Chapter 12: 
EUKARYOTIC MICROBES

1. Protista: Algae & Protozoa
2. Fungi
3. Helminths

Overview of the Algae
Characteristics of algae:

• unicellular or multicellular eukaryotes
• almost all are photoautotrophs (photosynthetic)
• all are essentially aquatic (live in fresh or saltwater)
• all are capable of asexual reproduction
  • some are capable of sexual reproduction as well

**produce an estimated 80% of O₂ in the atmosphere!**
Diatoms

• unicellular or filamentous (form multicellular filaments)
• have a unique cell wall structure composed of a carbohydrate called pectin & silica
  • responsible for geometric, glass-like appearance
• widely distributed throughout photic zone
  • important part of aquatic food webs

Dinoflagellates

• what are commonly referred to as “plankton”
• unicellular algae with 2 perpendicular flagella
  • some produce potent neurotoxins
  • source of toxic algal blooms (e.g., “red tide”)
  • important part of the oceanic food web

Overview of the Protozoa

Characteristics of protozoa:

• all are unicellular eukaryotes
• all are heterotrophs (a few can be photosynthetic)
• capable of asexual reproduction (some sexual reproduction)
• parasitic species have complex life cycles
• some form protective cysts as part of their life cycles

Protozoan phyla we will consider:

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Parabasalids & Diplomonads

- do NOT have mitochondria
  - have an analogous organelle called a mitosome
- most have multiple flagella, Diplomonads have 2 nuclei
- several parasitic genera can cause human disease
  - *Trichomonas, Giardia*

Apicomplexa

- non-motile obligate intracellular parasites
- have a unique “apical complex” of fibers and vacuoles that release digestive enzymes
  - aid in penetration of host animal tissue
- includes species of *Plasmodium* responsible for the disease malaria

**Plasmodium Life Cycle (malaria)**

- *P. vivax* (inside RBCs)
Ciliophora ("ciliates")

- all have many small projections called cilia
  - used for locomotion & to direct food into the cytostome ("mouth")
  - have contractile vacuole to expel excess water taken in by osmosis (expelled by exocytosis)
  - some have multiple nuclei

Euglenozoa

- some are photosynthetic (Euglena)
  - have a light-sensitive eyespot & a single flagellum
- includes the hemoflagellates (Trypanosoma)
  - responsible for "sleeping sickness" & Chagas disease

Conjugation

1. Mates couple.
2. Meiosis of micronuclei produces 4 haploid micronuclei in each.
3. Three micronuclei in each disintegrate, the remaining 2 replicate by mitosis.
4. Mates each swap one micronucleus.
5. Partners separate.
6. Micronuclei fuse to form diploid micronucleus.
7. Three mitoses without cytokinesis produce 8 micronuclei.
8. Original macronucleus disintegrates. Four micronuclei become macronuclei, four remain micronuclei.
9. Three cytokineses partition pairs of nuclei into four daughter cells.
Sleeping Sickness  
Chagas Disease

Trypanosoma brucei  
Trypanosoma cruzi

**Amoebozoa**

- aka “amoebas”
- have distinct form of locomotion called “amoeboid movement”
  - extend cytoplasmic projections called pseudopods
  - also used to engulf and ingest food by phagocytosis

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2. **Fungi**

Chapter Reading – pp. 363-373
Overview of the Fungi

General characteristics:

• eukaryotic absorptive heterotrophs
• unicellular (yeasts) or multicellular (molds, club fungi)
• reproduce asexually OR sexually
• cell walls that contain chitin
• vast majority are terrestrial (i.e., live on land)
• all fungi develop from haploid spores (no embryos)
• do NOT have flagella (spores are immotile)

**study of fungi is known as mycology**

Structure of Multicellular Fungi

The thallus ("body") of a fungus consists largely of filamentous chains of cells called hyphae:

• vegetative (non-reproductive) or aerial (reproductive)
• some have septa (septate), some don't (coenocytic)

Hyphae form a Mycelium

On a rich source of nutrients, many hyphae can be produced to form a continuous mass called a mycelium.

• vegetative hyphae spread across food source & "absorb"
• aerial hyphae grow vertically & produce spores in a number of different ways, depending on the fungus
Reproduction in Filamentous Fungi

Can reproduce asexually by fragmentation:
- hyphae fragments grow by mitosis

Produce spores asexually or sexually:

Asexual spore production
- occurs at the tip of aerial hyphae
- derived from single parent fungus
- produced by mitosis

Sexual spore production
- involves a partner of opposite mating type, meiosis

### Asexual Spore Production

- sporangiospores are produced within an enclosed sac called a sporangium
- spores not enclosed in a sac are conidiospores (aka conidia)

### Sexual Spore Production

Sexual spores in fungi require 3 phases not seen in the production of asexual spores:

1) transfer of a haploid nucleus to a cell of the opposite mating type: plasmogamy
   - produces a dikaryon

2) fusion of the haploid nuclei to form a diploid zygote nucleus: karyogamy
   - haploid nuclei may reproduce by mitosis before fusing
   - this is the ONLY occasion when fungal cells are diploid

3) meiosis to produce haploid sexual spores
3 Major Fungal Phyla

Zygomycota
- conjugation fungi (molds)

Basidiomycota
- club fungi (mushrooms, smuts, rusts, puffballs)

Ascomycota
- sac fungi (yeasts, molds, truffles, lichens)

Zygomycota
- have aseptate coenocytic hyphae, sporangia

Basidiomycota
- have aseptate coenocytic hyphae, sporangia

Vegetative mycelium grows.

Asexual Reproduction
1. Sporangium (1n)
2. Sporangiospore
3. Sporangiospore matures.
4. Nuclear meiosis occurs (not shown).
5. Zygosporangium forms. (2n)
6. Mating hyphae join and fuse.
7. Dikaryon (2n)
8. Meiosis produces four haploid nuclei.
9. Zygosporangium produces an assexual sporangium (1n).
10. Sporangium (1n)

Sexual Reproduction
11. Spores (1n) are released from sporangium.
12. Spore germinates to produce mycelium.
13. Gamete forms at tip of hypha. 
14. + - Mating hyphae join and fuse.
15. Dikaryon (2n)
16. Meiosis produces four haploid nuclei.
17. Basidiospore released.
18. Basidiospores germinate to produce mycelia.
20. Dikaryotic mycelium produces basidiocarp (mushroom).
21. Dikaryon (2n)
22. Meiosis produces four haploid nuclei.
23. Gills Basidium
24. Four basidiospores (1n) develop.
Hypha produces conidiophore and conidiospores.

Asci contain ascospores produced by meiosis.

Conidiospores released from conidiophore germinate to produce mycelium.

Vegetative mycelium grows.

Asexual reproduction +

Sexual reproduction:

Hyphal tip undergoes cytoplasmic fusion with opposite mating type.

Dikaryon forms. nuclei fuse in terminal cells to form 2n nuclei.

Dikaryon ascospores germinate to produce mycelia.

Meiosis produces four haploid (1n) cells.

Mitosis produces eight haploid ascospores on each tip.

Ascomycota:
- septate hyphae
- asexual conidiospores
- sexual spores in an ascus
- includes the yeasts

Budding Yeasts
Spherical unicellular fungi.
- reproduce asexually by budding
  - also reproduce sexually
- facultative anaerobes (used for beer, wine...)
- important in biological research
  - studying the cell cycle
  - production of insulin & other important things

Saccharomyces cerevisiae

Lichens
Lichens are actually 2 different organisms in a mutualistic symbiosis:
- cyanobacteria or green algae living among the hyphae of an ascomycete (or basidiomycete)
  - fungus gets free carbs!
  - algae or cyanobacteria protected from elements
- important pioneers
  - can grow on inorganic surfaces, begin succession
Lichen Structure

Fungal hyphae form the following structures:

- protective cortex
- inner medulla where algae grow
- rhizines to attach to growth surface

3. Helminths

Chapter Reading – pp. 667-668, 742-746

Overview of the Helminths

Helminths are parasitic worms found in 2 animal phyla, the Platyhelminthes (flatworms) and the Nematodes (roundworms).

- multicellular eukaryotic heterotrophs
- have complex life cycles frequently involving multiple hosts
- contain distinct organ systems
  - some may be reduced or absent due to dependence on host (e.g., no digestive system, no locomotion)
Platyhelminthes (flatworms):
- typically hermaphroditic (monoecious)
- have a proctostome (single opening, no anus)
- we will look at 2 classes:
  - Trematodes (flukes) & Cestodes (tapeworms)

Nematodes (roundworms):
- typically dioecious (2 sexes)
- have complete digestive system (mouth & anus)
- we will look at 2 types: pinworms & hookworms

Trematodes (flukes)
- can have multiple larval stages and intermediate hosts
- hermaphroditic (monoecious)
- attach to host tissue via oral and ventral suckers
- absorb nutrients through outer cuticle

Trematodes (flukes)
- Members of this class of flatworms are all parasites associated with particular host tissues (liver, blood, lung)
  - can have multiple larval stages and intermediate hosts
  - hermaphroditic (monoecious)
  - attach to host tissue via oral and ventral suckers
  - absorb nutrients through outer cuticle

Fluke Life Cycle (blood fluke)
Tapeworms (cestodes)
- intestinal parasites
- scolex (head) has hooks & suckers for attachment
- no digestive system, absorb nutrients
- repeating proglottids have male & female reproductive organs (monoecious)
- mature proglottids detach & pass w/feces allowing transmission to other hosts

Typical Tapeworm Life Cycle

Pinworms
- entire life cycle in human hosts
- live in large intestine
- females lay eggs on anus
- a dioecious parasitic roundworm (nematode)
- transmitted to new hosts via eggs

Enterobius vermicularis
Hookworms
- dioecious nematodes
- live, mate, lay eggs in small intestine
- eggs pass with feces, hatch in soil
- larvae enter new host through skin, pass to lungs via blood, lymph
- coughed up, swallowed to reach small intestine repeat life cycle

Hookworm Life Cycle

Key Terms for Chapter 12
- thallus, hyphae, mycelium
- septate, asceptate, coenocytic
- conidia, sporangia
- plasmodogamy, karyogamy, dikaryon
- zygospore, basidium, ascus
- saprophytic, monoecious, dioecious
- mitosome, cytostome, pseudopods
- scolex, proglottids

Relevant Chapter Questions
MC: 1, 4-5, 12, 1  Matching: 2nd set  Labeling: 1-2