Characterizing and Classifying Eukaryotes
General Characteristics of Eukaryotic Organisms

- Eukaryotic microorganisms
  - Protozoa
  - Fungi
  - Algae
  - Slime molds
  - Water molds

- Include both human pathogens and organisms vital for human life
General Characteristics of Eukaryotic Organisms

• **Reproduction of Eukaryotes**
  • More complicated than that in prokaryotes
    • Most eukaryotic DNA 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
General Characteristics of Eukaryotic Organisms

• **Reproduction in Eukaryotes**
  • Nuclear division
    • Nucleus has one or two complete copies of genome
      • Single copy (**haploid**)
        • Most fungi, many algae, some protozoa
      • Two copies (**diploid**)
        • Include plants, animals, fungi, algae, and protozoa
    • Two types
      • Mitosis
      • Meiosis
General Characteristics of Eukaryotic Organisms

• **Reproduction in Eukaryotes**
  • Nuclear division
    • **Mitosis**
      • Cell partitions replicated DNA equally between two nuclei
      • Maintains ploidy of parent nucleus
    • Four phases
      • Prophase
      • Metaphase
      • Anaphase
      • Telophase
Figure 12.1a The two kinds of nuclear division: mitosis and meiosis.
General Characteristics of Eukaryotic Organisms

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

(b) Meiosis

Diploid nucleus (2n)

DNA replication

1. Prophase I

Tetrad (two homologous chromosomes, four chromatids)

2. Late prophase I

Crossing over

3. Metaphase I

4. Anaphase I

Chromosome (two chromatids)

5. Telophase I
Figure 12.1b  The two kinds of nuclear division: mitosis and meiosis (2 of 2).
Table 12.1  Characteristics of the Two Types of Nuclear Division

<table>
<thead>
<tr>
<th></th>
<th>Mitosis</th>
<th>Meiosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNA Replication</td>
<td>During interphase, before nuclear division</td>
<td>During interphase, before meiosis I begins</td>
</tr>
<tr>
<td>Phases</td>
<td>Prophase, metaphase, anaphase, telophase</td>
<td>Meiosis I—prophase I, metaphase I, anaphase I, telophase I Meiosis II—prophase II, metaphase II, anaphase II, telophase II</td>
</tr>
<tr>
<td>Formation of Tetrads (alignment of homologous chromosomes)</td>
<td>Does not occur</td>
<td>Early in prophase I</td>
</tr>
<tr>
<td>Crossing Over</td>
<td>Does not occur</td>
<td>Following formation of tetrads during prophase I</td>
</tr>
<tr>
<td>Number of Accompanying Cytoplasmic Divisions That May Occur</td>
<td>One</td>
<td>Two</td>
</tr>
<tr>
<td>Resulting Nuclei</td>
<td>Two nuclei with same ploidy as the original</td>
<td>Four nuclei with half the ploidy of the original</td>
</tr>
</tbody>
</table>
Mitosis

BioFlix™: Mitosis
General Characteristics of Eukaryotic Organisms

• **Reproduction in Eukaryotes**
  • Cytokinesis (cytoplasmic division)
    • Typically occurs simultaneously with telophase of mitosis
    • In some algae and fungi, postponed or does not occur at all
      • Results in multinucleated cells called **coenocytes**
Figure 12.2 Different types of cytoplasmic division.
Figure 12.3 Schizogony.
General Characteristics of Eukaryotic Organisms

• Classification of Eukaryotic Organisms
  • Early taxonomy schemes grouped organisms based on structural similarities
  • Modern classification is based more on similarities in nucleotide sequences
Figure 12.4 The changing classification of eukaryotes over the centuries.
General Characteristics of Eukaryotic Organisms

• **Tell Me Why**
  • Why is it incorrect to call mitosis “cell division?”
Protozoa

- 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
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
Protozoa

• Morphology of Protozoa
  • Great morphological diversity
  • Some have two nuclei
    • Macronucleus
      • Contains many copies of the genome
    • Micronucleus
  • 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
Figure 12.5 Contractile vacuoles.
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
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
Protozoa

- **Classification of Protozoa**
  - Classification of protozoa has shifted over the years
  - Revised and updated based on nucleotide sequences
  - One current scheme groups protozoa into six groups
    - Parabasala
    - Diplomonadida
    - Euglenozoa
    - Alveolates
    - Rhizaria
    - Amoebozoa
Protozoa

- **Classification of Protozoa**
  - Parabasala
    - Lack mitochondria
    - Have a single nucleus
    - Contain Golgi body–like structure called a parabasal body
    - Important parabasalids
      - *Trichonympha*
      - *Trichomonas*
Figure 12.6 *Trichonympha acuta*, a parabasalid with prodigious flagella.
Protozoa

- **Classification of Protozoa**
  - Diplomonadida
    - Lack mitochondria
      - Have *mitosomes* in the cytoplasm
      - Mitochondrial genes found in the nuclear chromosomes
    - Also lack Golgi bodies and peroxisomes
    - Have two equal-sized nuclei and multiple flagella
    - Prominent diplomonad
      - *Giardia*
Protozoa

• **Classification of Protozoa**
  
  • **Euglenozoa**
    
    • Characteristics of both plants and animals
    
    • Flagella contain a crystalline rod of unknown function
    
    • Mitochondria have disk-shaped cristae

  • Two groups
    
    • Euglenids
    
    • Kinetoplastids
Protozoa

• Classification of Protozoa
  • Euglenozoa
    • Euglenids
      • Photoautotrophic, unicellular microbes with chloroplasts
      • Historically classified as plants
      • Store food as polysaccharide called paramylon
    • Kinetoplastids
      • Have region of mitochondrial DNA called a kinetoplast
      • Some kinetoplastids are pathogenic
        • Trypanosoma
        • Leishmania
Figure 12.7 Two representatives of the kingdom Euglenozoa.
Protozoa

- **Classification of Protozoa**
  - Alveolates
    - Have membrane-bound cavities called alveoli
      - Purpose is unknown
    - Divided into three subgroups
      - Ciliates
      - Apicomplexans
      - Dinoflagellates
Figure 12.8 Membrane-bound alveoli found in some protozoa.
Protozoa

- Classification of Protozoa
  - Alveolates
  - Ciliates
    - Use cilia to move themselves or water
    - All are chemoheterotrophs and have two nuclei
    - Balantidium is the only ciliate pathogenic to humans
  - Apicomplexans
    - Chemoheterotrophic pathogens of animals
    - Complex of organelles allow them to penetrate host cells
    - Plasmodium, Cryptosporidium, and Toxoplasma cause disease in humans
Figure 12.9 A predatory ciliate, *Didinium* (left), devouring another ciliate, *Paramecium*.
Protozoa

• Classification of Protozoa
  • Alveolates
    • Dinoflagellates
      • Unicellular microbes with photosynthetic pigments
      • Historically classified as algae
      • Large proportion of freshwater and marine plankton
      • Motile dinoflagellates have two flagella
      • Many dinoflagellates are bioluminescent
      • Abundance in marine water is one cause of red tides
      • Some dinoflagellates produce neurotoxins
Figure 12.10 *Gonyaulax*, a motile armored dinoflagellate.
Protozoa

• Classification of Protozoa
  • Rhizaria
    • Amoebae are protozoa that move and feed with pseudopods
    • Amoebae exhibit little uniformity
    • Rhizaria are amoebae with threadlike pseudopods
      • Foraminifera
        • Often live attached to the ocean floor
        • Most are fossil species
      • Radiolaria
        • Have ornate shells of silica
        • Live as part of the marine plankton
Figure 12.11 Rhizaria called foraminifera (here, *Globigerina*) have multichambered, snail-like shells of calcium carbonate.
Figure 12.12  Radiolarians, a type of rhizaria.
Protozoa

• Classification of Protozoa
  • Amoebozoa
    • Amoebae with lobe-shaped pseudopods and no shells
    • Includes some human pathogens
      • *Naegleria*
      • *Acanthamoeba*
      • *Entamoeba*
    • Slime molds are now classified as amoebozoa
      • Two types
        • Plasmodial slime molds
        • Cellular slime molds
## Table 12.2 Characteristics of Protozoa

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

• Tell Me Why
  • Why did early taxonomists categorize such obviously different microorganisms as parabasalids, diplomonads, euglenozoa, alveolates, rhizaria, and amoebozoa in a single taxon, Protozoa?
Fungi

- Chemoheterotrophic
- Have cell walls typically composed of **chitin**
- Do not perform photosynthesis
  - Lack chlorophyll
- Related to animals
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
• Morphology of Fungi
  • Two basic body shapes
    • Molds—composed of long filaments called hyphae
    • Yeasts—small, globular, and composed of a single cell
  • Some fungi are **dimorphic**
    • Produce both yeastlike and moldlike shapes
    • Change in response to environmental conditions
Figure 12.13  Fungal morphology.

(a) Septate hypha

(b) Aseptate hypha

(c) Yeast cells’ buds

(d) Dimorphic fungus
Figure 12.14  A fungal mycelium.
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
Figure 12.15 Predation of a nematode by the fungus *Drechslerella*.
Fungi

• Reproduction in Fungi
  • All have some means of asexual reproduction involving mitosis and cytokinesis
  • Most also reproduce sexually
• **Reproduction in 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
    
    • Asexual spores of molds grouped by mode of development
Figure 12.16 Representative asexual spores of molds.
Fungi

• **Reproduction in Fungi**
  • Sexual spore formation
    • Fungal mating types designated as “plus” and “minus”
  • Four basic steps
Figure 12.17  The process of sexual reproduction in fungi.
• **Dr. Bauman’s Microbiology Video Tutor**
  • For more information, listen to Dr. Bauman describe the main stages of sexual reproduction in fungi.
Fungi

• Classification of Fungi
  • Division Zygomycota
  • Division Ascomycota
  • Division Basidiomycota
  • Deuteromycetes
Fungi

• **Classification of Fungi**
  • Division Zygomycota
    • 1100 known species
    • Most are saprobes
    • Others are obligate parasites of insects and other fungi
    • Reproduce asexually via sporangiospores
  • Microsporidia
    • Once classified as protozoa
    • More similar to zygomycetes by genetic analysis
    • Obligate intracellular parasites
      • Spread as small, resistant spores
Figure 12.18 Zygosporangium.
Fungi

- **Classification of Fungi**
  - Division Ascomycota
    - 32,000 known species
    - Ascomycetes form *ascospores* in sacks called *asci*
    - Also reproduce by conidiospores
    - Includes most of the fungi that spoil food
    - Some infect plants and humans
    - Many are beneficial
      - *Penicillium*
      - *Saccharomyces*
Figure 12.19 Ascocarps (fruiting bodies) of the common morel, *Morchella esculenta*.
Fungi

• Classification of Fungi
  • Division Basidiomycota
    • 22,000 known species
    • Mushrooms and other fruiting bodies of basidiomycetes called **basidiocarps**
  • Basidiomycetes affect humans in several ways
    • Most are decomposers that return nutrients to the soil
    • Many mushrooms produce toxins or hallucinatory chemicals
    • Some cause expensive crop damage
Figure 12.20 Basidiocarps (fruiting bodies).
• **Classification of Fungi**
  • **Deuteromycetes**
    • Heterogeneous collection of fungi with unknown sexual stages
    • Most deuteromycetes belong to the division Ascomycota based on rRNA analysis
    • No longer considered a formal taxon
• **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 12.21  Makeup of a lichen.
Figure 12.22  Gross morphology of lichens.
<table>
<thead>
<tr>
<th>Division and Type of Sexual Spore</th>
<th>Distinguishing Features</th>
<th>Representative Genera</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Zygomycota</strong></td>
<td>Multinucleate (aseptate)</td>
<td><strong>Rhizopus</strong></td>
</tr>
<tr>
<td>Zygosporas</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Ascomycota</strong></td>
<td>Septate; some associate with cyanobacteria or green algae to form lichens</td>
<td><strong>Claviceps</strong>, <strong>Neurospora</strong>, <strong>Penicillium</strong>, <strong>Saccharomyces</strong>, <strong>Tuber</strong></td>
</tr>
<tr>
<td>Ascospores</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Basidiomycota</strong></td>
<td>Septate</td>
<td><strong>Agaricus</strong>, <strong>Amanita</strong>, <strong>Cryptococcus</strong></td>
</tr>
<tr>
<td>Basidiosporas</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
• **Tell Me Why**
  
  Why isn’t a fungal dikaryon—with its two haploid \( n \) nuclei—considered diploid?
Algae

- Simple, eukaryotic photoautotrophs
- Have sexual reproductive structures in which every cell becomes a gamete
- Differ widely in distribution, morphology, reproduction, and biochemical traits
Algae

• Distribution of Algae
  • Most are aquatic
    • Live in the *photic zone* of fresh, brackish, and salt bodies of water
  • Have *accessory photosynthetic pigments* that trap energy of short-wavelength light
    • Allows algae to inhabit deep parts of the photic zone
Algae

- Morphology of Algae
  - Can have different morphologies
    - Unicellular
    - Colonial
    - Simple multicellular bodies
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*
Figure 12.23  Alternation of generations in algae, as occurs in the green alga *Ulva*.
Algae

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

• Classification of Algae
  • Division Chlorophyta (green algae)
    • Share numerous characteristics with plants
      • Have chlorophylls $a$ and $b$
      • Use sugar and starch as food reserves
      • Many have cell walls of cellulose
      • 18S rRNA sequences are similar
    • Most are unicellular and filamentous
      • Live in freshwater
    • Some multicellular forms grow in marine waters
Algae

• Classification of Algae
  • Kingdom Rhodophyta (red algae)
    • Have the red accessory pigment phycoerythrin
    • Use the storage molecule glycogen
    • Cell walls composed of agar or carrageenan
      • Both are used as thickening agents
    • Nonmotile male gametes called spermatia
    • Most are marine algae
Figure 12.24 *Pterothamnion plumula*, a red alga.
Algae

• **Classification of Algae**
  • Phaeophyta (brown algae)
    • Motile gametes have two flagella
    • Produce chlorophylls $a$ and $c$, carotene, and xanthophylls
    • Most are marine algae
    • Use *laminarin* and oils as food reserves
    • Cell walls composed of cellulose and **alginic acid**
      • Alginic acid is used medically and as a thickening agent
Figure 12.25  Hairy flagellum.
Figure 12.26  Portion of the giant kelp *Macrocystis*, a brown alga.
Algae

• Classification of Algae
  • Chrysophyta (golden algae, yellow-green algae, and diatoms)
    • All use *chrysolaminarin* as a storage product
    • Produce more carotene than chlorophylls
    • Now grouped with brown algae and water molds
    • Include diatoms
      • Component of marine *phytoplankton*
      • Major source of the world’s oxygen
Figure 12.27 *Paralia sulcata*, a diatom.
## Table 12.4 Characteristics of Various Algae

<table>
<thead>
<tr>
<th>Group (Common Name)</th>
<th>Kingdom</th>
<th>Pigments</th>
<th>Storage Product(s)</th>
<th>Cell Wall Component(s)</th>
<th>Habitat</th>
<th>Representative Genera</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chlorophyta</strong></td>
<td>Plantae</td>
<td>Chlorophylls a and b, carotene, xanthophylls</td>
<td>Sugar, starch</td>
<td>Cellulose or glycoprotein; absent in some</td>
<td>Freshwater, brackish water, and saltwater; terrestrial</td>
<td>Spirogyra, Prototheca, Codium, Trebouxia</td>
</tr>
<tr>
<td><strong>Rhodophyta</strong></td>
<td>Rhodophyta</td>
<td>Chlorophyll a, phycoerythrin, phycocyanin, xanthophylls</td>
<td>Glycogen</td>
<td>Agar or carrageenan, some with calcium carbonate</td>
<td>Mostly saltwater</td>
<td>Chondrus, Gelidium, Antithamnion</td>
</tr>
<tr>
<td><strong>Phaeophyta</strong></td>
<td>Stramenopila</td>
<td>Chlorophylls a and c, carotene, xanthophylls</td>
<td>Laminarin, oils</td>
<td>Cellulose and alginic acid</td>
<td>Brackish water and saltwater</td>
<td>Macrocystis</td>
</tr>
<tr>
<td><strong>Chrysophyta</strong></td>
<td>Stramenopila</td>
<td>Chlorophylls a, c₁, and c₂; carotene; xanthophylls</td>
<td>Chrysolaminarin, oils</td>
<td>Cellulose, silica, calcium carbonate</td>
<td>Freshwater, brackish water, and saltwater; terrestrial; ice</td>
<td>Stephanodiscus</td>
</tr>
</tbody>
</table>
Algae

• **Tell Me Why**
  • Why aren’t there large numbers of pathogenic algae?
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 rather than haploid bodies

• Decompose dead animals and return nutrients to the environment

• Some species are pathogens of crops
  • *Phytophthora infestans* caused the Irish potato famine
Figure 12.28 Water molds help recycle organic nutrients in aquatic habitats.
Water Molds

• **Tell Me Why**

  • How do scientists know that water molds are more closely related to brown algae than to true molds?
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
Figure 12.29 Representative arthropod vectors.
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.
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
Other Eukaryotes of Microbiological Interest: Parasitic Helminths and Vectors

• **Tell Me Why**
  • Why are large eukaryotes such as mosquitoes and ticks considered in a microbiology class?