

Characterizing & Classifying Eukaryotes

Chapter 12 Abbreviated
CCV
Microbiology

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General Characteristics of Eukaryotic Organisms

- Eukaryotic microorganisms
 - Protozoa
 - Fungi
 - Algae
 - Water molds
 - Slime molds
- Include both human pathogens and organisms vital for human life

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General Characteristics of Eukaryotic Organisms

■ Reproduction of Eukaryotes

- More complicated than that in prokaryotes
 - Eukaryotic DNA is packaged as chromosomes in the nucleus
 - Have variety of methods of asexual reproduction
 - Many reproduce sexually by forming gametes and zygotes
 - Algae, fungi, and some protozoa reproduce both sexually and asexually

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General Characteristics of Eukaryotic Organisms

■ Reproduction of Eukaryotes

- Nuclear division
 - Nucleus has one or two complete copies of genome
 - Single copy (haploid)
 - Most fungi, many algae, some protozoa
 - Two copies (diploid)
 - Other fungi, algae, and protozoa
 - Two types
 - Mitosis
 - Meiosis

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General Characteristics of Eukaryotic Organisms

Reproduction of Eukaryotes

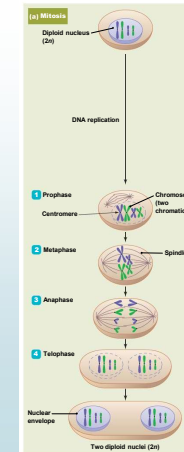
Nuclear division

Mitosis

- Cell partitions that replicate DNA equally between two nuclei
- Maintains ploidy of parent nucleus
- Four phases
 - Prophase
 - Metaphase
 - Anaphase
 - Telophase

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Figure 12.1a The two kinds of nuclear division: mitosis and meiosis.



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General Characteristics of Eukaryotic Organisms

Reproduction of Eukaryotes

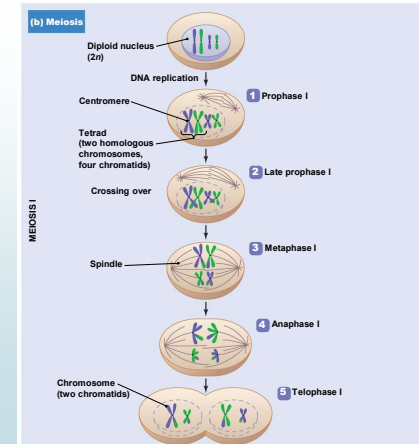
Nuclear division

Meiosis

- Nuclear division that partitions chromatids into four nuclei
- Diploid nuclei produce haploid daughter nuclei
- Two stages – meiosis I and meiosis II
- Each stage has four phases
 - Prophase
 - Metaphase
 - Anaphase
 - Telophase

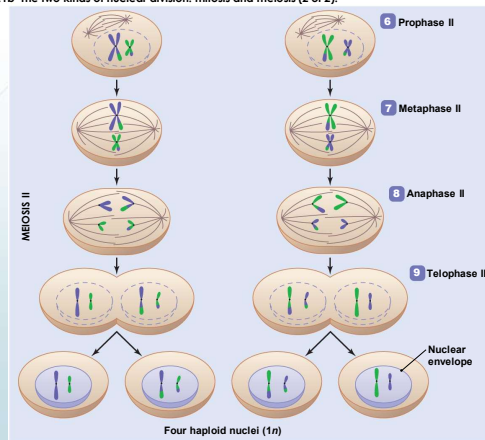
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Figure 12.1b The two kinds of nuclear division: mitosis and meiosis (1 of 2).



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Figure 12.1b The two kinds of nuclear division: mitosis and meiosis (2 of 2).



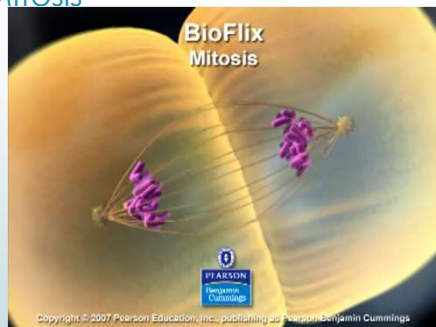
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TABLE 12.1 Characteristics of the Two Types of Nuclear Division

	Mitosis	Meiosis
DNA replication	During interphase, before nuclear division	During interphase, before meiosis I begins
Phases	Prophase, metaphase, anaphase, telophase	Meiosis I—prophase I, metaphase I, anaphase I, telophase I Meiosis II—prophase II, metaphase II, anaphase II, telophase II
Formation of tetrads (alignment of homologous chromosomes)	Does not occur	Early in prophase I
Crossing over	Does not occur	Following formation of tetrads during prophase I
Number of accompanying cytoplasmic divisions that may occur	One	Two
Resulting nuclei	Two nuclei with same ploidy as the original	Four nuclei with half the ploidy of the original

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Mitosis



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Meiosis



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General Characteristics of Eukaryotic Organisms

Reproduction of Eukaryotes

- Cytokinesis (cytoplasmic division)
 - Typically occurs simultaneously with telophase of mitosis
 - In some algae and fungi, is postponed or does not occur at all
 - Results in multinucleated cells called coenocytes

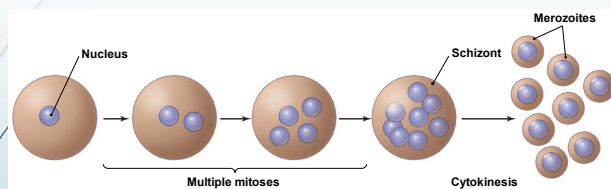
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Figure 12.2 Different types of cytoplasmic division.



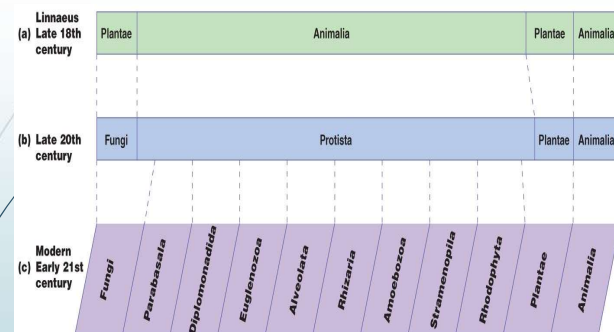
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Schizogony—as occurs in *Plasmodium*



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The changing classification of eukaryotes over the centuries



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Protozoa

Defined: single-celled eukaryotes that lack a cell wall and are similar to animals in their nutritional needs & structure

- Diverse group defined by three characteristics
 - Eukaryotic
 - Unicellular
 - Lack a cell wall
- Motile by means of cilia, flagella, and/or pseudopods
 - Except a subgroup: apicomplexans

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Protozoa

■ Distribution of Protozoa

- Require moist environments
- Most live in ponds, streams, lakes, and oceans
 - Critical members of plankton
- Others live in moist soil, beach sand, and decaying organic matter
- Very few are pathogens

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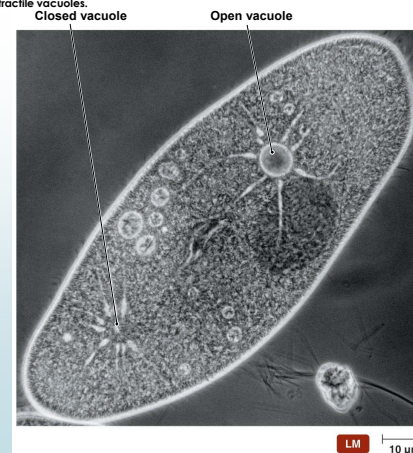
Protozoa

■ Morphology of Protozoa

- Great morphological diversity
- Some have two nuclei
 - Macronucleus
 - Contains many copies of the genome
 - Controls metabolism, growth, & sexual reproduction
 - Micronucleus
 - Involved in genetic recombination, sexual reproduction & regeneration of macronucleus
- Variety in number and kinds of mitochondria
- Some have contractile vacuoles that pump water out of cells
- Different stages in life cycle
 - Motile feeding stage called a *trophozoite*
 - Resting stage called a *cyst*

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Figure 12.5 Contractile vacuoles.



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Protozoa

► Nutrition of Protozoa

- Most are chemoheterotrophic
 - Obtain nutrients by phagocytizing bacteria, decaying organic matter, other protozoa, or the tissues of host
- Few absorb nutrients from surrounding water
- Dinoflagellates and euglenoids are photoautotrophic

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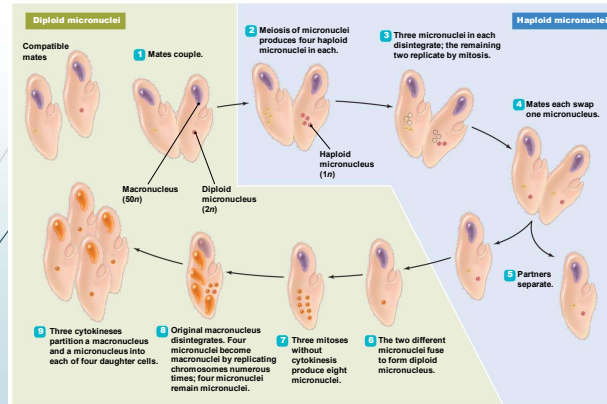
Protozoa

► Reproduction of Protozoa

- Most reproduce only asexually
 - Binary fission or schizogony
- Few also have sexual reproduction
 - Some become gametocytes that fuse to form diploid zygotes
 - Some utilize a process called *conjugation*

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Figure 12.6 Sexual reproduction via conjugation in ciliates.



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Protozoa

► Classification of Protozoa

- Classification of protozoa has shifted over the years
- Revised and updated based on 18S rRNA sequences (on small 40S ribosomal subunit)
- One current scheme groups protozoa into six groups
 - Parabasala
 - Diplomonadida
 - Euglenozoa
 - Alveolates
 - Rhizaria
 - Amoebozoa

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TABLE 12.2 Characteristics of Protozoa

Category	Distinguishing Features	Representative Genera Mentioned in the Text
Parabasal	Parabasal body; single nucleus; lack mitochondria	<i>Trichomonas</i>
Diplomonadida	Two equal-sized nuclei; lack mitochondria, Golgi bodies, and peroxisomes	
Diplomonads	Multiple flagella	<i>Giardia</i>
Euglenozoa	Flagella with internal crystalline rod; disk-shaped mitochondrial cristae	
Euglenids	Photosynthesis; pellicle; "eyespot"	<i>Euglena</i>
Kinetoplastids	Single mitochondrion with DNA localized in kinetoplast	<i>Trypanosoma</i> , <i>Leishmania</i>
Alveolates	Alveoli (membrane-bound cavities underlying the cytoplasmic membrane); tubular cristae in mitochondria	
Ciliates	Cilia	<i>Balantidium</i> , <i>Paramecium</i> , <i>Didinium</i>
Apicomplexans	Apical complex of organelles	<i>Plasmodium</i> , <i>Cryptosporidium</i> , <i>Toxoplasma</i>
Dinoflagellates	Photosynthesis; two flagella; internal cellulose plates	<i>Gymnodinium</i> , <i>Gonyaulax</i> , <i>Pfiesteria</i>
Rhizaria	Threadlike pseudopods	
Foraminifera	Shells of calcium carbonate	
Radiolarians	Threadlike pseudopods, shells of silica	
Amoebozoa	Lobe-shaped pseudopods; no shells	
Free-living and parasitic forms	Do not form aggregates	<i>Naegleria</i> , <i>Acanthamoeba</i> , <i>Entamoeba</i>
Plasmodial (acellular) slime molds	Multinucleate body called plasmodium	<i>Physarum</i>
Cellular slime molds	Cells aggregate to form pseudoplasmodium but retain individual nature	<i>Dictyostelium</i>

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Fungi

- Chemoheterotrophic
- Have cell walls typically composed of chitin
- Do not perform photosynthesis
 - Lack chlorophyll
- Related to animals

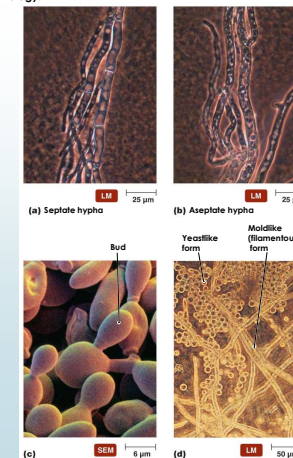
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Fungi

► The Significance of Fungi

- Decompose dead organisms and recycle their nutrients
- Help plants absorb water and minerals
- Used for food, in religious ceremonies, and in manufacture of foods and beverages
- Produce antibiotics and other drugs
- Serve as important research tools
- 30% cause diseases of plants, animals, and humans
- Can spoil fruit, pickles, jams, and jellies

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Figure 12.15 Fungal morphology.

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Fungi

■ Nutrition of Fungi

- Acquire nutrients by absorption
- Most are saprobes
- Some trap and kill microscopic soil-dwelling nematodes
- Haustoria allow some fungi to derive nutrients from living plants and animals
- Most fungi are aerobic
- Many yeasts are facultative anaerobes

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Fungi

■ Reproduction of Fungi

- All have some means of asexual reproduction involving mitosis and cytokinesis
- Most also reproduce sexually

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Fungi

■ Reproduction of Fungi

- Budding and asexual spore formation
 - Yeasts bud in manner similar to prokaryotic budding
 - Some yeasts produce long filament called a *pseudohypha*
 - Filamentous fungi produce lightweight spores that disperse over large distances
- Sexual spore formation
 - Fungal mating types designated as "+" and "-"
 - Four basic steps

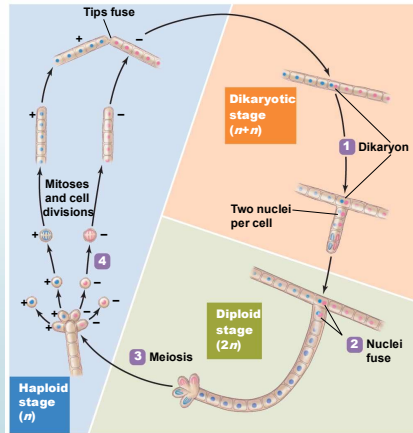
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Figure 12.18 Representative asexual spores of molds.



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Figure 12.19 The process of sexual reproduction in fungi.



Fungi

► Classification of Fungi

- Division Zygomycota
- Division Ascomycota
- Division Basidiomycota
- Deuteromycetes

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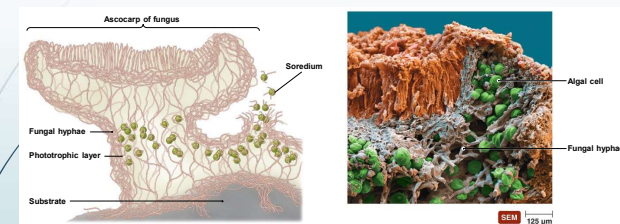
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Fungi

► Lichens

- Partnerships between fungi and photosynthetic microbes
 - Fungus provides nutrients, water, and protection
 - Photosynthetic microbe provides carbohydrates and oxygen
- Abundant throughout the world
- Grow in almost every habitat
- Occur in three basic shapes
 - Foliose, crustose, fruticose
- Create soil from weathered rocks
- Some lichens provide nitrogen in nutrient-poor environments
- Eaten by many animals

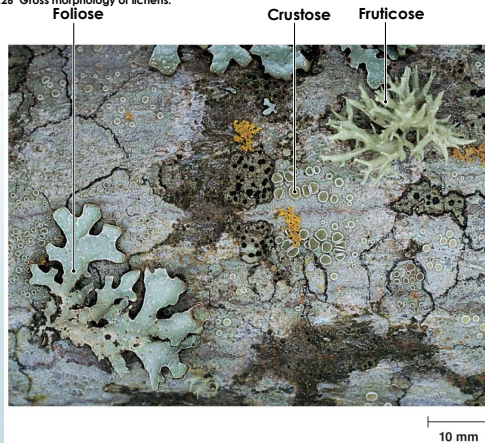
Figure 12.25 Makeup of a lichen.



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Figure 12.26 Gross morphology of lichens.



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TABLE 12.3 Characteristics of Fungi

Division and Type of Sexual Spore	Comments	Representative Genera
Zygomycota Zygospores	Coenocytic (aseptate)	<i>Rhizopus</i>
Ascomycota Ascospores	Septate; some associated with cyanobacteria or green algae to form lichens	<i>Claviceps</i> , <i>Neurospora</i> , <i>Penicillium</i> , <i>Saccharomyces</i> , <i>Tuber</i>
Basidiomycota Basidiospores	Septate	<i>Agaricus</i> , <i>Amanita</i> , <i>Cryptococcus</i>

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Algae

- Simple, eukaryotic phototrophs
- Carry out oxygenic photosynthesis using chlorophyll *a*
- Have sexual reproductive structures in which every cell becomes a gamete
- Differ widely in distribution, morphology, reproduction, and biochemical traits

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Algae

■ Distribution of Algae

- Most are aquatic
 - Live in the photic zone of freshwater, brackish water, and saltwater
- Have accessory photosynthetic pigments that trap energy of short-wavelength light
 - Allows algae to inhabit deep parts of the photic zone

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Algae

► Morphology of Algae

- Can have different morphologies
 - Unicellular
 - Colonial
 - Simple multicellular bodies called *thalli*

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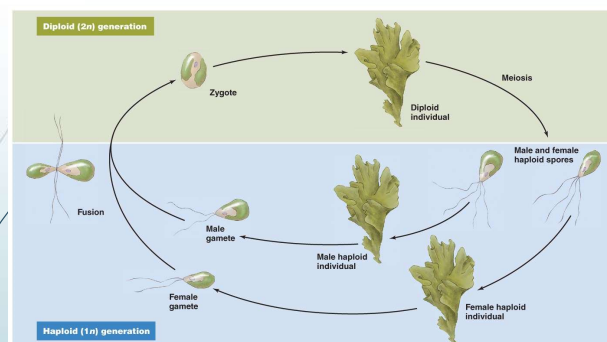
Algae

► Reproduction of Algae

- Reproduction in unicellular algae
 - Asexual reproduction involves mitosis followed by cytokinesis
 - In sexual reproduction, individual gametes form zygotes that undergo meiosis
- Reproduction in multicellular algae
 - Reproduce asexually by fragmentation
 - Reproduce sexually with alternation of generations

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Figure 12.27 Alternation of generations in algae, as occurs in the green alga *Ulva*.



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Algae

► Classification of Algae

- Classification is not settled
- Classification schemes are based on different features
 - Differences in photosynthetic pigments
 - Storage products
 - Cell wall composition
- Various groups
 - Division Chlorophyta
 - Kingdom Rhodophyta
 - Phaeophyta
 - Chrysophyta

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TABLE 12.4 Characteristics of Various Algae

Group (Common Name)	Kingdom	Pigments	Storage Product(s)	Cell Wall Component(s)	Habitat	Representative Genera
Chlorophyta (green algae)	Plantae	Chlorophylls a and b, carotene, xanthophylls	Sugar, starch	Cellulose or glycoprotein; absent in some	Fresh, brackish, and salt water; terrestrial	<i>Spirogyra</i> <i>Prototheca</i> <i>Codium</i> <i>Trebouxia</i>
Rhodophyta (red algae)	Rhodophyta	Chlorophyll a, phycoerythrin, phycocyanin, xanthophylls	Glycogen (floridean starch)	Agar or carrageenan, some with calcium carbonate	Mostly salt water	<i>Chondrus</i> <i>Gelidium</i> <i>Antithamnion</i>
Chrysophyta (golden algae, yellow-green algae, diatoms)	Stramenopila	Chlorophylls a, c ₁ , and c ₂ ; carotene; xanthophylls	Chrysolaminarin, oils	Cellulose, silica, calcium carbonate	Fresh, brackish, and salt water; terrestrial; ice	<i>Stephanodiscus</i>
Phaeophyta (brown algae)	Stramenopila	Chlorophylls a and c, carotene, xanthophylls	Laminarin, oils	Cellulose and alginic acid	Brackish and salt water	<i>Macrocystis</i>
Pyrrhophyta (dinoflagellates)	Alveolata	Chlorophylls a, c ₁ , c ₂ ; carotene	Starch, oils	Cellulose	Fresh, brackish, and salt water	<i>Gymnodinium</i> <i>Gonyaulax</i> <i>Pfiesteria</i>
Euglenophyta (euglenids)	Euglenozoa	Chlorophylls a and b, carotene	Paramylon, oils, sugar	Absent	Fresh, brackish, and salt water; terrestrial	<i>Euglena</i>

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Water Molds

- Differ from fungi in several ways
 - Have tubular cristae in their mitochondria
 - Cell walls are of cellulose instead of chitin
 - Spores have two flagella
 - Have true diploid bodies
- Decompose dead animals and return nutrients to the environment
- Some species are pathogens of crops
 - *Phytophthora infestans* caused the Irish potato famine

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Figure 12.32 An example of the important role of water molds in recycling organic nutrients in aquatic habitats.

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Other Eukaryotes of Microbiological Interest: Parasitic Helminths and Vectors

- Parasitic worms have microscopic infective and diagnostic stages
- Arthropod vectors are animals that carry pathogens
 - Mechanical vectors
 - Biological vectors
- Disease vectors belong to two classes of arthropod
 - Arachnida
 - Insecta

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Other Eukaryotes of Microbiological Interest: Parasitic Helminths and Vectors

► Arachnids

- Adult arachnids have four pairs of legs
- Ticks are the most important arachnid vectors
 - Hard ticks are most prominent tick vectors
- A few mite species transmit rickettsial diseases

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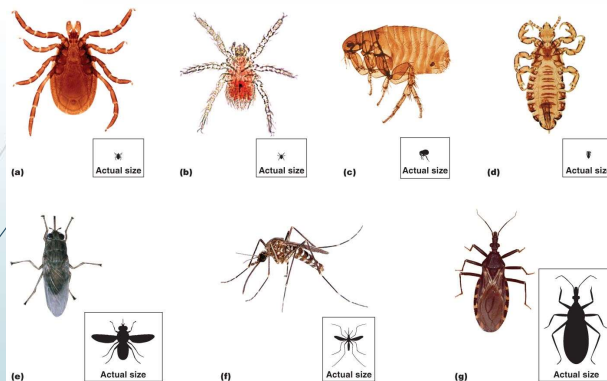
Other Eukaryotes of Microbiological Interest: Parasitic Helminths and Vectors

► Insects

- Adult insects have three pairs of legs and three body regions
- Include
 - Fleas
 - Lice
 - Flies
 - Mosquitoes
 - Most important arthropod vectors of disease
 - Kissing bugs

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Figure 12.33 Representative arthropod vectors.



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