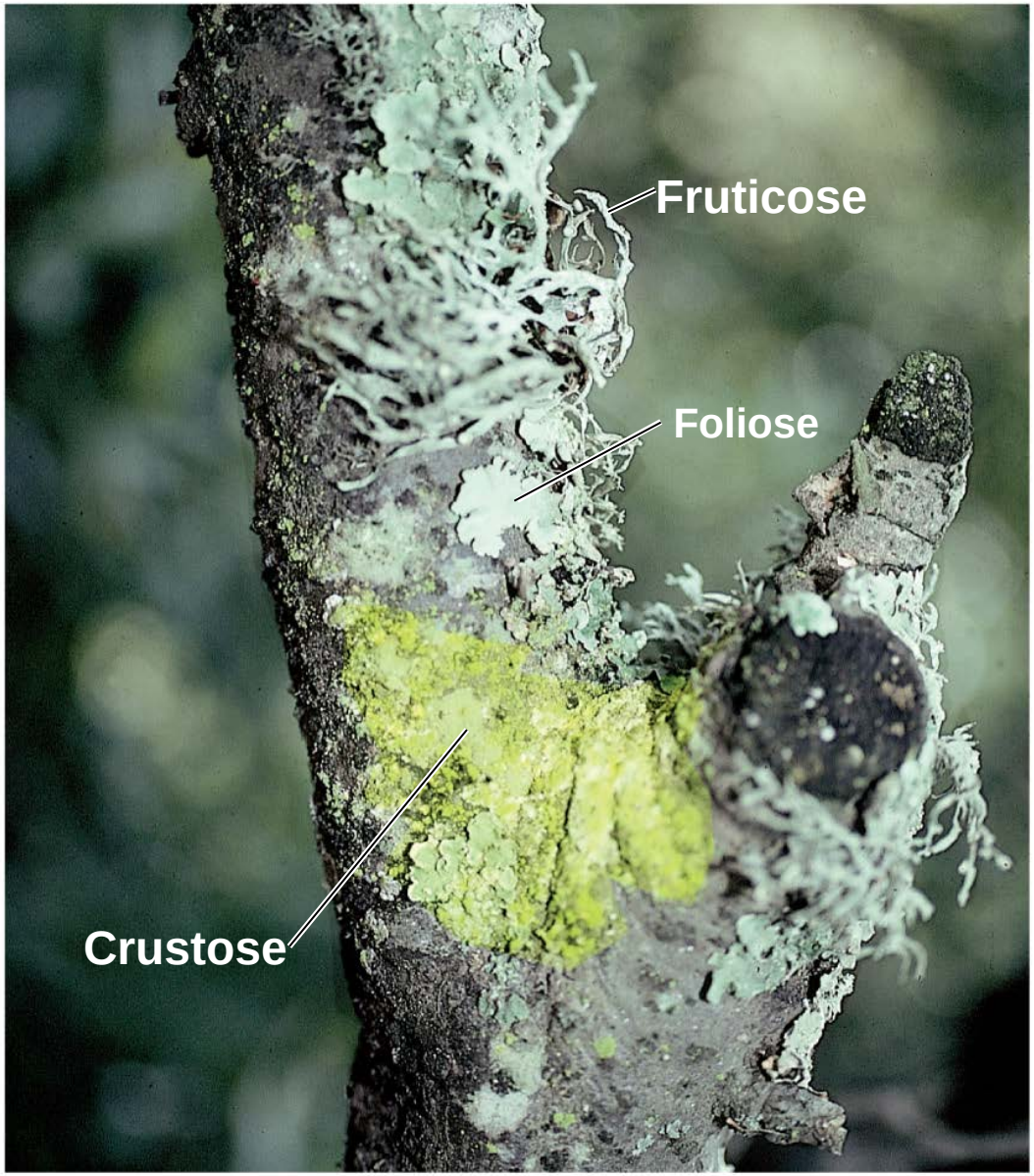
12-5 List the distinguishing characteristics of lichens, and describe their nutritional needs.

12-6 Describe the roles of the fungus and the alga in a lichen.

Lichens

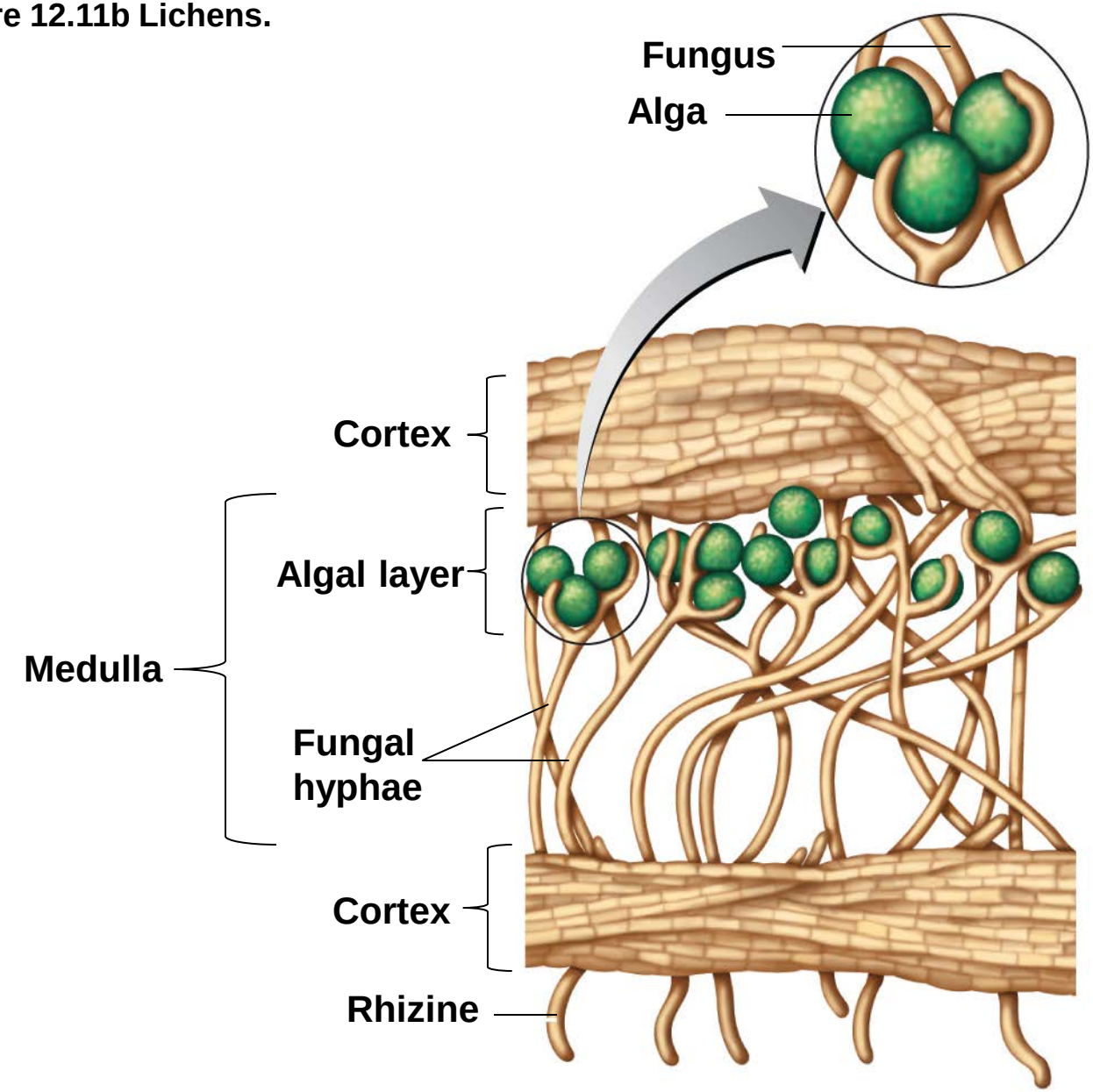
- Mutualistic combination of an alga (or cyanobacterium) and fungus
- Alga produces and secretes carbohydrates; fungus provides holdfast

Figure 12.11a Lichens.



(a) Three types of lichens

Figure 12.11b Lichens.



(b) Lichen thallus

Economic Effects of Lichens

- Dyes
- Antimicrobial (*Usnea*)
- Litmus

Check Your Understanding

- ✓ What is the role of lichens in nature? 12-5
- ✓ What is the role of the fungus in a lichen? 12-6

Algae

Learning Objectives

12-7 List the defining characteristics of algae.

12-8 List the outstanding characteristics of the five phyla of algae discussed in this chapter.

12-9 Identify two beneficial and two harmful effects of algae.

Algae

Kingdom	Protista
Nutritional Type	Photoautotroph
Multicellularity	Some
Cellular Arrangement	Unicellular, colonial, filamentous, tissues
Food Acquisition Method	Diffusion
Characteristic Features	Pigments

Figure 12.12a Algae and their habitats.

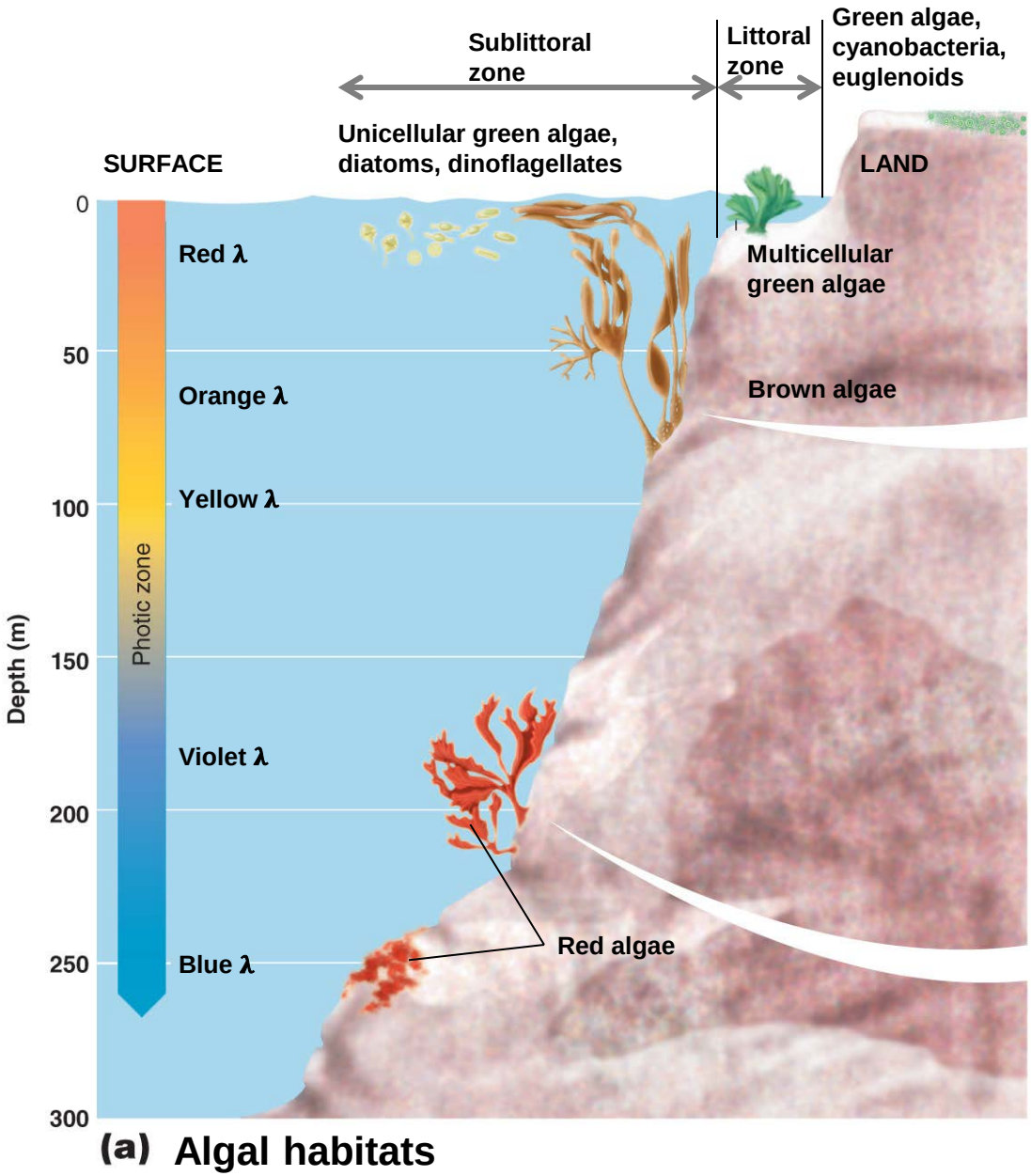
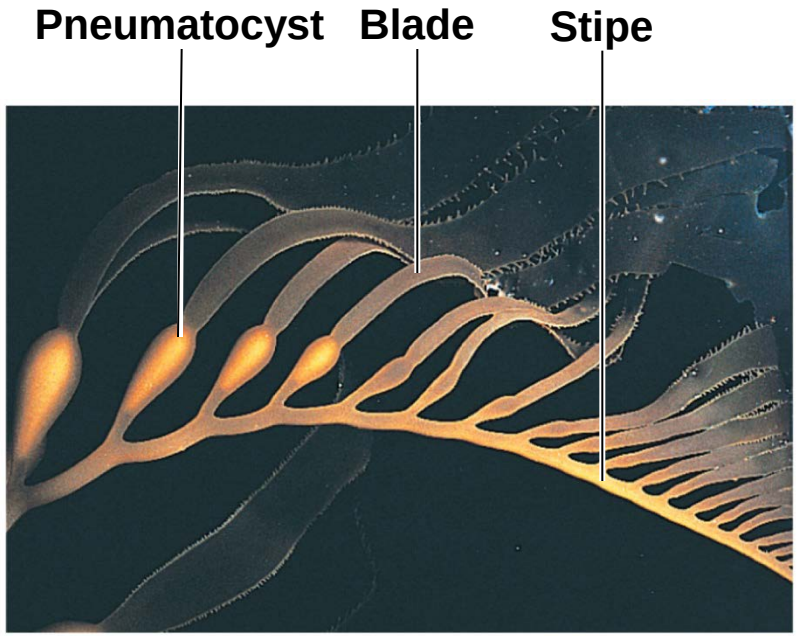


Figure 12.12 Algae and their habitats.



(b) Brown alga (*Macrocystis*)

0.5 m

(c) Red alga (*Microcladia*)

10 cm

Figure 12.13a Green algae.

(a) Multicellular green alga (*Ulva*)

Figure 12.14a Diatoms.

(a) ***Eunotia*, a freshwater diatom that grows in acidic water**

Figure 12.15 *Peridinium*, a dinoflagellate.

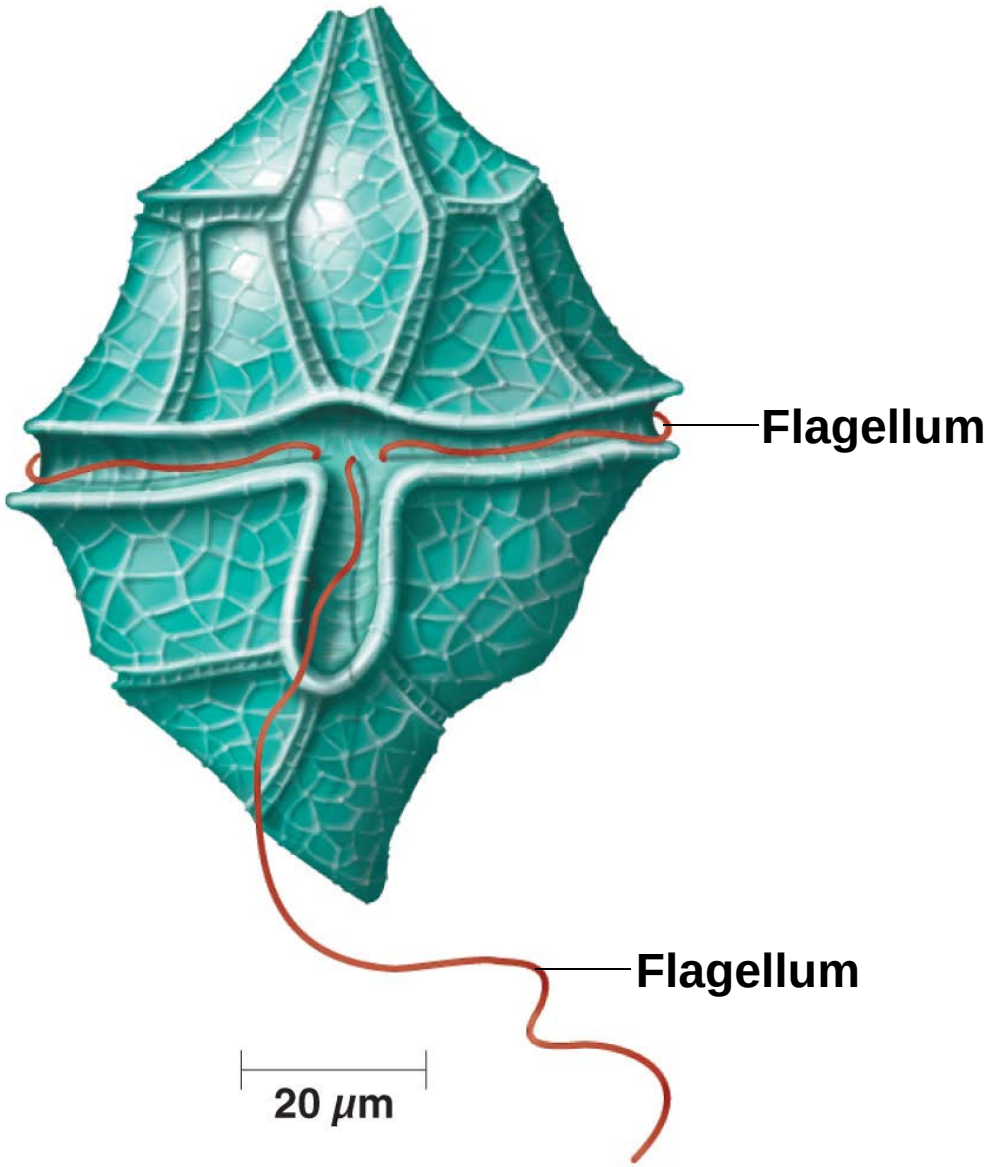
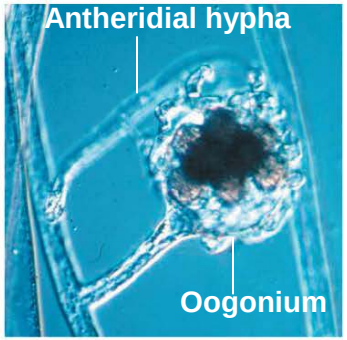


Figure 12.16 Oomycotes.



8 Zygote germinates.

2 Hyphae produce sporangia.

1 Vegetative hyphae grow on organic matter.

7 Zygotes are released.

Sexual reproduction

Asexual reproduction

3 Motile zoospores swim from the sporangium.

6 Male antheridial hyphae grow around female oogonium and insert their nuclei into the oogonium.

5 Produce male and female hyphae.

4 On a suitable substrate, zoospore germinates to produce hyphae.

Phaeophyta

- Brown algae (kelp)
- Cellulose and alginic acid cell walls
- Multicellular
- Chlorophyll *a* and *c*, xanthophylls
- Store carbohydrates
- Harvested for **algin**

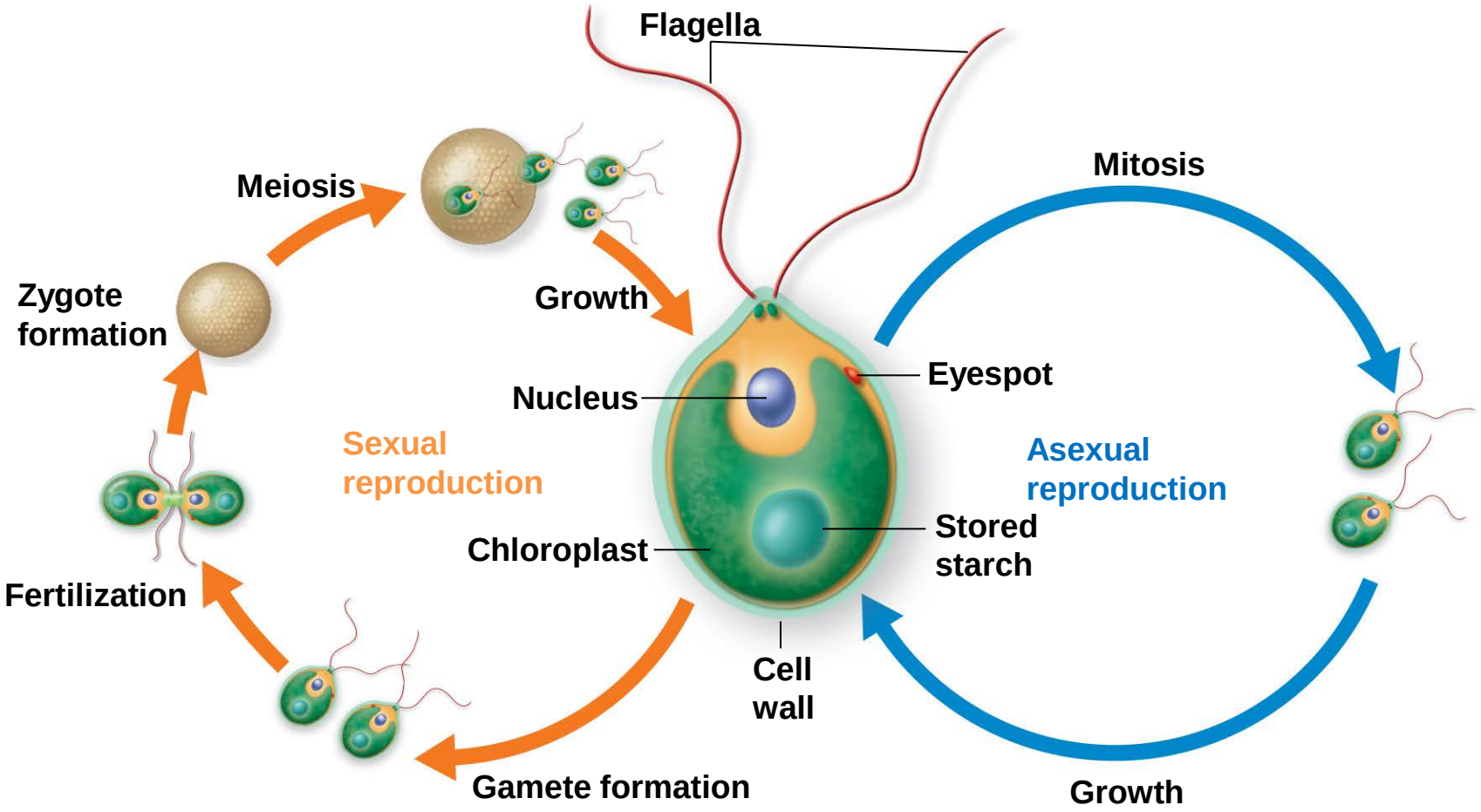
Rhodophyta

- Red algae
- Cellulose cell walls
- Most are multicellular
- Chlorophyll *a* and *d*, phycobiliproteins
- Store glucose polymer
- Harvested for agar and carrageenan

Chlorophyta

- Green algae
- Cellulose cell walls
- Unicellular or multicellular
- Chlorophyll *a* and *b*
- Store glucose polymer
- Gave rise to plants

Figure 12.13b Green algae.



(b) Life cycle of a unicellular green alga (*Chlamydomonas*)

Diatoms

- Pectin and silica cell walls
- Unicellular
- Chlorophyll *a* and *c*, carotene, xanthophylls
- Store oil
- Fossilized diatoms formed oil
- Produce domoic acid

Figure 12.14 Diatoms.

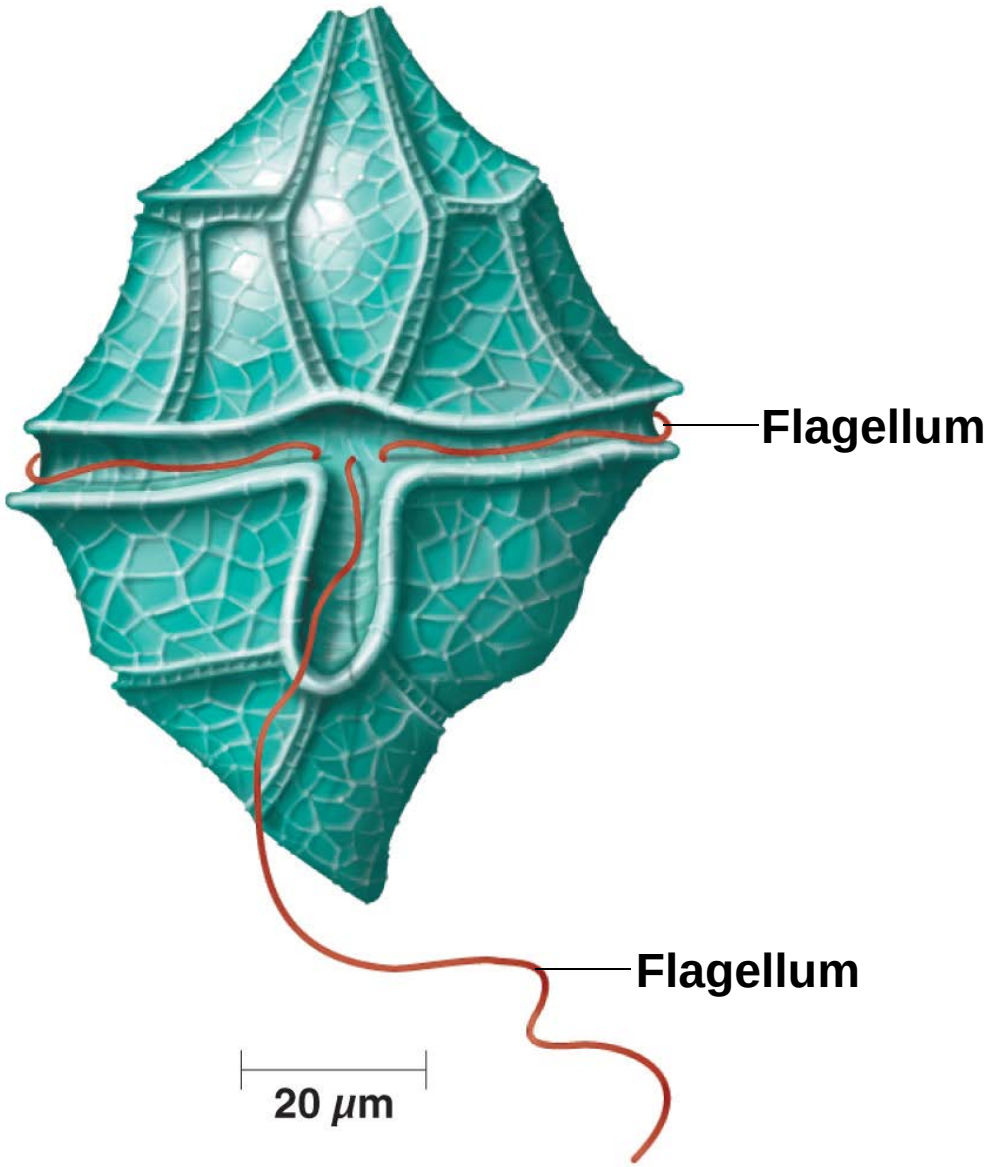
(a) ***Eunotia*, a freshwater diatom that grows in acidic water**

(b) **Asexual reproduction of a diatom**

Dinoflagellates

- Cellulose in plasma membrane
- Unicellular
- Chlorophyll *a* and *c*, carotene, xanthins
- Store starch
- Some are symbionts in marine animals
- Neurotoxins cause paralytic shellfish poisoning

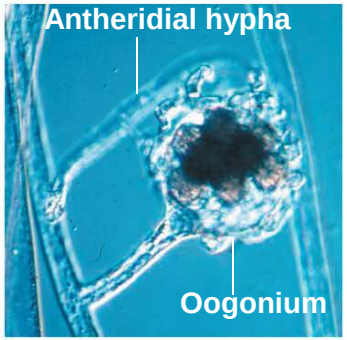
Figure 12.15 *Peridinium*, a dinoflagellate.



Oomycota

- Cellulose cell walls
- Multicellular
- Chemoheterotrophic
- Produce zoospores
- Decomposers and plant parasites
  - *Phytophthora infestans* responsible for Irish potato blight
  - *P. cinnamoni* infects *Eucalyptus*
  - *P. ramorum* causes “sudden oak death”
- Water molds

Figure 12.16 Oomycotes.



8 Zygote germinates.

2 Hyphae produce sporangia.

1 Vegetative hyphae grow on organic matter.

7 Zygotes are released.

Sexual reproduction

Asexual reproduction

3 Motile zoospores swim from the sporangium.

6 Male antheridial hyphae grow around female oogonium and insert their nuclei into the oogonium.

5 Produce male and female hyphae.

4 On a suitable substrate, zoospore germinates to produce hyphae.

Check Your Understanding

- ✓ How do algae differ from bacteria? From fungi? 12-7
- ✓ List the cell wall composition and diseases caused by the following algae: diatoms, dinoflagellates, oomycotes. 12-8, 12-9

Protozoa

Learning Objectives

12-10 List the defining characteristics of protozoa.

12-11 Describe the outstanding characteristics of the seven phyla of protozoa discussed in this chapter, and give an example of each.

12-12 Differentiate an intermediate host from a definitive host.

Protozoa

Kingdom	Various
Nutritional Type	Chemoheterotroph
Multicellularity	None
Cellular Arrangement	Unicellular
Food Acquisition Method	Absorptive; ingestive
Characteristic Features	Motility; some form cysts

Characteristics of Protozoa

- Vegetative form is a **trophozoite**
- Asexual reproduction is by fission, budding, or **schizogony**
- Sexual reproduction by **conjugation**
- Some produce **cysts**

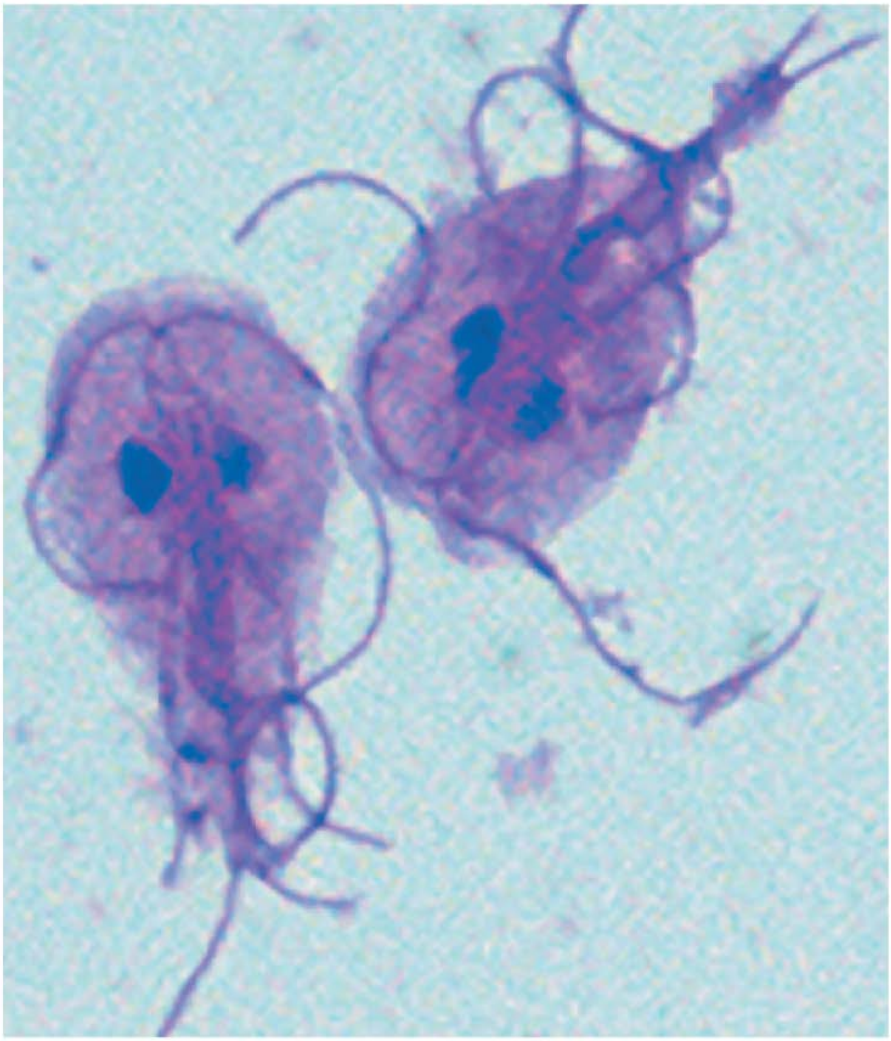
Medically Important Phyla of Protozoa

- Diplomonads
- Parabasalids
- Euglenozoa
- Amebae
- Apicomplexa
- Dinoflagellates
- Ciliates

Diplomonads

- No mitochondria
- Multiple flagella
- *Giardia lamblia*

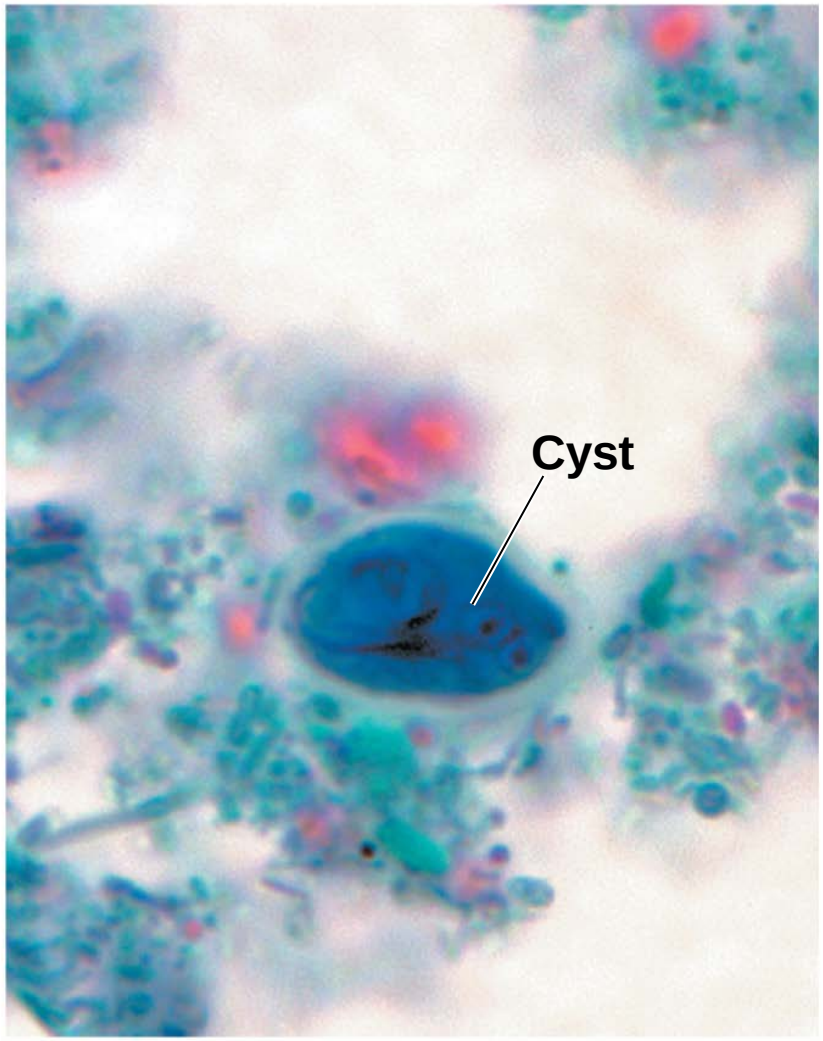
Figure 12.18 Members of the super kingdom Excavata.



LM

7 μm

(b) ***Giardia*** **trophozoites.**



LM

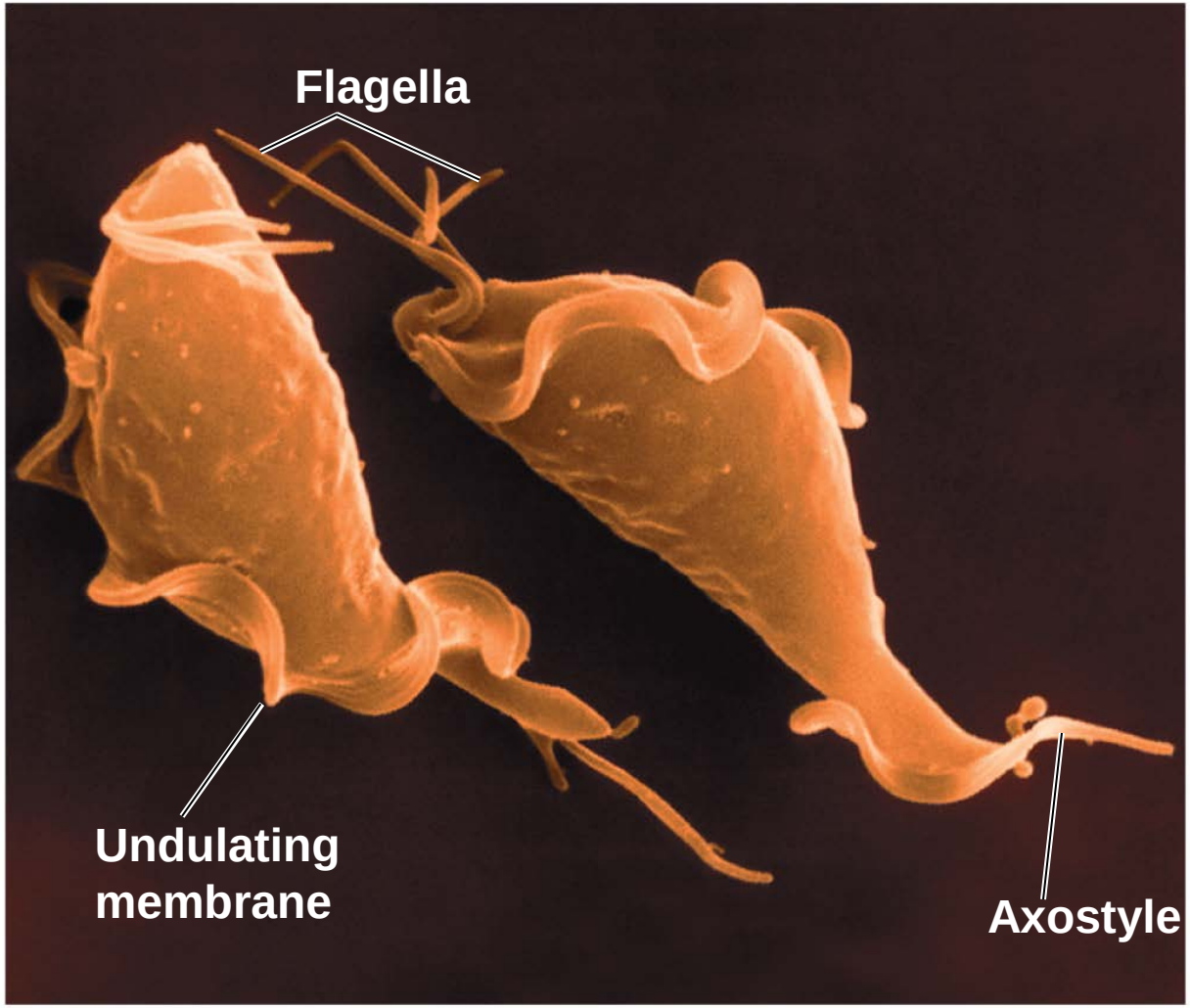
10 μm

(c) ***Giardia*** **cyst.**

Parabasalids

- No mitochondria
- Multiple flagella
- No cyst
- *Trichomonas vaginalis*

Figure 12.18d Members of the super kingdom Excavata.

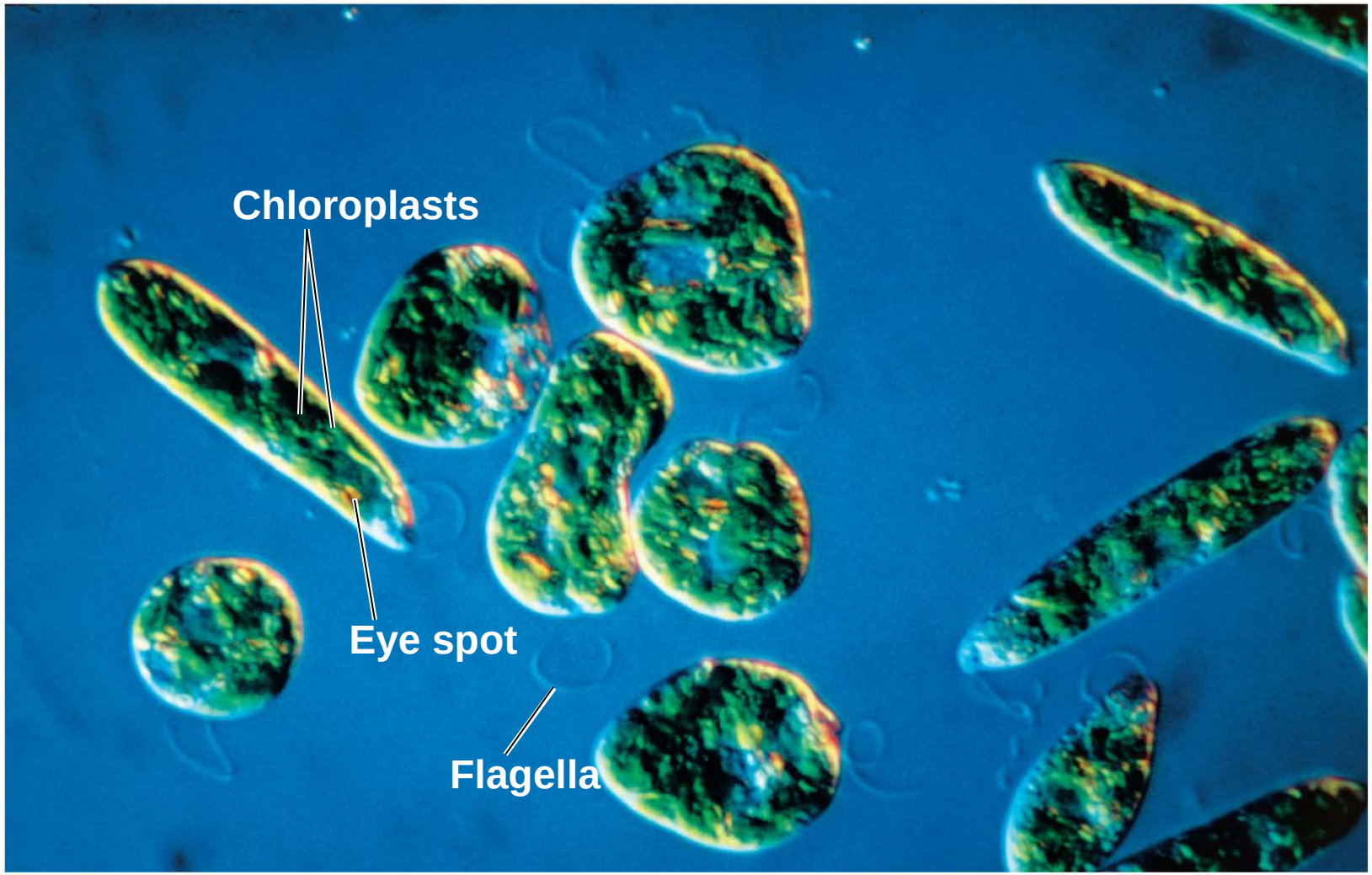


(d) *Trichomonas vaginalis.*

Euglenozoa

- Move by flagella
- Euglenoids
  - Photoautotrophs
- Hemoflagellates
  - *Trypanosoma* spp.
    - Sleeping sickness
    - Chagas' disease

Figure 12.18e Members of the super kingdom Excavata.



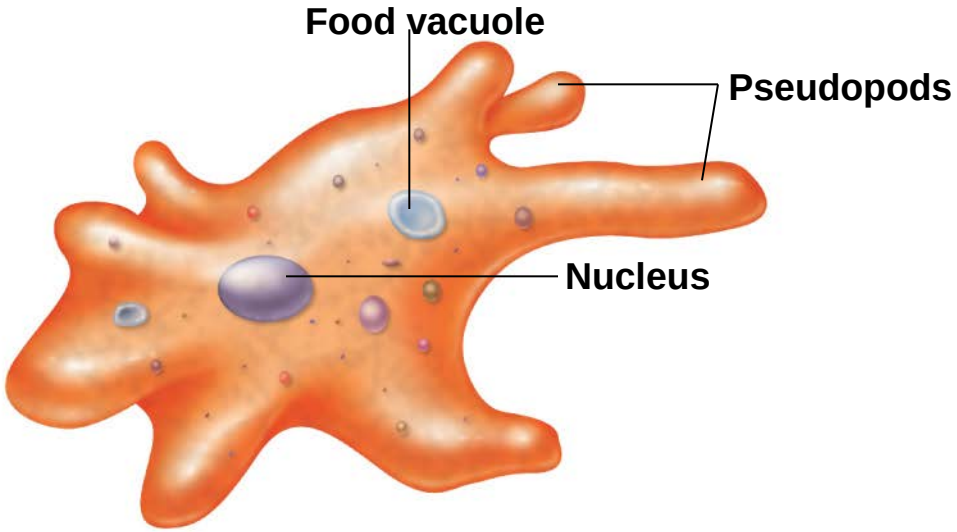
(e) *Euglena*.

Figure 23.23 *Trypanosoma cruzi*, the cause of Chagas' disease (American trypanosomiasis).

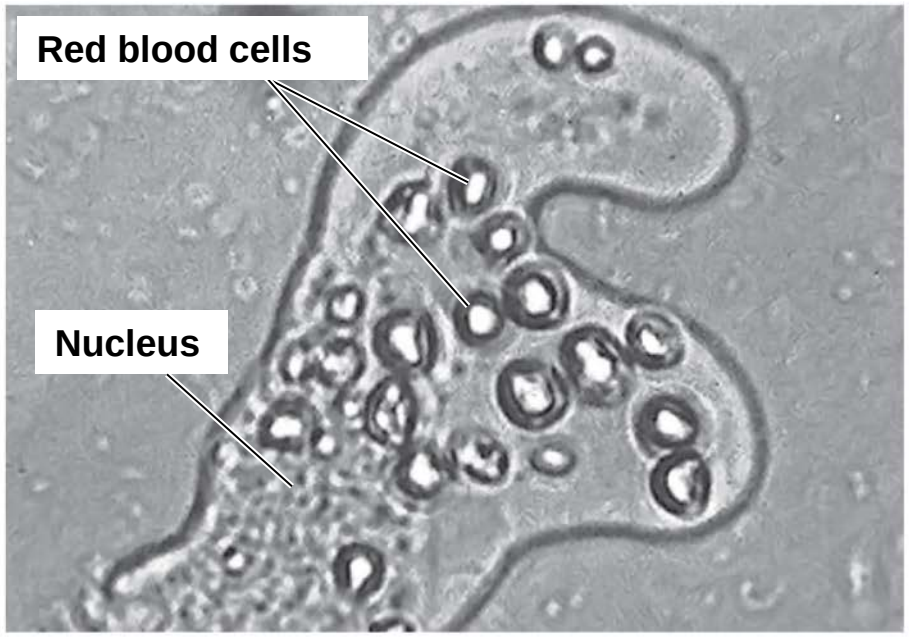
Amebae

- Move by **pseudopods**
- *Entamoeba*
- *Acanthamoeba*

Figure 12.19 Amebae.



(a) *Amoeba proteus*

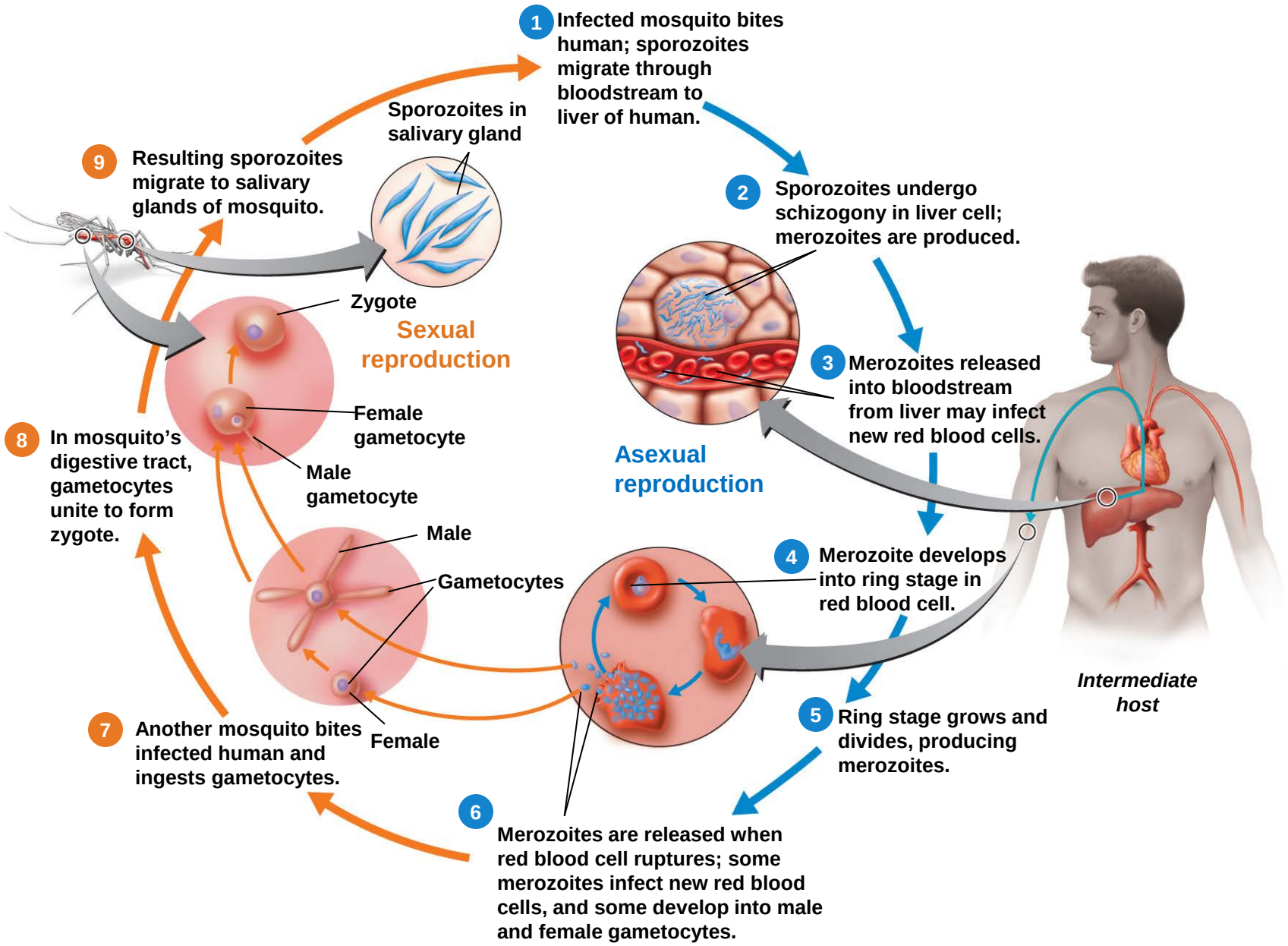


(b) *Entamoeba histolytica*

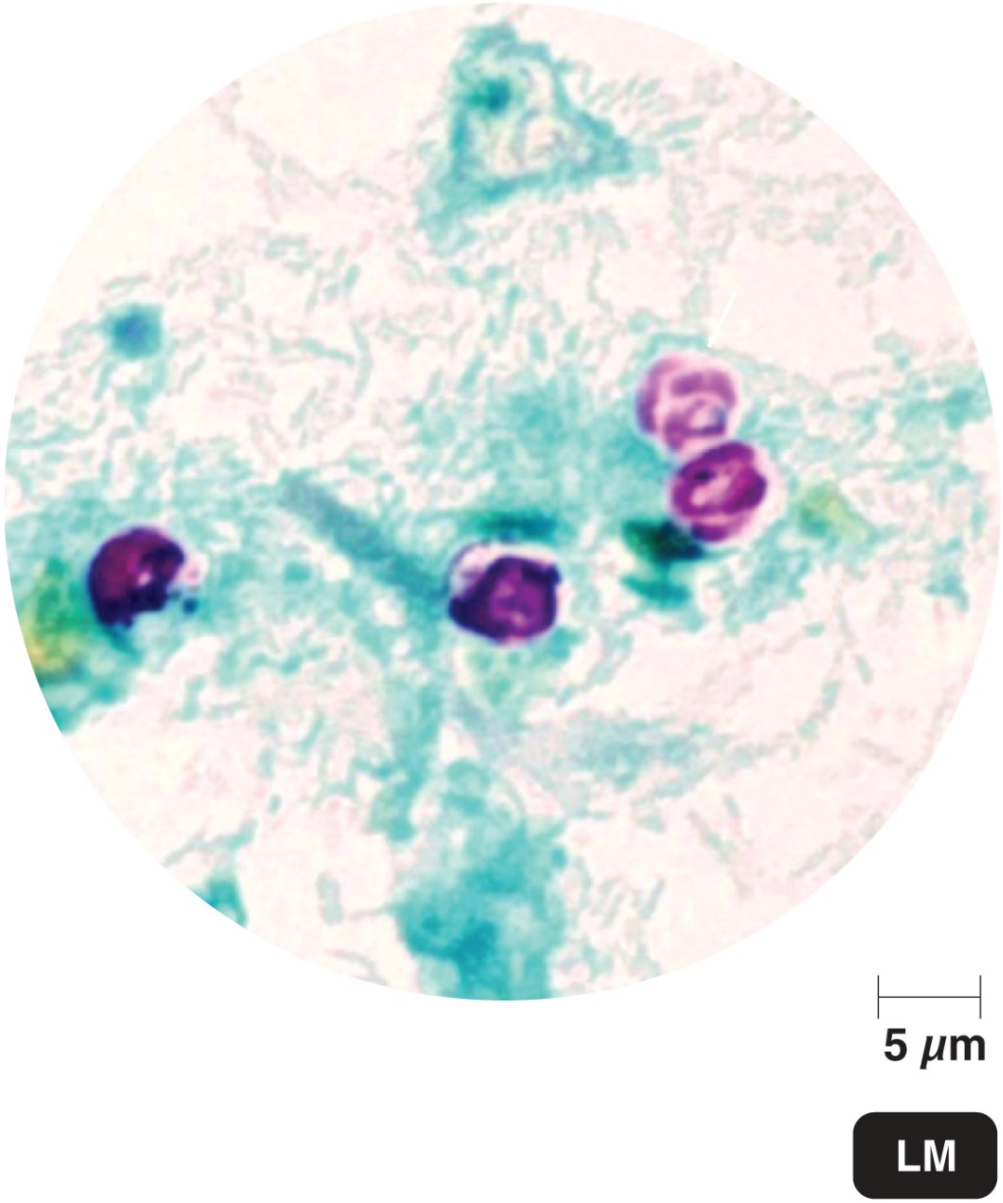
Apicomplexa

- Nonmotile
- Intracellular parasites
- Complex life cycles
- *Plasmodium*
- *Babesia*
- *Cryptosporidium*
- *Cyclospora*

Figure 12.20 The life cycle of *Plasmodium vivax*, the apicomplexan that causes malaria.



Chapter 12, unnumbered figure A, page 357.



Chapter 12, unnumbered figure B, page 357.

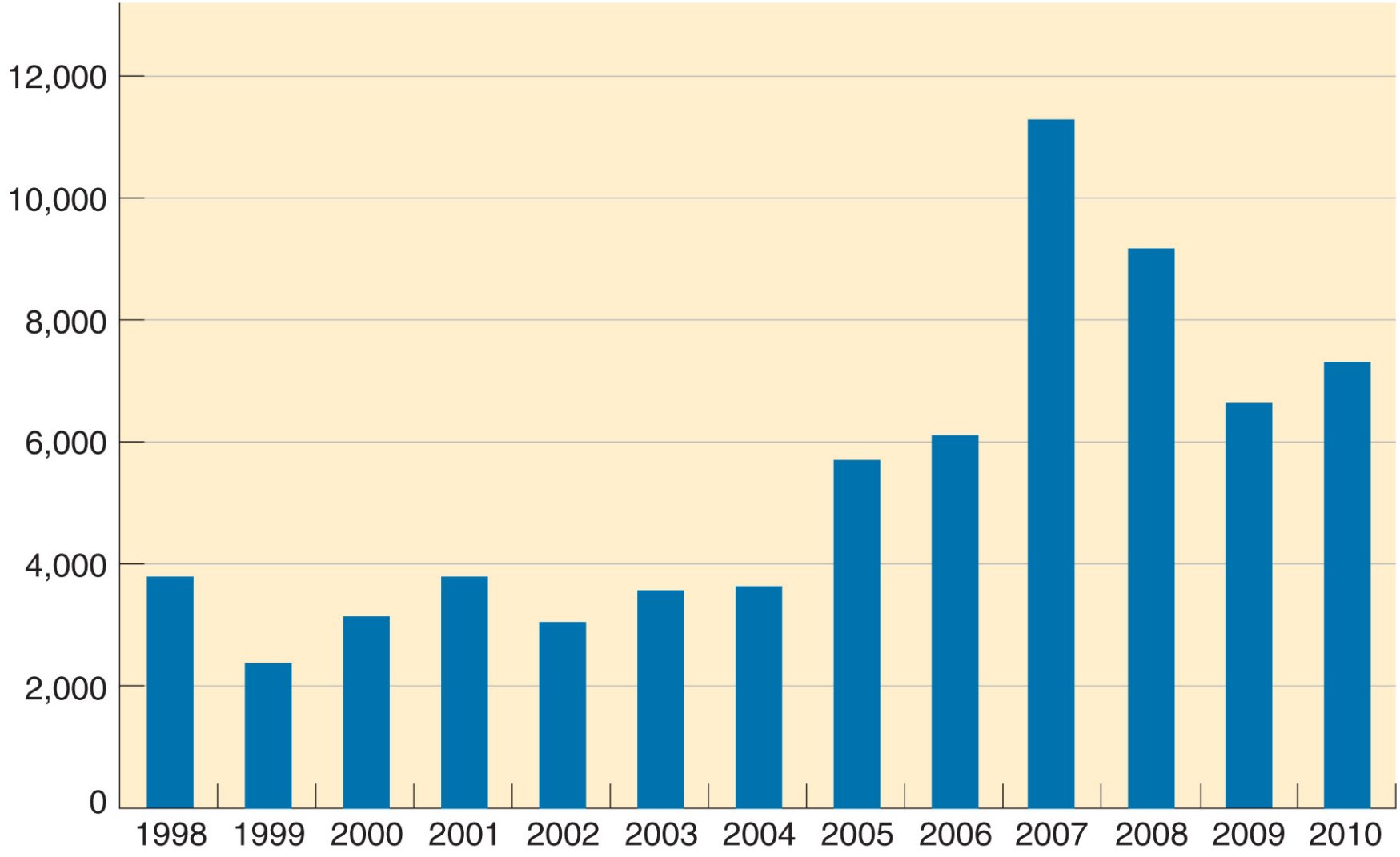


Figure 23.24 The life cycle of *Toxoplasma gondii*, the cause of toxoplasmosis.

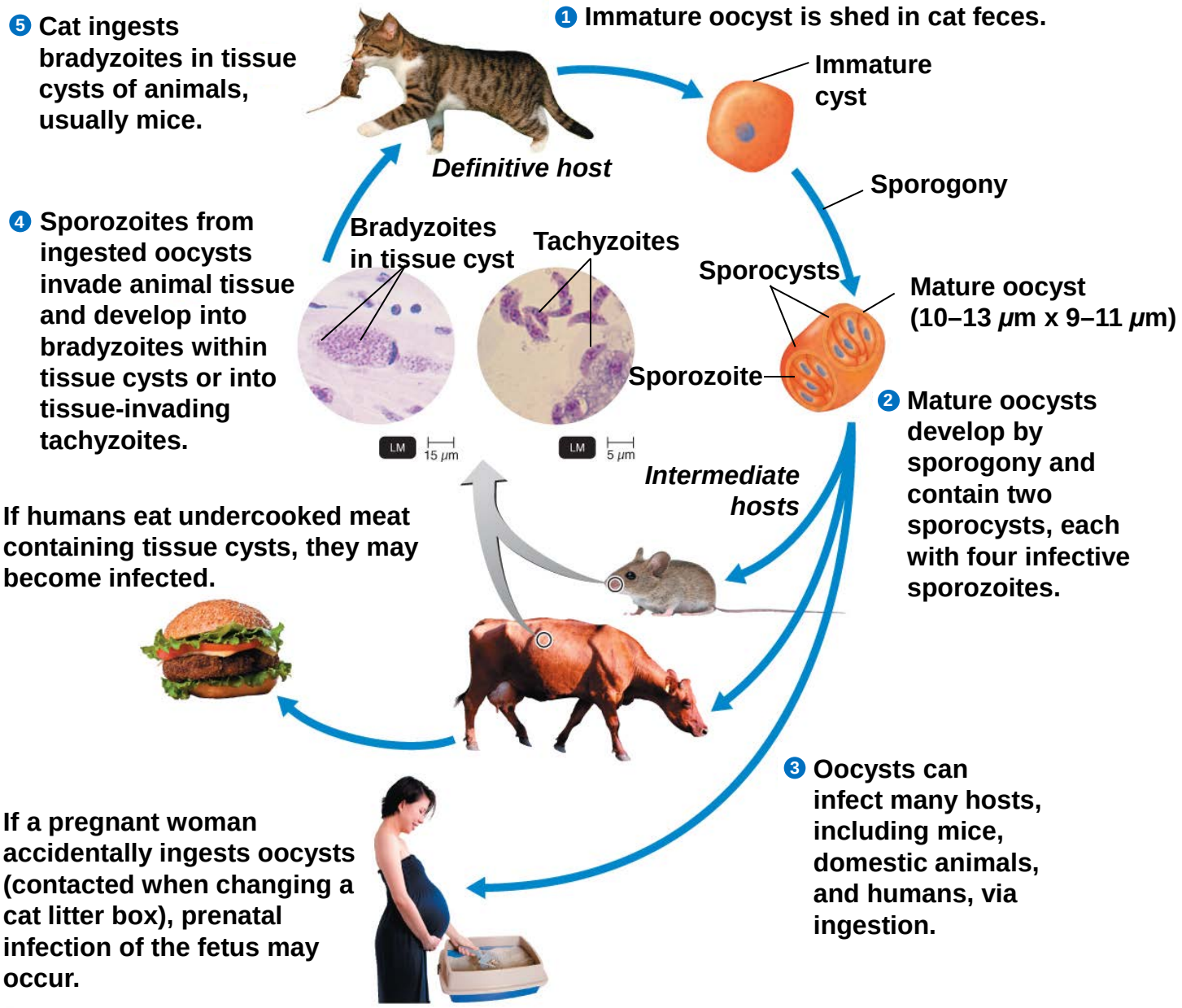


Figure 12.15 *Peridinium*, a dinoflagellate.

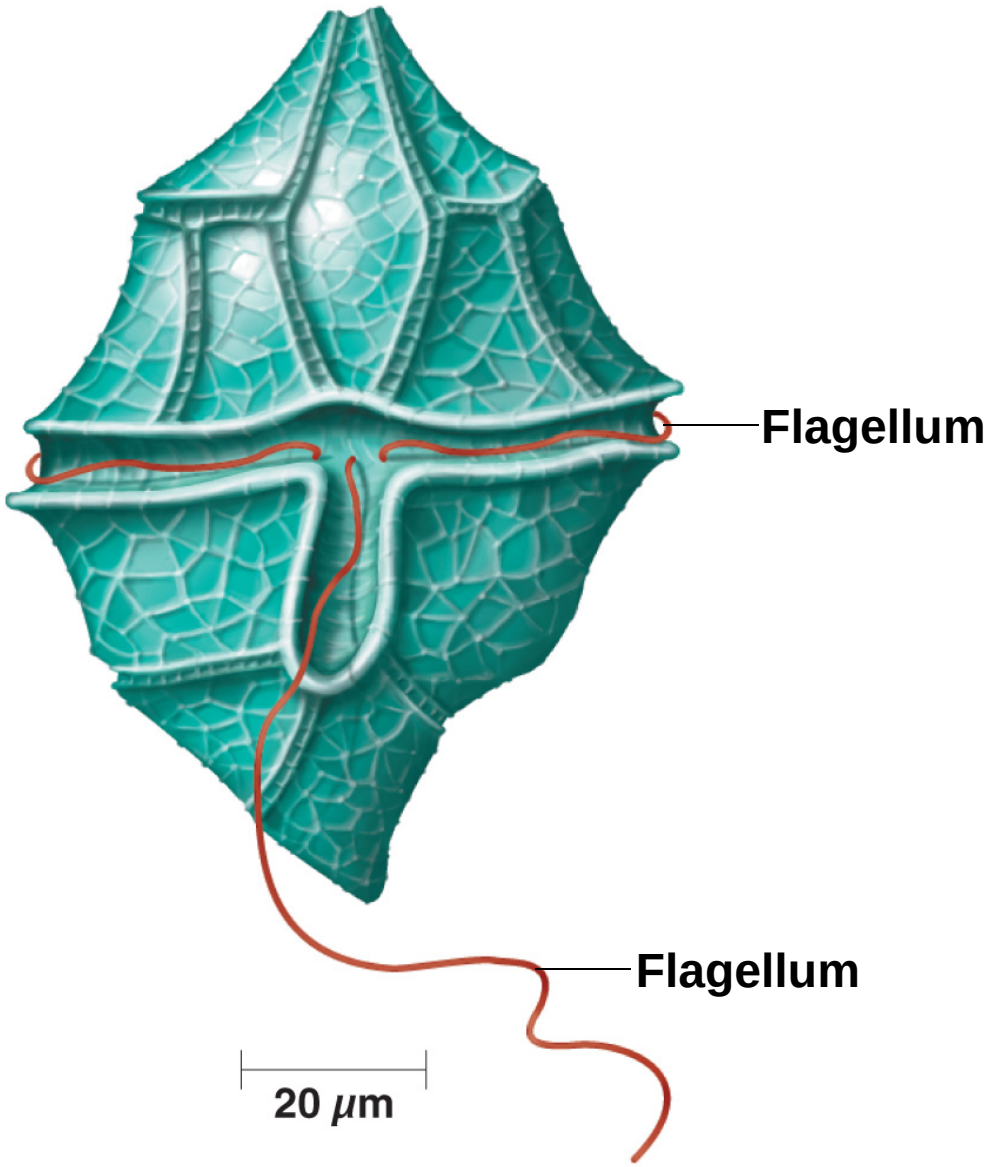
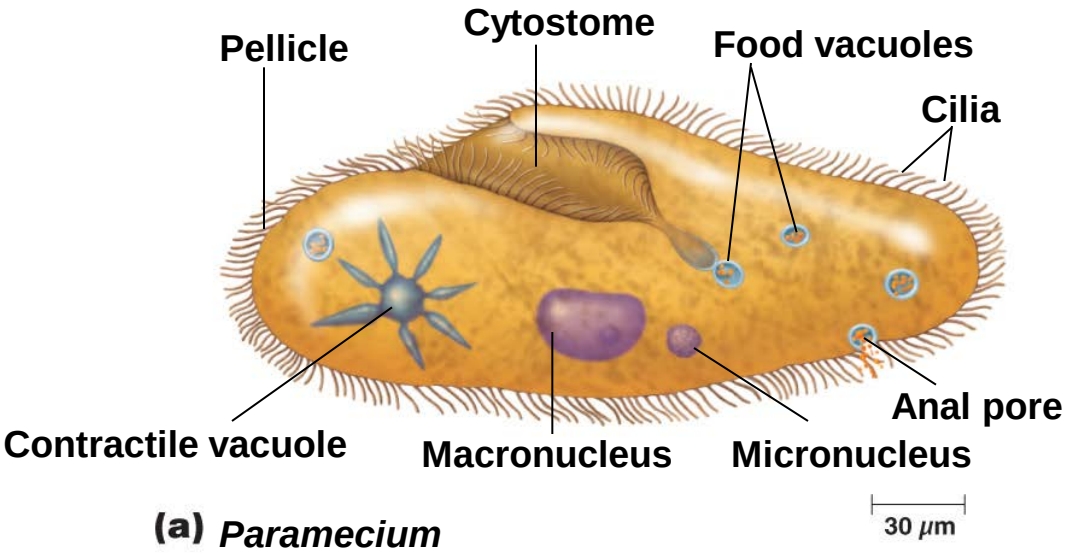


Figure 27.13 A red tide.

Ciliates

- Move by cilia
- Complex cells
- *Balantidium coli* is the only human parasite

Figure 12.21 Ciliates.



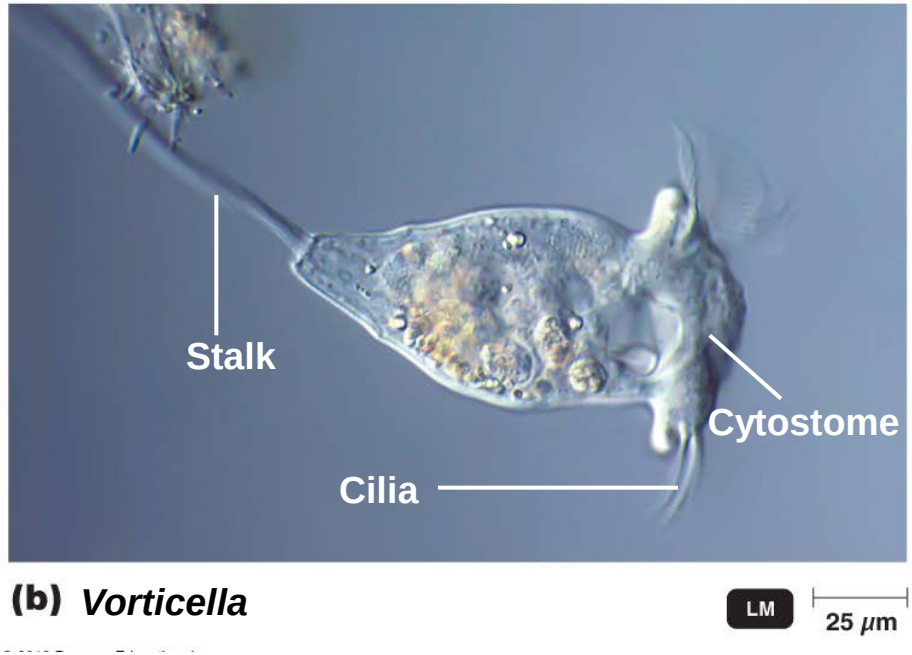
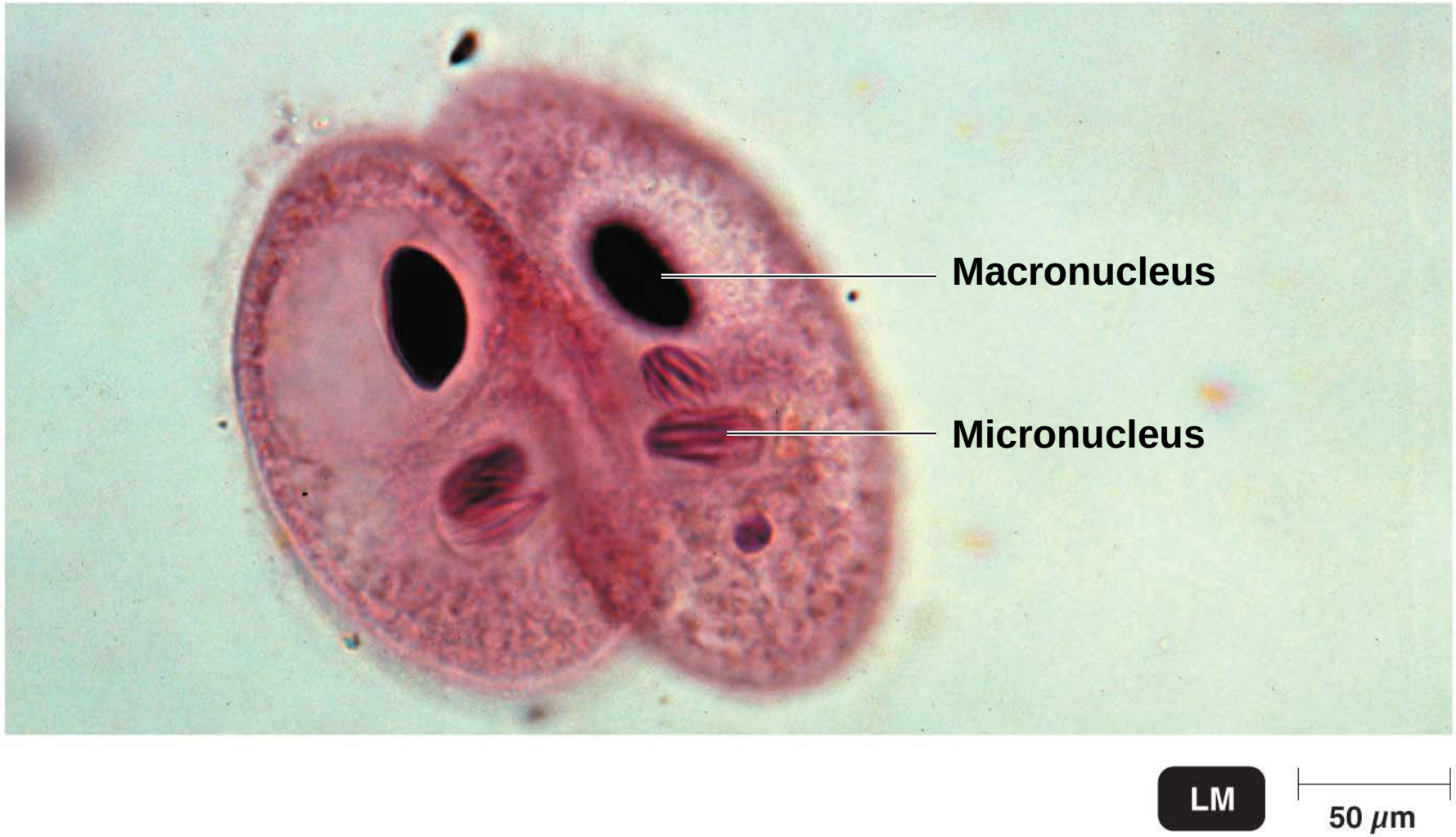


Figure 12.17 Conjugation in the ciliate protozoan *Paramecium*.



Check Your Understanding

- ✓ Identify three differences between protozoa and animals. 12-10
- ✓ Do protozoa have mitochondria? 12-11
- ✓ Where does *Plasmodium* undergo sexual reproduction? 12-12

Slime Molds

Learning Objective

12-13 Compare and contrast cellular slime molds and plasmodial slime molds.

Figure 12.22 The generalized life cycle of a cellular slime mold.

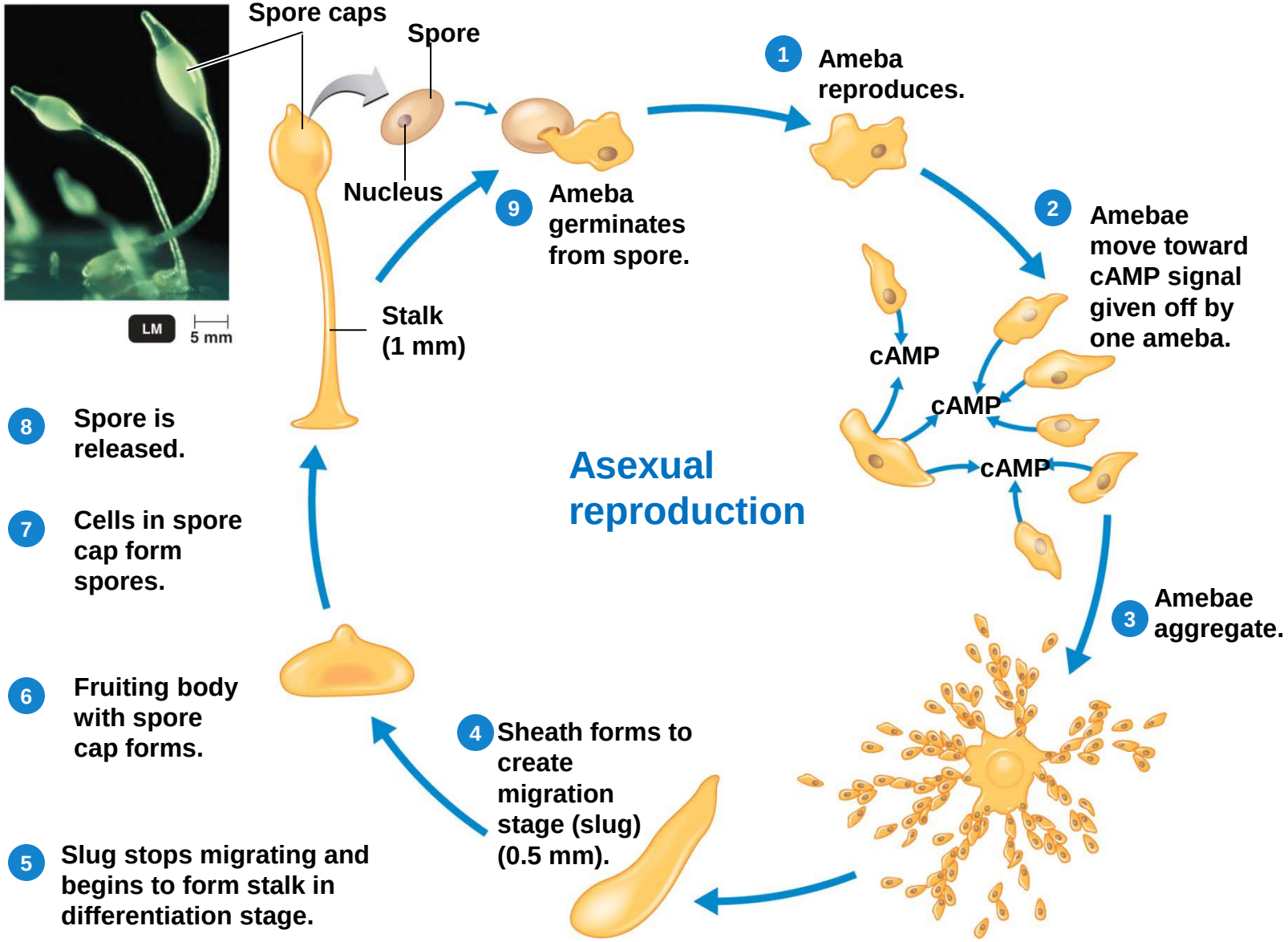
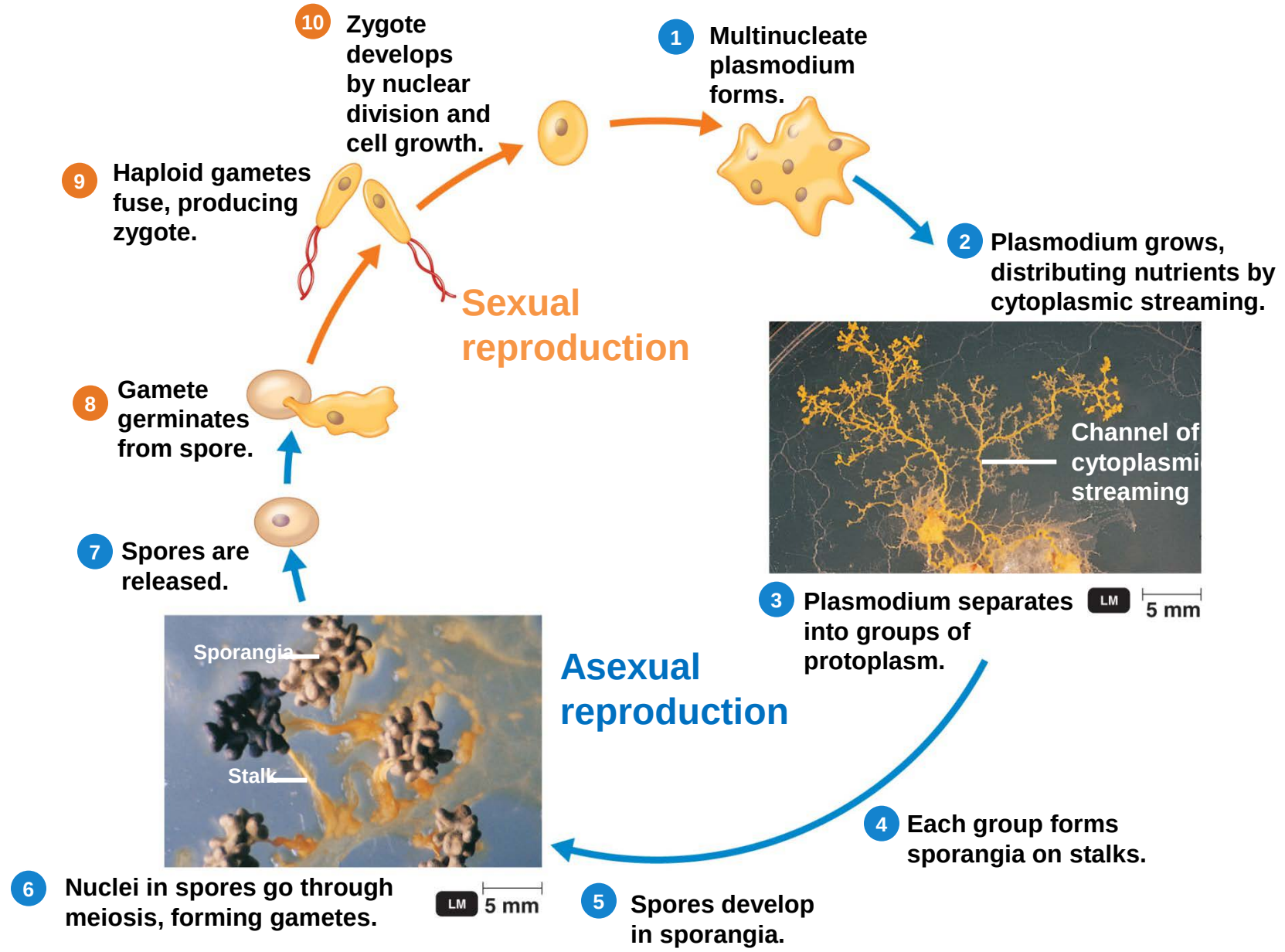


Figure 12.23 The life cycle of a plasmodial slime mold.



Check Your Understanding

- ✓ Why are slime molds classified with amebae and not fungi? 12-13

Helminths

Learning Objectives

12-14 List the distinguishing characteristics of parasitic helminths.

12-15 Provide a rationale for the elaborate life cycle of parasitic worms.

Helminths

Kingdom	Animalia
Nutritional Type	Chemoheterotroph
Multicellularity	All
Cellular Arrangement	Tissues and organs
Food Acquisition Method	Ingestive; absorptive
Characteristic Features	Elaborate life cycles

Helminths (Parasitic Worms)

- Kingdom: Animalia
  - Phylum: Platyhelminthes (flatworms)
    - Class: trematodes (flukes)
    - Class: cestodes (tapeworms)
  - Phylum: Nematoda (roundworms)

Characteristics of Helminths

- Reduced digestive system
- Reduced nervous system
- Reduced locomotion
- Complex reproduction

Life Cycle of Helminths

- **Monoecious (hermaphroditic)**
  - Male and female reproductive systems in one animal
- **Dioecious**
  - Separate male and female
- **Egg → larva(e) → adult**

Check Your Understanding

- ✓ Why are the drugs used to treat parasitic helminths often toxic to the host? 12-14
- ✓ Of what value is the complicated life cycle of parasitic helminths? 12-15

Helminths

Learning Objectives

12-16 List the characteristics of the two classes of parasitic platyhelminths, and give an example of each.

12-17 Describe a parasitic infection in which humans serve as a definitive host, as an intermediate host, and as both.

12-18 List the characteristics of parasitic nematodes, and give an example of infective eggs and infective larvae.

12-19 Compare and contrast platyhelminths and nematodes.

Figure 12.25 Flukes.

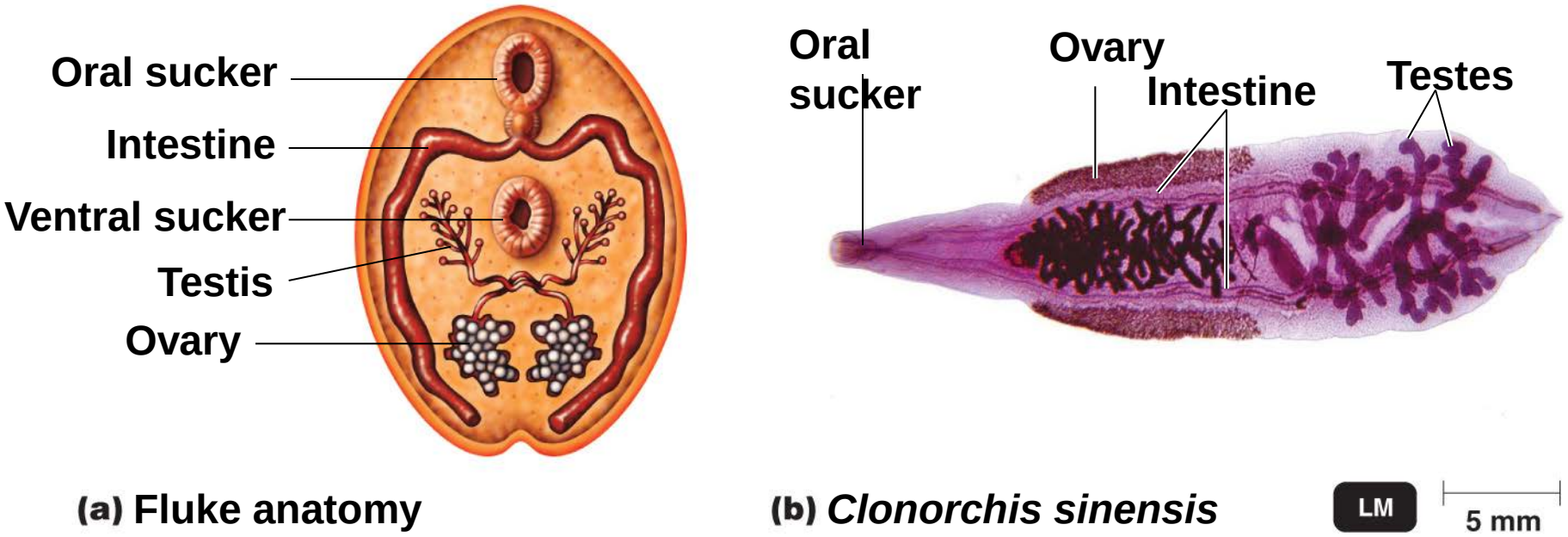
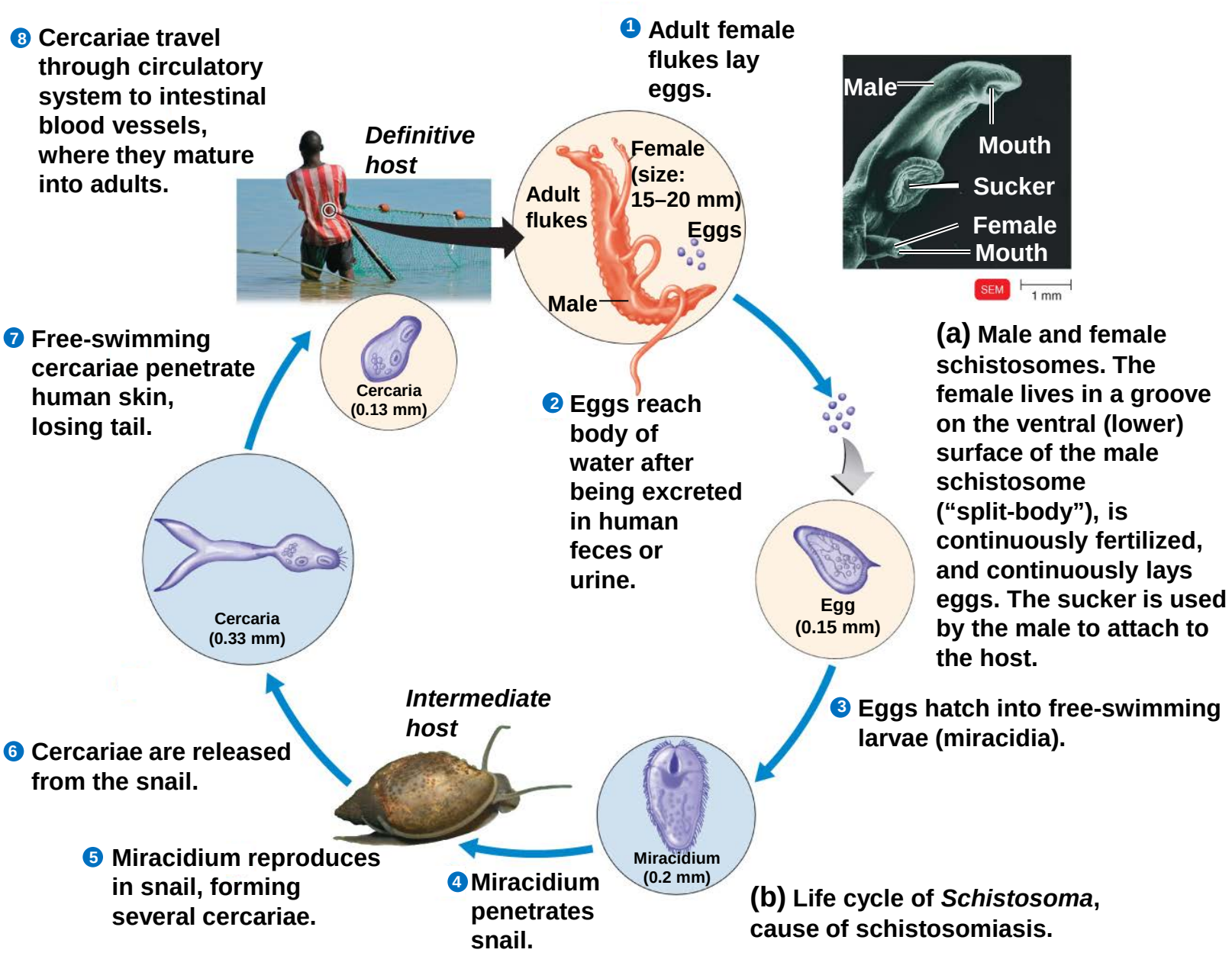


Figure 23.28 Schistosomiasis.



(a) Male and female schistosomes. The female lives in a groove on the ventral (lower) surface of the male schistosome ("split-body"), is continuously fertilized, and continuously lays eggs. The sucker is used by the male to attach to the host.

(b) Life cycle of *Schistosoma*, cause of schistosomiasis.

Figure 12.26 The life cycle of the lung fluke, *Paragonimus*, spp.

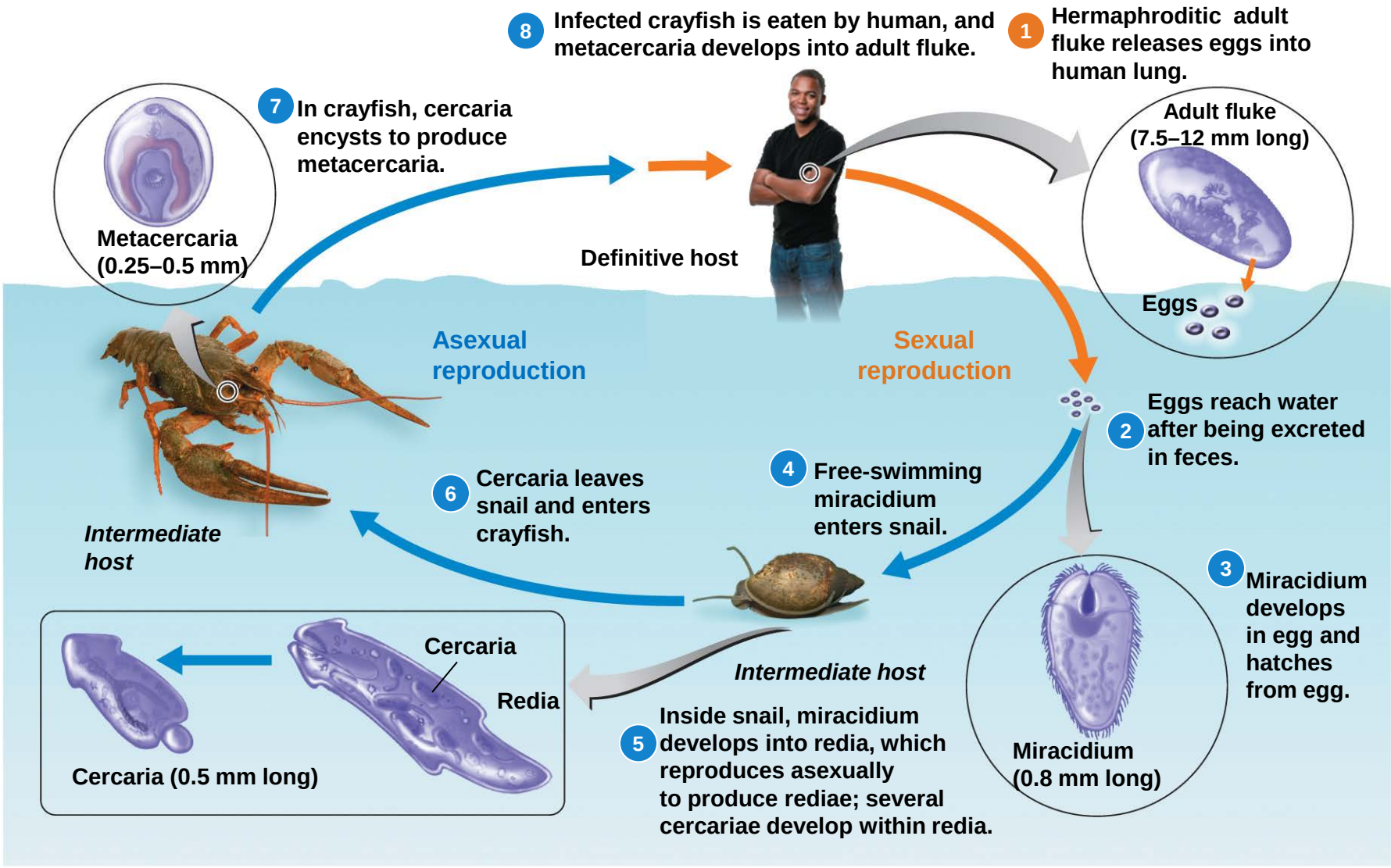
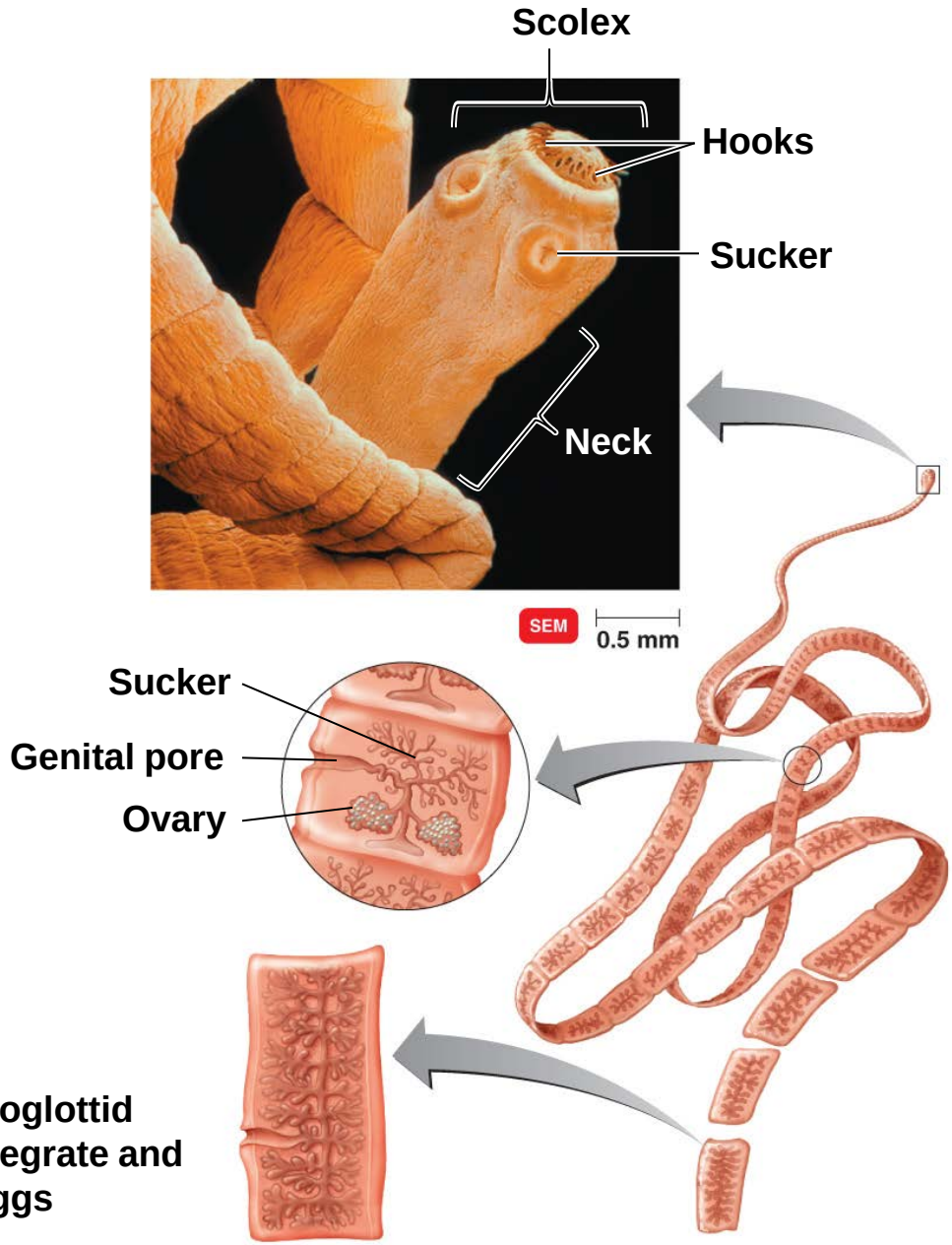


Figure 12.27 General anatomy of an adult tapeworm.



Humans as Definitive Hosts

Definitive Host	*Taenia saginata*	Cysticerci in beef muscle
Intermediate Host	*Echinococcus granulosus*	Adult in dog

Figure 12.28 The life cycle of the tapeworm, *Echinococcus*, spp.

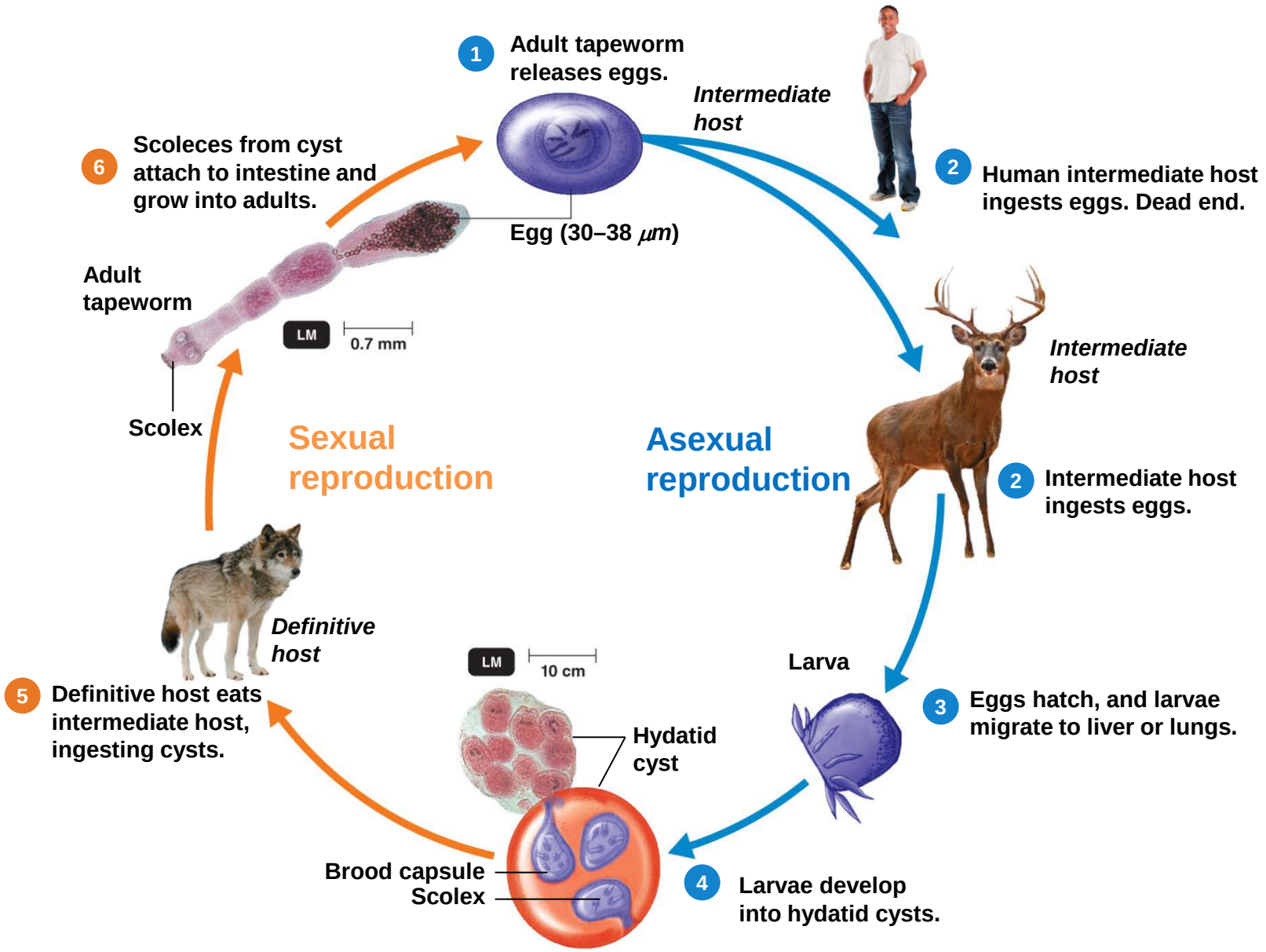


Figure 12.29a The pinworm *Enterobius vermicularis*.

(a) Adult pinworm

Figure 12.30 The heartworm *Dirofilaria immitis*.

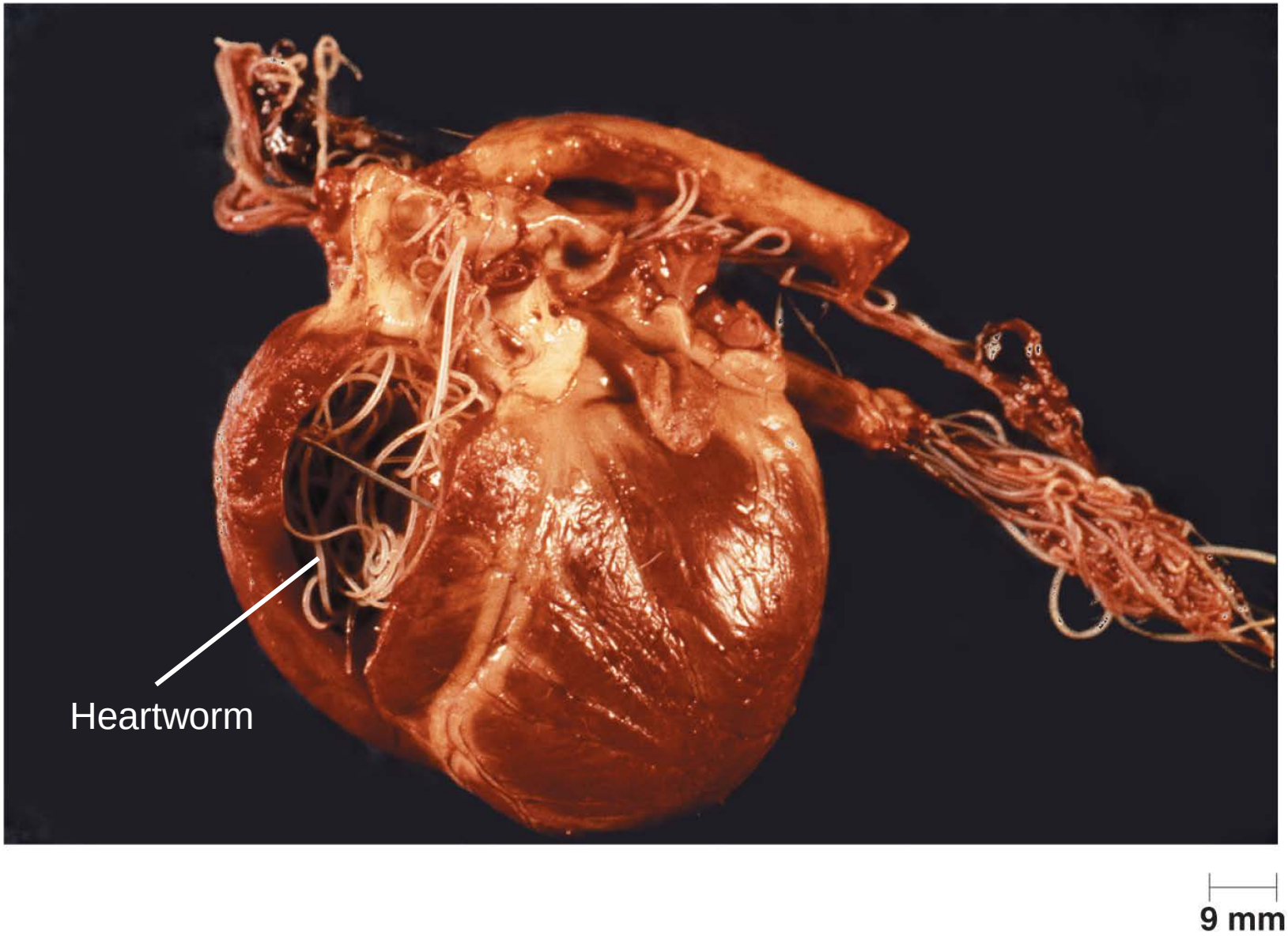


Figure 12.29 The pinworm *Enterobius vermicularis*.

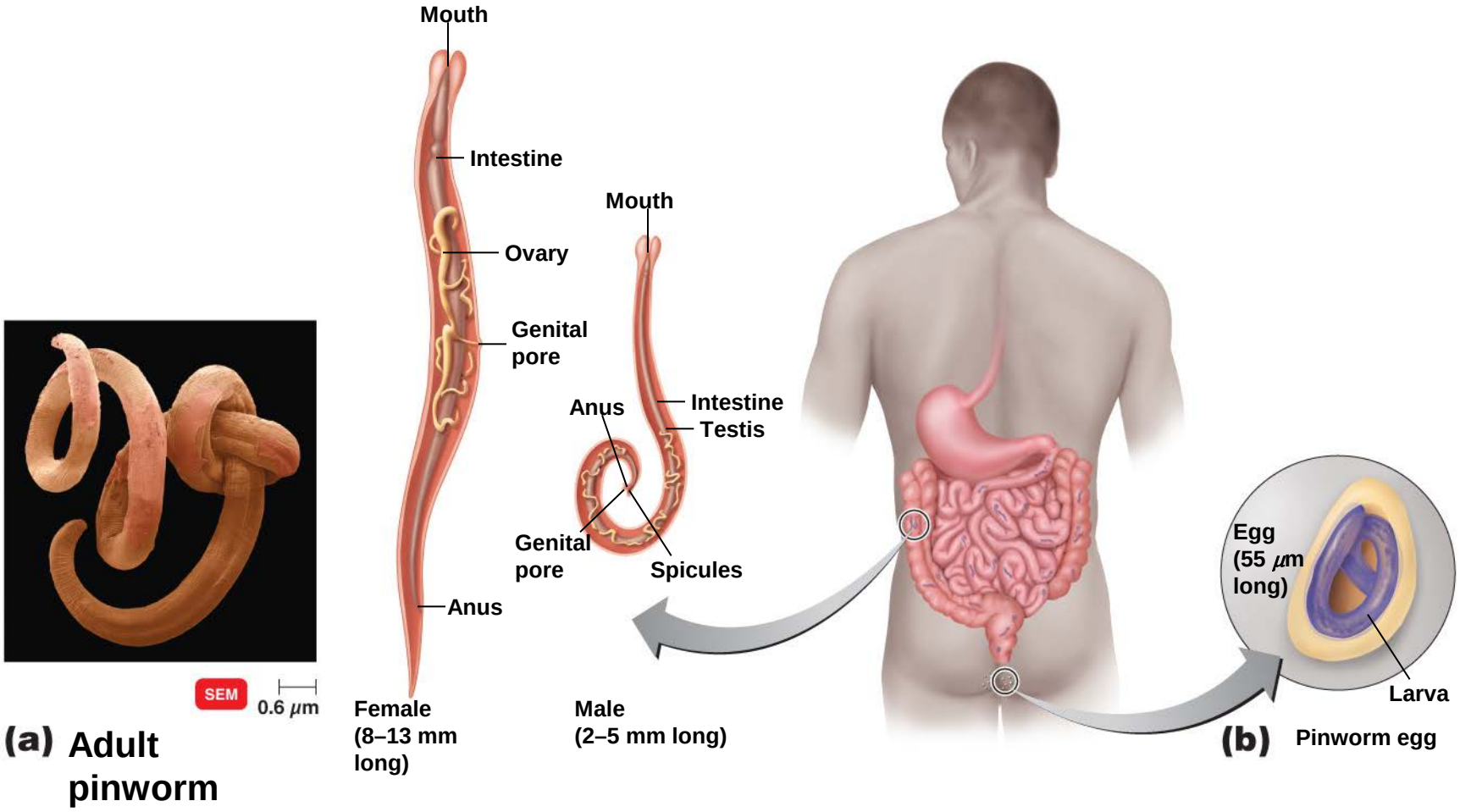


Figure 25.26 The life cycle of *Trichinella spiralis*, the causative agent of trichinellosis.

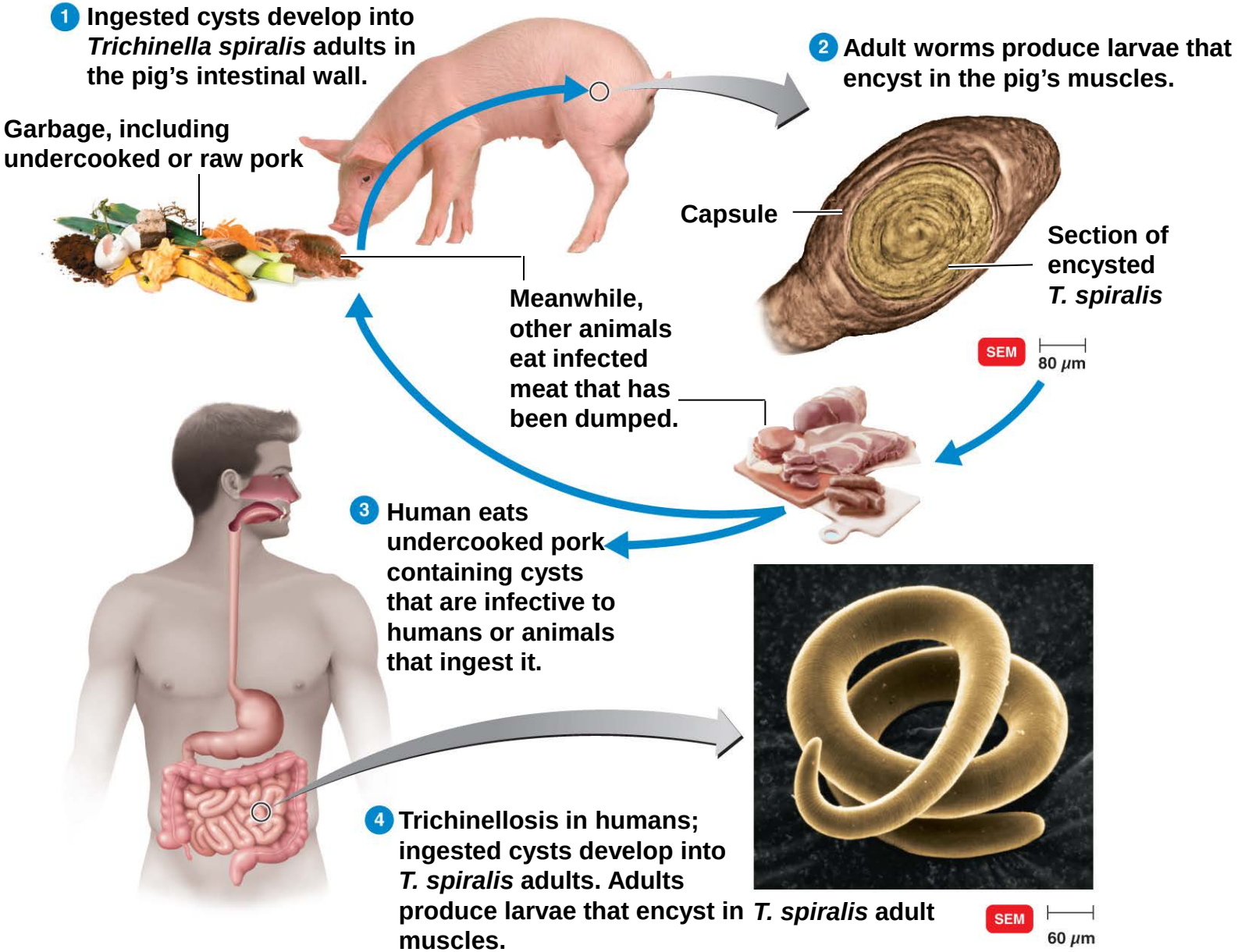


Figure 25.23 An *Ancylostoma* hookworm attached to intestinal mucosa.

Check Your Understanding

- ✓ Differentiate *Paragonimus* and *Taenia*. 12-16
- ✓ What is the definitive host for *Enterobius*? 12-17
- ✓ What stage of *Dirofilaria immitis* is infectious for dogs and cats? 12-18
- ✓ You find a parasitic worm in a baby's diapers. How would you know whether it's a *Taenia* or a *Necator*? 12-19

Arthropods as Vectors

Learning Objectives

12-20 Define *arthropod vector*.

12-21 Differentiate a tick from a mosquito, and name a disease transmitted by each.

Arthropods as Vectors

- May transmit diseases (**vectors**)
- Kingdom: Animalia
  - Phylum: Arthropoda (exoskeleton, jointed legs)
    - Class: Insecta (6 legs)
      - Lice, fleas, mosquitoes
    - Class: Arachnida (8 legs)
      - Mites and ticks

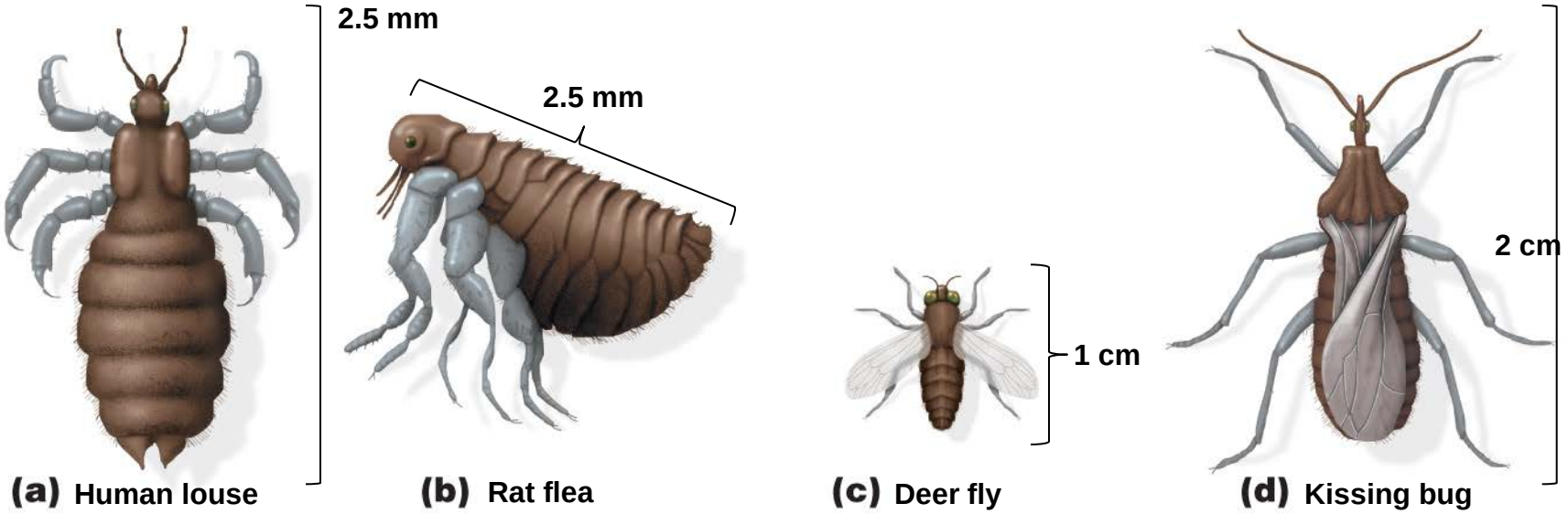
Arthropods as Vectors

- Mechanical transmission
- Biological transmission
  - Microbe multiplies in vector
- Definitive host
  - Microbe’s sexual reproduction takes place in vector

Figure 12.31 Mosquito.

Figure 12.32 Tick.

Figure 12.33 Arthropod vectors.



Check Your Understanding

- ✓ Vectors can be divided into three major types, according to roles they play for the parasite. List the three types and a disease transmitted by each. 12-20
- ✓ Assume you see an arthropod on your arm. How will you determine whether it is a tick or a flea? 12-21