

Chapter 5 - Eukaryotic microorganisms

Some things to think about as we discuss the difference between prokaryotic and eukaryotic organisms

Relate importance of differences between prokaryotic pathogens and eukaryotic victims and similarities of eukaryotic pathogens and victims relative to treatment of disease

Note the organelles and their function

Endosymbiotic Hypothesis

- Explains the origin of eukaryotic organelles
- Eukaryotic cells arose from engulfing smaller prokaryotic (bacteria) cells
- Symbiosis so perfect that relationship ended up into a single functioning cell

Table 5.1

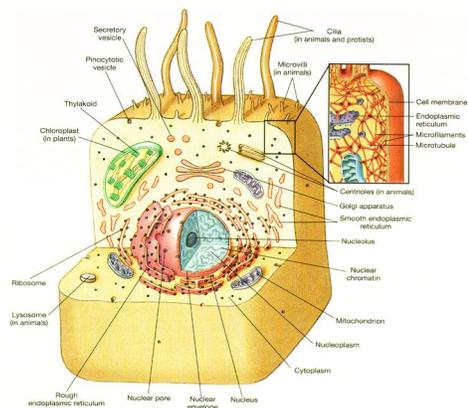
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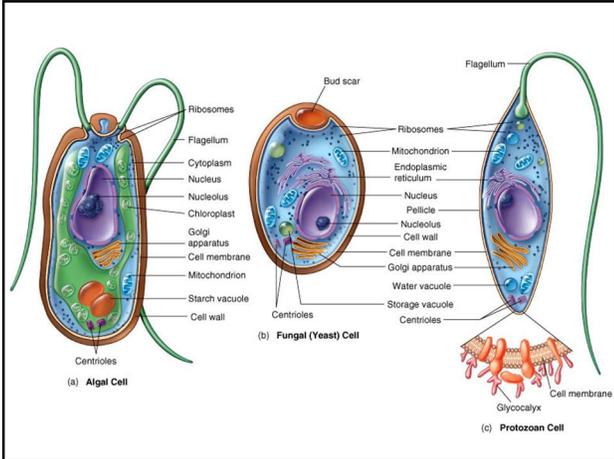
TABLE 5.1 Eucaryotic Organisms Studied in Microbiology

Always Unicellular	May Be Unicellular or Multicellular	Always Multicellular
Protozoa	Fungi Algae	Helminths (have unicellular egg or larval forms)

Eukaryotes

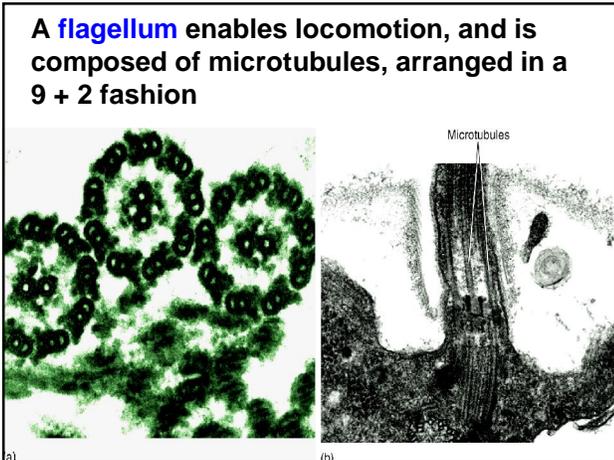
- External and internal structures are more complex than prokaryotes
- Examples of eukaryotes
 - Yeast
 - Protozoa
 - Algae
 - Helminths
 - Animal cells



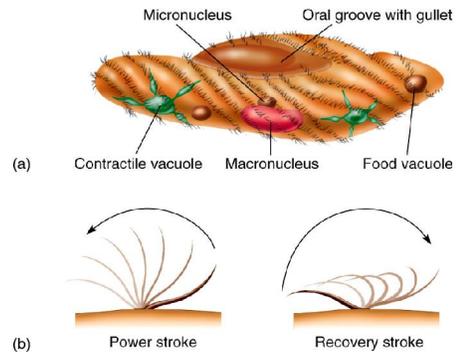


External Structures

- Appendages
 - Flagella (Microtubules and Microfilaments)
 - Cilia
- Glycocalyx
- Cell wall
- Cell membrane



- *Paramecium* have cilia which are similar to flagella but are smaller and more numerous
- Similar 9+2 arrangement

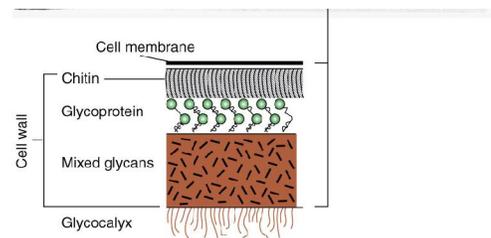


Glycocalyx

- Similar to prokaryotes
- Composed of polysaccharides
- Slime layer or capsule
- **Role:** protection, adherence to surfaces, reception of signals from other cells and the environment

Cell Wall

- Present in some fungi and algae
- Made of cellulose or chitin



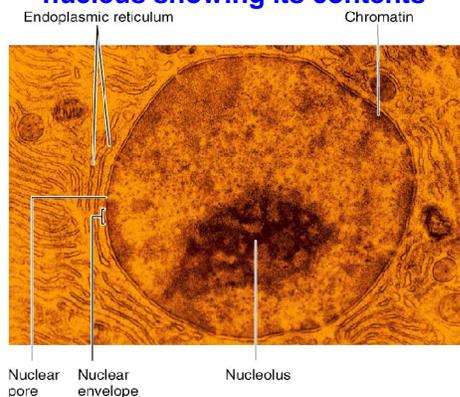
Internal Structures

- Nucleus
- Endoplasmic reticulum
- Golgi apparatus
- Mitochondria
- Chloroplast (photosynthetic cells only)
- Ribosomes
- Cytoskeleton

Nucleus

- **Membrane bound** organelle
- **Chromatin**- chromosomal DNA
- **Nucleolus**- site for RNA synthesis
- **Histones**-proteins that associate with DNA during mitosis

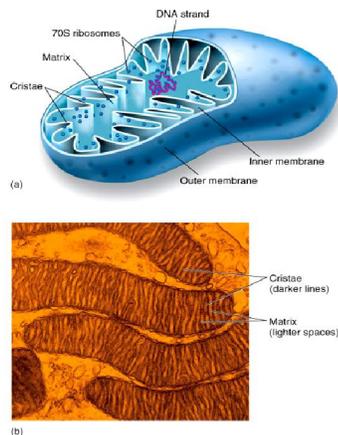
An electron micrograph section of the nucleus showing its contents



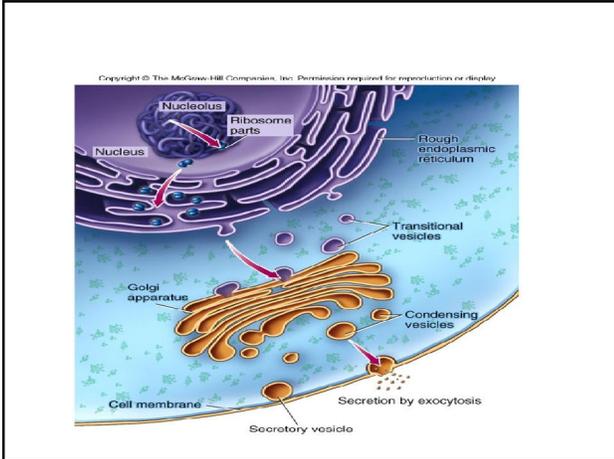
Mitochondria

- Site of **energy generation**
- **Cristae**-folds of the inner membrane
- **Matrix**-consist of ribosomes, DNA, and enzymes
- **Note the similarity to a single bacterial cell!** Eukaryotic *mitochondria* contain prokaryotic ribosomal material

The structure of the mitochondria and its contents



- **Endoplasmic Reticulum** – Two kinds, Rough (RER) and Smooth (SER)
- **RER** – due to presence of ribosomes – Protein synthesis
- **SER** – Synthesis of lipids
- **RIBOSOMES** - 60S and 40S subunits = 100S ribosome
- **GOLGI APPARATUS** – Modification and packaging of molecules



Chloroplast

- **Site of photosynthesis**
- Thylakoids- folded membrane containing the green pigment chlorophyll
- Stroma- surrounds the thylakoids

Chloroplasts transform solar energy to chemical energy, which is then used to synthesize carbohydrates

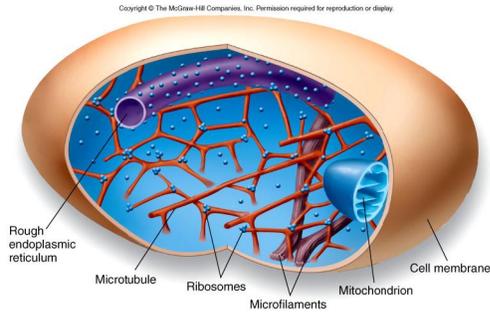
Eucaryotic cell division involves mitosis, in which the cell and nucleus undergo several stages of change.

- Lysosomes contain enzymes for digestion of food particles.
- Originate from Golgi

Cytoskeleton

- Anchor organelles
- Cellular structural support
- Enable cell shape changes
- Two types
 - **Microfilaments**
 - **Microtubules**

Microfilaments allow movement of molecules in the cytoplasm, and microtubules maintain shape of the cell and enable movement of molecules within the cell.

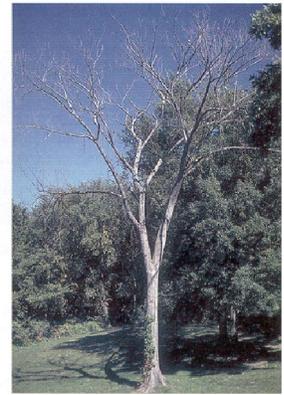


Eukaryotic Pathogens

Fungi

- Present in nature (ex. mushrooms)
- Medically important (ex. athlete's foot)
- Industrially important (ex. fermentation)
- Fungi can cause disease in plants - Dutch elm disease in elm trees - or humans - aspergillosis, candidiasis, histoplasmosis, coccidiomycosis
- Fungi produce antimicrobics - penicillin
- Fungi are facultative parasites - never obligate!

The scourge of a
Montana State
Mad Scientist!!!!

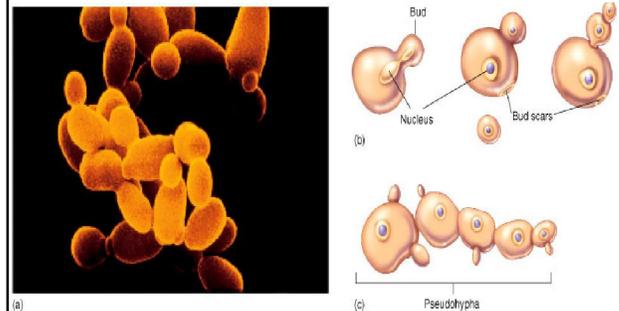


> Figure 11.9 Dutch elm disease. American elms (*Ulmus americana*) killed by Dutch elm disease.

Fungi

- Classification
 - Morphology - dimorphism yeast or hyphal
 - Reproduction (asexual and sexual)
 - Budding is most straightforward example of fungal reproduction

A scanning electron micrograph of yeast cells, and the budding reproductive process



Morphology and Reproduction

- Hyphae cell
 - Septate
 - Nonseptate
- Yeast cells
 - Single cells
 - Pseudohypha
- Reproduction
 - **Asexual** and **sexual** process - mostly dealing with spores

Mushrooms undergo sexual spore formation

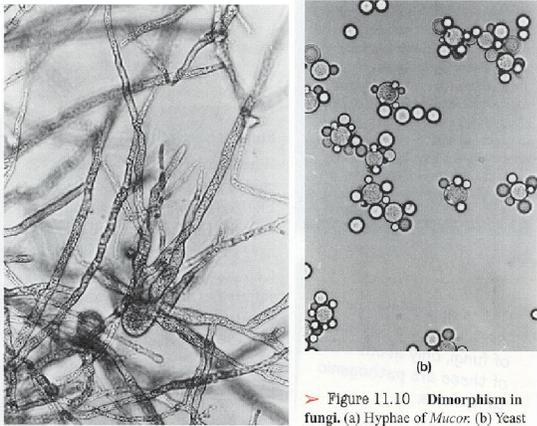
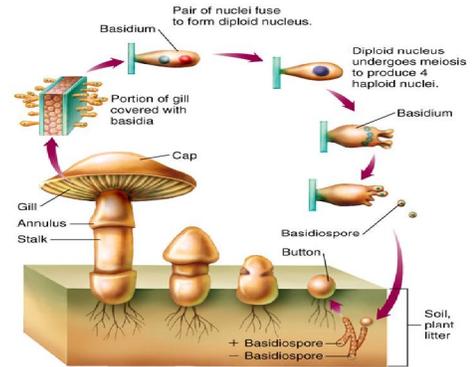
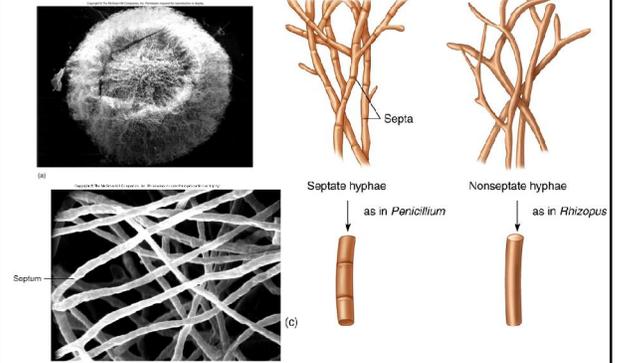


Figure 11.10 Dimorphism in fungi. (a) Hyphae of *Mucor*. (b) Yeast form of *Mucor*.

A scanning electron micrograph of the hyphae cells



Fungi are capable of causing superficial and systemic infection

TABLE 5.2 Major Fungal Infections of Humans		
Degree of Tissue Involvement and Area Affected	Name of Infection	Name of Causative Fungus
Superficial (not deeply invasive)		
Outer epidermis	Tinea versicolor	<i>Malassezia furfur</i>
Epidermis, hair, and dermis can be attacked	Dermatophytosis, also called tinea or ringworm of the scalp, body, feet (athlete's foot), toenails	<i>Microsporum</i> , <i>Trichophyton</i> , and <i>Epidermophyton</i>
Mucous membranes, skin, nails	Candidiasis, or yeast infection	<i>Candida albicans</i>
Systemic (deep; organism enters lungs; can invade other organs)		
Lung	Coccidioidomycosis (San Joaquin Valley fever)	<i>Coccidioides immitis</i>
	North American blastomycosis (Chicago disease)	<i>Blastomyces dermatitidis</i>
	Histoplasmosis (Ohio Valley fever)	<i>Histoplasma capsulatum</i>
	Cryptococcosis (torulosis)	<i>Cryptococcus neoformans</i>
Lung, skin	Paracoccidioidomycosis (South American blastomycosis)	<i>Paracoccidioides brasiliensis</i>

Fungal infection caused by a soil microorganism



Tinea cruris – ringworm infection, a fungal infection



> Figure 19.14 *Tinea cruris*, ringworm of the groin (“jock itch”). This infection is caused by the fungus *Trichophyton*.

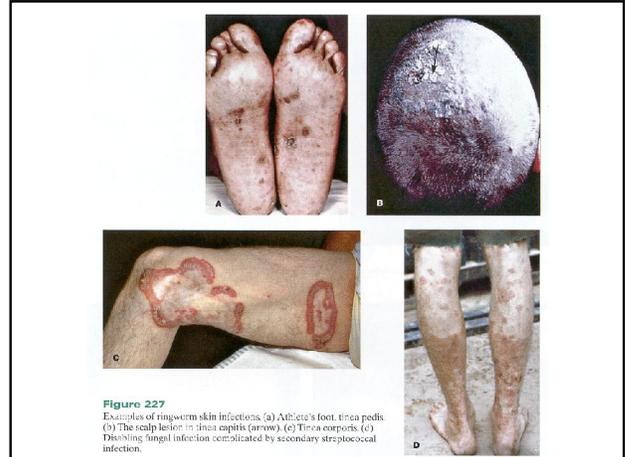


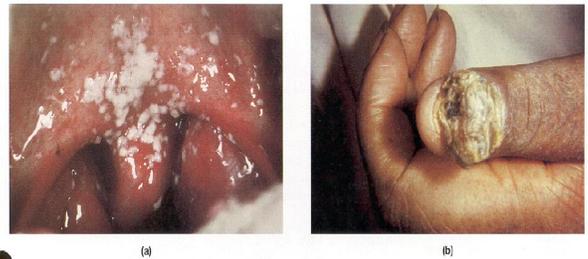
Figure 227
Examples of ringworm skin infections. (a) Athlete's foot, tinea pedis. (b) The scalp lesion is tinea capitis (arrow). (c) Tinea corporis. (d) Disabling fungal infection complicated by secondary streptococcal infection.

Blastomycosis lesions



> Figure 19.16 Blastomycosis lesions. (a) Before treatment; (b) after treatment with antifungal drugs.

Candidiasis



> Figure 19.16 Candidiasis. (a) *Candida* infections of the oral cavity (thrush), seen as white patches, are a common complication of AIDS, diabetes, and prolonged antibiotic therapy. (b) *Candida* infections of the nails are very difficult to eradicate.

Algae

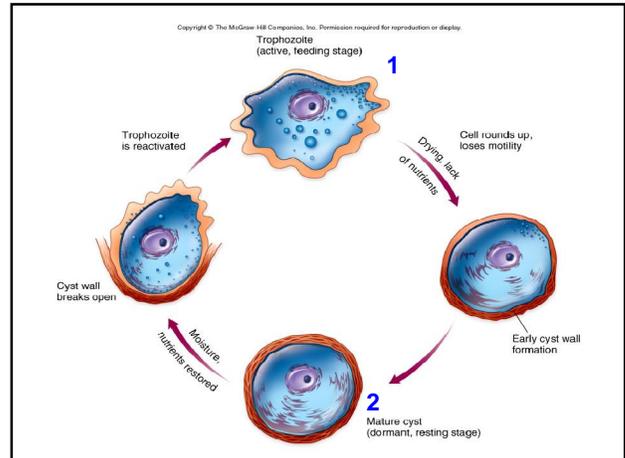
- Photosynthetic
- Inhabitants of fresh and marine waters
- **Most are not considered human pathogens**
- Pathogens produce toxins (ex. red tide) -- *Pfiesteria*
- Unique morphology enables identification

Medically important protozoa

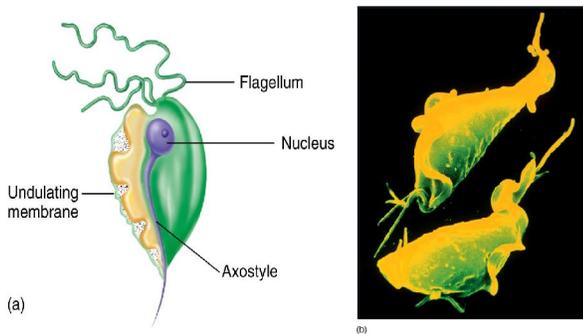
- Amoeboid protozoa
 - Brain infections -
- Flagellated protozoa
 - Giardiasis
- Apicomplexan protozoa
 - Malaria

Protozoa- the classical idea of a parasite

- Complex structure and function
 - Pseudopods, flagella, cilia
- Inhabitants of fresh water and soil
- Reproduction (asexual)
 - Trophozoite
 - Encystment



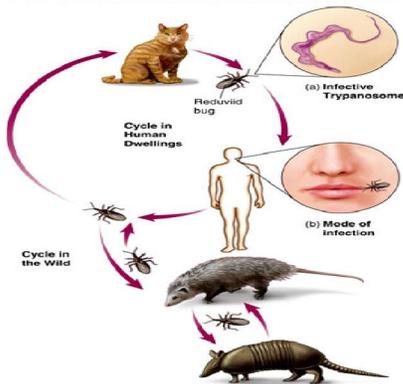
Trichomonas vaginalis - a human sexually transmitted disease



Medically important protozoa

- Flagellated protozoa
 - Giardiasis
 - Trypanosomes
- Apicomplexan protozoa
 - Malaria

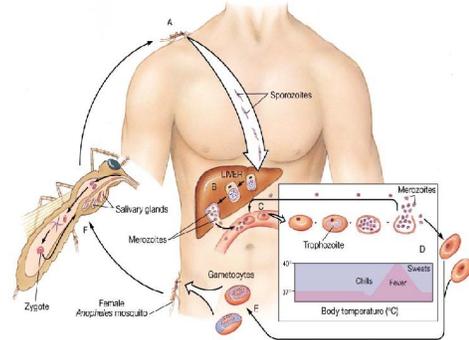
Life cycle of *Trypanosoma cruzi* – causative agent of Chagas disease



- The causative agent of malaria is an animal-like protist and is a member of the apicomplexans.
- The causative agent is any of several species of *Plasmodium*. When a female *Anopheles* mosquito bites a human it transmits sporozoites from its salivary glands into the blood of the human.
- The sporozoites go to the liver and develop into merozoites which are shed into the blood.

- **Merozoites** enter red blood cells and become **trophozoites** which feed and form new **merozoites**.
- When the merozoites are **released by the red cells**, fever ($>40^{\circ}\text{C}$) ensues with chills and sweating. After several asexual reproductive cycles, **gametocytes** are formed, transferred to the blood and **ingested by mosquitoes**.
- The gametocytes form a **zygote** which in turn produce more **sporozoites** **in the mosquito** and develop into **oocysts** and the cycle begins again.

Lifecycle of *Plasmodium* – causative agent of malaria



Helminths – fancy word for **WORMS!**

Fluke Tapeworm Roundworm

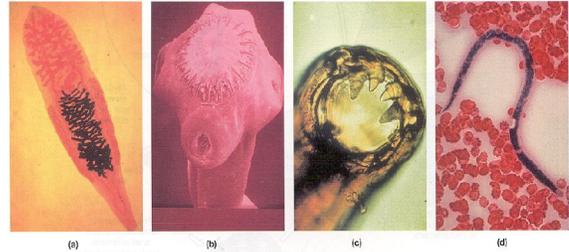
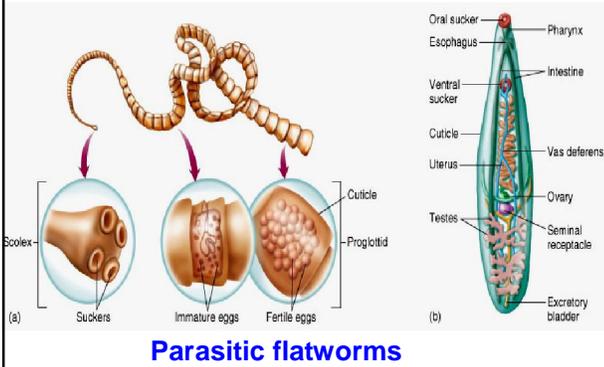
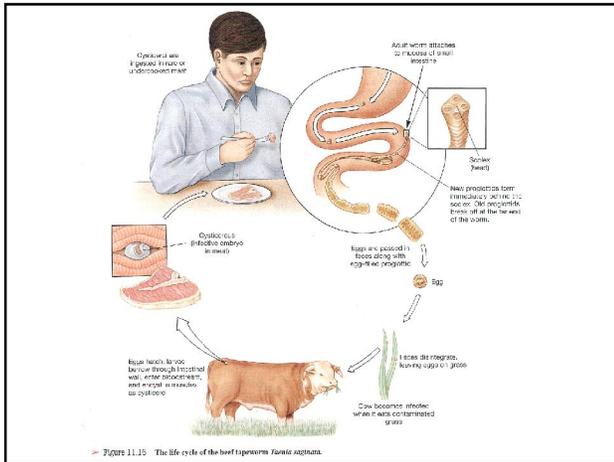


Figure 11.14 Representative helminths. (a) *Clonorchis sinensis*, the Chinese liver fluke, stained to show internal organs. It infests the gallbladder, bile ducts, and pancreatic ducts, where it causes biliary cirrhosis and jaundice. (b) Head (scolex) of a tapeworm (220X). The hooked spines and suckers are used for attachment to intestinal surfaces. (c) Mouth of the Old World hookworm *Ancylostoma duodenale*. The muscular pharynx of this roundworm pumps blood from the intestinal lining of its host. (d) The microfilarial (miniature, larval) stage of the heartworm *Dirofilaria immitis*, in a sample of dog blood (370X), is transmitted by mosquito bites. The larger stages live inside the heart and permeate its walls.

Helminths are multicellular animals with organ-like systems

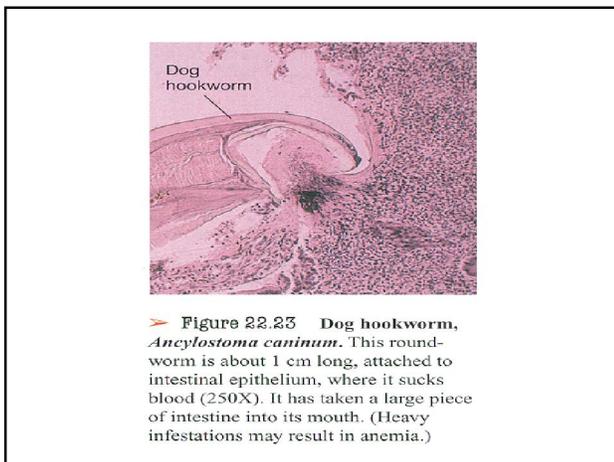
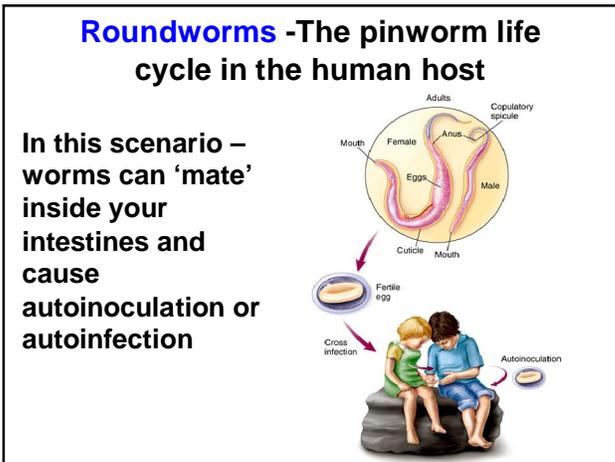
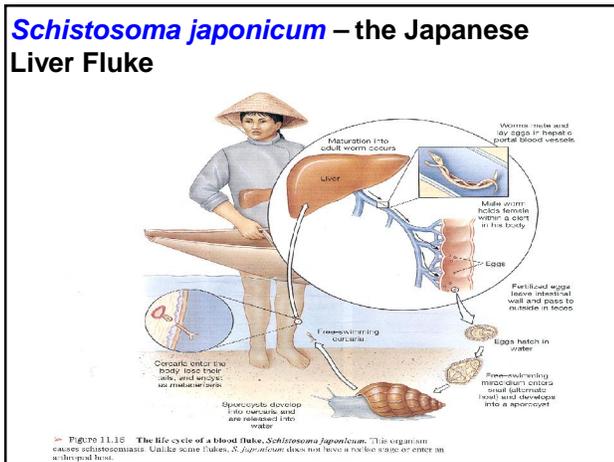


A variety of tapeworms can infect humans - from beef, pork, dogs and fish - ***Taenia saginata*** - beef tapeworm

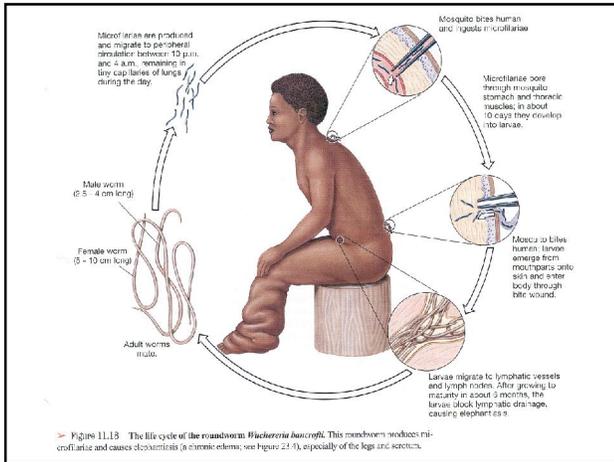


Flukes

- The most important genus of flukes that cause disease in humans are the **Schistosomes**
- Their larvae can actively **PENETRATE** human skin
- All Schistosomes require a **snail host** for reproduction AND for subsequent infection



Some of the roundworms are transmitted by mosquitoes and enter the body as larvae with the bite of a mosquito - e.g. *W. bancrofti* causes elephantiasis.



Arthropods

Arthropods can serve as **vectors** in addition to being parasites - e.g. lice, ticks, mosquitoes etc.

