

The Eukaryotes: Fungi, Algae, & Protozoa (Chapter 12)

Lecture Materials

for

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Primary Source for figures and content:

Tortora, G.J. *Microbiology An Introduction* 8th, 9th, 10th ed. San Francisco: Pearson Benjamin Cummings, 2004, 2007, 2010.

-50% of world population infected with eukaryotic pathogens

Two microbial kingdoms:

1. Fungi
2. Protista

Subkingdoms

- A. Protozoa (animal-like)
- B. Algae (plant-like)

Kingdom Fungi

mycology = study of fungi

common characteristics of fungi:

1. all are chemoheterotrophs
2. most are saprophytes
3. most are aerobic or facultatively anaerobic
4. few are human pathogens
5. cell walls are composed of chitin

Organized into three general groups based on shape:

1. Molds and Fleshy Fungi

-consist of long filaments of cells joined end to end = hyphae

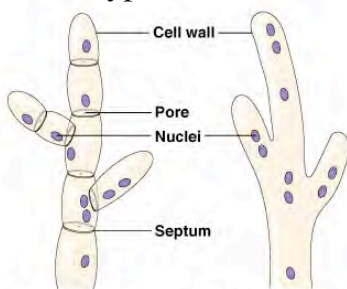
-hyphae can be one of two structural types (genetically determined for a particular fungus):

1. Septate Hyphae

-joined cells have distinct separations called septa

2. Coenocytic Hyphae

-hyphae consists of fused cells

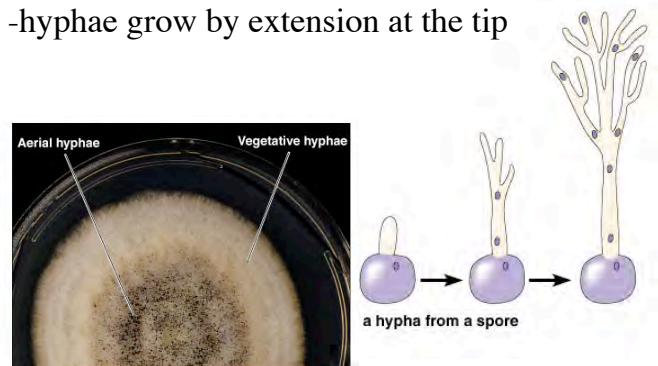


(a) Septate hypha

(b) Coenocytic hypha

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-hyphae grow by extension at the tip



-a mass of hyphae is called a mycelium

-a mold mycelium will produce two different versions of its hyphae:

1. vegetative hyphae

-grow flat along surfaces
-used to obtain nutrients

2. aerial hyphae

-stick up off the mycelium
-used to produce spores for reproduction



2. Yeasts

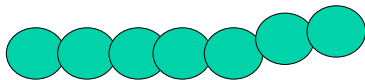
- nonfilamentous, unicellular, ovaloid
- all are facultative anaerobes
- in absence of oxygen will ferment carbohydrates into alcohol & carbon dioxide

A. Budding Yeasts

- divide by producing outgrowth called a bud
- bud will enlarge and separate from mother cell following mitosis



- if bud fails to separate = pseudohyphae

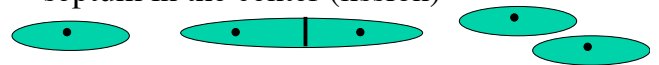


(not true hyphae like molds:

hyphae = cells tightly attached by shared walls, cytoplasm joined by pores
pseudohyphae = daughters remain stuck but no shared walls or cytoplasm)

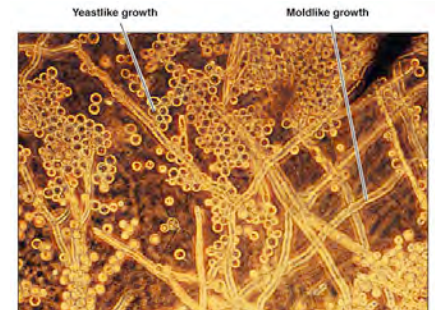
B. Fission Yeasts

- divide by mother cell elongating and undergoing mitosis
- daughter cells separated by formation of a septum in the center (fission)



3. Dimorphic Fungi

- can grow in multicellular mold-like hyphal form or unicellular yeast-like ovaloid form depending on conditions



e.g. *Candida albicans*

25°C, acid pH = yeast

37°C, neutral pH = hyphae

Life cycle of fungi

- fungi can reproduce asexually by:

1. fragmentation of hyphae (mold), budding (budding yeast) or fission (fission yeast)
2. asexual spores

- fungi can reproduce sexually by the formation of spores

spores are formed on the ends of aerial hyphae (**not** endospores: reproductive, outside cell)

- asexual spores:

- form on the hyphae of one organism
- germinate to form exact clones of the parent

- sexual spores:

- form after the fusion of two haploid nuclei from opposite mating type cells of the same species
- when spore germinates it has characteristics of both parents

- sexual reproduction is NOT common in fungi

Asexual Spores

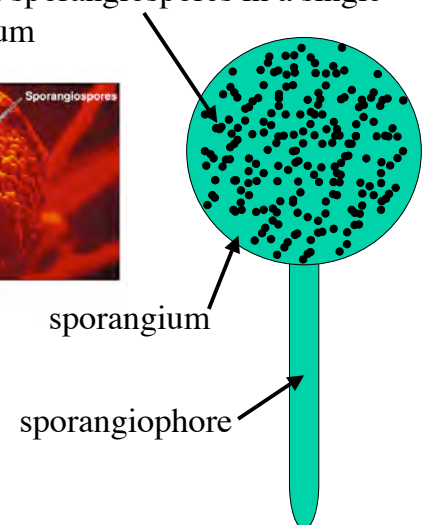
- produced by mitosis and cell division
- contain DNA that is exact copy of parent

1. Sporangiospore

- spores form in sac called sporangium
- sporangium forms at end of aerial hyphae called a sporangiophore
- hundreds of sporangiospores in a single sporangium



(e) Sporangiospores

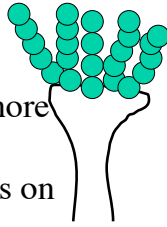


2. Conidiospore

-spores produced at the end of an aerial hyphae called a conidiophore

-most common type:

Conidia: chains of conidiospores on conidiophore



Ed. P. Frenkel

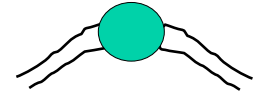
Sexual Spores

-formed by fusion of two haploid nuclei into single diploid zygote

-zygote then undergoes meiosis to generate haploid spores (usually multiples of four)

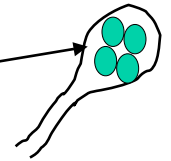
1. Zygosporangium

-one thick spore between two parent hyphae



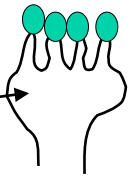
2. Ascospores

-four spores in a sac called an ascus, at the end of one hyphae



3. Basidiospores

-four spores on the end of a basidium



Zygosporangium containing zygospore

Ascospore

Fungi organized into three Phyla based on the type of sexual spore:

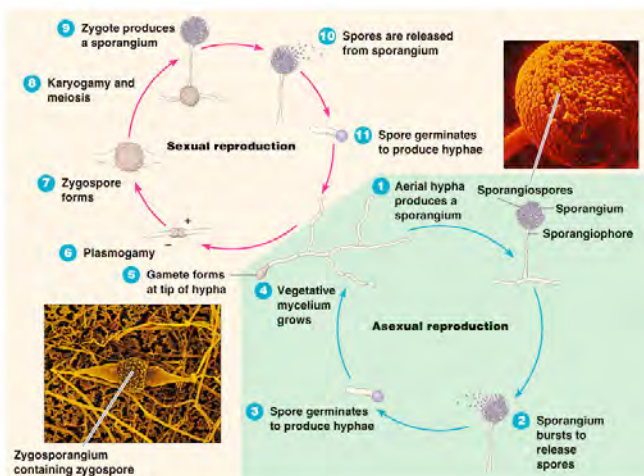
1. Zygomycota (conjugation fungi: molds)

-coenocytic hyphae

-asexual spore = sporangiospores

-sexual spore = zygospores

e.g. *Rhizopus* (common bread mold)



Zygosporangium containing zygospore

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2. Ascomycota (sac fungi: yeasts and molds)

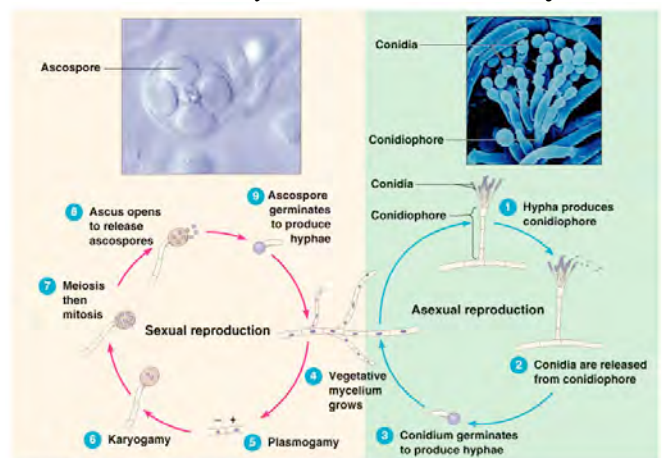
-septate hyphae

-asexual spores = conidiospores

-sexual spores = ascospores

e.g. *Aspergillus* (black house mold)

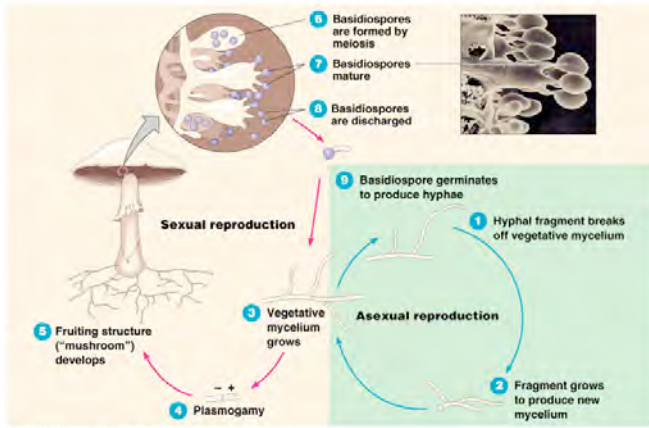
Saccharomyces (bread and beer yeast)



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3. Basidiomycota (club fungi: mushrooms)

- septate hyphae
- asexual spores = conidiospores
- sexual spores = basidiospores



Anamorphs - fungi that have lost ability to reproduce sexually; DNA sequence analysis used to assign phylum
e.g. *Penicillium* (green fruit mold)

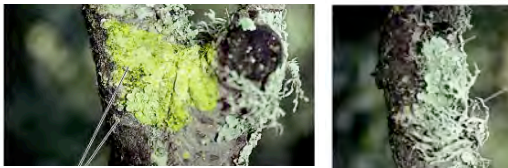
Fungi differ from bacteria:

- grow in acidic environments (pH 5)
- resistant to osmotic pressure
- grow in low moisture
- require less nitrogen
- can metabolize complex carbohydrates

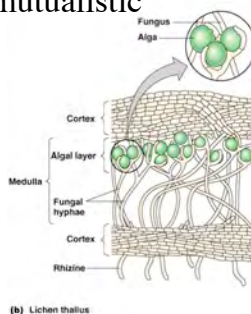
Fungal Disease

- few fungi are pathogens
- if pathogenic, tend to be opportunistic pathogens (only cause disease in immunocompromised host)
- mycosis = fungal infection: can range superficial (skin) to systemic (blood,organs)
- Most are chronic due to slow growth and difficultly in treating

Lichens



- combination of green algae and fungus
- classified by fungus species
- the two organisms exist in mutualistic relationship: both benefit
- algae: photosynthesis to synthesize organics to feed both
- fungi: holdfast, & protection from desiccation
- together can survive in environments where neither would survive alone
- often first and only life forms to colonize newly exposed rock, slow growing
- lichens (fungal part) degrade rock to produce soil for plants
- lichen serves as food for animals



Fungi and Society

The good:

- recycle vital nutrients: compost
- aid plant growth
- food and beverage production
- vaccine production
- drug production
- biological control of pests
- lichens:
 - air quality testing
 - dyes and pH indicator litmus

The bad:

- food spoilage
- crop death
- human pathogens
 - nosocomial infections
 - immunocompromised patients
 - respiratory illness

Kingdom Protista

Subkingdom Algae

-plant-like protists

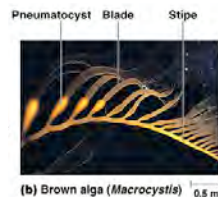
Common features of algae:

1. most have cellulose walls
2. carry out oxygenic photosynthesis using chlorophyll a in chloroplasts
3. require high moisture
4. are photoautotrophs
5. unicellular or multicellular (colonial or filamentous, no tissues)
6. reproduce sexually and asexually

Five Phyla/Divisions:

1. Brown algae

- dark brown pigment & chlorophyll a + c
 - cellulose walls
 - non motile, multicellular
 - produce algin
 - food storage as mannitol
- e.g. seaweed



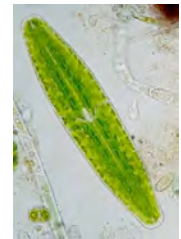
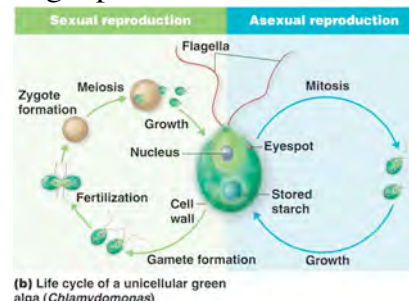
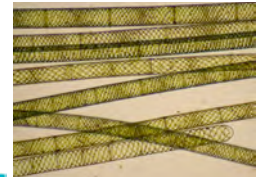
2. Red algae

- red pigment & chlorophyll a + d
 - cellulose walls
 - non motile, multicellular
 - produce agar
 - food storage as starch
- e.g. seaweed



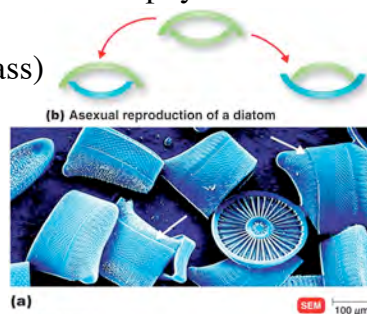
3. Green algae

- cellulose walls, chlorophyll a + b
 - flagellated or filamentous
 - unicellular or multicellular
 - food storage as starch
- e.g. "pond scum"



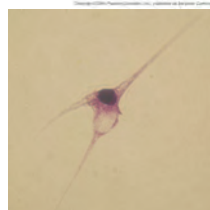
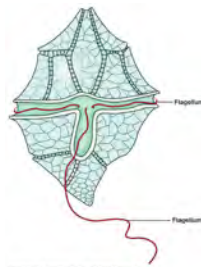
4. Diatoms

- light brown pigment & chlorophyll a + c
- walls of pectin and silicon oxide (glass)
- box + lid structure
- unicellular
- food storage as oil



5. Dinoflagellates

- cellulose walls of interlocked plates
 - unicellular, flagellated
 - food storage as starch
- e.g. plankton, "red tide"



Algae and Society

The good:

- produce 80% of O₂ on earth today
- foundation of many food chains (fix CO₂ into glucose)
- petroleum deposits (oils from dead diatoms compressed in the earth)
- diatomaceous earth (diatom silica shells): used for pool filters and metal polishing
- algin and agar used as thickeners

The bad:

- human disease:
 - paralytic shellfish poisoning due to neurotoxins produced by dinoflagellates (red tide)
 - domoic acid intoxication due to diatoms in shellfish, diarrhea & memory loss
- plant disease:
 - Irish potato blight

Subkingdom Protozoa

-animal-like protists

Common features of protozoa:

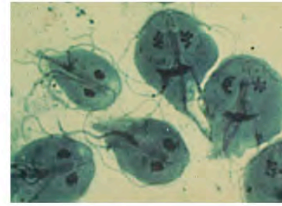
1. all unicellular
2. all chemoheterotrophs
3. reproduce sexually or asexually
4. most are aerobic
5. require high moisture
6. have specialized structures to take in food
7. usually covered by a pellicle (no wall)
8. digestion occurs in vacuoles
9. excretion occurs through anal pore

Life cycle

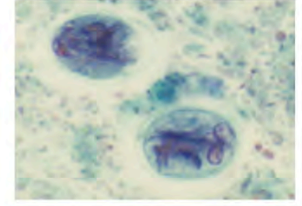
-switch between two forms:

1. trophozoite
 - vegetative state, feeding and growing
2. cyst
 - survival state
 - form cyst when conditions bad or need to move from one host to next (cysts survive stomach acid)

-cysts convert back to trophozoite in favorable conditions (free living ones) or intestine (parasitic ones)



(c) *Giardia lamblia*

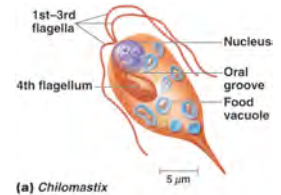


(d) *Giardialamblia* cyst

Five major Phyla based on gene sequencing and motility:

1. Archaezoa

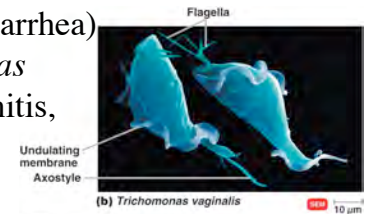
- lack mitochondria
- spindle shaped
- flagella on front end
- common symbionts in animal G.I.



(a) *Chilomastix*

e.g. *Giardia* (diarrhea)

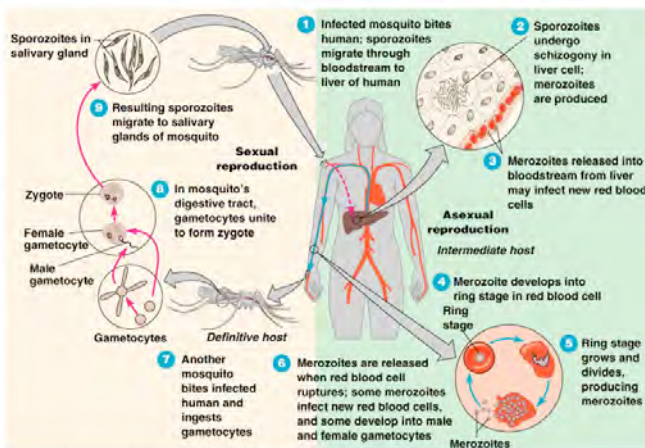
Trichomonas
(STD vaginitis, urethritis)



(b) *Trichomonas vaginalis*

2. Apicomplexa

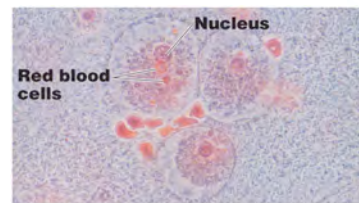
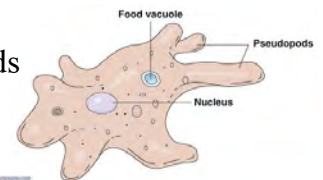
- non motile in mature form
 - complex organelles at apex house enzymes
 - obligate intracellular parasites
 - usually transmitted by insects
 - usually complex life cycle with different stages in different hosts
- e.g. *Plasmodium* (malaria)



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3. Amoebozoa

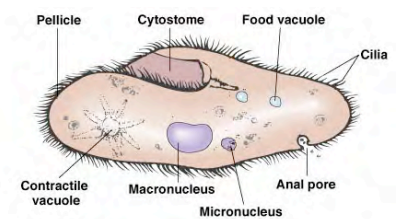
- move via pseudopods
- e.g. *Entamoeba*
(amoebic dysentery)



(b) *Entamoeba histolytica*

4. Ciliophora

- move via cilia
- e.g. *Paramecium*



(only one pathogen in group: *Balantidium coli*
-causes dysentery)

5. Euglenozoa

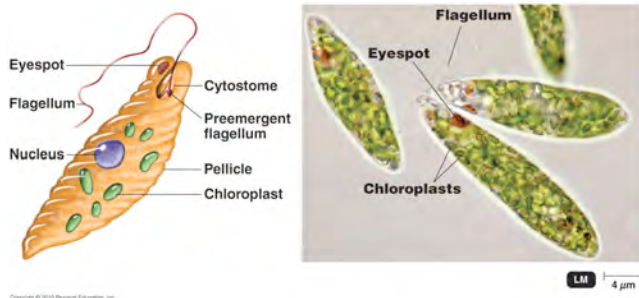
- move via flagella (zooflagellates)
- no sexual reproduction

Two groups:

A. Euglenoids

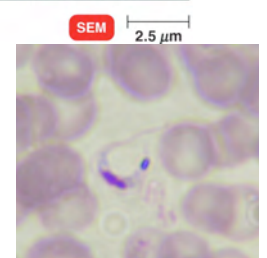
- have pellicle
- has flagella and eye spot (animal-like)
- has chlorophyll a (plant-like)
- photoautotroph or chemoheterotroph depending on light

(intermediate between algae and protozoa)



B. Hemoflagellates

- transmitted by biting insects
- live in host blood
- long slender cells with undulating membrane and flagellum
- e.g. *Trypanosoma* (African sleeping sickness, Chagas' disease)



Slime Molds

-fungus-like protists, most related to Amoebozoa

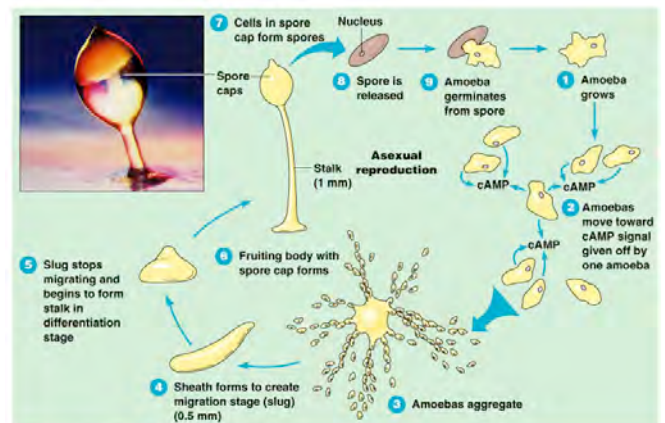
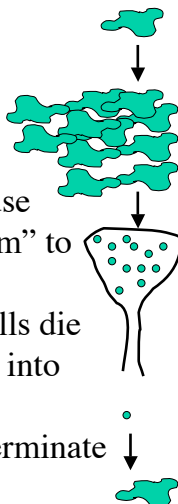
Common features of slime molds:

1. have both fungal and amoeba-like qualities
2. hunters of bacteria and fungi
3. will produce spores in unfavorable conditions (survival, not reproduction)

Two Phyla:

1. Cellular slime molds

- in favorable conditions exist as unicellular "amoeba"
- in unfavorable conditions:
 - many cells congregate and fuse
 - form multicellular "mushroom" to generate spores (not reproductive: some cells die as stalk, others convert into spores)
 - return to favorable: spores germinate into unicellular "amoeba"



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2. Plasmodial Slime Molds

-favorable conditions: exist as plasmodium

= multi-nucleate mass of protoplasm

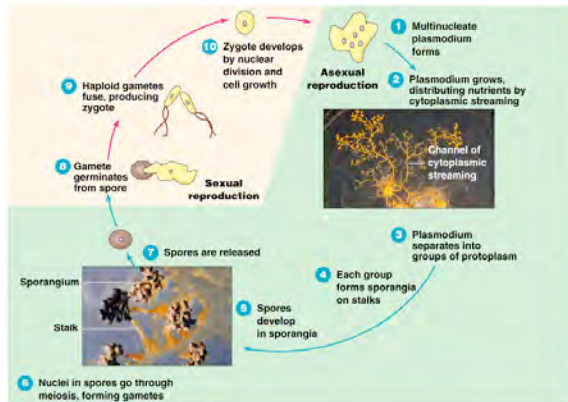
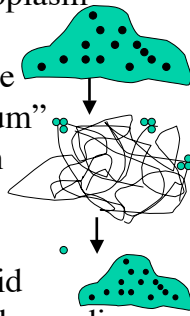
-moves as giant “amoeba”

-unfavorable conditions: mold like

-spreads out forming “mycelium”

-produces clumps of spores on aerial hyphae

-favorable conditions: spores germinate and undergo rapid cell division to form new plasmodium



Protozoa and Society

The good:

-apicomplexa: insect pest control

-slime molds: decomposition

The bad:

-human disease:

diarrhea

STD

blood infections