



PowerPoint® Lecture Slides for

MICROBIOLOGY

ROBERT W. BAUMAN

Chapter 12

Characterizing and Classifying Eukaryotes

Eukaryotes

- Major groups
 - Protozoa
 - _____
 - Algae
 - Slime Molds (& water molds)
 - Helminthes
- Include both human pathogens and organisms vital for human life

Reproduction in Eukaryotes

- More complicated than that in prokaryotes
 - Why?
 - More DNA –
 - Eukaryotic DNA packaged with histones as chromosomes in the nucleus
 - Nuclear _____

Nuclear Division

- Nucleus has one or two complete copies of genome
 - Two types
 - Mitosis – division into two equal nuclei
 - (1) $2N \rightarrow (2) 2N$
 - _____ – nuclear division in which chromatids are separated
 - (1) $2N \rightarrow (4) 1N$

Nuclear Division

- Mitosis

- Prophase
- Metaphase
- Anaphase
- Telophase

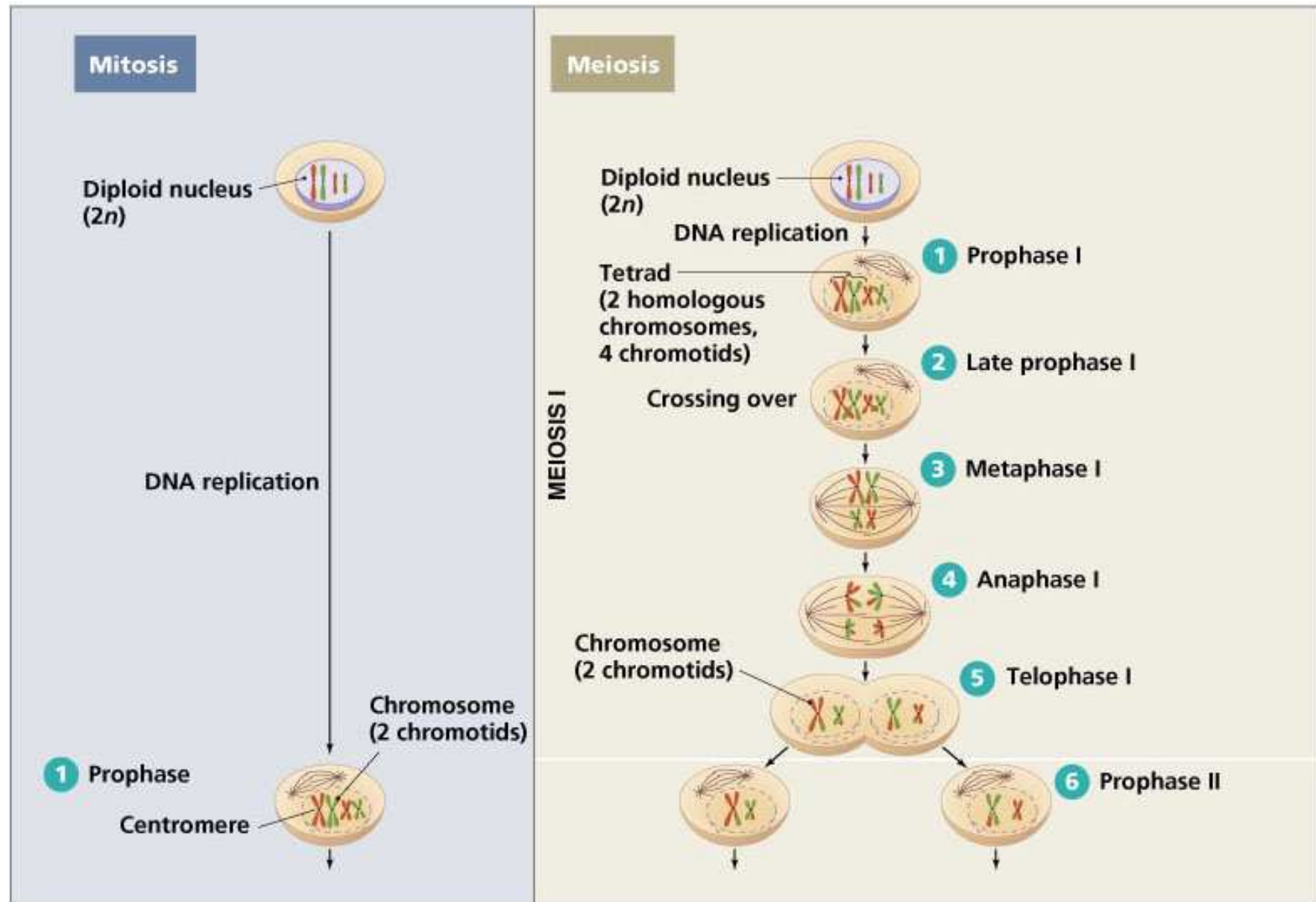
- Meiosis I

- Prophase I
- Metaphase I
- Anaphase I
- Telophase I

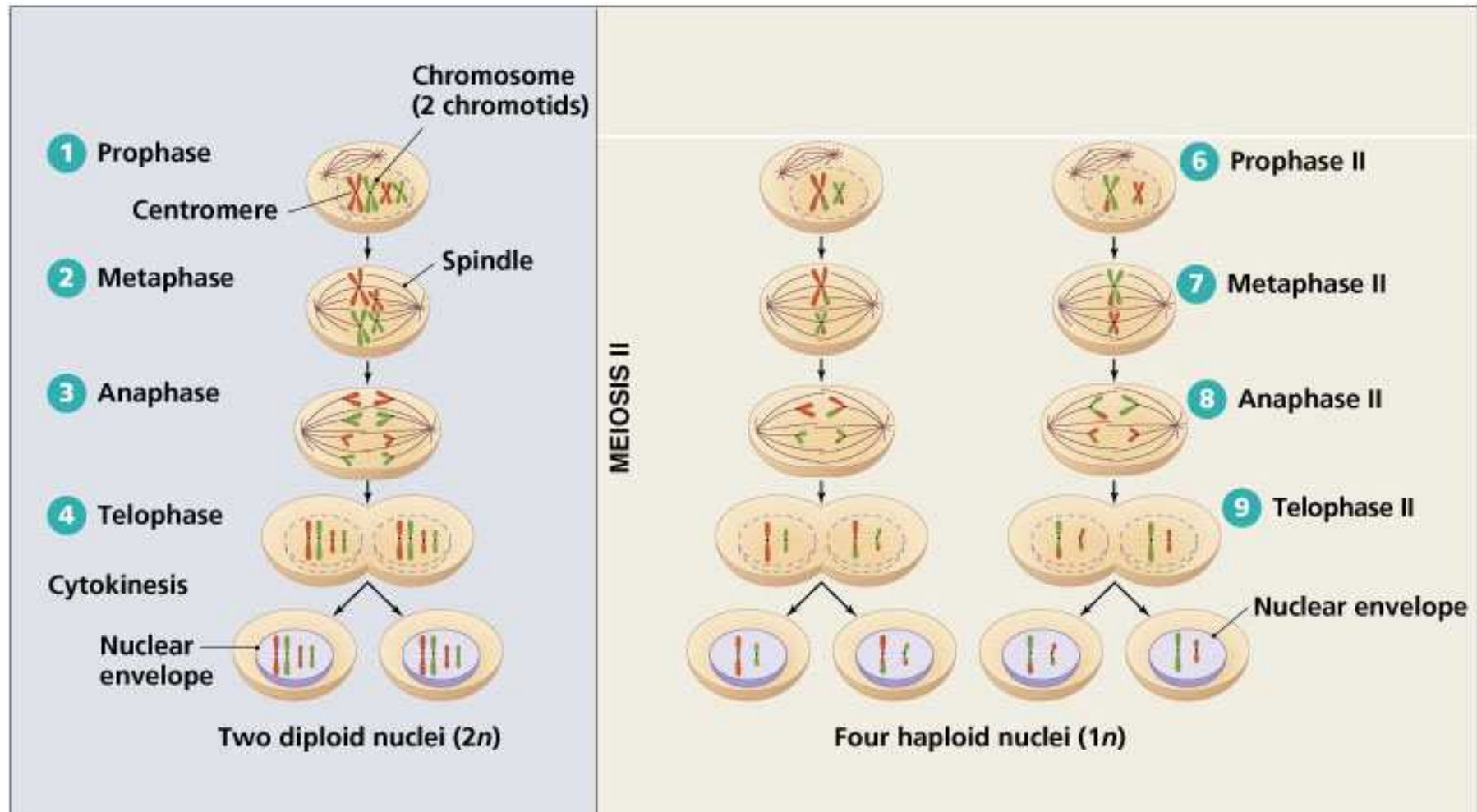
- Meiosis II

- Prophase II
- Metaphase II
- Anaphase II
- Telophase II

Nuclear Division

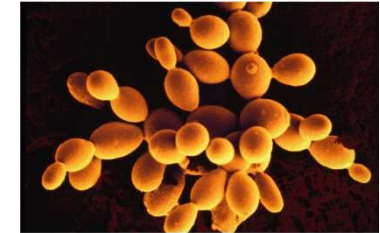


Nuclear Division

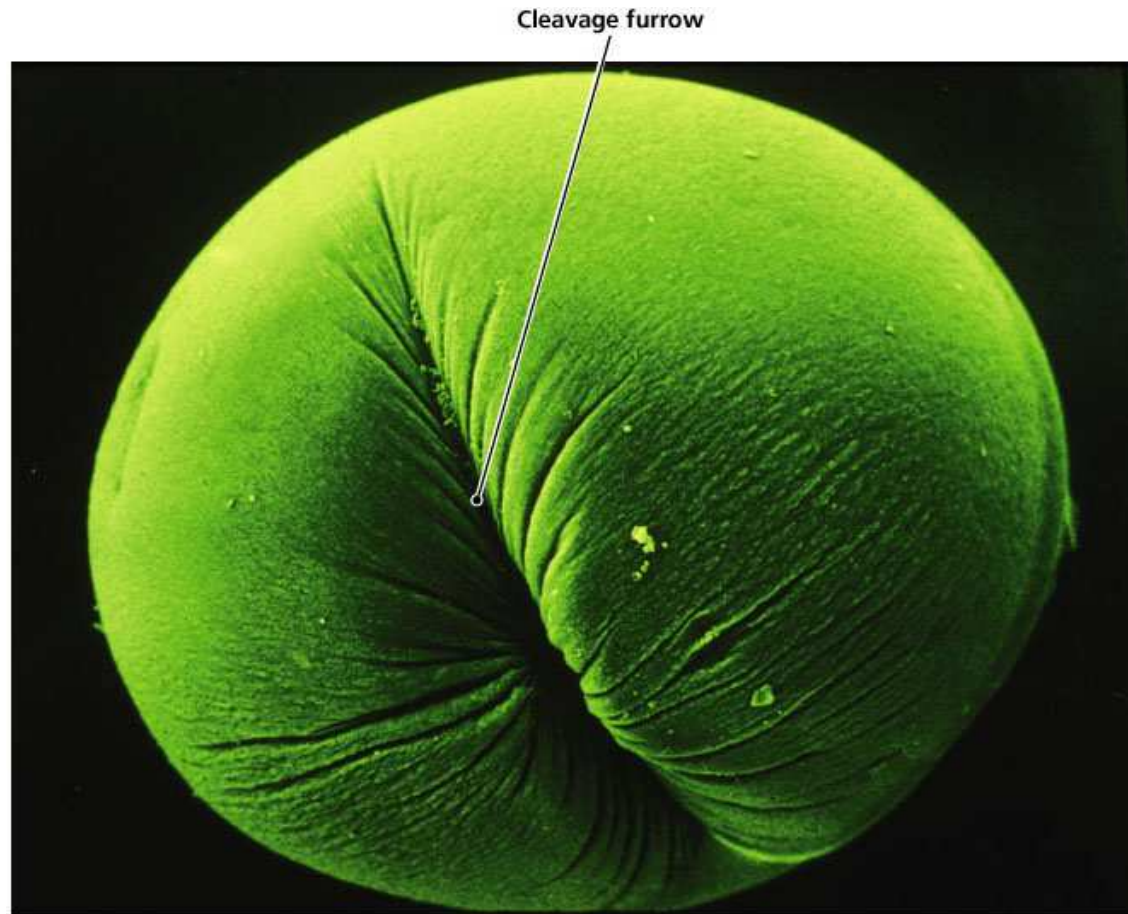


Cytokinesis (Cytoplasmic Division)

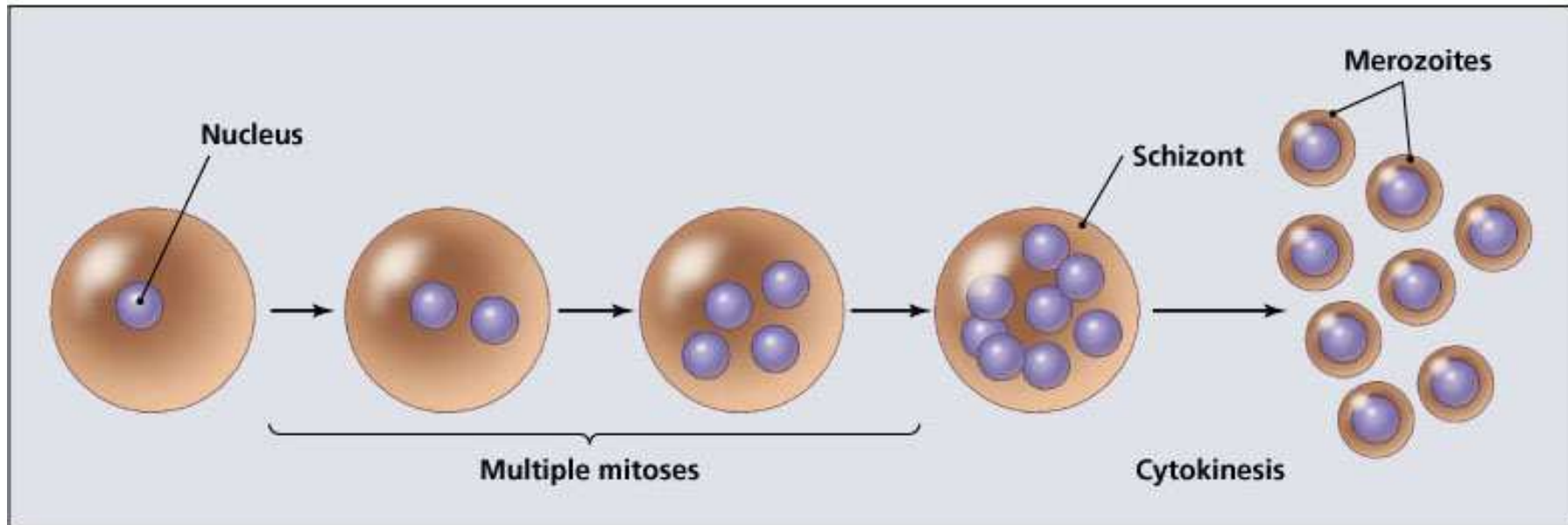
- Typically occurs simultaneously with _____ of mitosis



- _____ in some algae and fungi,
 - Results in coenocytes



Schizogony



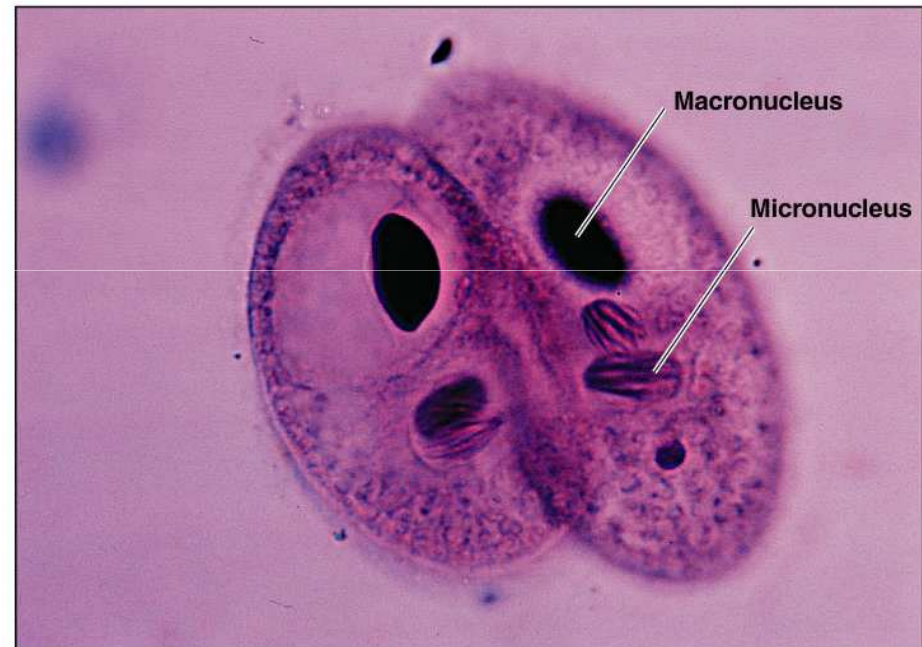
Protozoa

- Eukaryotic
- Unicellular
- Lack cell walls
- _____
- Usually _____
 - How?
- Nutrition
 - Chemoheterotrophs - most
 - _____ - a few



Protozoa

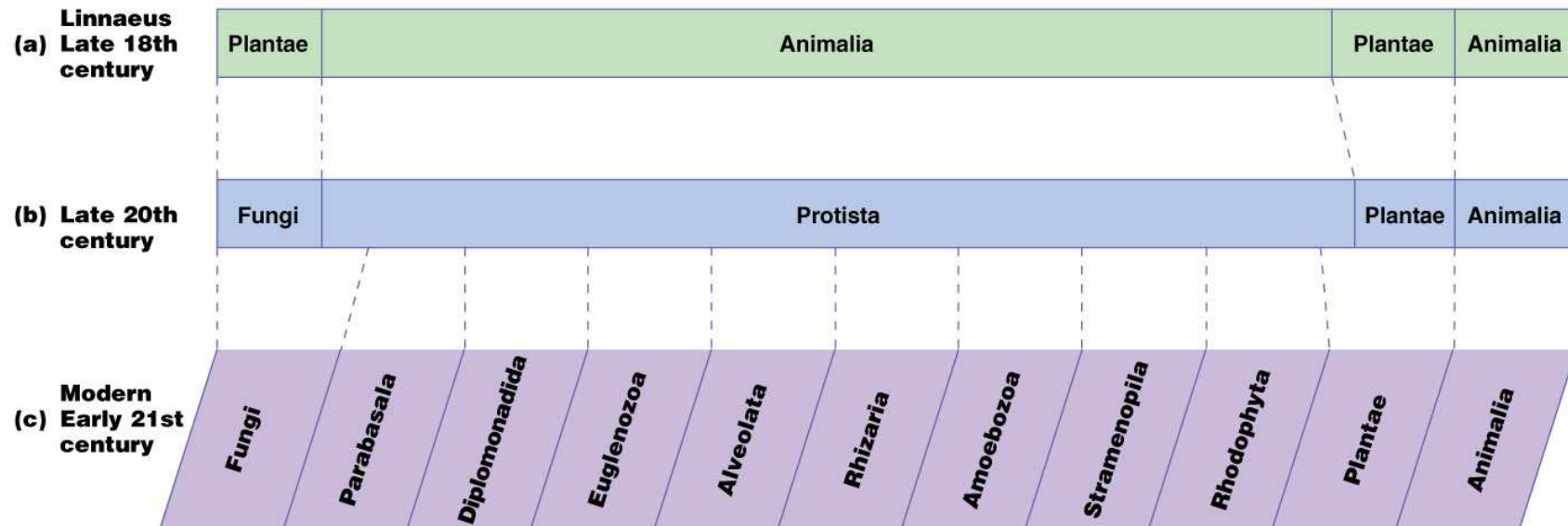
- Vegetative form
 - trophozoite
- Asexual reproduction
 - fission
 - _____
 - or schizogony
- Sexual reproduction
 - conjugation
- Some produce cysts



Distribution of Protozoa

- Require moist environments
- Most live worldwide
 - in ponds, streams, lakes, and oceans
 - part of the plankton
- Very few are pathogens

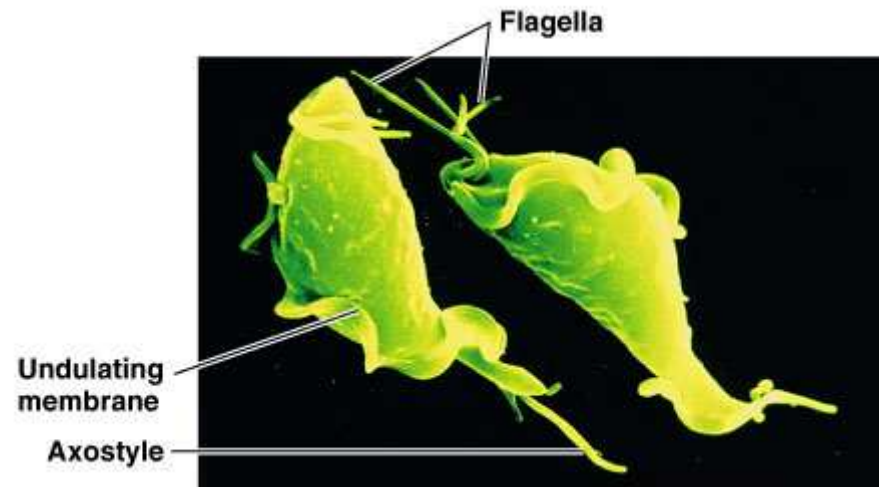
Changes in Classification



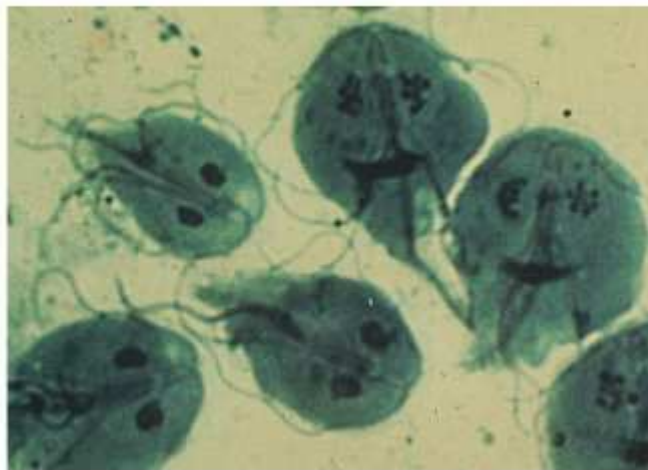
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Archaezoa

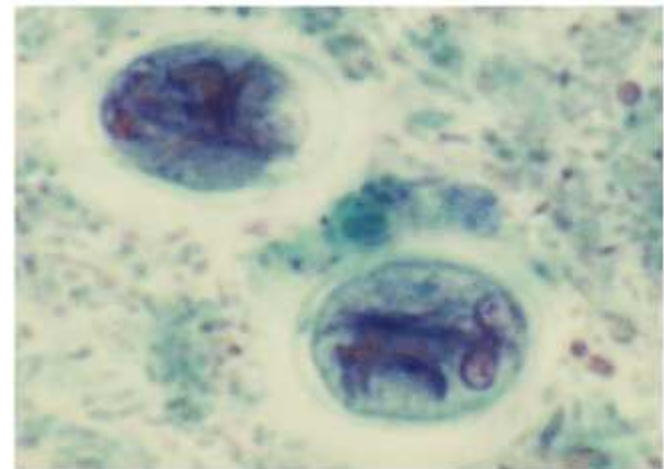
- No mitochondria
- Multiple flagella
- *Giardia lamblia*
- *Trichomonas vaginalis* (no cyst stage)



(b) *Trichomonas vaginalis*



(c) *Giardi lamblia*

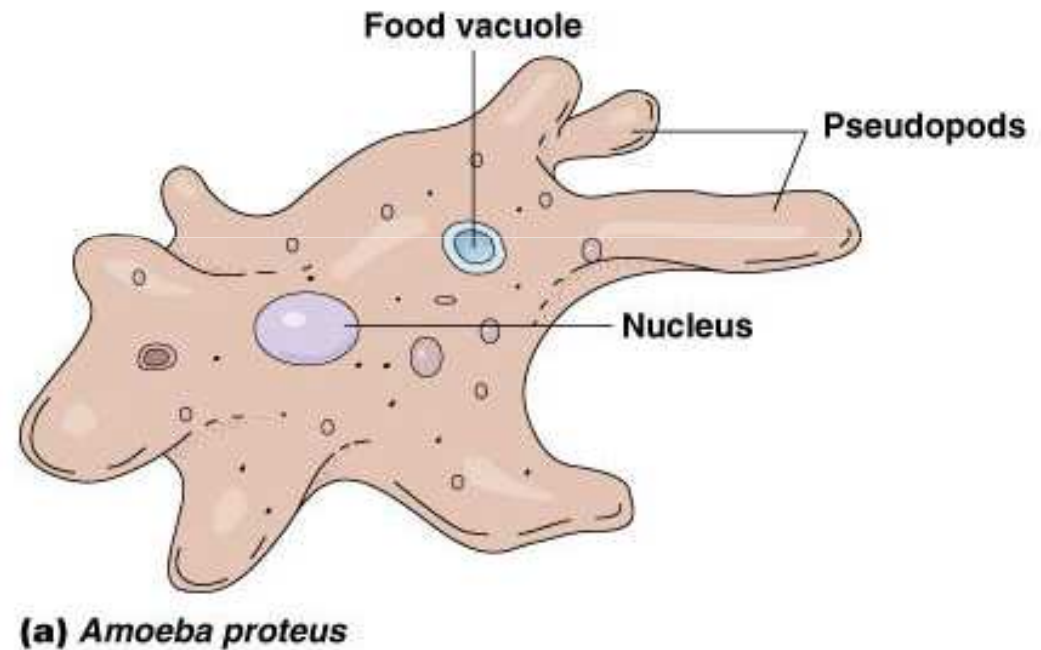


(d) *Giardialambli*a cyst

Rhizopoda (amoebas)

- Move by

- *Entamoeba*
- *Acanthamoeba*



No jpeg for Figure 21.21

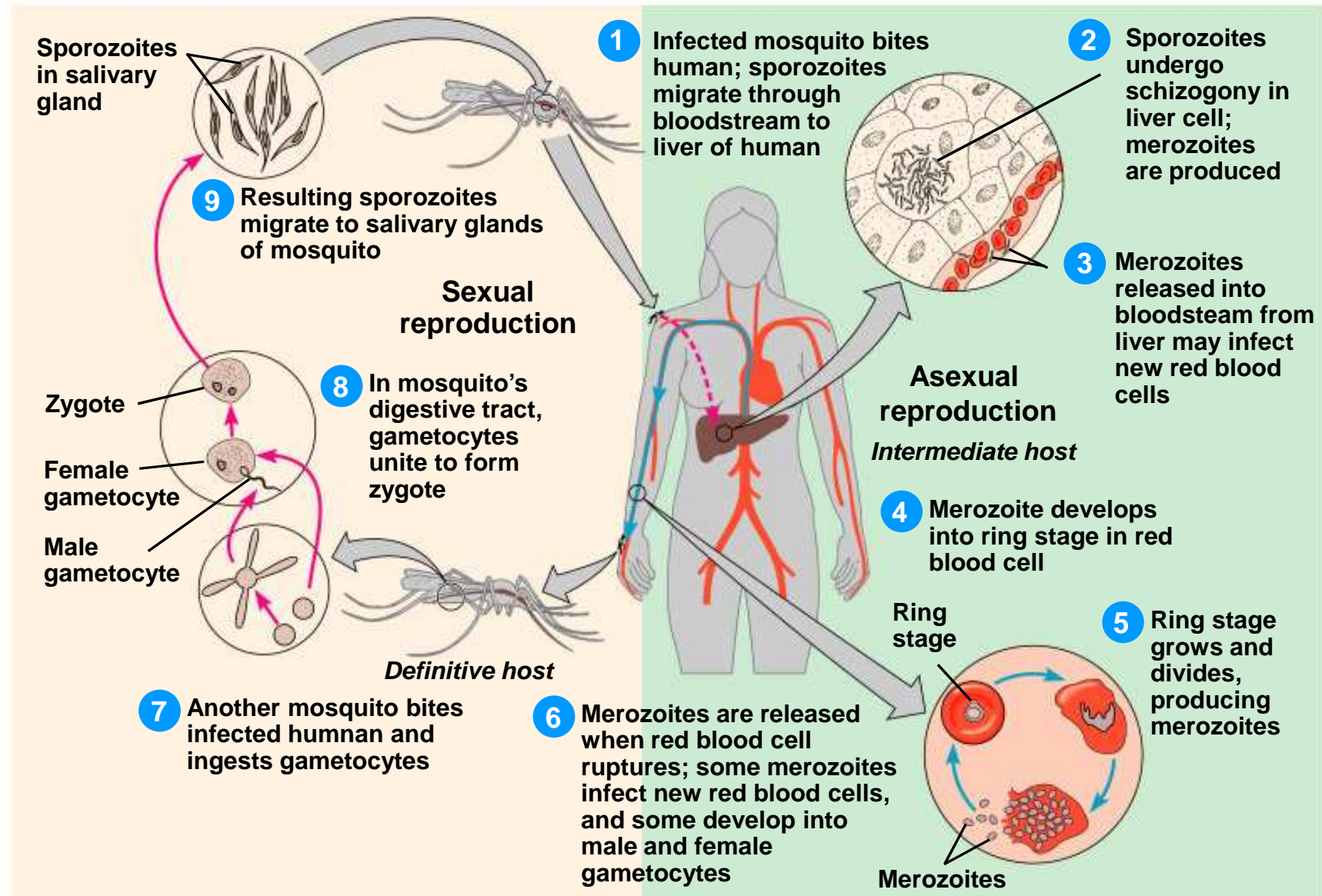
Figure 12.18a

Apicomplexa

- Nonmotile
- _____
- Complex _____
- *Plasmodium*
- *Babesia*
- *Cryptosporidium* →
- *Cyclospora*

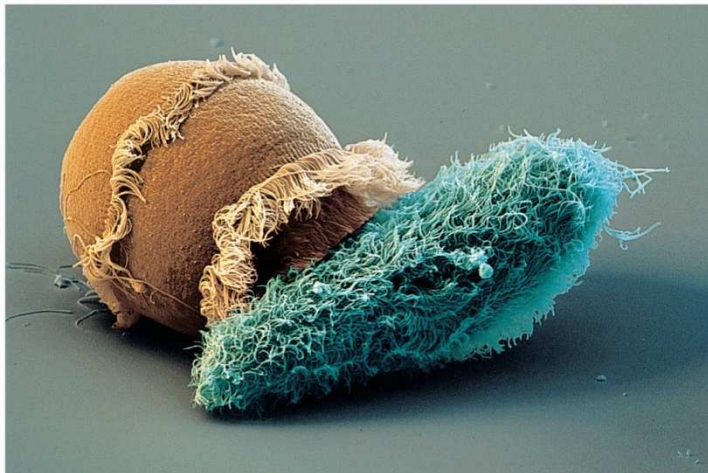


Plasmodium



Ciliophora (ciliates)

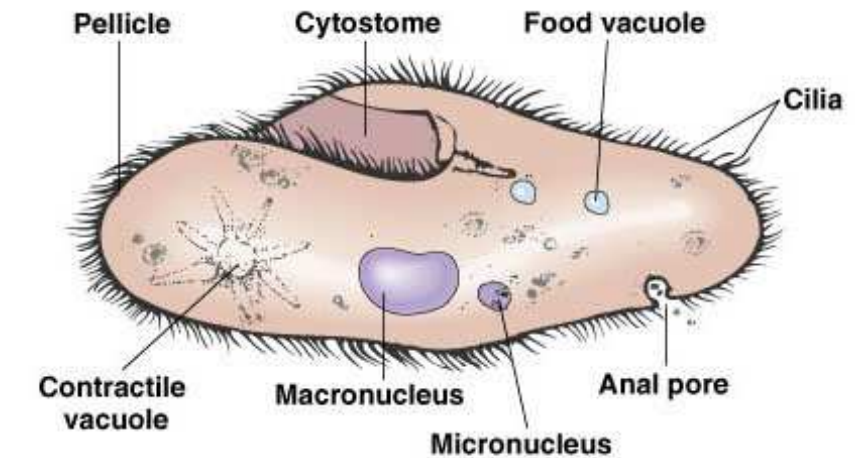
- Move by _____
- Complex cells
- *Paramecium*
- *Balantidium coli* is the only human parasite



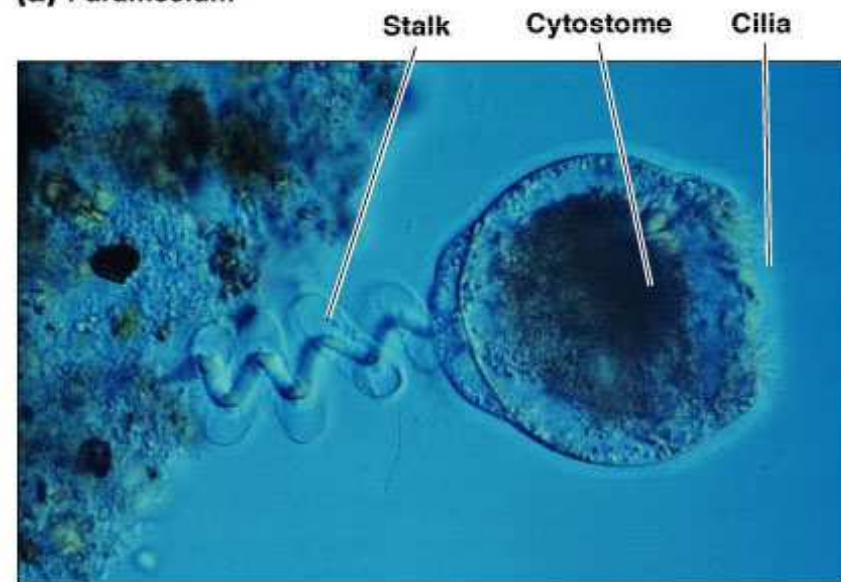
SEM 25 µm

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(a) *Paramecium*



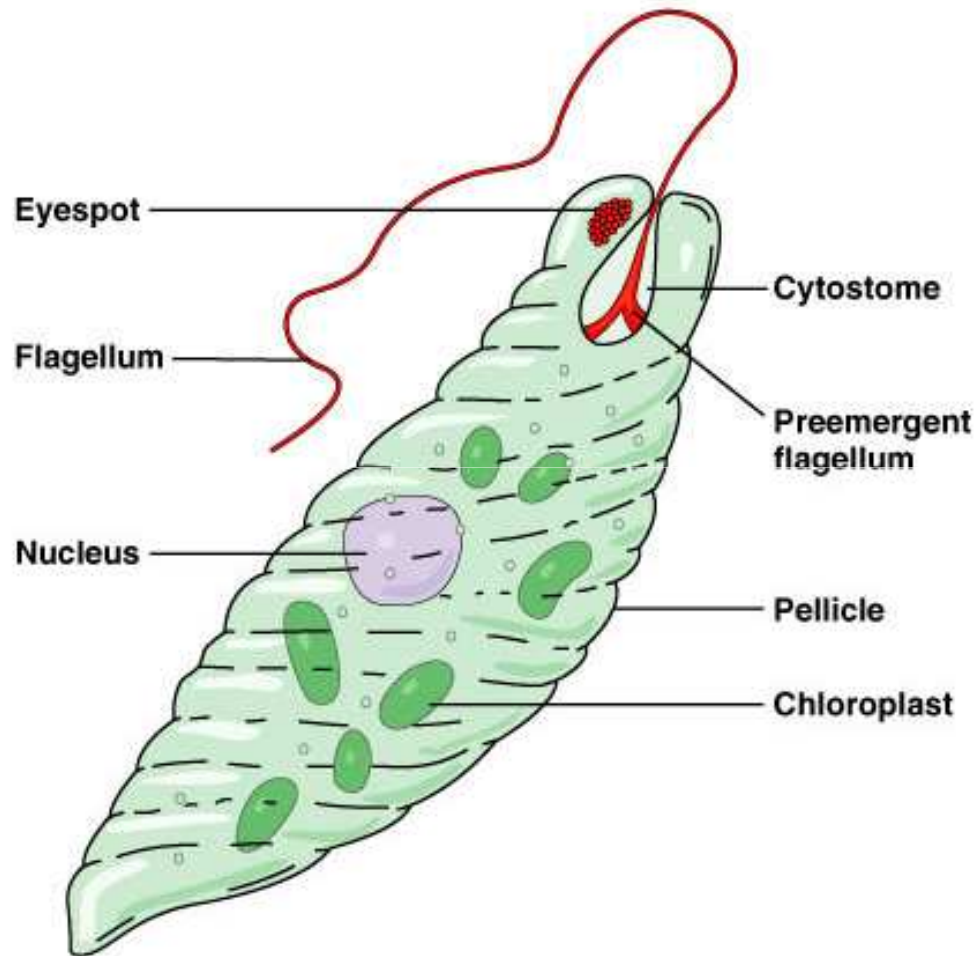
(b) *Vorticella*

Figure 12.20

Euglenozoa

- Move by _____
- Photoautotrophs - *Euglenoids*
- Chemoheterotrophs
 - *Naegleria*
 - Flagellated and amoeboid forms, meningoencephalitis
 - *Trypanosoma*
 - *Leishmania*

Euglenozoa



Dinoflagellata

- 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

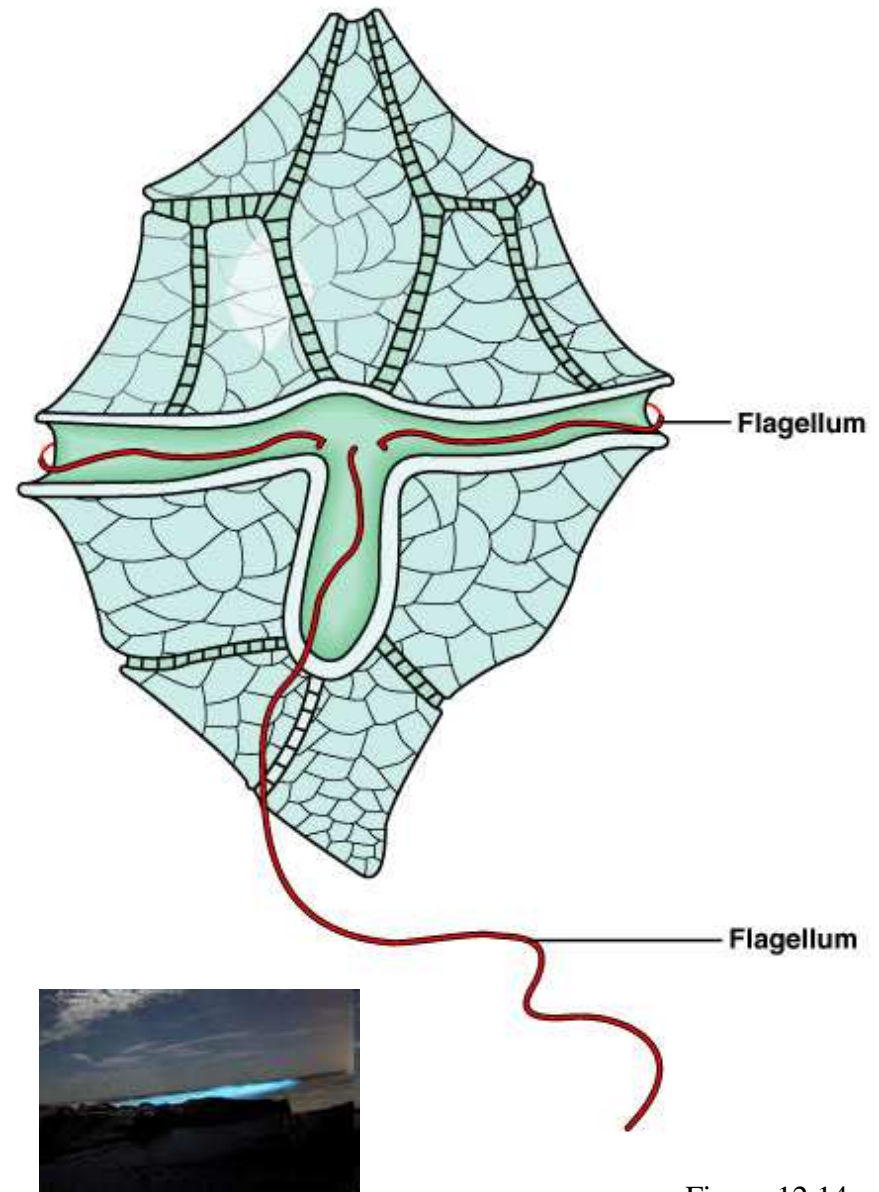
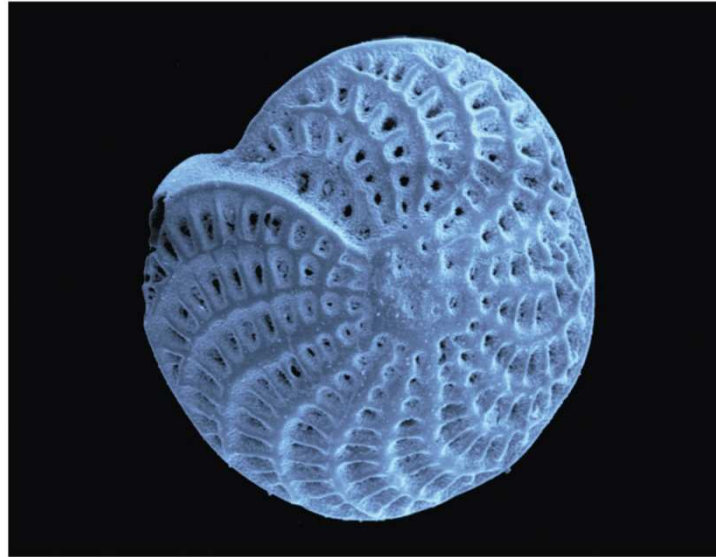


Figure 12.14

Other protozoans

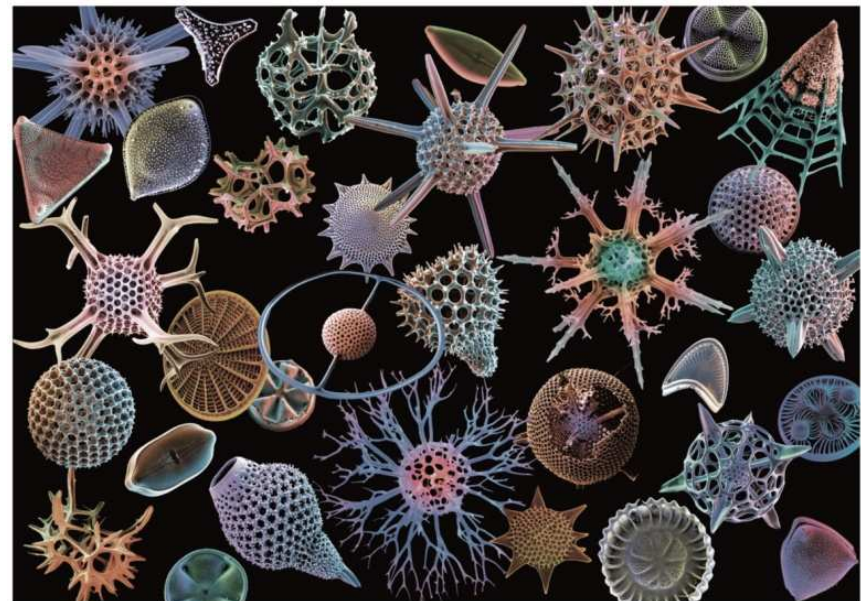


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Foraminifera

SEM 0.25 mm

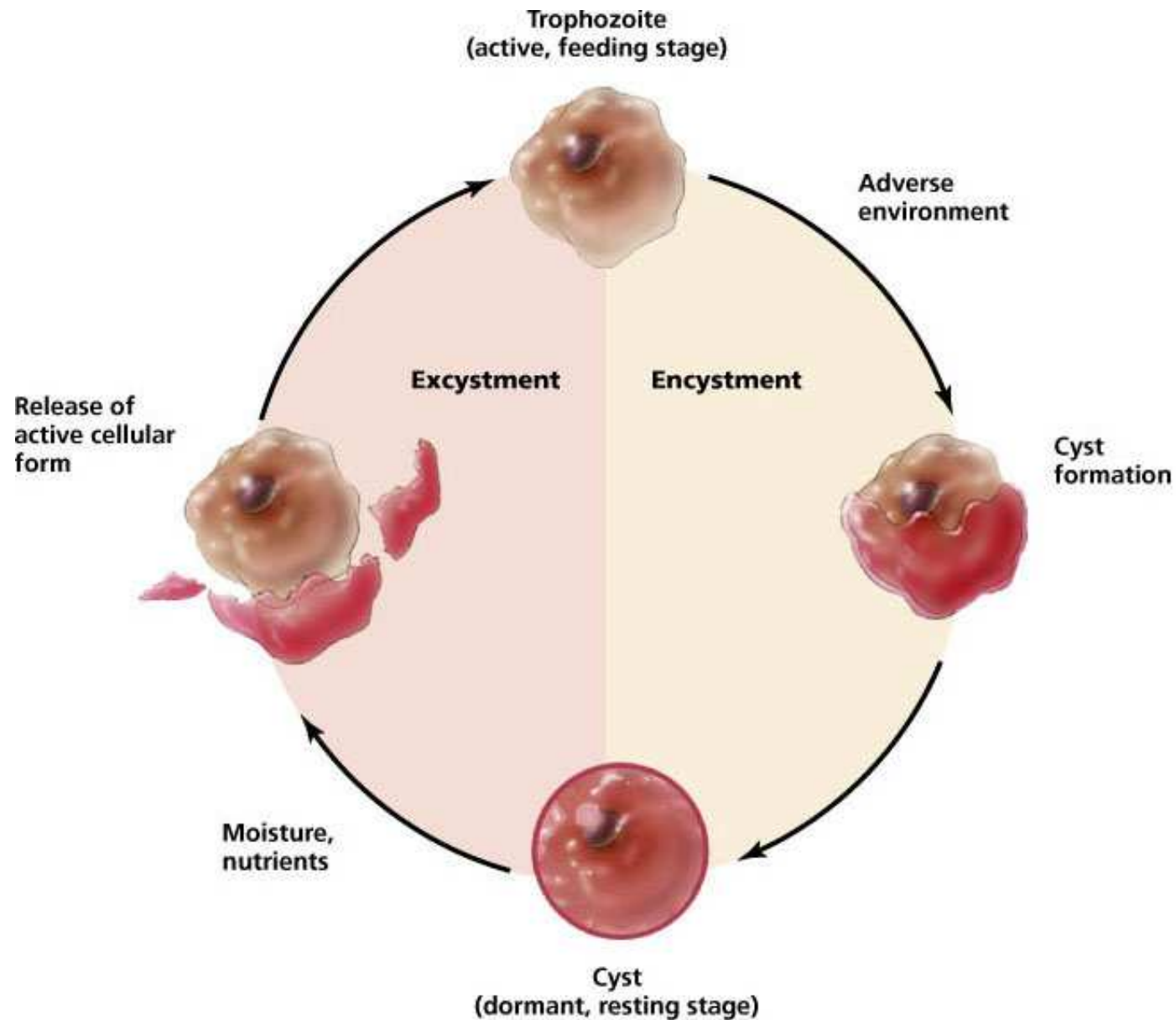
Radiolaria



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SEM 0.5 mm

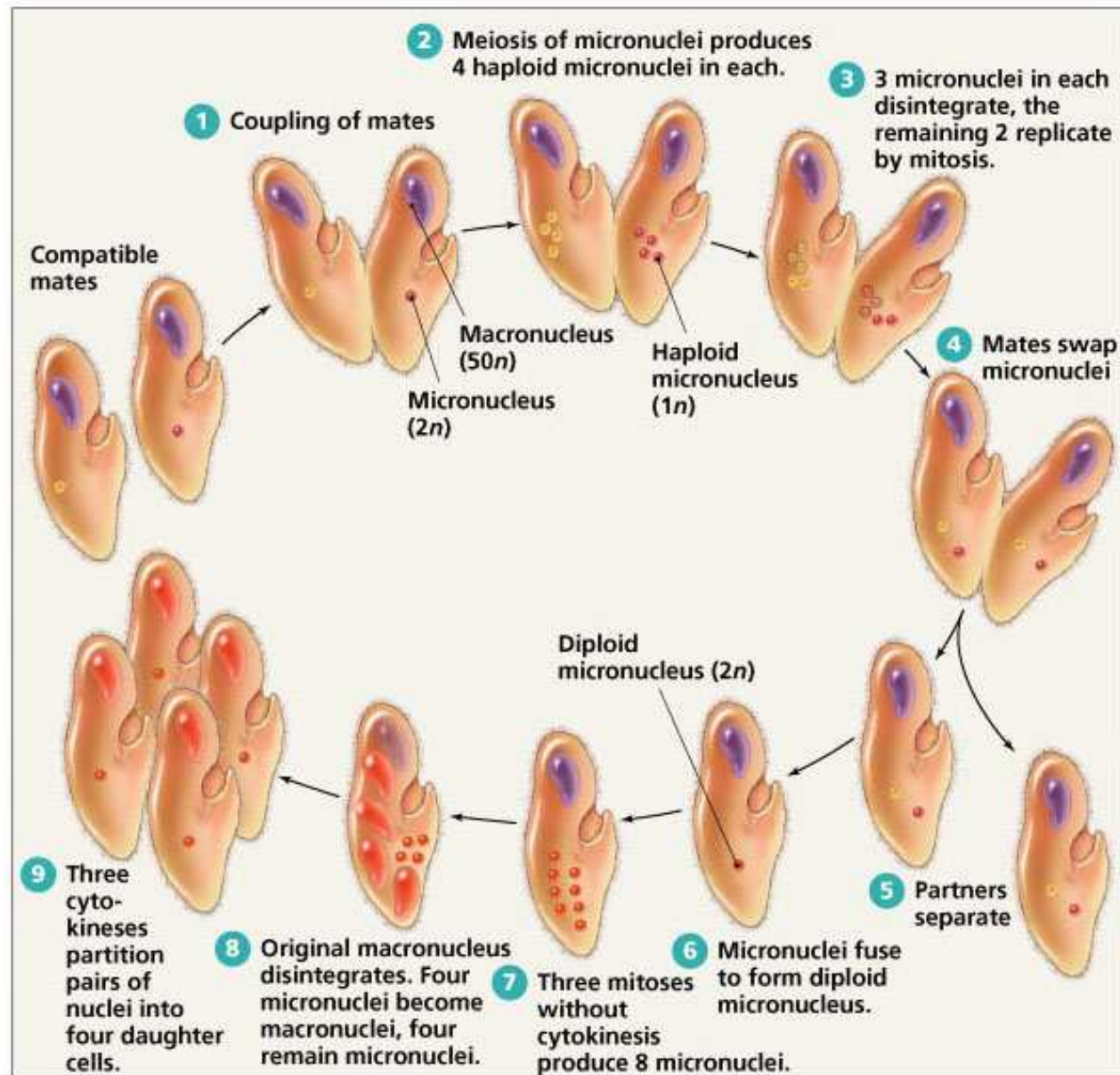
Protozoan Life Cycle



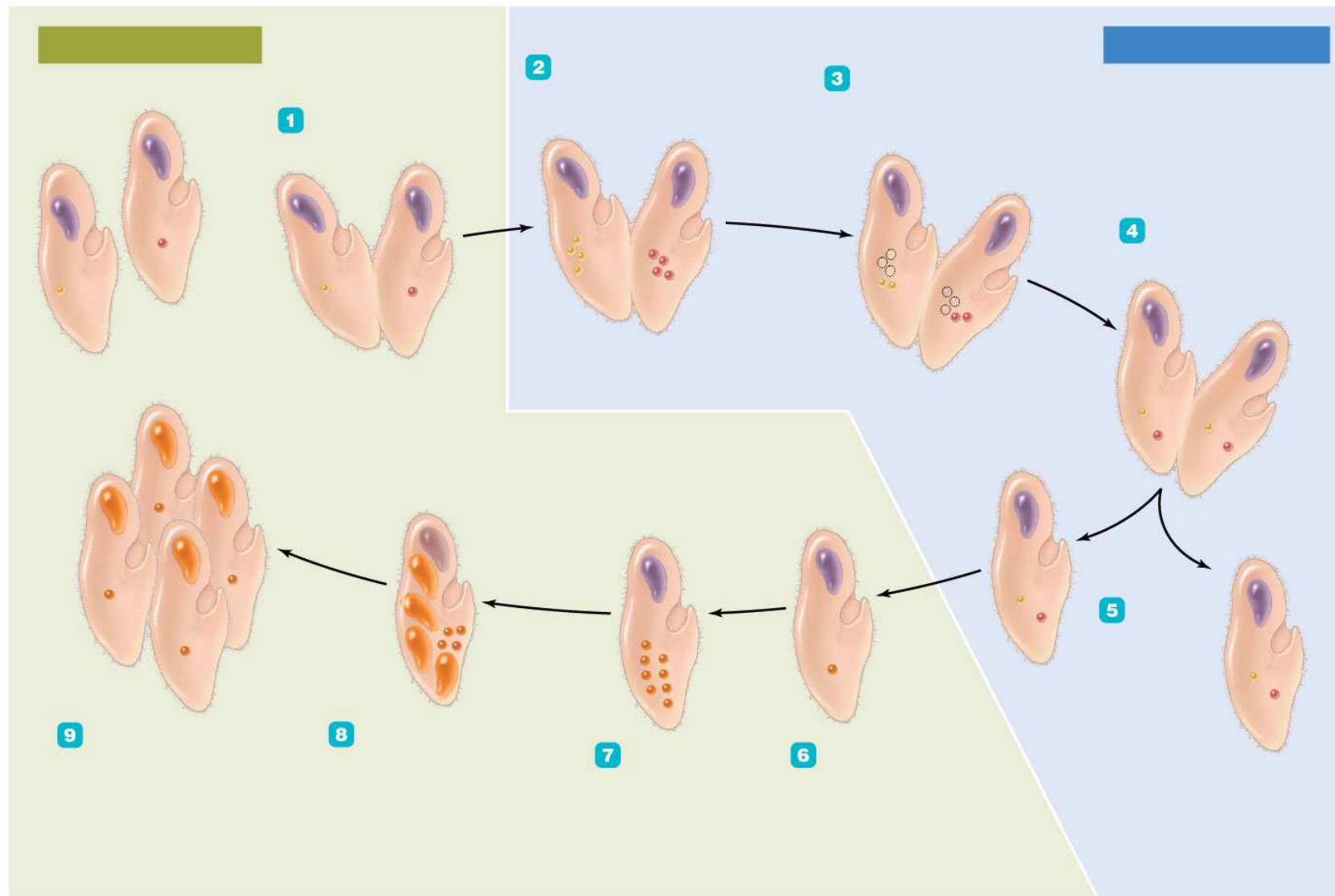
Reproduction in Protozoa

- Most reproduction - asexual only
 - binary fission or _____
- A few also use sexual reproduction
 - _____
 - Gametocytes that fuse to form diploid zygote
- Some have _____ nuclei
 - **Macronucleus** - many copies of genome
 - controls _____, growth, and sexual reproduction
 - **Micronucleus** – involved in genetic recombination, sexual reproduction, and regeneration of _____

Conjugation in *Paramecium*



Practice



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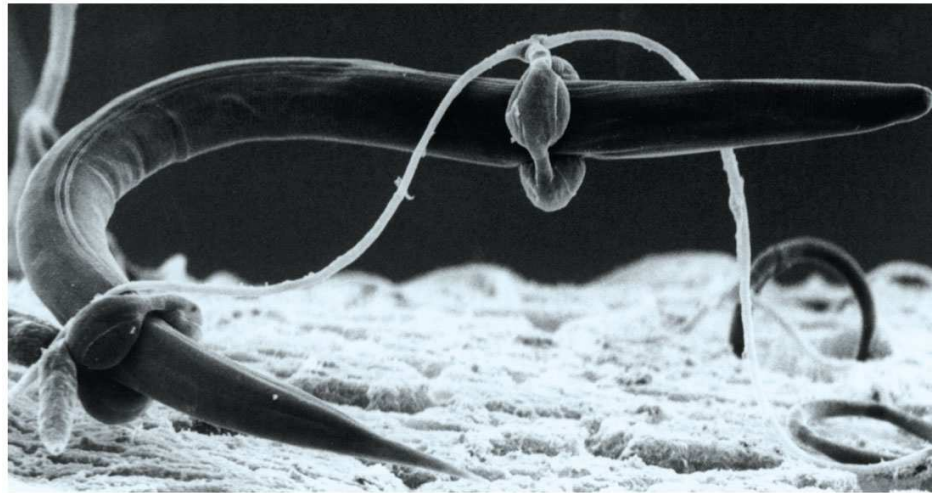
Fungi

- Aerobic or facultatively anaerobic
- Chemoheterotrophic
- Most are _____ (nutrient recycling)
- Cell walls composed of chitin
- Lack chlorophyll; do not perform _____
- _____ antibiotics
- Can spoil fruit, pickles, jams, and jellies
- 30% cause diseases of _____, animals, and humans
- **Mycology** is the study of fungi



Fungi

- Acquire nutrients by absorption
- Most are saprobes
- Some trap and kill microscopic soil-dwelling nematodes



SEM 75 μ m

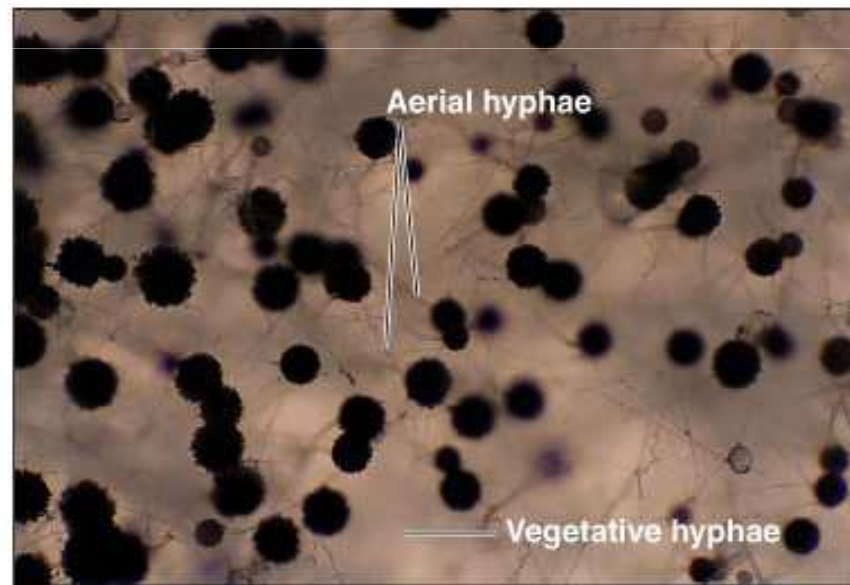
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Fungi

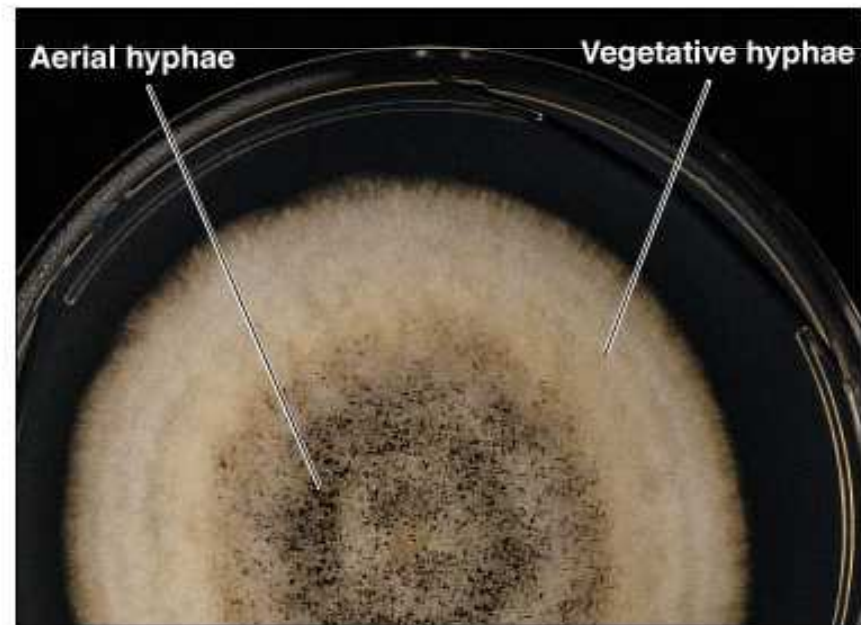
	Fungi	Bacteria
Cell type	Eukaryotic	Prokaryotic
Cell membrane	Sterols present	Sterols absent, except in <i>Mycoplasma</i>
Cell wall	Glucans; mannans; chitin (no peptidoglycan)	Peptidoglycan
Spores	Produce a wide variety of sexual and asexual reproductive spores	Endospores (not for reproduction); some asexual reproductive spores
Metabolism	Limited to heterotrophic; aerobic, facultatively anaerobic	Heterotrophic, chemoautotrophic, photoautotrophic; aerobic, facultatively anaerobic, anaerobic
Sensitivity to antibiotics	Often sensitive to polyenes, imidazoles, and griseofulvin	Often sensitive to penicillins, tetracyclines, and aminoglycosides
SOURCE: After B. D. Davis et al., <i>Microbiology</i> , 4th ed. Philadelphia: J. B. Lippincott, 1990, p. 746.		

Molds

- _____
- The fungal thallus consists of hyphae
- A mass of hyphae is a mycelium.

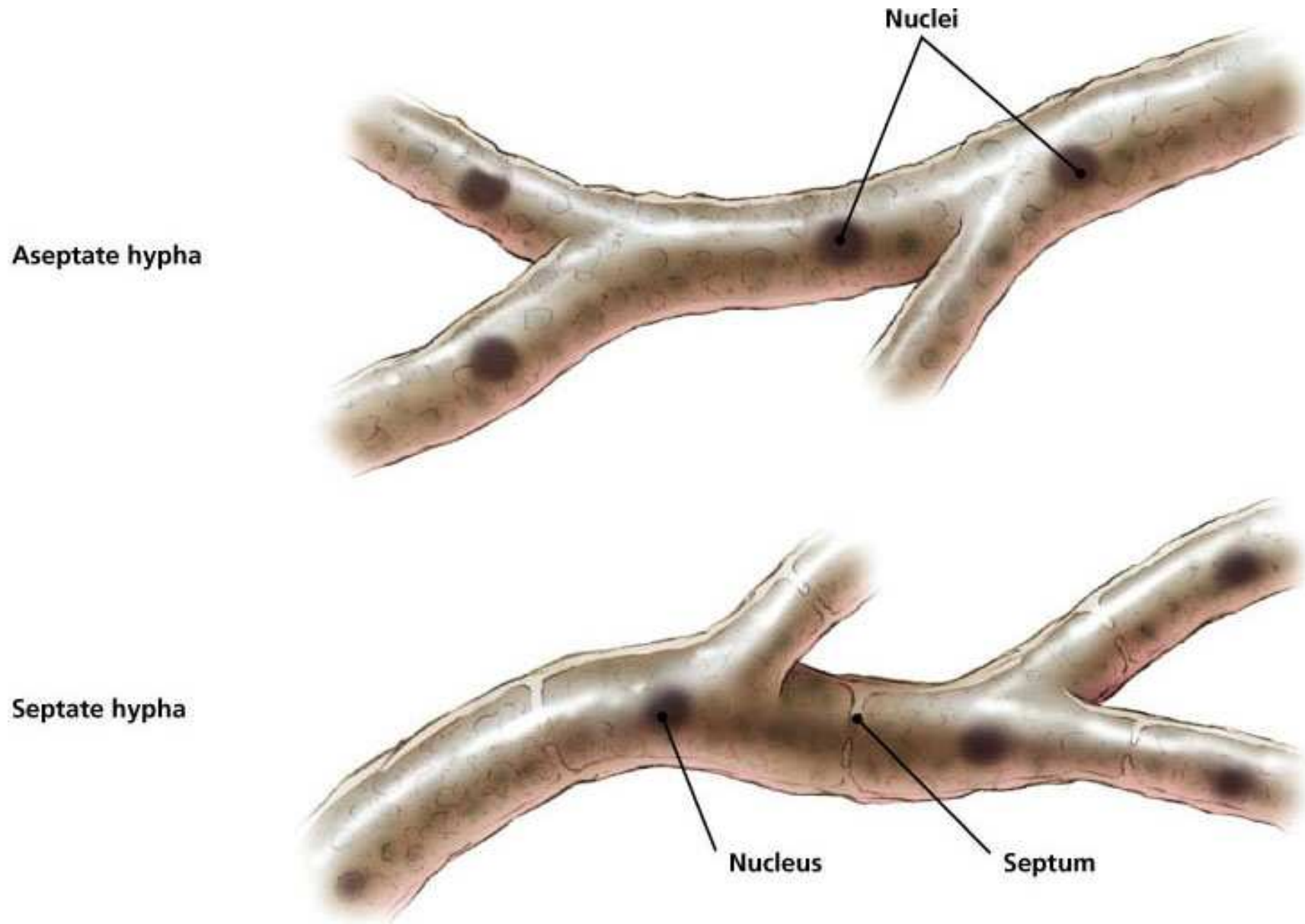


(a) *Aspergillus niger*

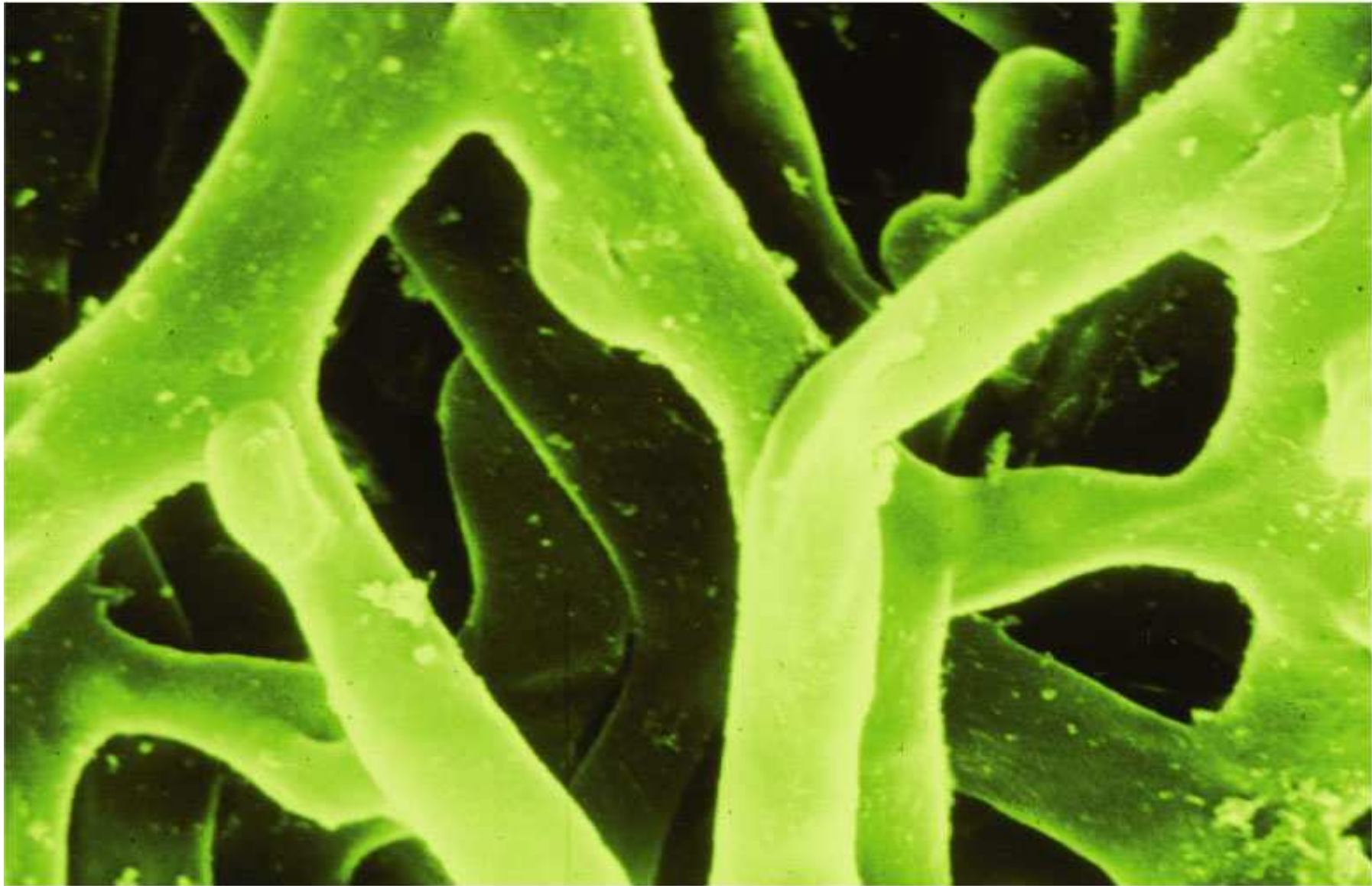


(b) *A. niger* on agar

Fungal Morphology



Fungal Morphology

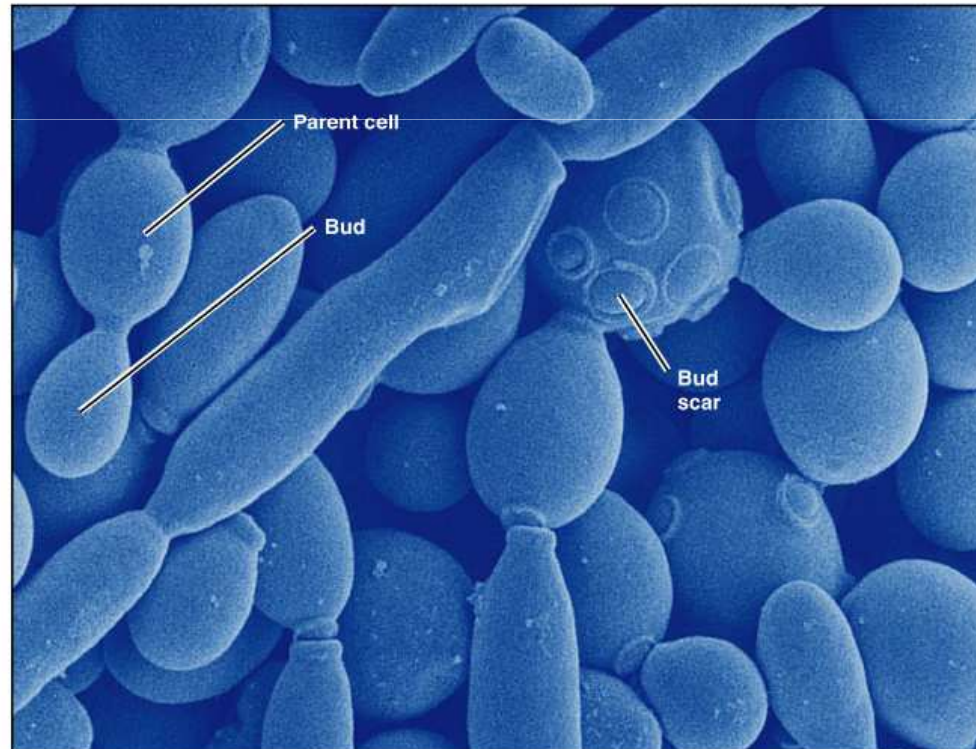


Fungal Morphology



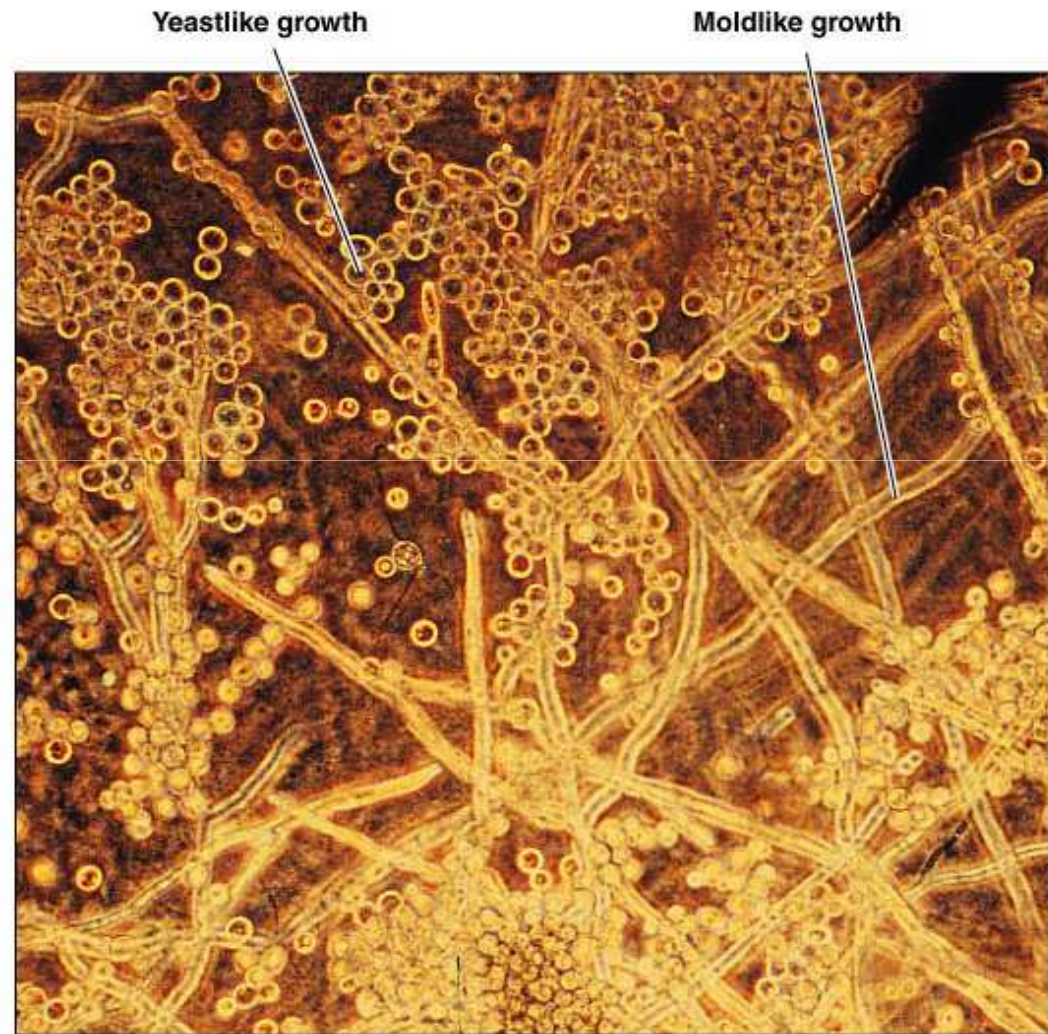
Yeasts

- Unicellular fungi
- Fission yeasts divide symmetrically
- Budding yeasts divide _____



Dimorphism

- Pathogenic dimorphic fungi
 - yeastlike at 37°C
 - moldlike at ___°C



Characteristics of Fungi

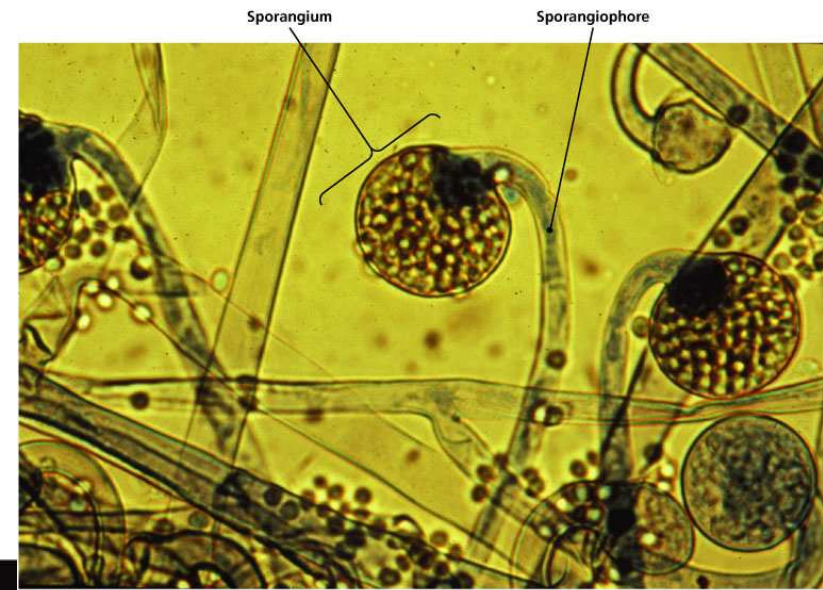
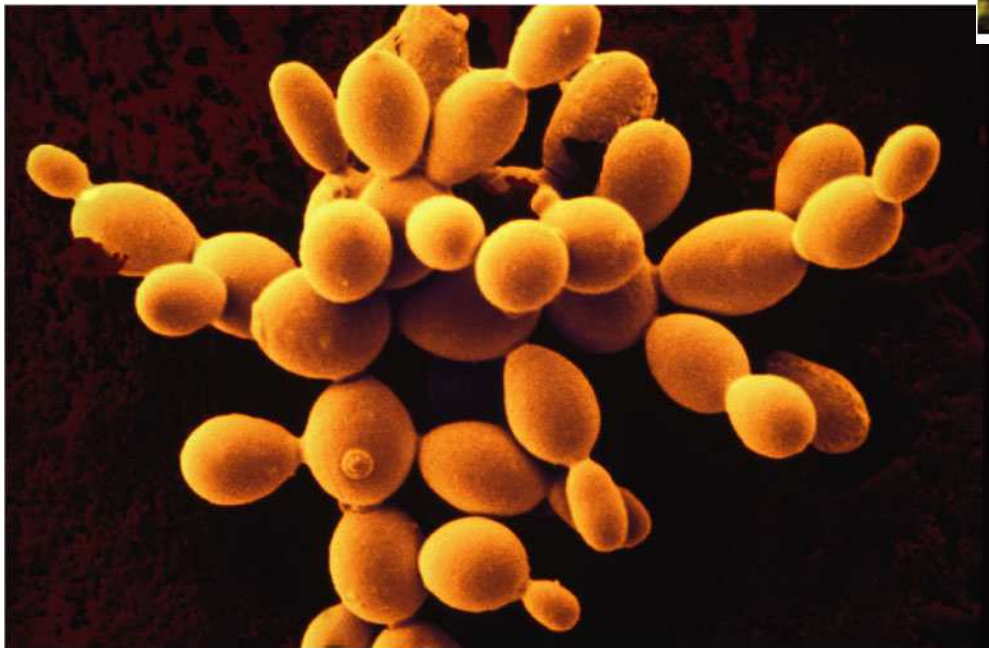
Table 12.3 **Characteristics of Fungi**

Group	Type of Sexual Spore	Comments	Representative Genera
Division Zygomycota	Zygospores	Coenocytic (aseptate)	<i>Rhizopus</i>
Division Ascomycota	Ascospores	Septate; some associated with cyanobacteria or green algae to form lichens	<i>Claviceps</i> <i>Saccharomyces</i> <i>Eupenicillium</i> <i>Tuber</i> <i>Neurospora</i>
Division Basidiomycota	Basidiospores	Septate	<i>Agaricus</i> <i>Cortinellis</i> <i>Cryptococcus</i> <i>Amanita</i>
Deuteromycetes	None known	Septate	<i>Histoplasma</i> <i>Trichophyton</i>

Reproduction of Fungi

- Asexual reproduction – occurs in all fungus
 - mitosis and cytokinesis
 - Budding
 - Pseudohypha - series of buds that remain attached
 - Asexual spores
- Sexual reproduction – most but not all
 - Zygote gives rise to _____

Asexual Budding in Yeast

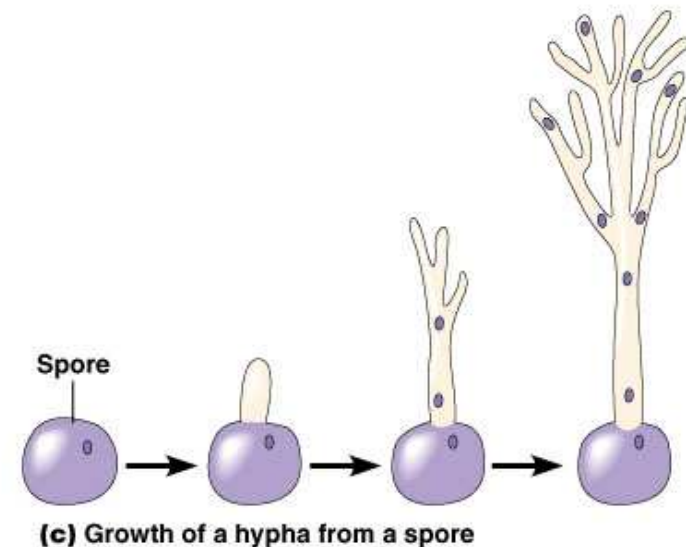
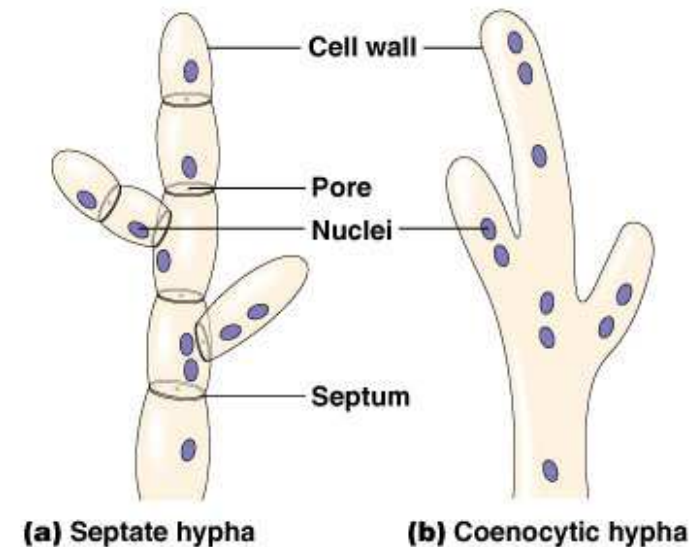


Asexual Spores of Molds

Figure 12.14a

Asexual spores

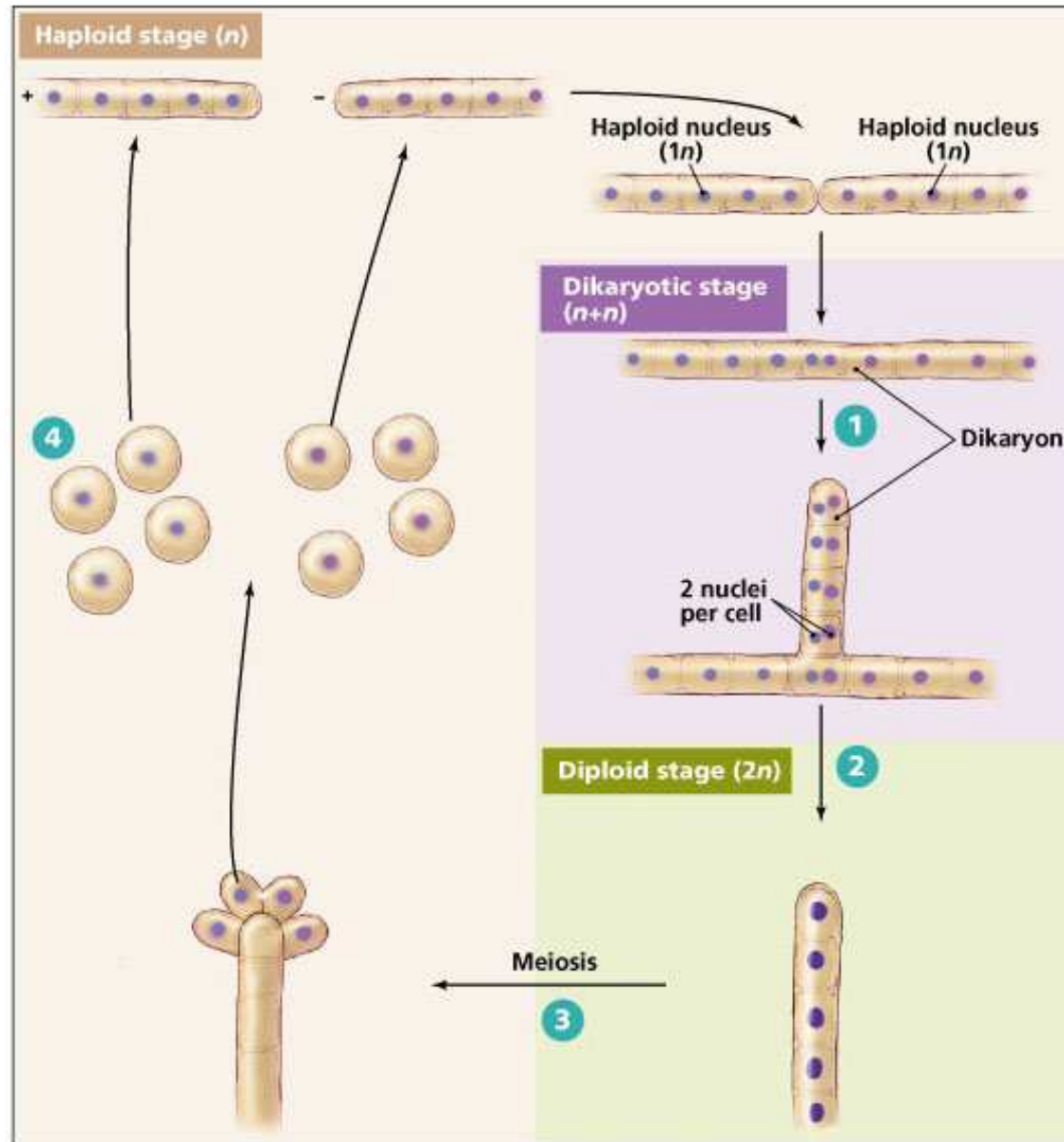
- _____
- Conidiospore
 - Arthrospore
 - Blastoconidium
- Chlamydo-spore



Sexual reproduction

- Meiosis Diploid nucleus produces haploid nuclei (sexual spores)
- Plasmogamy Haploid donor cell nucleus (+) penetrates _____ of recipient cell (–)
- Karyogamy + and – nuclei fuse
- Sexual Spores

Sexual Spores Formation



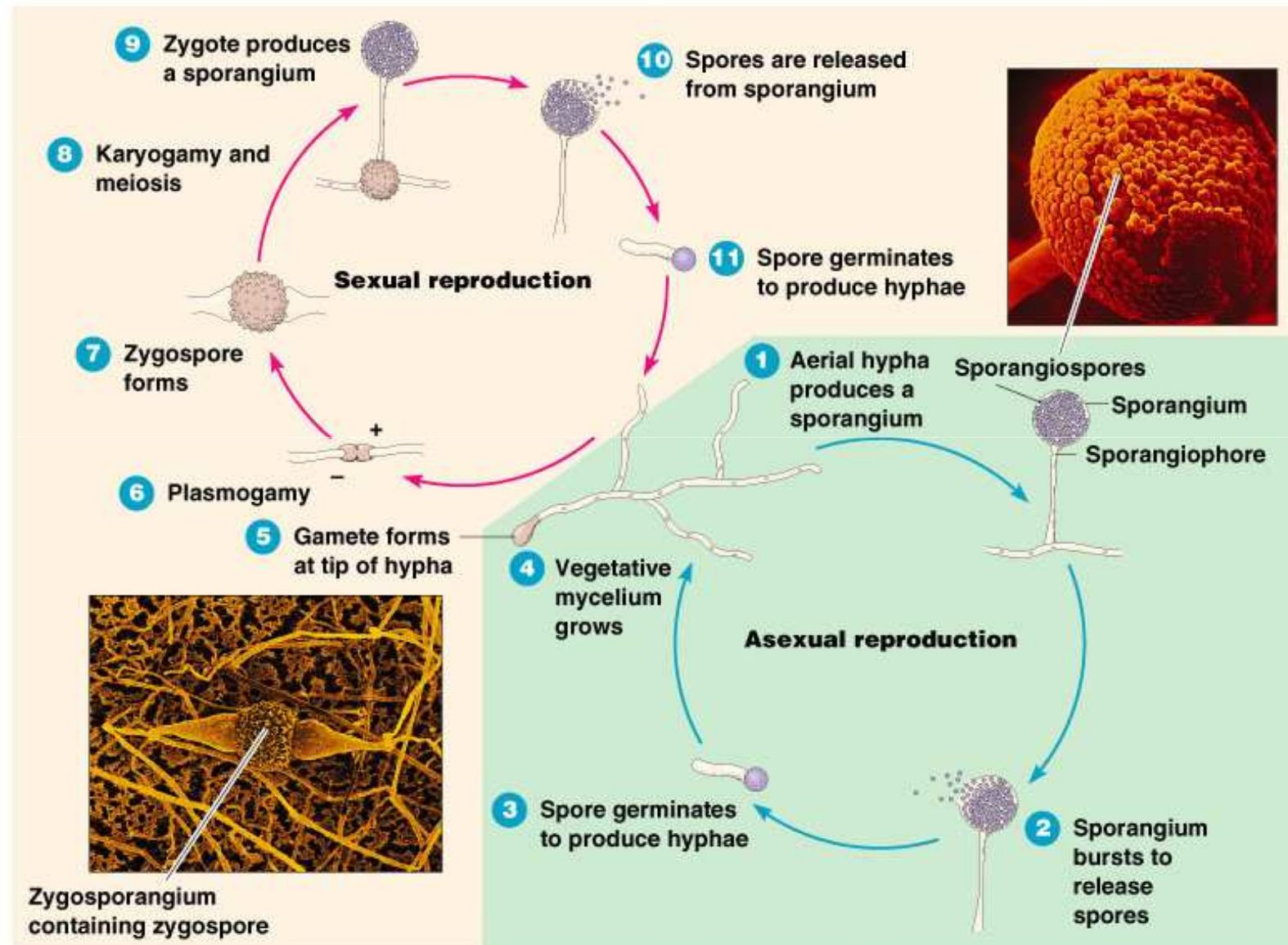
Subgroups Within the Fungi

- Division Zygomycota
- Division Ascomycota
- Division _____
- Deuteromycetes

Zygomycota

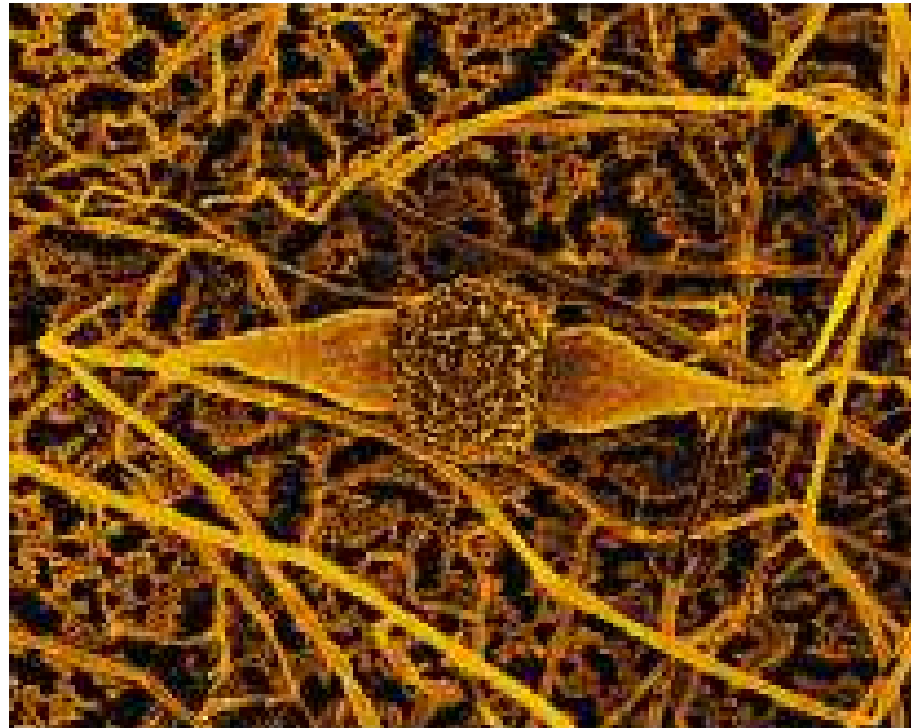
- Conjugation fungi
- Coenocytic
- Produce sporangiospores and _____.
 - *Rhizopus*, *Mucor* (Opportunistic, systemic mycoses)

Zygomycete Life Cycle

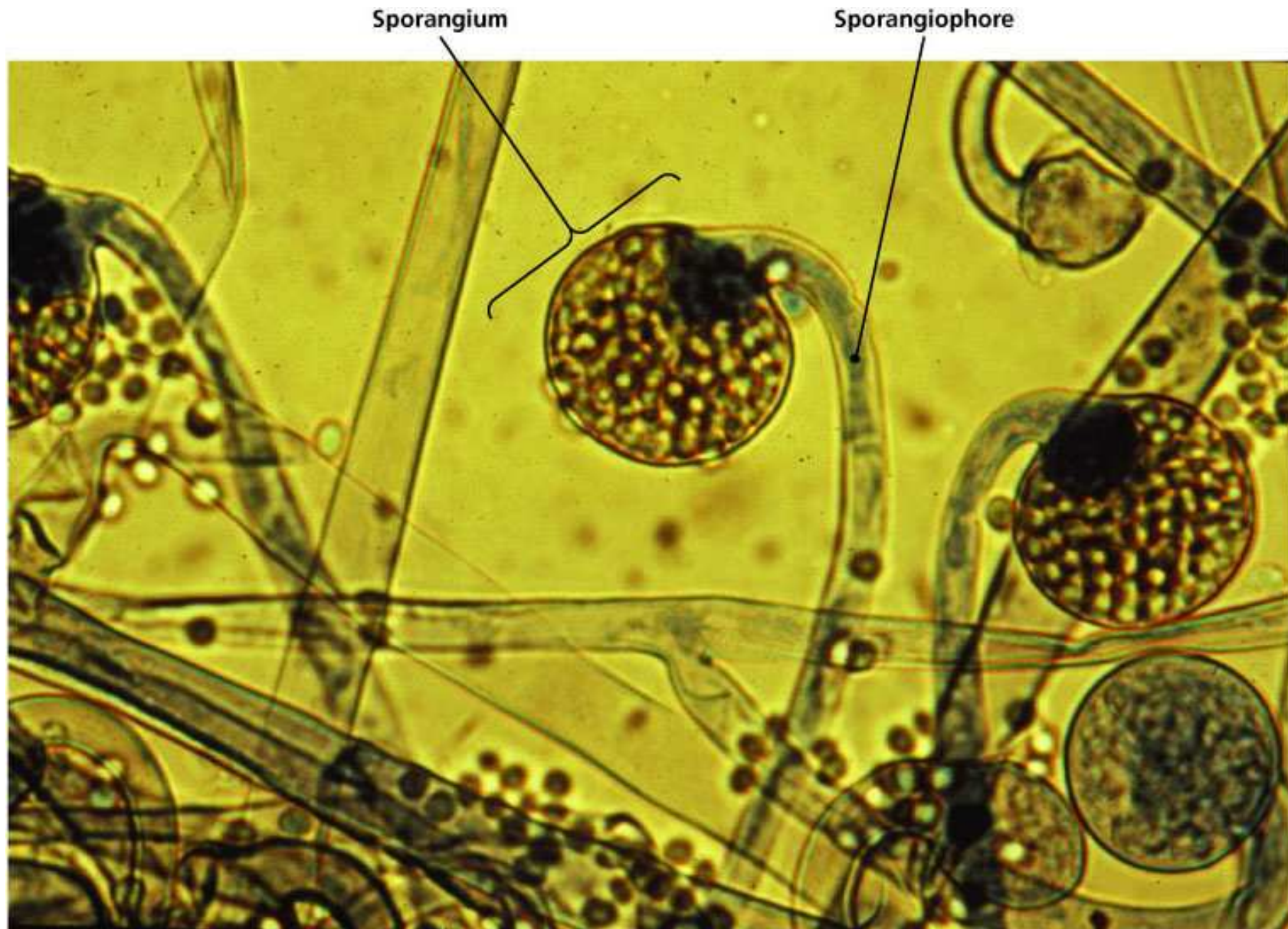


Sexual spores

- Zygosporangium Fusion of haploid cells produces one zygosporangium



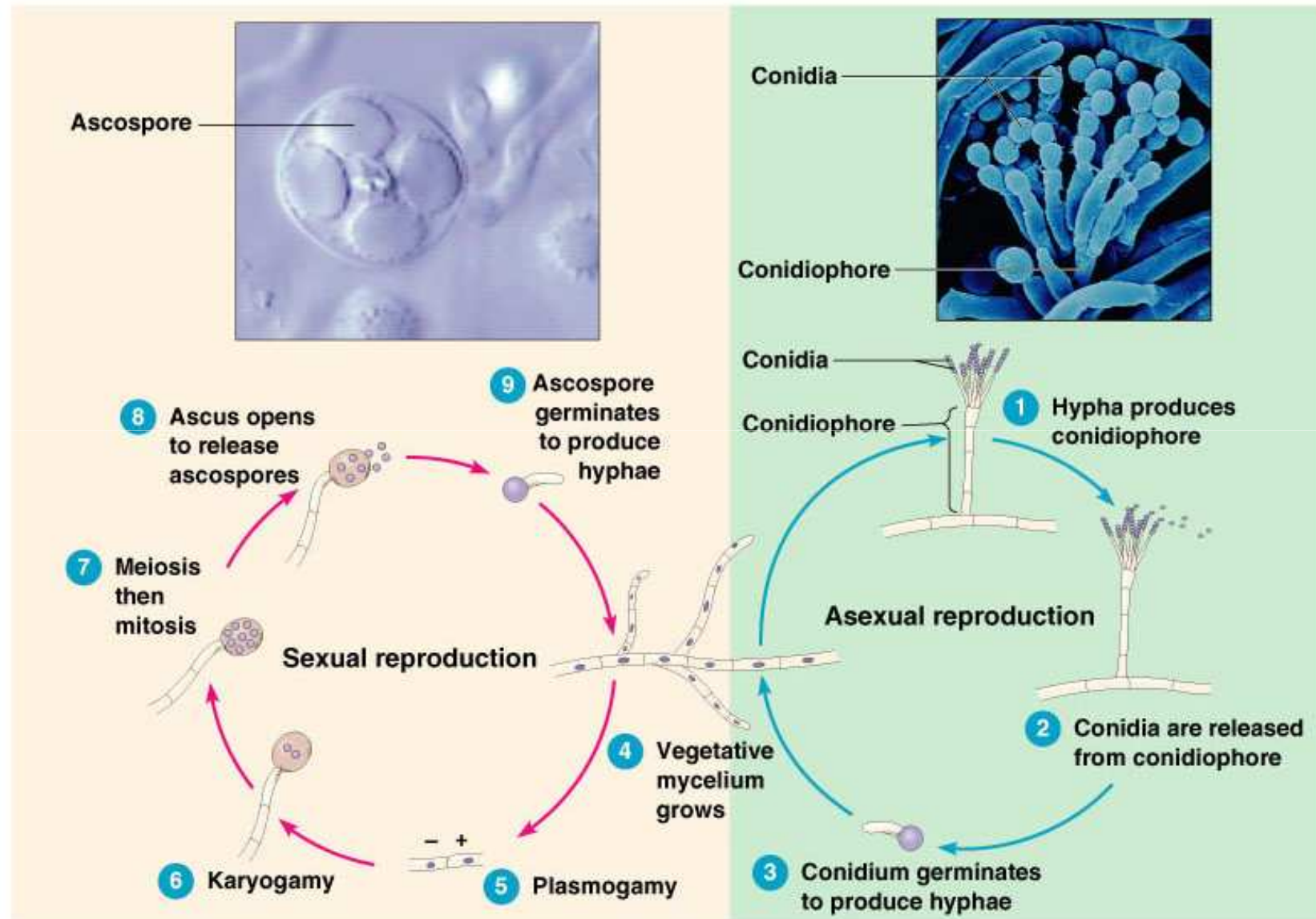
Asexual Spores of Molds



Ascomycota

- Sac fungi
- Septate
- Produce ascospores and frequently _____.
 - *Aspergillus* (opportunistic, systemic mycosis)
 - *Blastomyces dermatitidis*, *Histoplasma capsulatum* (systemic mycoses)
 - *Microsporum*, *Trichophyton* (cutaneous mycoses)

Ascomycete Life Cycle

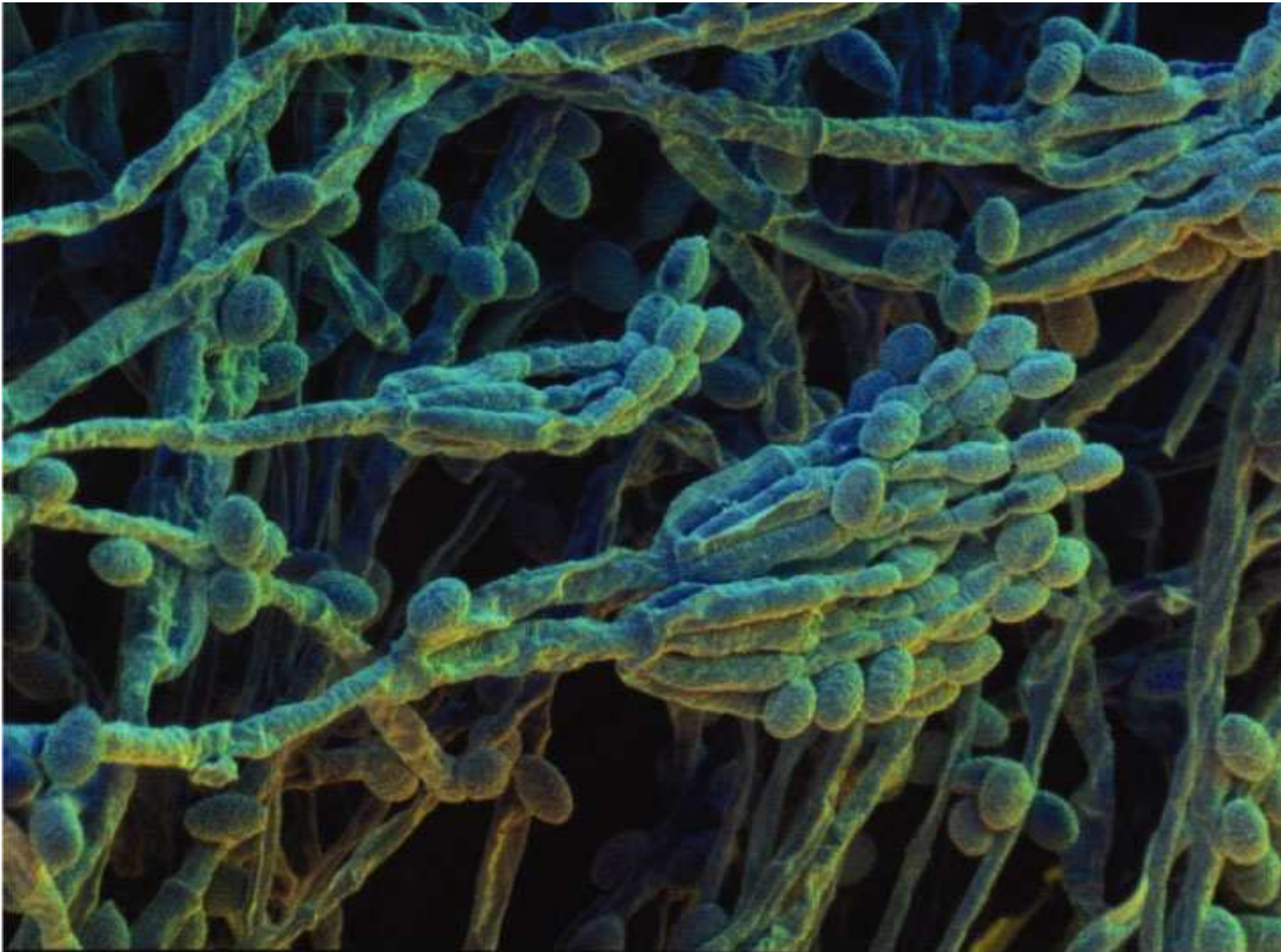


Sexual spores

- Ascospore Formed in a sac (ascus)



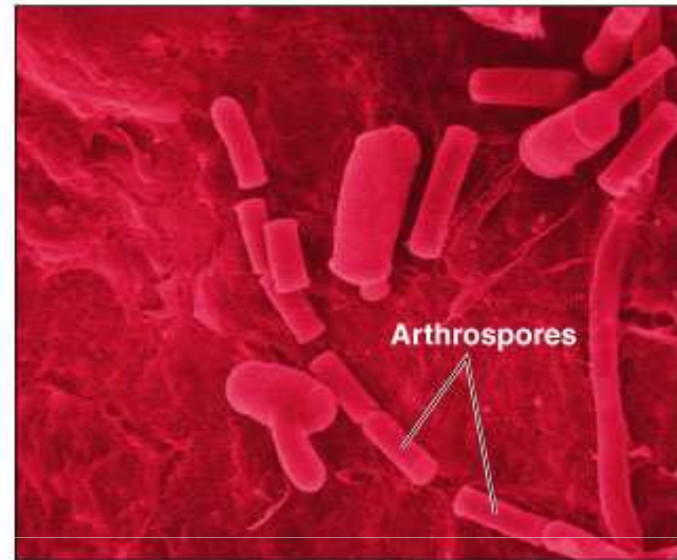
Asexual Spores of Molds



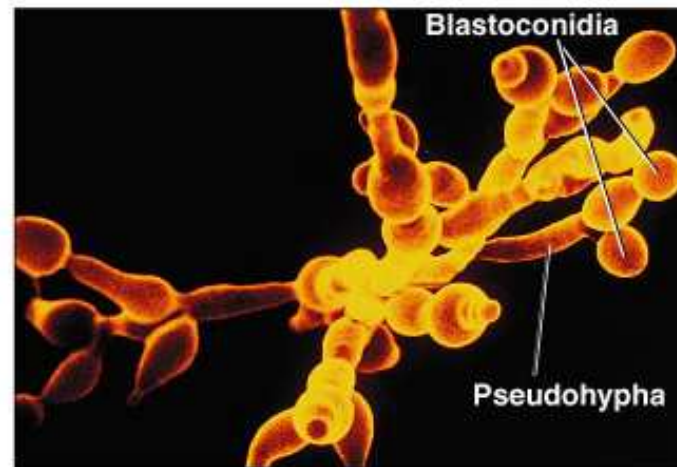
Conidiospores



(a) Conidia



(b) Arthrospores

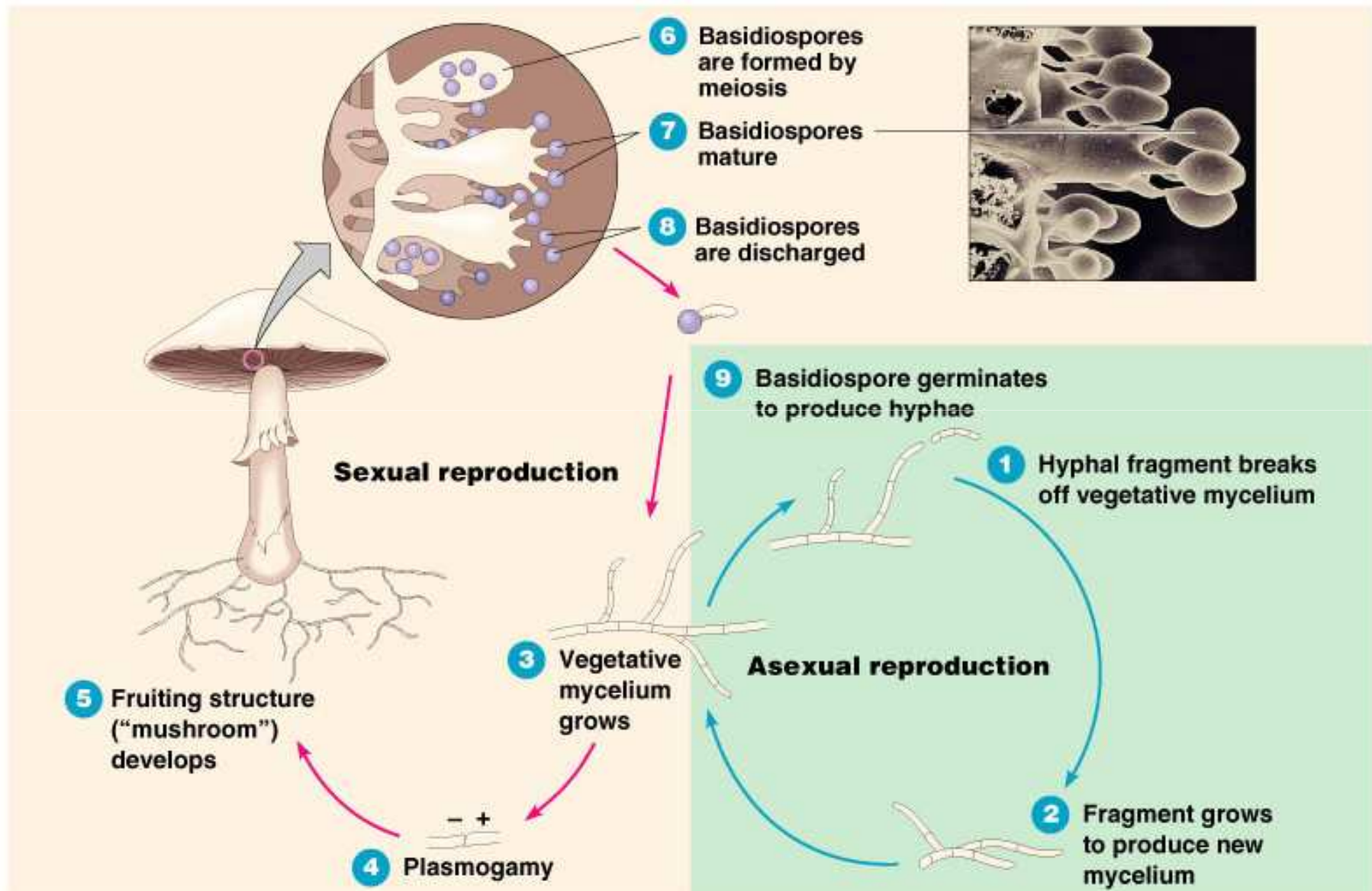


(c) Blastoconidia

Basidiomycota

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

Basidiomycete Life Cycle

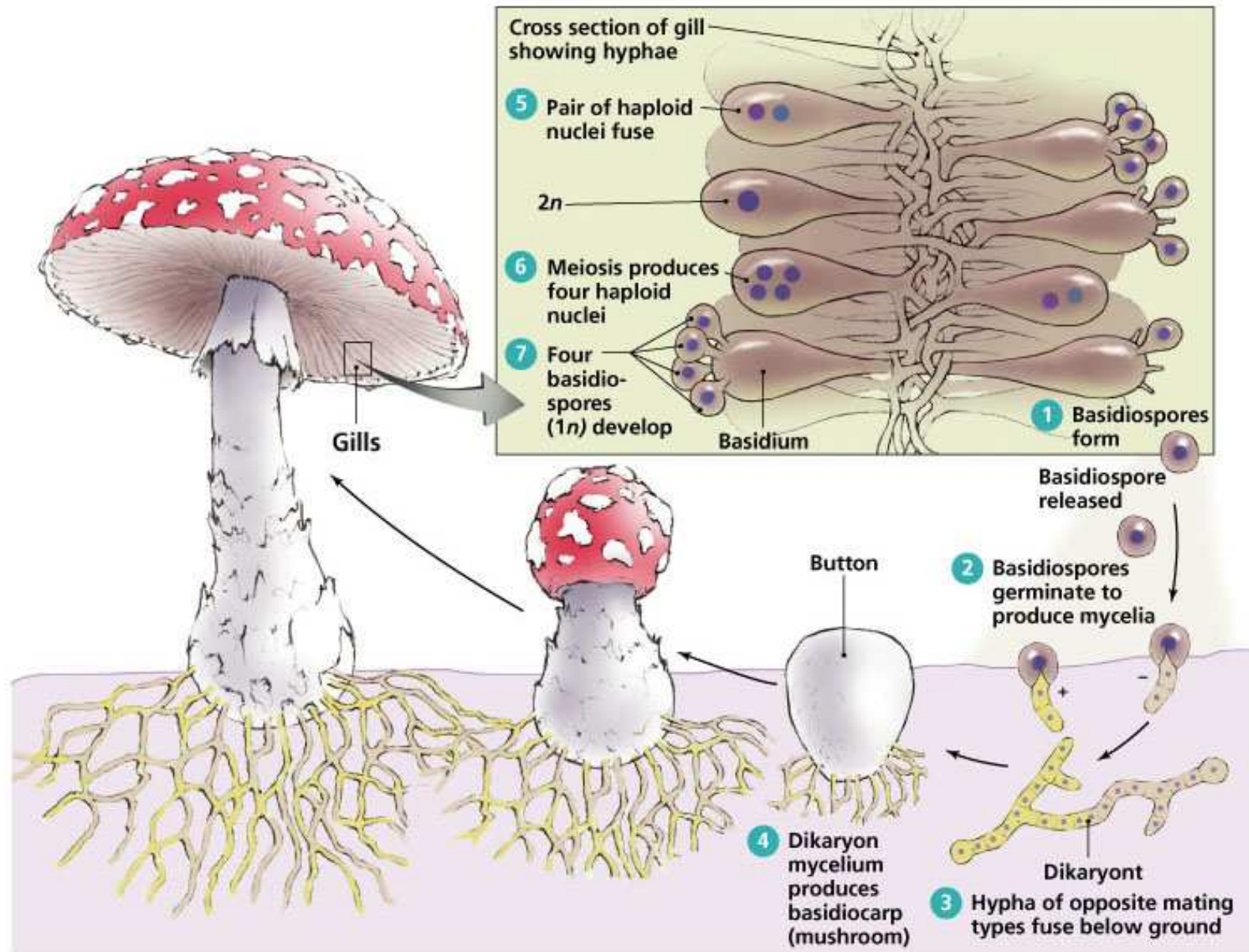


Sexual spores

- Basidiospore Formed externally on a pedestal (basidium)



Division Basidiomycota



Deuteromycetes

- Contains heterogeneous collection of fungi whose sexual stages are unknown
 - rRNA sequencing places most in Ascomycota, a few are Basidiomycota
 - *Penicillium*
 - *Sporothrix* (subcutaneous mycosis)
 - *Stachybotrys*, *Coccidioides*, *Pneumocystis* (systemic mycoses)
 - *Candida albicans* (Cutaneous mycoses)

Economic Effects of Fungi

Fungi	Positive Effects	Negative Effects
<i>Saccharomyces</i>	Bread, wine, beer	Food spoilage
<i>Trichoderma</i>	Cellulose used for juices and fabric	<i>Cryphonectria parasitica</i> (chestnut blight)
<i>Taxomyces</i>	Taxol production	<i>Ceratocystis ulm</i> (Dutch elm disease)
<i>Entomorphaga</i>	Gypsy moth control	

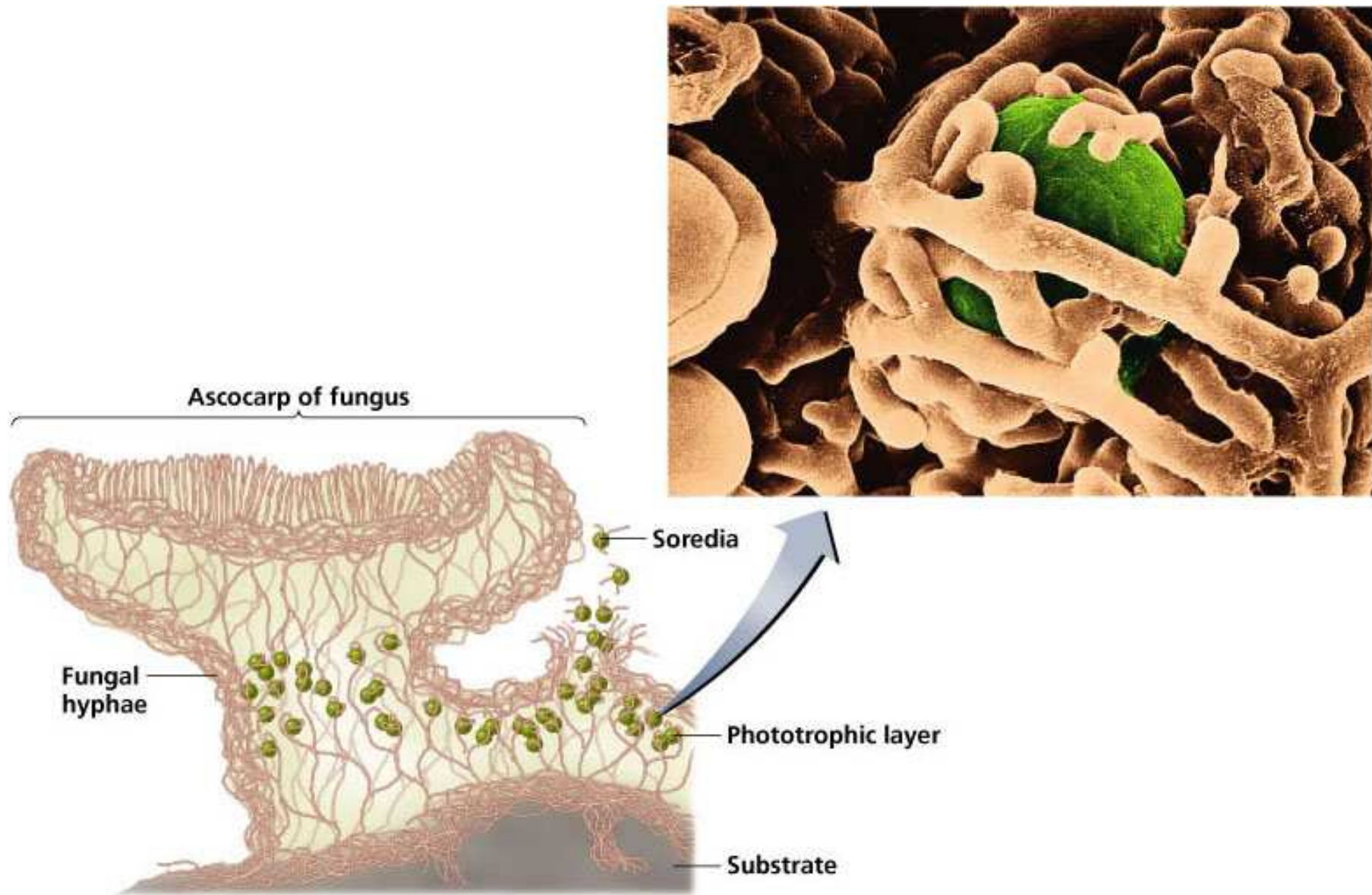
Fungal Diseases (mycoses)

- | | |
|-------------------------|--|
| • Systemic mycoses | Deep within body |
| • Subcutaneous mycoses | Beneath the skin |
| • Cutaneous mycoses | Affect hair, skin, nails |
| • Superficial mycoses | Localized (eg. hair shafts) |
| • Opportunistic mycoses | Caused by normal microbiota or fungi that are normally |

Lichens

- Mutualistic combination
 - Green alga (or cyanobacterium) & fungus
- Alga produces and secretes carbohydrates
- Fungus provides holdfast
- Abundant throughout the world
- Grow on soil, rocks, leaves, tree bark,
 - other lichens, _____
- Important in creation of soil from rocks
- Eaten by many animals

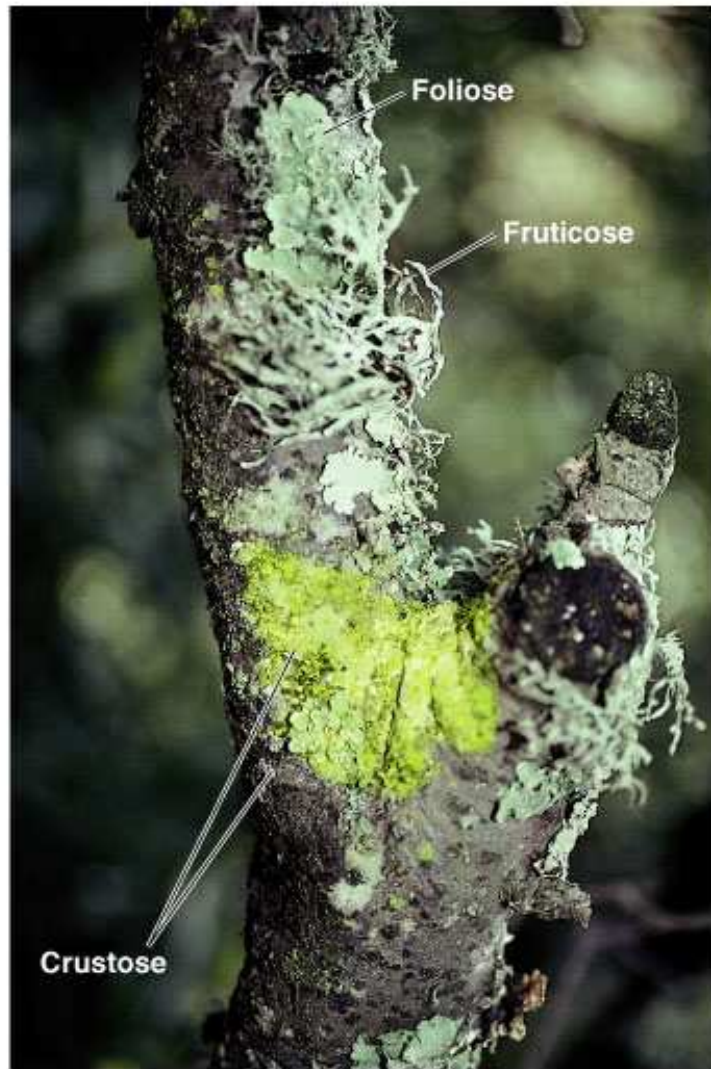
Makeup of a Lichen



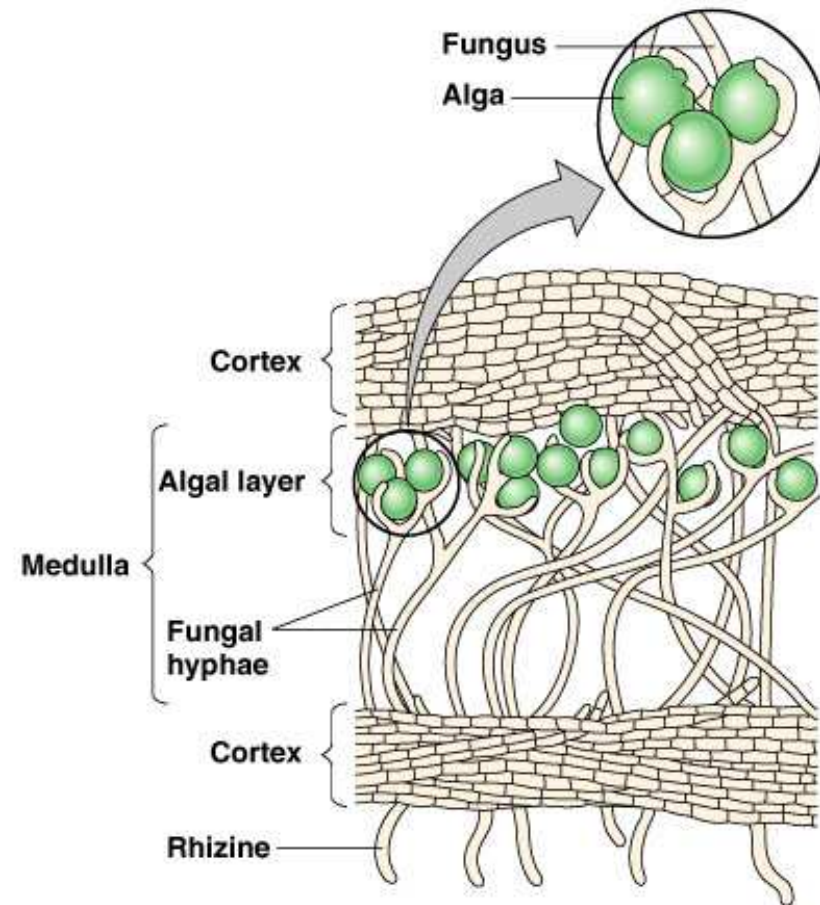
Three Basic Shapes of Lichens



Lichens



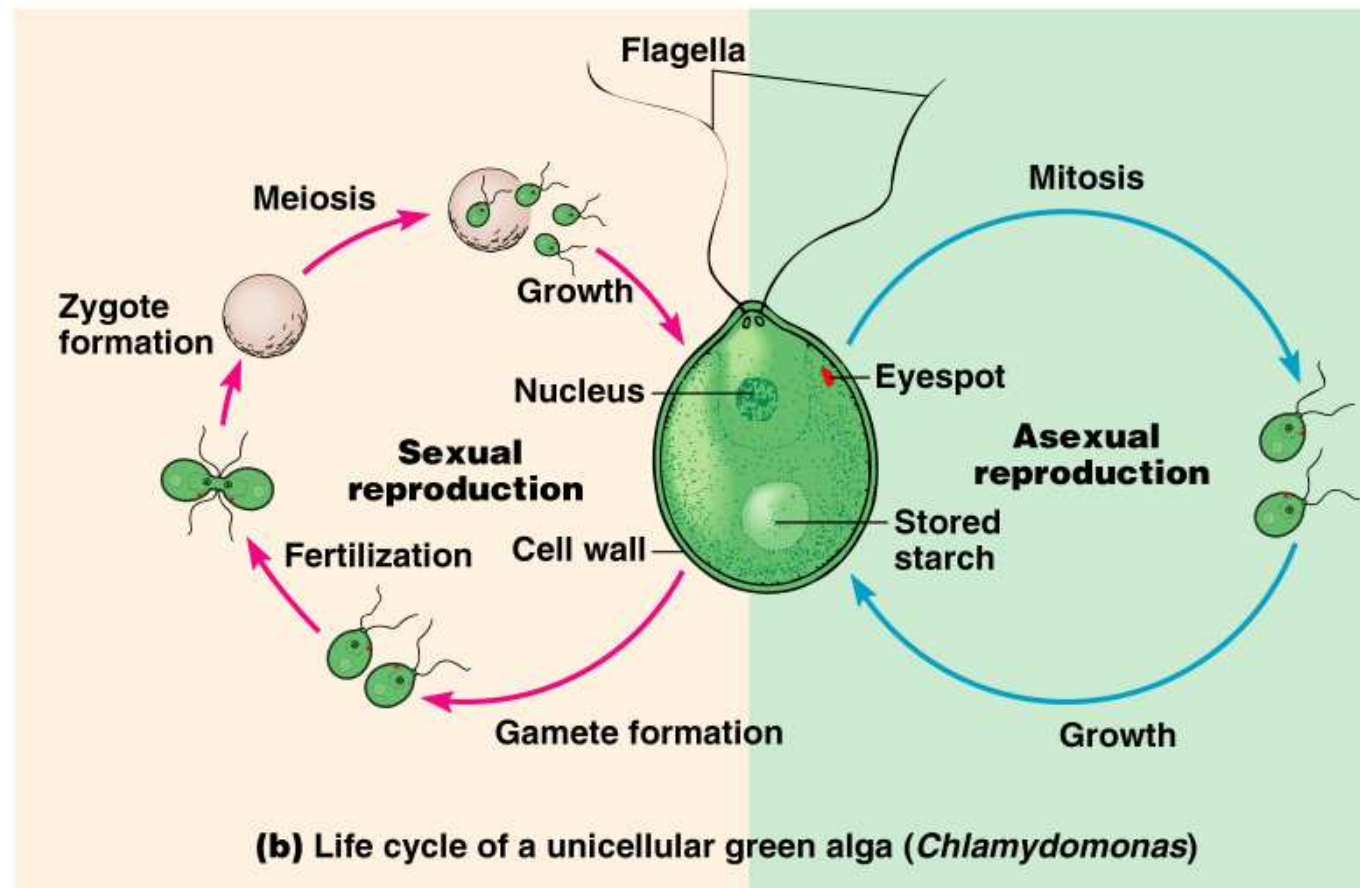
(a) Three types of lichens



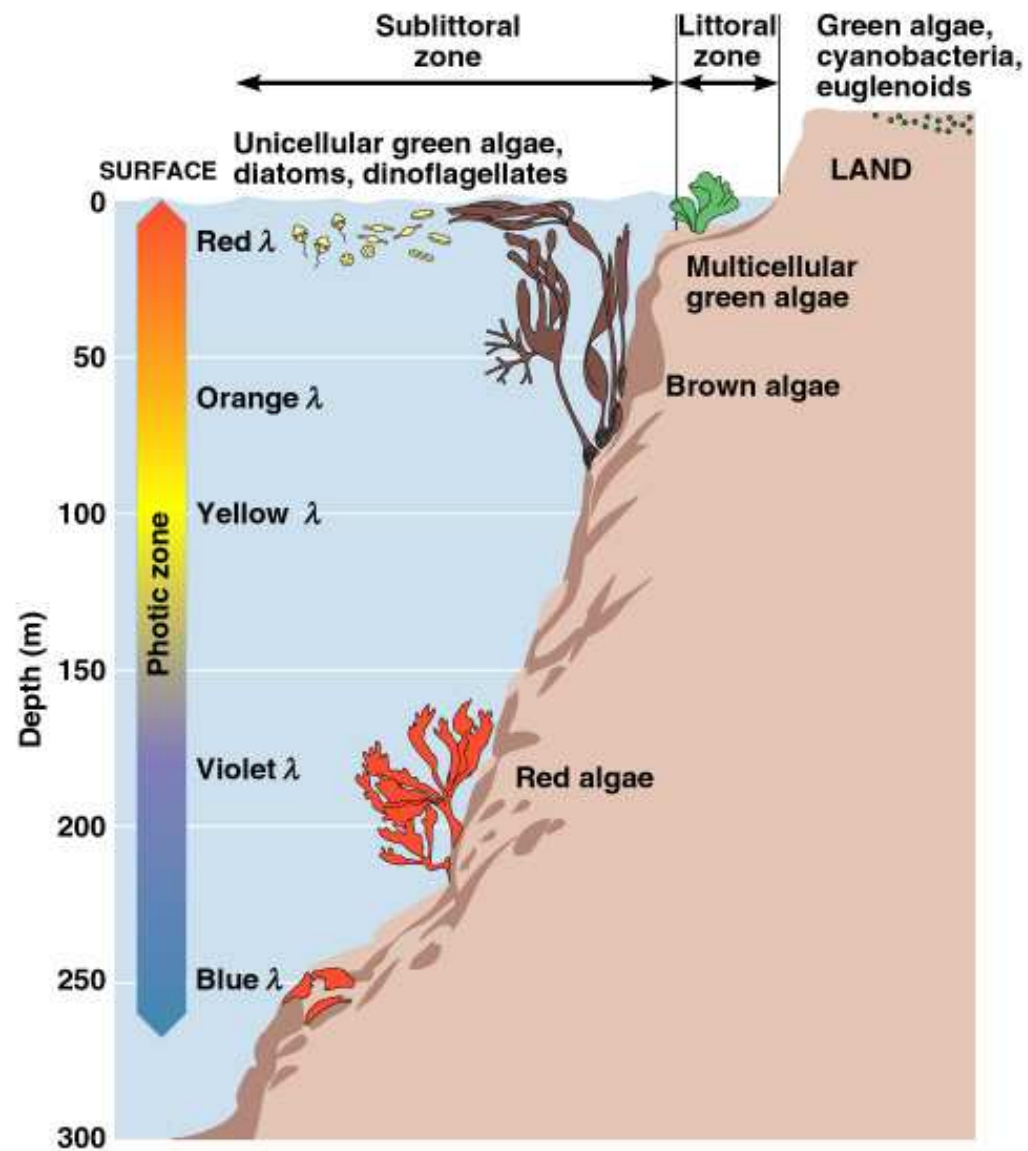
(b) Lichen thallus

Algae

- Eukaryotic
- Unicellular, filamentous, or multicellular (thallic)
- Most are photoautotrophs



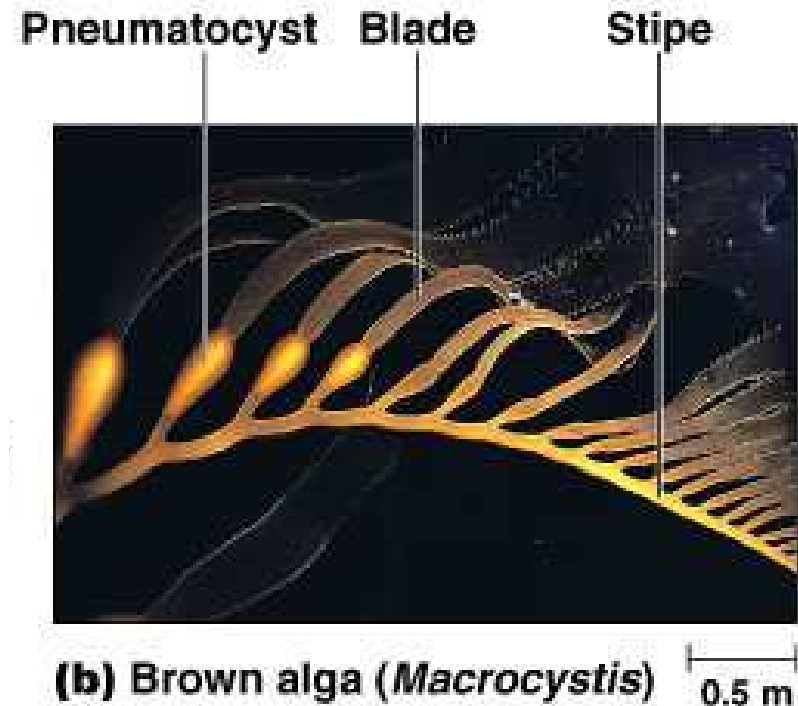
Grow in
the photic
zone



(a) Algal habitats

Phaeophyta

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

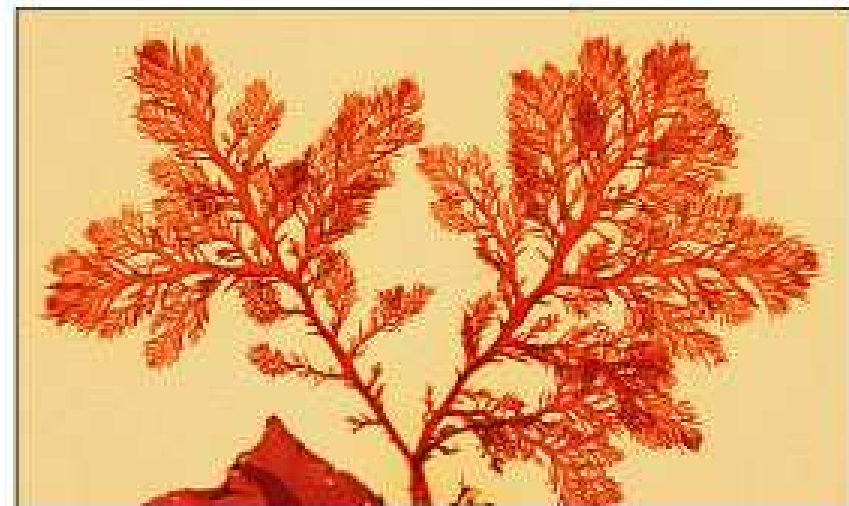


Brown Algae



Rhodophyta

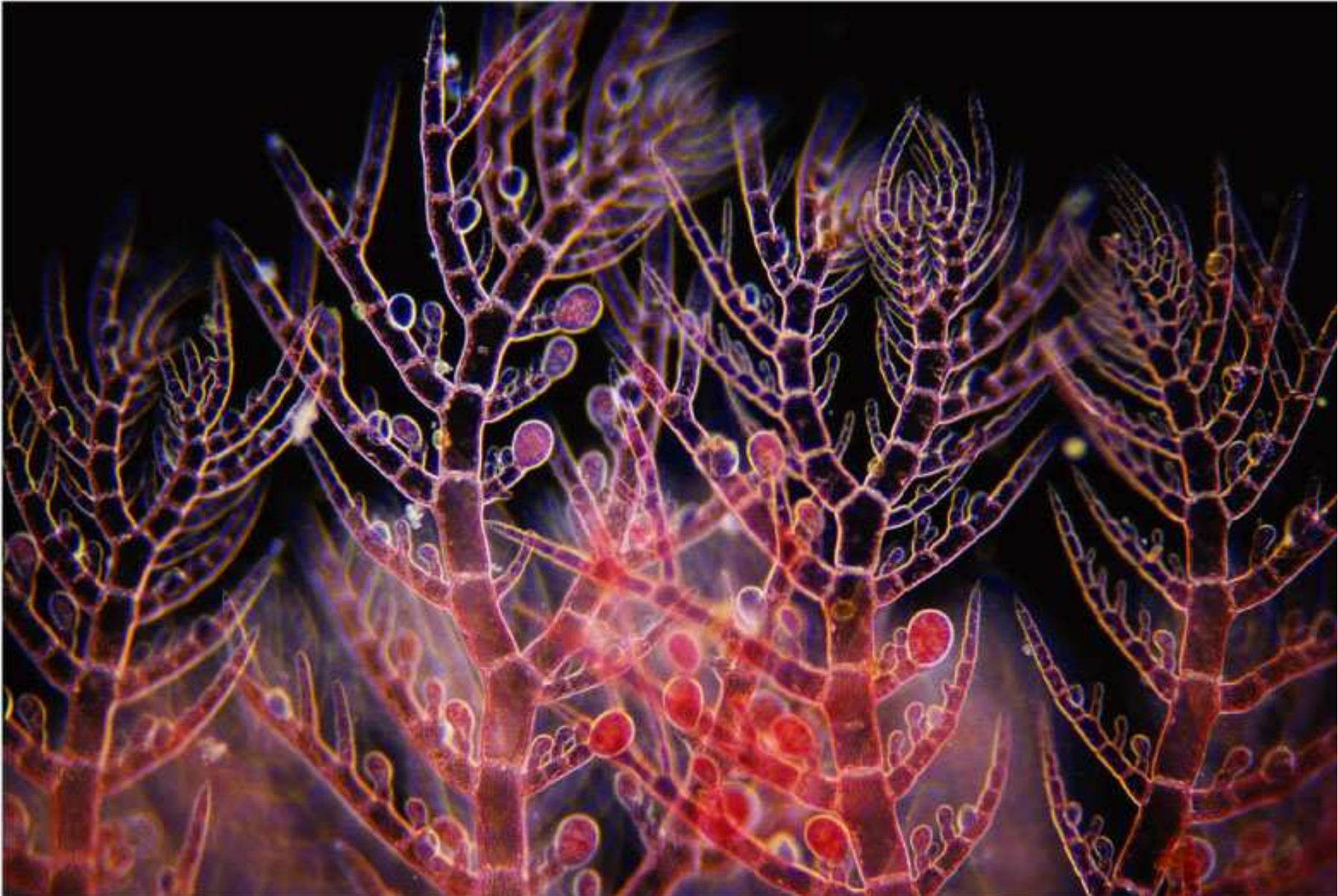
- Red algae
- Cellulose cell walls
- Most multicellular
- Chlorophyll *a* and *d*, phycobiliproteins
- Store glucose polymer
- Harvested for agar and carrageenan



(c) Red alga (*Microcladia*)

10 cm

Red Algae



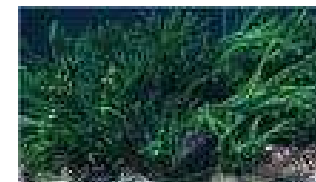
Chlorophyta

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



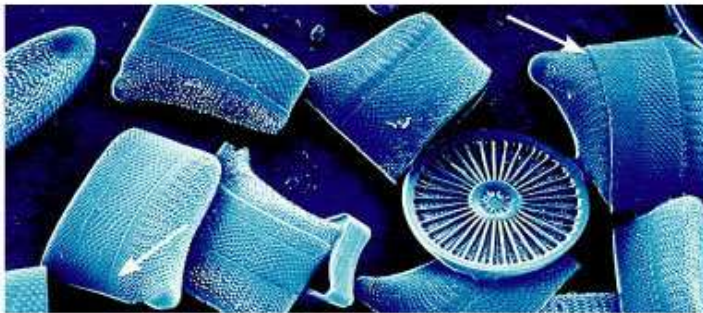
(a) Multicellular green alga (*Ulva*)

10 cm

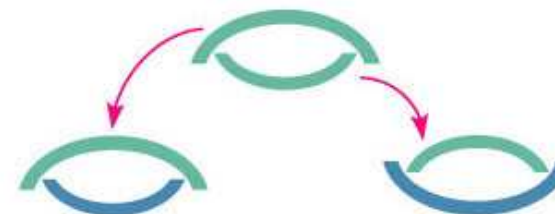


Bacillariophyta

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

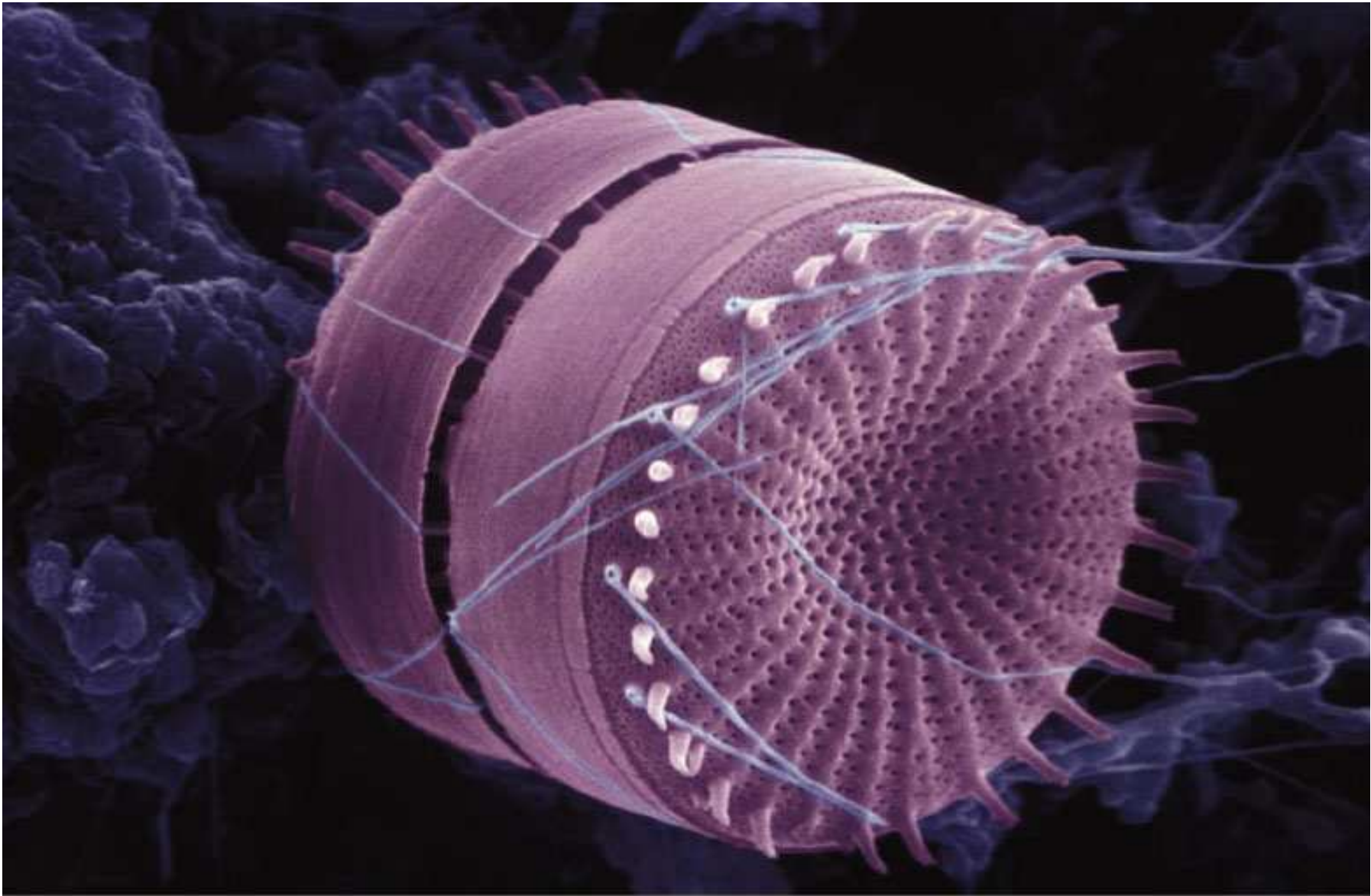


(a)



(b) Asexual reproduction of a diatom

Diatom



Dinoflagellata

- 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

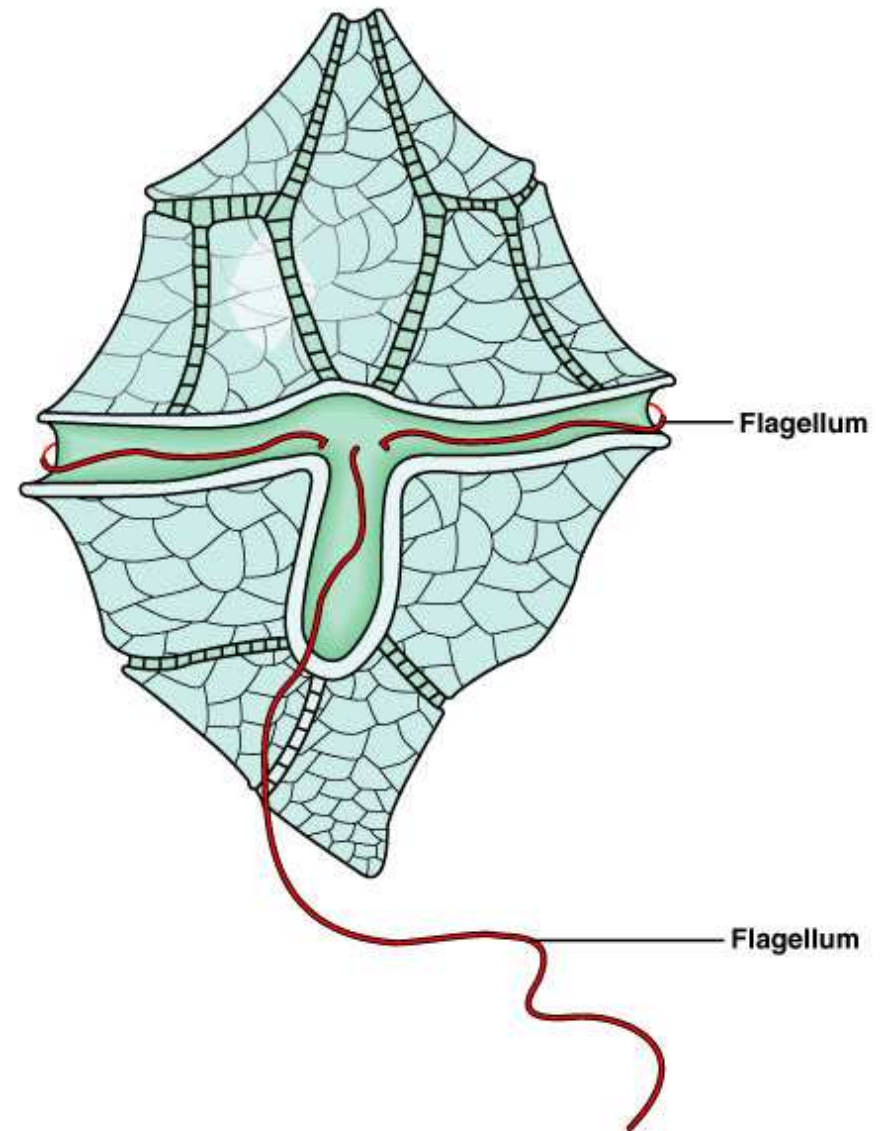


Figure 12.14

Oomycota

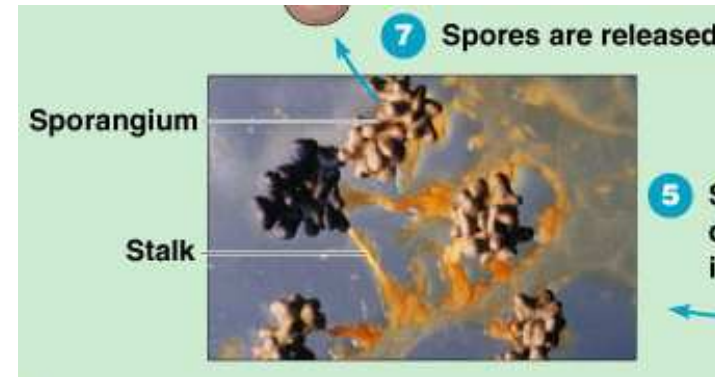
- Water molds
- Cellulose cell walls
- Multicellular
- Chemoheterotrophic
- Produce zoospores
- Decomposers and plant parasites
 - *Phytophthora infestans* responsible for Irish potato blight
 - *P. cinnamomi* infects *Eucalyptus*
 - *P. ramorum* causes sudden oak death



Slime Molds



- Cellular slime molds
 - Resemble amoebas, ingest bacteria by phagocytosis
 - Cells aggregate into stalked fruiting body.
 - Some cells become spores

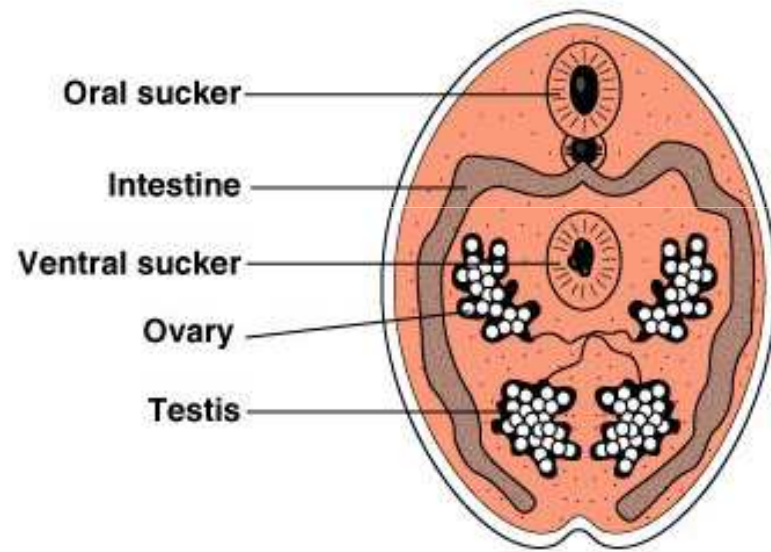


- Plasmodial slime molds
 - Multinucleated large cells
 - Cytoplasm separates into stalked sporangia
 - Nuclei undergo meiosis and form uninucleate haploid spores

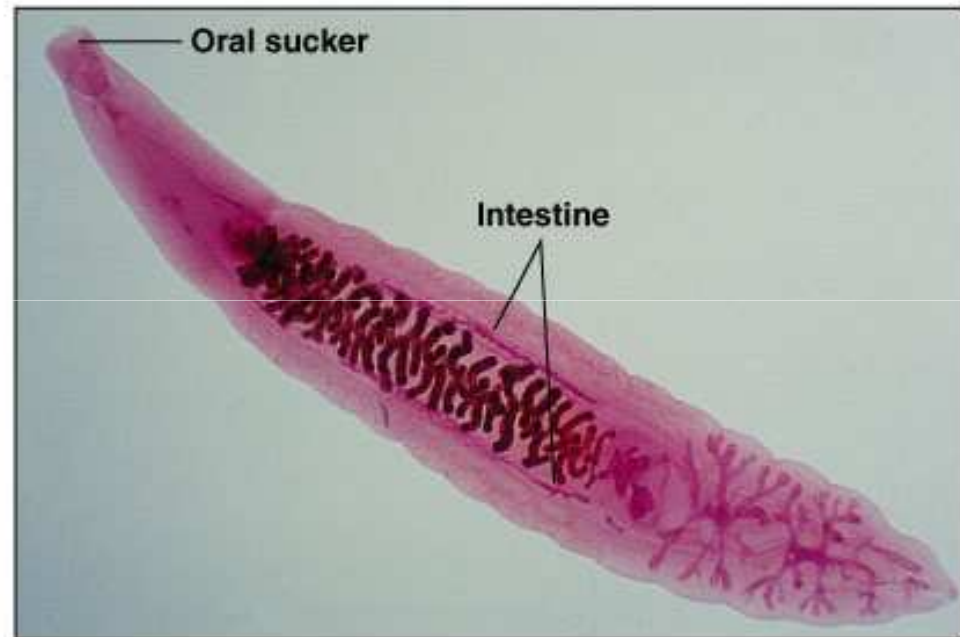
Helminths

- Normal Helminths –
 - Free living
 - Soil or water
 - Decomposers
- Parasitic worms
 - Multicellular animals
 - microscopic diagnostic stages
 - usually eggs or larvae
 - Dependent on host - Chemoheterotrophic
- Kingdom: Animalia
 - Phylum: Platyhelminthes (flatworms)
 - Class: Trematodes (flukes)
 - Class: Cestodes (tapeworms)
 - Phylum: Nematodes (roundworms)

Trematodes

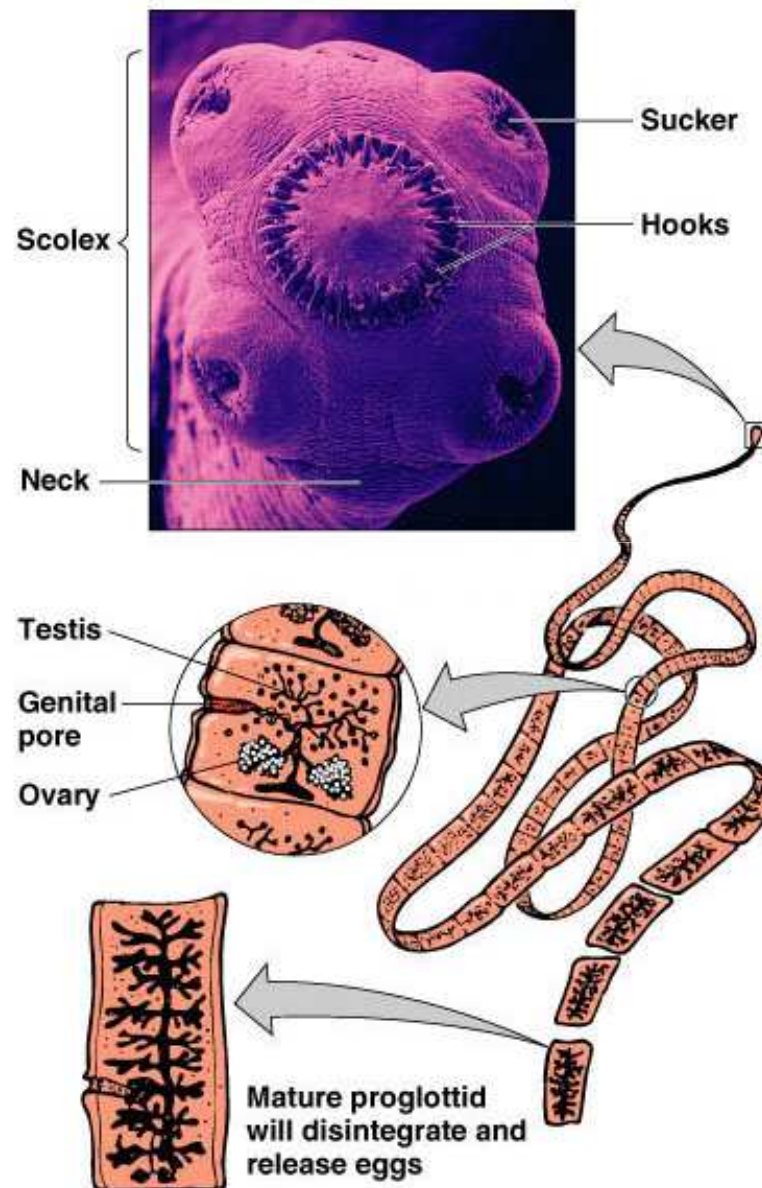


(a) Fluke anatomy

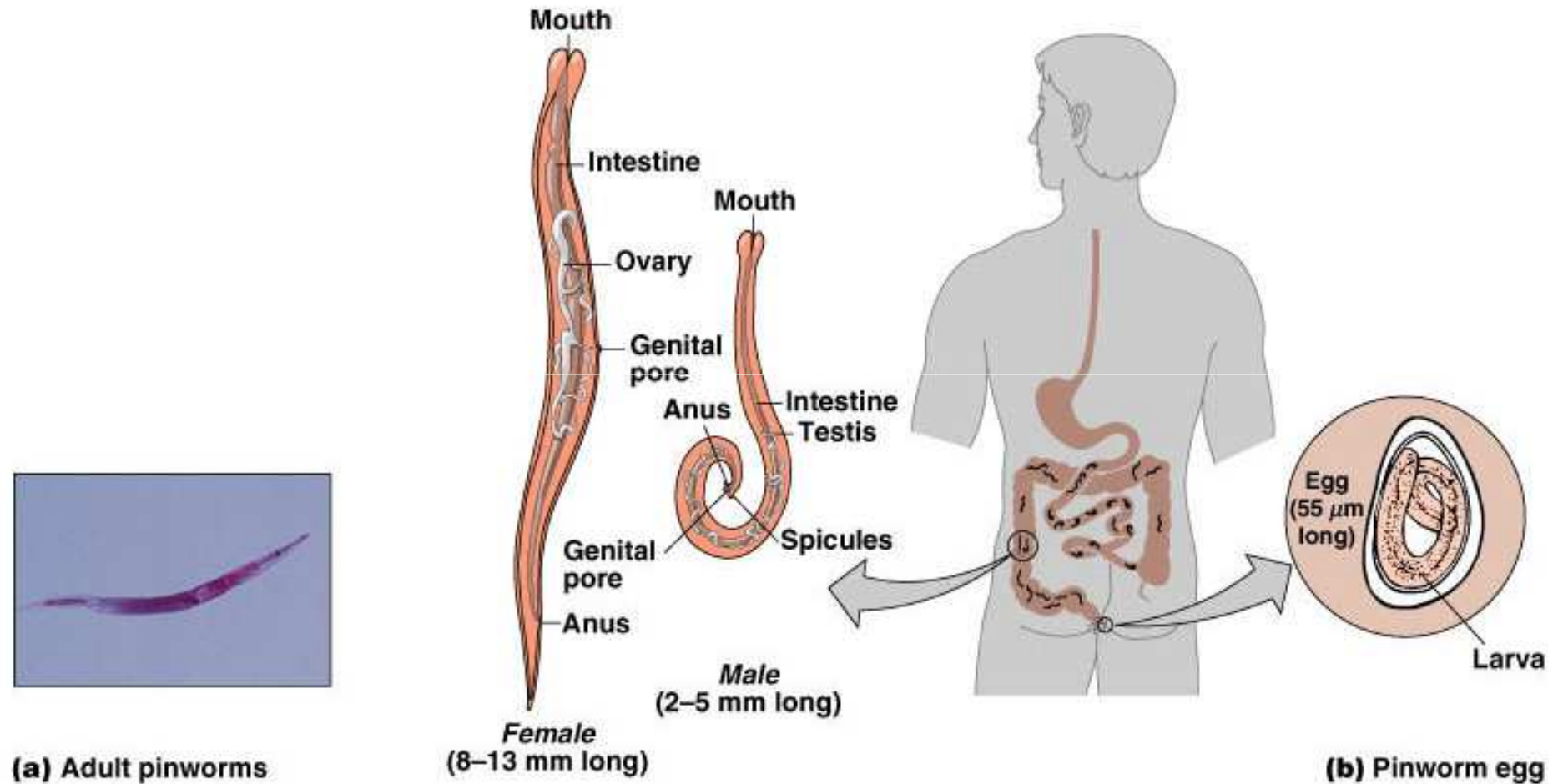


(b) *Clonorchis sinensis*

Cestodes



Nematodes: Eggs Infective for Humans



Arthropods as Vectors

- Vectors = animals that carry and transmit microscopic pathogens
- Kingdom: Animalia
 - Phylum: Arthropoda (exoskeleton, jointed legs)
 - Class: Insecta (6 legs)
 - Lice, fleas, mosquitoes
 - Class: Arachnida (8 legs)
 - Mites and ticks
 - May transmit diseases (vectors)



(a) Female mosquito



Figure 12.31, 32

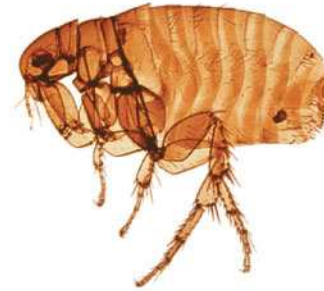
Arthropods as Vectors



(a)



(b)



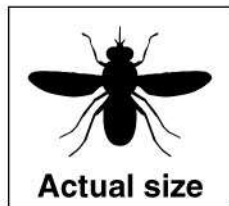
(c)



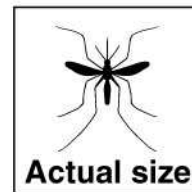
(d)



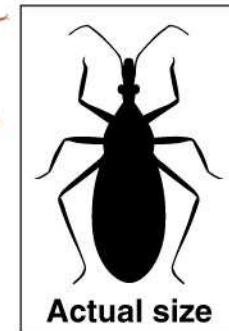
(e)



(f)



(g)



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The Eukaryotes

TABLE 12.1	Major Differences Among Eukaryotic Microorganisms: Fungi, Algae, Protozoa, and Helminths			
	Fungi	Algae	Protozoa	Helminths
Kingdom	Fungi	Protist	Protist	Animalia
Nutritional type	Chemoheterotroph	Photoautotroph	Chemoheterotroph	Chemoheterotroph
Multicellularity	All, except yeasts	Some	None	All
Cellular arrangement	Unicellular, filamentous, fleshy (such as mushrooms)	Unicellular, colonial, filamentous; tissues	Unicellular	Tissues and organs
Food acquisition method	Absorptive	Absorptive	Absorptive; ingestive (cytostome)	Ingestive (mouth); absorptive
Characteristic features	Sexual and asexual spores	Pigments	Motility; some form cysts	Many have elaborate life cycles, including egg, larva, and adult
Embryo formation	None	None	None	All