Lecture 7: “Protists”

Campbell & Reece chapters: Ch 28

“Protista” (“Protists”) sometimes recognized as a “Kingdom” but is a highly paraphyletic group

NOT RECOGNIZED HERE!

[“Animal” versus “Plant” features]
Chapter 28: Recognizes 5 Supergroups of Eukaryotes

We will not use these in this course. Studies are unclear!

We will cover various subgroups within.
"Protista" paraphyletic
Diplomonads & Parabasalids

Lack (or have very reduced) mitochondria
- Mitochondrial loss/reduction thought secondarily derived (reversal).
Diplomonads

Example: *Giardia lamblia* [=*G. intestinalis*]
- intestinal parasite
- cause of “giardiasis”
What are the symptoms of giardiasis?

Giardia infection can cause a variety of intestinal symptoms, which include:
- Diarrhea
- *Gas or flatulence
- *Greasy stools that tend to float
- *Stomach cramps
- *Upset stomach or nausea.

Flu-like symptoms in humans, sometimes including diarrhea and vomiting and less commonly resulting in death.

Treatment options include metronidazole (25 to 30mg/kg for at least 5 days), fenbendazole (Pancur Rx) at 50mg/kg for 3 days, albendazole and furazolidone.

In animals, clinical signs of giardia include weight loss, inability to gain weight appropriately during growth, diarrhea, vomiting, lack of appetite and greasy appearing stools. The most commonly used medication for giardia infection is metronidazole (Flagyl). The organisms come from the environment and live in moist to wet areas. They are susceptible to quaternary ammonium disinfectants, Lysol and dilute chlorine bleach. Keeping the dog's environment dry helps a lot.
Parabasalids

[Trichomonas vaginalis] - infects vagina of human females (and urethra of males); sexually transmitted.
anterior flagella
eyespot (functions with photoreceptor)
autotrophic  \(<-\text{or}-\text{> heterotrophic
chloroplasts: chlorophyll a & b
storage: paramylon
no cell wall: inner pellicle layer (proteinaceous)
Eukarya (Eukaryotes)

Bacteria
- Diplomonads
- Parabasalids
- Kinetoplastids
- Euglenozoa
  - Alveolates
  - Stramenopiles

Archaea

Secondary Endosymbiosis? 
“brown” chloroplast 
“red” chloroplast (similar to ancestor) 
“green” chloroplast

Primary Endosymbiosis 
Mitochondria (by endosymbiosis), plus other organelles 
Cytoskeletal/contractile elements (actin, myosin, tubulin) 
Other membrane-bound organelles (endoplasm. retic., golgi, lysosomes) 
Mitosis (+ meiosis in sexually reproducing organisms) 
Nucleus (membrane bound), enclosing chromosomes 
DNA linear, bound to histones, as chromosomes

= endosymbiotic origin of organelles from ancestral Bacterium
Kinetoplastids [single large mitochondrion with *kinetoplast*]

Include *Trypanosoma*, cause of sleeping sickness
- Transmitted by tsetse fly (w/symbiotic bacterium)
- 80% chance death if not treated, 1,000s die yearly
- Also kills 3 million livestock each year
Kinetoplastids

Elude detection from our immune system by frequent changes in proteins on surface of membrane.
Rhizaria

Two major groups:

Foraminifera
Radiolarians
Radiolarians / Foraminiferans
- Some secrete shells of silica (radiolarians) or calcium carbonate (foraminiferans)
- Feeding "axopodia" or "pseudopodia" that extrude from shells
Radiolarians / Foraminifera

-Fossilized skeletons make up vast fossilized deposits (e.g., limestone deposits of foram’s); used in geological dating of sediments
This diagram illustrates the phylogenetic relationships among different domains of life, from Bacteria to Eukarya (Eukaryotes). It highlights the endosymbiotic origin of organelles from ancestral Bacterium, such as:

- Mitochondria (by endosymbiosis), plus other organelles
- Cytoskeletal/contractile elements (actin, myosin, tubulin)
- Other membrane-bound organelles (endoplasm. retic., golgi, lysosomes)
- Mitosis (+ meiosis in sexually reproducing organisms)
- Nucleus (membrane bound), enclosing chromosomes
- DNA linear, bound to histones, as chromosomes

The diagram also shows the origin of chloroplasts in certain lineages, indicating secondary endosymbiosis.

Other key points include:
- Rhizaria
- Euglenozoa
- Alveolates
- Dinoflagellates
- Ciliata-Ciliates
- Oomycetes (water molds)
- Chromohytonia (Brown Plants)
- Rhodophyta (Red Algae)
- Chlorophyta (Green Plants)
- Amoebzoa
Alveolates

Monophyletic group

Many have alveoli - membrane-enclosed sacs to periphery of cells
Eukarya (Eukaryotes)

Bacteria
- Diplomonads
- Parabasalids
- Kinetoplastids
- Euglenoza

Archaea
- Alveolates
- Amoeboid (Sporozoans)
- Oomycetes (water molds)
- Chromohyba (Brown Plants)
- Rhodophyta (Red Algae)
- Chlorophyta (Green Plants)
- Anamoebida

Eukarya
- Ciliata-Clitellata

- Chloroplast
- "Brown" chloroplast
- "Red" chloroplast (similar to ancestor)
- "Green" chloroplast
- Chloroplast origin

Secondary Endosymbiosis?

Primary Endosymbiosis

Mitochondria (by endosymbiosis), plus other organelles

Cytoskeletal/contractile elements (actin, myosin, tubulin)

Other membrane-bound organelles (endoplasm. retic., golgi, lysosomes)

Mitosis (+ meiosis in sexually reproducing organisms)

Nucleus (membrane bound), enclosing chromosomes

DNA linear, bound to histones, as chromosomes

=endosymbiotic origin of organelles from ancestral Bacterium
Ciliates

Very Diverse!

cilia = short, numerous have 9+2 pattern
E.g., *Paramecium*

*Paramecium*, like other freshwater protists, constantly takes in water by osmosis from the hypotonic environment. Bladderlike contractile vacuoles accumulate excess water from radial canals and periodically expel it through the plasma membrane.

*Paramecium* feeds mainly on bacteria. Rows of cilia along a funnel-shaped oral groove move food into the cell mouth, where the food is engulfed into food vacuoles by phagocytosis.

Thousands of cilia cover the surface of *Paramecium*.

**Food vacuoles** combine with lysosomes. As the food is digested, the vacuoles follow a looping path through the cell.

The undigested contents of food vacuoles are released when the vacuoles fuse with a specialized region of the plasma membrane that functions as an anal pore.
Contractile vacuole - expels excess $\text{H}_2\text{O}$
Feeding in *Paramecium*

food in gullet
Contractile vacuole
Eukarya (Eukaryotes)

Dinoflagellates

chloroplast

“brown” chloroplast

“red” chloroplast (similar to ancestor)

“green” chloroplast

Secondary Endosymbiosis?

Mitochondria (by endosymbiosis), plus other organelles
- Cytoskeletal/contractile elements (actin, myosin, tubulin)
- Other membrane-bound organelles (endoplasm. retic., golgi, lysosomes)
- Mitosis (+ meiosis in sexually reproducing organisms)

Nucleus (membrane bound), enclosing chromosomes
- DNA linear, bound to histones, as chromosomes

Endosymbiotic origin of organelles from ancestral Bacterium
Dinoflagellates

- chloroplasts: chlorophyll a & c
- storage: starch
- cell walls: absent or in plates (thecae)
- flagella: 2, in grooves
Dinoflagellates
- important components of plankton
- primary producers
Dinoflagellates
- some cause “red tide”
= “harmful algal blooms” - (natural or human-accelerated)
[e.g., Karenia brevis]
- can produce neurotoxins, can also deplete oxygen, fish kills, harm to birds, marine mammals
- can be passed up food chain to humans, e.g., toxic oysters, other shellfish
Dinoflagellates

some bioluminescent: luciferin / luciferase
Dinoflagellates

some bioluminescent: luciferin / luciferase
Eukarya (Eukaryotes)

Bacteria
- Diplomonads
- Parabasalids
- Kinetoplastids
- Euglenids
- Rhizaria
- Euglenozoa
- Alveolates
- Stramenopiles
  - Oomycetes (water molds)
  - Chromobionta (Brown Plants)
  - Rhodophyta (Red Algae)
  - Chlorophyta (Green Plants)
  - Amoebozoans
  - Fungi
  - Animalia

- Chloroplast
- "Brown" chloroplast
- "Red" chloroplast (similar to ancestor)
- "Green" chloroplast
- Chloroplast origin
- Primary endosymbiosis
- Secondary endosymbiosis?

Endosymbiotic origin of organelles from ancestral Bacterium

Mitochondria (by endosymbiosis), plus other organelles
- Cytoskeletal/contractile elements (actin, myosin, tubulin)
- Other membrane-bound organelles (endoplasm. retic., golgi, lysosomes)
- Mitosis (+ meiosis in sexually reproducing organisms)
- Nucleus (membrane bound), enclosing chromosomes
- DNA linear, bound to histones, as chromosomes
Ampicomplexans (Sporozoans)
Include *Plasmodium* (4 spp.), direct cause of malaria
- Requires intermediate host, e.g., mosquito (*Anopheles* spp., ca. 24 spp. infect humans)
- Invade and lyse (burst) red blood cells in cycles
Ampicomplexans (Sporozoans)

*Cryptosporidium* – ampicomplexan that can be a human intestinal parasite; can infect water supplies (Sydney, Australia 1998). Symptom: diarrhea.
Eukarya (Eukaryotes)

Bacteria
- Diplomonads
- Parabasalids
- Kinetoplastids
- Euglenoids
- Rhizaria
- Amoeboplaconnas (Sporozoans)
- Dinoflagellates
- Ciliates

Archaea

Euglenozoa

Alveolates
- Oomycetes (water molds)
- Chromophyta (Brown Plants)
- Rhodophyta (Red Algae)
- Chlorophyta (Green Plants)
- Amoebae (Protozoans)
- Fungi
- Animalia

Secondary Endosymbiosis?
- Chloroplast origin
- "Brown" chloroplast
- "Red" chloroplast (similar to ancestor)
- "Green" chloroplast

Primary Endosymbiosis

Mitochondria (by endosymbiosis), plus other organelles
- Cytoskeletal/contractile elements (actin, myosin, tubulin)
- Other membrane-bound organelles (endoplasm. retic., golgi, lysosomes)
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=endosymbiotic origin of organelles from ancestral Bacterium
Stramenopiles

- Monophyletic Group
- Strameno-pile means “straw hair”, referring to flagella:
- Most have **heterokont** cells with 2 flagella:
  - 1 whiplash (smooth)
  - 1 tinsel (hairy; hairs tubular)
Oomycota - Water Molds

Formerly classified as Fungi

\( Oon = \text{egg} \quad mycota = \text{fungus} \)

Most are saprobes (heterotrophs feeding on dead, decaying matter), e.g., Saprolegnia
Filaments - long chains of tubular cells (cell walls with cellulose)

*Coenocytes* - many nuclei per cell
Can reproduce asexually or sexually!

**asexual** zoosporangia  **sexual** oogonia
Oomycota - Water Molds

Some are parasites (heterotrophs feeding on living organisms)

E.g., *Phytophthora infestans*  Potato Blight
Cause of Irish Potato Famine, ca. 1845
1 million died, 2 million emigrated to U.S.
Eukarya (Eukaryotes)

Bacteria
- Diplomonads
- Parabasalids
- Kinetoplastids
- Euglenozoa
- Euglenids
- Rhizaria
- Apicomplexans (sporozoans)
- Alveolates
- Dinoflagellates
- Ciliata-Ciliates
- Oomycetes (water molds)
- Stramenopiles
- Chromophyta (Brown Plants)
- Rhodophyta (Red Algae)
- Chlorophyta (Green Plants)
- Amoebozoans
- Fungi
- Animalia

Primary Endosymbiosis

Secondary Endosymbiosis

Endosymbiotic origin of organelles from ancestral Bacterium

- Mitochondria (by endosymbiosis), plus other organelles
- Cytoskeletal/contractile elements (actin, myosin, tubulin)
- Other membrane-bound organelles (endoplasm. retic., golgi, lysosomes)
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Chromobionta (Brown “Plants”)

• Chloroplasts with:
  – chlorophyll a & c
  – photosynthetic “accessory” pigments
    • carotenoids (yellow)
    • fucoxanthin (brownish)
  – storage compound = chrysolaminarin, oil
Chromobionta very diverse

• Include Coccolithophore phytoplankton, very important primary producers

*Emiliana huxleyi*: one of most plentiful organisms on earth
Brown "Algae" (Phaeophytes)

Brown or green-brown color: 
*fucoxanthin* accessory pigment
Brown “Algae” (Phaeophytes)
Brown “Algae” (Phaeophytes)
Brown “Algae” (Phaeophytes)

• Some complex structure (thallus):
Brown Algae
Some with “alternation of generations” life cycle

- gametophyte - haploid (n)
- sporophyte - diploid (2n)
Brown “Algae” (Phaeophytes)

• Cell wall: **algae** (alginic acid)
  – Used as emulsifier in ice cream, soups, cosmetics, etc.
  [emulsifier-keeps ingredients from separating]
  – Used in dentistry (tooth impressions)

• Harvesting of kelp (*Macrocystis*) in San Diego
[Macrocystis pyrifera - giant kelp]
Stramenopiles

Chromobionta (Brown Plants)

- Oomycota (Water molds)
- Xanthophyta (Yellow-green algae)
- Phaeophyta (Brown algae)
- Chrysophyta (Golden algae)
  - Bacillariophyta (Diatoms)

- Algin
- Flagella absent
- Silica cell walls
- Chloroplast Chl. a & c
- 2 heterokont flagella
Diatoms
2 forms:

centric

pennate
Diatoms (Bacillariophyta)

Centric and pennate forms:
Diatoms (Bacillariophyta)

Cell walls in 2 interlocking halves, composed of silica!
Economic Importance of Diatoms

• Important components of phytoplankton

• “Diatomaceous earth”
  – fossilized, mined remains of diatom cell walls
  – used for filtering and polishing
Diatoms can produce neurotoxins too!

- *Pseudonitzschia*: if too much Nitrogen from water pollution, will produce excess domoic acid, a neurotoxin; mimics glutamic acid, affects seals (permanent short-term memory loss!)
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- Apicomplexans (Sporozoans)
- Alveolates
- Dinoflagellates
- Ciliates
- Oomycetes (water molds)

Archaea
- Chromophyta (Brown Plants)
- Rhodophyta (Red Algae)
- Chlorophyta (Green Plants)
- Amoebozoans
- Fungi
- Animalia

Secondary Endosymbiosis?

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Endosymbiotic origin of organelles from ancestral Bacterium
Red Algae: Rhodobionta/Rhodophyta

• chloroplasts:
  – chlorophyll a & d
  – accessory pigments: phycobilins & phycocyanins, resemble blue green bacteria (Cyanobacteria)
  – storage compound: floridean starch
  – lack flagella!
Red Algae: can be many colors
(depending on pigments)
Red Algae can have complicated life cycles! (e.g., two diploid phases)
Economic Importance of Red Algae

• Some edible
  – Dulse
  – Nori (used to wrap sushi)
Economic Importance of Red Algae

• Some harvested for **carrageenans & agar**
  – used as emulsifiers in foods (e.g., ice cream) & other products
  – **agar** used as microbiological culture medium
Mitochondria (by endosymbiosis), plus other organelles
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Secondary Endosymbiosis?

Primary Endosymbiosis

= endosymbiotic origin of organelles from ancestral Bacterium
Amoebozoans ("amoeboids")
-now thought to be close to fungi & animals [Unikonts]

**pseudopodia** – arm-like extensions of cytoplasm

**phagocytosis** (type of endocytosis, using pseudopodia, surround and engulf prey)

**contractile vacuoles** in some - remove excess water
Some amoeba (entamoebae) are parasites

E.g., *Entamoeba histolytica*

Cause of **amoebic dysentery**

- spread by contaminated food, water, eating utensiles
- causes over 100,000 deaths per year (3rd leading cause due to eukaryotic parasites)
Amoebozoans: Slime Molds
Formerly (like water molds) classified as fungi
Acellular slime molds:
- One huge, multinucleate cytoplasmic mass, called a **plasmodium** (don’t confuse with genus)
- Can slowly move over a substrate and digest it.
- Exhibit **cytoplasmic streaming** (outer cytoplasm fluid, motile)
- Feed by phagocytosis (like a huge amoeba!)
Slime Molds

- Can form resting or fruiting stages
- Cellular slime molds
  - composed of cells (mxyamoebae) that aggregate together into:

SLUG! (pseudoplasmodium)