Eukaryotes – General

eukaryote = “true nucleus”
larger cells (100-500µm vs 1-5µm)
→100x’s larger than prokaryotes
only one cell produces all the tasks essential for life
cell subdivided into distinct compartments
→nucleus, organelles such as chloroplasts, mitochondria, etc
makes them much more efficient than bacteria

Origin of Eukaryotes

appeared in fossil record about 2 BY ago from symbioses between several different kinds of prokaryote cells

Kingdom Protista – General

~65,000 species described; up to 200,000 species probable
simplest eukaryotic organisms
very efficient cells compared to procaryotic cells
most protists are aerobic
→ a much more efficient way to make energy
some with cell walls some without
most unicellular, some colonial, filamentous, some are large multicellular forms
some of the largest cells of any organism
→ can see them without magnification
diverse group of organelles with highly developed division of labor
found anywhere there is water or moisture:
→ freshwater ponds, lakes, creeks, rivers
→ marine environments
→ damp soil
→ leaf litter
→ snow & ice

in aquatic environments they are an important part of plankton

Movement

most protists are motile

cilia
→ usually many short whiplike filaments that beat in unison to move protozoan along
→ a few are sessile, but use cilia to draw in food

flagella
→ much longer whiplike filaments; usually only one or a few per cell

amoeboid motion (false feet)
→ some can send extensions outward, then "ooze" into them (eg. "the blob")
or they can even actually "walk" on these false feet

gliding
→ secrete a "slime trail" to slide on
→ a few are nonmotile

Nutrition

autotrophs
→ photosynthesis using mainly chlorophyll inside chloroplasts to capture solar energy
→ also have one or more accessory pigments (yellow, orange, brown, red) to enhance the capture of sunlight and increase efficiency of photosynthesis
→ autotrophic protists are an important part of the phytoplankton (plant-like plankton)

heterotrophs
→ must eat organic food:
→ food becomes enclosed in vacuole which travels through cytoplasm
→ digestive enzymes are injected into the vacuole and digest the food
→ undigested material is expelled by a reverse process (exocytosis) or through an "anal pore"

Reproduction and Life Cycles

highly varied reproduction and life cycles
Protists reproduce both asexually and sexually:

asexual: main form of reproduction
**fission** = divide in equal halves
(not same as bacterial fission)
eucaryotic fission involves mitosis
some split longitudinally (flagellages)
some split transversely (ciliates)

**budding** = unequal fission

**multiple fission** = >2 daughter cells

**sexual:** involves some exchange of genes

**conjugation** = exchange of a few genes
(diliates only)

**syngamy** = fusion of gametes (egg & sperm)

some have alternation of sexual and asexual
generations

**Classification of Protists:**

Protists are not a natural grouping, some divide protists into 5 or 6
separate kingdoms and 50 or so phyla

Protists consist of three major groupings:

1. **Algae: Plant-like Protists** (22,000 species)
   mostly single celled, colonial, some multicellular
   photosynthetic autotrophs
   most with cell wall of varying composition
   most nonmotile but some motile with flagella or gliding

2. **Protozoa: Animal-like Protists** (31,000 species)
   mostly single celled or colonial heterotrophs, non
   photosynthetic,
   mostly motile with flagella, cilia or false feet

3. **Slime Molds & Water Molds: Fungus-like Protists** (1,100 sp)
   mostly complex life cycles involving amoeba-like stage and
   fungal spore-like stage
   alternating sexual and asexual reproduction
   heterotrophs
   cell wall, when present, of cellulose

**Protists - Algae**

~22,000 species
diverse group of mostly photosynthetic protists
=use sunlight as energy source to make organic food
mostly single celled or colonial
but some algae form large multicellular bodies;
eg seaweeds
most are aquatic
oceans, ponds, lakes, rivers, springs, hot springs, etc
and make up the phytoplankton
base of food chain in aquatic environments
in low density; only few 1000/liter
but ocean area is so great that their total productivity is:
3 x’s production of all world’s grasslands and
4 x’s all world’s croplands
the larger, multicellular algae are found closer to
shore usually attached to substrate in shallow
water
they provide both food and shelter for many other
organisms

a few are terrestrial
found on tree trunks, damp soil, ice & snow
many are symbiotic with fungi and animals
algal protists store food as starches, proteins, or
lipids
many contain some form of chlorophyll for
photosynthesis
most also have a variety of additional
“accessory” pigments to increase
photosynthetic efficiency

**Classification of Algae:**
classification based on:
1. type of accessory photosynthetic pigment
2. type of energy reserves (stored food)
3. composition of cell wall

- **Fire Algae**
  - Diatoms
  - Coccoliths
  - Euglenas
  almost all are unicellular species

- **Green Algae**
mixture of unicellular, colonial and
**1. Fire Algae** (Dinoflagellates, Pyrrophyta)

- ~1000 sp
- unicellular
- mostly large **multicellular** species
- most are **armored**
  - produce cell walls of fused interlocking cellulose plates
  - usually with spines
- 2 **flagella** in grooves perpendicular to each other
  - cause organism to spin like a top while moving forward
- some are **bioluminescent**
  - "burning of the sea" at night

**Ecological Importance:**

1. many symbiotic in coral animals as **zooxanthellae**
   - base of food chain of tropical coral reefs since waters are poor in nutrients
2. **blooms** of dinoflagellates color water red or brown
   - **red or brown tides**
   - some produce powerful **toxins** which can kill fish and other organisms that eat them
     - eg. 100,000’s of fish may die

**Human Impacts:**

1. dinoflagellate blooms
   - eg. 1980, Maine coast – costs $7M losses to commercial fisheries
   - shellfish often not hurt by toxins but can accumulate and concentrate them
   - may make them dangerous to humans
   - oyster harvesting is restricted during red tides

**2. Diatoms** (glass algae, Chrysophyta, golden-brown algae)

- ~10,000 sp
- very distinctive group
- single celled (**unicellular**)
- **silica cell walls** of very geometric shapes
  - large numbers of intricately shaped pits, pores and passageways
  - radial symmetry
  - CW in two parts (petri dish)
- no cilia or flagella
  - some have **gliding** movement = slime trail
- most abundant group of algae
  - eg. "gritty" texture of sea water
  - major base of aquatic food chains (fw and marine)
  - **phytoplankton**

**Human Impact of Diatoms**

1. all **oil reserves** were formed mainly by diatom deposits (along with other protists & bacteria)
2. source of diatomaceous earth
   = chalky rock composed of diatom shells (fossil)
   both freshwater and marine deposits
   some deposits are over 3000’ thick

3. industrial uses:
   silica in shells make them useful for:
   - filters
   - cement & plaster
   - paper
   - metal polishes
   - abrasives
   - reflective paints for license plates and highway markers
   - used in sugar refining

4. future use as diesel fuel substitute
   40% of diatom cells are oils
   → one group is working to convert oil from diatom blooms into a “clean” diesel fuel substitute

3. Coccoliths (coccolithophores)
   a single celled algae surrounded by calcareous plates
   motile by flagellum
   extremely abundant in the ocean
   important contributor to ocean primary productivity
   extensive fossil record
   eg. white cliffs of dover ~300 ft thick
   important in dating layers of rock for paleontology and geological exploration

4. Euglenas (euglenoids)
   ~800 sp
   small group
   unicellular
   motile by flagellum
   mostly freshwater
   mainly in eutrophic ponds and pools
   = lots of nutrients and organic material
   eg farm ponds, cattle tanks
   most unusual feature is lack of cell wall
   flexible pellicle covering instead like in protozoa
   has stigma = photoreceptor => attracted to light
   has chloroplasts but can survive without them as well
   (lives in dark like protozoan => heterotroph)

5. Green Algae (chlorophyta)
   ~7000 sp
   most diverse group of algae in sizes and shapes
   the only algal group that is found mainly in freshwaters and moist habitats on land
   eg. damp soil, tree trunks, snow, ice, etc
   mostly unicellular and colonial,
   some multicellular filamentous forms and small seaweeds (eg sea lettuce)
   most motile by flagella
   very similar cell structure to plants
   → plants probably evolved from a green alga
   some form symbiosis with fungi called lichens

Human Impacts
1. Biofuels
   some species of green algae (eg. Chlorella) is being studied as a source of biofuels
   many strains can grow in saltwater or wastewater
can potentially make over 50x’s as much oil as land plants in the same area

the oil is easily converted to diesel or other fuels

2008 estimate that 20 million acres (2% of US agricultural land) of algal ponds could produce all the US transportation fuel needs

6. **Brown Algae** (phaeophyta)

~1500 sp

all multicellular **seaweeds**,

most large seaweeds are in this group

complicated specializations of cells into structures of specific functions:

- **blade** - leaflike, does most photosynthesis
- **stipe** (stalk)
- **floats** - lifts blades toward water’s surface
- **holdfast** – attaches base to solid surface

almost all marine

usually inhabit cooler, rocky shores, intertidal areas

**Ecological Impacts:**

1. **Kelp Forests**

   giant kelp can grow 300 ft long

   kelp beds can be so dense they are essentially jungles

   rapid growth rate: can renew tissues 1-5 x’s/yr

   provide food and home for numerous sea creatures

   1. **Sargassum**

      =gulfweed, rockweed, seaholly

      sargassum refers to ‘grapelike’ appearance of gas bladders

      only seaweed that is not attached to a substrate

      → it’s planktonic

      **sargasso sea**

      ~2/3rd’s area of continental US

      trapped in ring of currents in atlantic

      sargassum can live for many years

      reproduces mainly by **fragmentation**

      when it becomes too encrusted it slowly sinks to bottom

      some weed is blown to gulf shores by winds and currents

      entire ecosystem of different organisms highly adapted to it:

      crabs, shrimp, pipefish, “furry white” bryozoa, sargassum fish *Histrio histrio*

      lots of camouflage

**Human Impacts of Brown Algae:**

1. brown algae (kelp) are used directly as food especially in SE Asian countries

   provide such products as Kombu, Barech and Seche.

2. **Alginites** (or **Alginates**) are extracted from various species including **Macrocystis**, **Laminaria** and **Fucus**.

   alginates are used as thickeners and emulsifiers in various commercial products

   eg. About half of the ice cream in the US contains alginates. where it used to produce a smooth consistency and eliminate ice crystals in ice creams.

   eg. It is also used as a thickening agent in toppings, pastry fillings, potato salad, canned foods, gravies, jellies, icings, syrups, candies and puddings

   eg. alginites are also used in beer production, jelly beans, toothpaste

   eg. as smoothing agent in lotions, creams, lubricating jellies

   eg. paper production, textiles, latex paint, floor polish,
leather processing, adhesives, tapes, insecticides, resins,
eg. alginates used as blood anticoagulant, in surgical threads and to make wound dressings that speeds healing of leg ulcers

3. Kelp concentrates iodine and is used as a supplement to treat goiters in other countries

4. can be ground and used as fertilizer:
seaweeds contain iodine, K, N, P
→equivalent to manure as a fertilizer

7. **Red Algae** (rhodophyta)
~4000 sp
especially abundant in warm tropical waters,
(found in deeper waters than green algae)
mostly marine
body of filaments or sheets
most are multicellular seaweeds
some differentiation of cells into:
stalks, floats, blades in some species
often attached to substrate by holdfast
cell wall of cellulose but often has other carbohydrates (eg. agar)
some can deposit calcium carbonate in their cell walls
= coralline algae
→ important component of coral reefs
pigments: include chlorophyll a and red pigment = phycobilin (more effective at capturing light in deeper water))
food stored as starch

**Human Impacts of Red Algae:**

1. used directly as food, Nori.

The red seaweed, *Porphyra*, is cultivated in Japan. There are several species that are roasted and sometimes soaked in sugar and soy sauce for soup flavorings, wrapped rice crackers and to make other oriental dishes

2. **Agar** is extracted from several red seaweeds including *Gelidium* sp. and *Gracilaria* sp.
eg. It is used in the manufacture of processed cheese, mayonnaise, puddings, jellies, puddings, desserts, baking products, some cheeses and in some canned goods.
eg. also used in capsules for pills, as cosmetic base
eg. used extensively in microbiology to make "agar plates" for growing a large variety of microorganisms

**Protists - Protozoa**
protozoa = animal like protists
common name for an unrelated group of protists that share at least some characteristics with the animal kingdom
~31,000 living species; ~10,000 of these are parasitic
most are unicellular; a few are colonial
most are microscopic (3-300µm) or barely visible to unaided eye
but one species of amoeba (foraminiferan) is 2.5" long
protozoa share several animal-like traits:
lack cell wall
most are motile
heterotrophic nutrition

animals evolved from protozoa
protozoa are found in all aquatic environments
form important part of plankton
= zooplankton; animal like plankton
some found in terrestrial habitats where moisture is
abundant:
sand
soil
decaying organic matter

some are **symbiotic** in animals

some are **mutualistic**

many are **parasites** of animals
   eg. most vertebrates have protozoan parasites in their intestinal tract or in their blood
   eg. a few are ectoparasites of fish (Costia)

a few are **plant parasites**

most are **motile** by
   cilia
   flagella
   amoeboid motion (false feet)

some are **sessile** (nonmotile) but use cilia or flagella to create water currents for feeding

a few are **nonmotile** and **parasitic**

most have optimum temperature range of
   36 – 40 °C (=96.8 – 104º F)

heterotrophic protists are an important part of the **zooplankton** (animal-like protists)

heterotrophs feed by:

1. absorbing dissolved organic nutrients through cell membrane
2. ingest solid particles through a mouth-like opening (=cytostome)
   eg. eat bacteria
3. some are **herbivores**
   eat algae
4. some are **saprophytic**
   =eat decaying organic matter in water or sediment
   eg. scavengers, detritus feeders
5. many are **predators**
   some can eat prey larger than themselves
   (eg. didinium takes 1 min & digests for 2 hrs)
   some have long hollow "tentacles" and pierce other protozoa to suck contents out (suctoria)
6. some are **parasites**

**Life Cycles**

most protozoa exist in a single form which feeds and reproduces

some alternate between two stages in their life cycle:

   **troph** = active vegetative feeding form
   **cyst** = more resistant stage, low metabolic rate
   the resistant stage can withstand harsh conditions and become an active feeding stage again when conditions improve

**Reproduction**

reproduce both asexually and sexually:

   **asexual**: identical copies
      main form of reproduction
      most protozoa divide several times per day
   **fission**
   **budding**
   **multiple fission**
   (some flagellates, sarcodines, most sporozoans)

   **sexual**: involves some exchange of genes
      **conjugation**
      (ciliates only)
      **syngamy**

   a few parasitic forms alternate between sexual and asexual generations and have several different stages in more than one host
Classification of Protists:

as with the algae these are just convenient groupings of a considerably larger number of actual phyla and does not follow current classification schemes

1. **“Amoebas”**
   - protozoa that move primarily by amoeboid motion
   - 44,000 living and extinct species

2. **“Flagelliates”**
   - protozoa that move mainly with flagella
   - ~1,500 species

3. **“Ciliates”**
   - protozoa that use cilia for movement or for feeding
   - ~8,000 species

4. **Apicomplexans**
   - nonmotile, parasitic protozoa with complex life cycles
   - ~5,000 species

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**1. “Amoebas”**

amoeba = “to change form”

includes protozoa that move by **pseudopodia** (=false feet)

organism can alternate between solid gel-like and liquid cytoplasm to produce pseudopodia

→ false feet used for locomotion

→ false feet used to engulf food

→ some are long thin tentacle-like for grabbing food and drawing it in

simplest protozoans → relatively few organelles

found in all aquatic environments

many are **symbiotic** in animals

amoebas are the only group of protozoa that have an **extensive fossil record**

over 20,000 fossil species

some member of the group secrete or construct protective **shells**

→ the shell may be composed of **calcium carbonate** or **silica** secreted by cytoplasm

---

foreign material such as sand grains embedded in cement like secretion

two most important shelled forms:

- **radiolaria** secrete a silica shell (SiO$_2$)
- **foraminiferans** produce calcium carbonate shells (CaCO$_3$

amoebas reproduce mostly asexually

a few also reproduce sexually

**Human Impacts:**

1. some amoebas are common **human pathogens**:

   a. **Entamoeba gingivalis**
      - found in the mouth near base of teeth
      - found in 95% of people with gum disease and 50% of people with healthy gums
      - parasitic → feeds on RBC’s and WBC’s at sites of infection and gum disease
      - does not form cysts
      - → requires direct transmission by kissing, shared utensils

   b. **Entamoeba hystolytica** (amoebic dysentery)
      - intestinal parasite

---

infects 400 Million worldwide esp tropics and areas of poor sanitation

10% of world population is infected

up to 10 Million in US

kills >10,000/yr

90% hosts are **asymptomatic**

humans only reservoir

spread by fecal/oral route

- **cysts** passed in feces
  - → ingested with contaminated water

  invade intestinal lining and feed on RBC’s
  - can cause ulcerations and profuse bleeding in acute cases
  - may spread to liver, lungs, brain, etc

2. **Naegleria fowleri**

35 cases reported in Texas (2007) including a few in central Texas have died from infections of this amoeba parasite

found in almost all freshwater lakes, rivers, hot springs but extremely rare in them

usually infects from getting contaminated water into nose

makes its way to the brain

causes always-fatal primary amoebic meningoencephalitis or **PAM**
most die within 2 weeks
mature adults seem to be immune
the parasite prefers warm waters with a high iron content
especially warm stagnant water
usually cannot survive highly chlorinated water of swimming
pools but does seem to survive in low numbers even in
treated water supplies
may prefer areas where other organisms have been wiped
out by natural or man made disasters (eg Mt. St. Helens)

2. “Flagellates”
includes several major phyla
cell membrane surrounded by pellicle that “stiffens”
the cell membrane
move using one or a few long flagella
some have “sail-like” undulating membrane
used for food gathering and locomotion
reproduce by binary fission
most are symbiotic
one cellulose digesting group has a mutualistic
symbiosis with animals
animals are not able to produce the enzymes
to break down cellulose or lignin
eg. cellulose digesting flagellates in the gut of
termite
1/3 to 1/2 of a termite’s weight is these symbiotic
protozoa
eg. cellulose digesting flagellates in cow rumen
contains 1 M protozoa/ml (100 l of fluid total
they provide cow with ~20% of its protein needs

some are parasitic in humans and other animals
one group of flagellates, the “Choanoflagellates”
are believed to be the protists group most closely
related to the protozoa that gave rise to
animals and fungi
resemble feeding cells (collar cells) of sponges
common in freshwaters and salt water
many species are colonial

Human Impacts

many protozoan flagellates are important human
pathogens throughout the world

eg. Giardia (one cause of “traveler’s diarrhea”)  
first observed by von Leeuwenhoek in his own feces
worldwide distribution: one of most common intestinal
parasites in the world
→ up to 20% of all humans are infected (7% US )
also occurs in cattle, cats, bears, coyotes, etc
cysts shed in feces; fecal/oral transmission
epidemics associated with contaminated water

eespecially common in poor overcrowded areas with
poor sanitation and lack of clean water
can also be transmitted in ponds and pools
→ can survive up to 2 months in water
→ chlorine doesn’t always kill cysts

once ingested Giardia infects small intestine
it is not usually a parasite: It usually feeds on dead
organic material; no invasive ability
usually asymptomatic
in large #’s can cause chronic diarrhea, cramping,
dehydration

incidence is increasing in US where it affects 3x’s more
children than adults; esp daycare centers & public
places

eg. Trypanosoma (African Sleeping Sickness)
old world tropics; esp in Africa
kills 50,000 people/yr (2007)
requires two hosts:
the tse-tse fly is the final host for the sexual stage of
the parasite
humans and other animals are intermediate hosts
humans become infected when fly bites for blood meal
parasite moves into blood and lymphatic system
begins with aching joints, headache and fever
affects CNS: personality changes, headaches, apathy, sleepiness, emaciation
usually results in death from coma, malnutrition, secondary infections
so far, no safe and effective treatment

eg. Chagas disease (T. cruzi)
new world tropics; eg Mexico, Central America, So. America
40-50% of population in So. America
⇒ 50,000 die each year
only a few cases in extreme SW US
also requires 2 hosts in its life cycle:
  kissing bug and humans
  in kissing bug it's an intestinal parasite
  in humans it's a blood parasite
other mammals serve as reservoirs: rodents, possums, armadillos
contracted when "kissing bug" bites (usually on lips)
bug usually defecates after feeding
when the bite is scratch some of the infected feces is rubbed into the wound
symptoms somewhat similar to sleeping sickness
  chronic and hard to treat
may also affect many organs; eg. brain, heart, intestines
most dangerous to children
⇒ can affect many organs

eg. Trichomonas
several species; commensal or parasitic

T. tenax
lives in mouth, is not a pathogen
5-10% oral infections, esp with poor oral hygiene

T. vaginalis
20-40% infection rate worldwide
one of most common infections in US
(2.5 M inf/yr: 3-15% US infected)
lives in human urogenital tract: likes acidity of female tract
~50% are asymptomatic carriers
no cyst form ⇒ usually requires personal contact (STD)
ocasionally spread in communal baths
and mother to child
if acid balance is disturbed, eg. by other infections, can become more virulent
esp common in promiscuous young women who are already infected with other STD’s

in some women infection may produce a frothy, smelly green discharge & painful urination
not often virulent in men

3. "Ciliates"
the most diverse group of single celled 'protozoan' protists
they also tend to be larger and some can even be seen without magnification
most are freeliving
  in a wide variety of aquatic habitats, especially in freshwaters
most are motile by means of cilia
  = 1000's oarlike projections produce coordinated movements
  fastest of all the protozoans
  in some bundles of cilia are fused to form rigid spines that the organism uses to crawl on substrates
a few are nonmotile
  live attached to substrate by stalk
  use cilia for filter feeding, not for movement
ciliates have the greatest variety of organelles and internal structures of all the protists:
  eg. more than one nucleus
all ciliates have two kinds of nuclei

macronucleus → vegetative chores
micronuclei (up to 80) → sexual reproduction

eg. “mouth” (=cytostome) and throatlike area
most feed on microorganisms
have mouthlike cytostome; opens into a throat;
food vacuole forms at end of throat

eg. food vacuoles
contain digestive enzymes for processing organic food

eg. contractile vacuoles
freshwater species tend to take on water
must constantly pump out excess; like a bilge pump on a boat

eg. trichocysts
long thread like proteins that the protozoan is able to
shoot out to anchor the cell or to capture prey

eg. myonemes
muscle-like fibers that allow stalked forms (eg. Vorticella) to
rapidly contract from danger

“eg. chloroplasts!”
ciliates are heterotrophs but …
some ciliates can steal chloroplasts from the algae
they eat and then use them for photosynthesis

Reproduction:

asexual: binary fission
sexual: conjugation: portion of micronuclei are exchanged between + and – forms

Ecological Interactions
ciliates play a vital role in food webs, particularly of freshwater ecosystems

many are part of the zooplankton
others are benthic - spending their lives crawling about the substrate for food

4. “Apicomplexans”
All members of this group are nonmotile
all are endoparasites
most have fairly complex life cycles

→ same species exists in lots of different forms
alternating between forms that reproduce sexually and those that reproduce asexually
sometimes in two hosts

Human Impacts:

Human parasites include:

eg. Texas fever (Babesia)
killed 1000’s of cattle in US in late 1800’s and early 1900’s
spread by tick
destroy RBC’s → causes red urine → “red water fever”
today almost completely eliminated by dipping cattle to kill ticks

eg. Plasmodium (malaria); several species
malaria has probably killed more people than any other disease in history
chronic in some parts of world
worldwide infects 300 - 5000M each year and kills 1-3 M/yr
(90% of cases in Africa, also in Asia & Latin America)
every 12 seconds someone dies from malaria
relatively rare in US (usually travelers)
single most important disease hazard for people traveling to foreign lands
requires two hosts to complete life cycle:
Anopheles mosquito has sexual stages in its salivary glands
humans harbor the asexual stages in blood, especially vessels in liver
transmitted by mosquito bite
symptoms of infection:

7-14 days after infection cold chills and shaking begin
uncontrollable deep tremors take over the body (can propel a bed across a room)
next comes fever (up to 106º F) with profuse sweating
cyclic chills/fever, headache every 3-4 days
can produce irreversible damage to liver, spleen, kidneys and brain
many succumb by way of delerium and coma
if not treated may be **self limiting** but host may be a reservoir for up to 3 years

most effective prevention is elimination of mosquito

WHO has been trying to eliminate it but with little success
mosquitoes have developed resistance to insecticides
the parasite has developed antibiotic resistance
experimental vaccines are being tested
some living in endemic areas have developed genetic resistance to disease (sickle cell)

**eg. Toxoplasma**

zoonosis: **cats** are main host, release cysts in feces
rodents are intermediate hosts

to spread toxoplasma manipulates rodents brains making them reckless and more likely to be caught by cats
humans contract by contaminated soil, cat feces (litter box), infected meat
generally no human-human transfer
in humans can invade blood and multiply in WBC's and various organs
often asymptomatic in adults; children sometimes get rash ("macropapular rash")
if contracted by pregnant woman the parasite can cross placenta and cause retardation blindness and convulsions in embryo, fetus or newborn

new info that may have an effect on Rh- people
3900 drivers were monitored for 18 months those who were Rh- and infected with Toxoplasma were 2.5X's more likely to have an accident

→ .4-1 million of world's annual road deaths might be due to toxo infections
Toxoplasma has also been implicated in the mental disorder; obsessive-compulsive disorder, but results are not yet conclusive

**Protists - Slime Molds & Water Molds**

~1100 species

two distinct groups of fungus-like protists:

**slime molds** and **water molds**

both superficially resemble fungi at some stage in life cycle

→ heterotrophs

→ some produce chitinous cell walls at some stage in their life cycle

→ body of threadlike filaments = **hyphae**

→ many produce a **fruiting body** with **spores** for reproduction

but differ from fungi:

→ most are motile by false feet or flagella at some point during life cycle; fungi are NEVER motile

→ produce flagellate reproductive cells; fungi produce nonmotile spore

→ some have cellulose cell walls or no cell walls; all fungi have cell walls, usually made of chitin
1. **Slime Molds**

This group is probably more closely related to amoebas than to fungi

- Sometimes referred to as “social amoebas”

Common in cool, moist shady places

- Most easily found in summer and early fall
  - Eg. crevasses of rotting wood

Two basic stages to its life cycle:

a. A relatively large motile **feeding stage**

b. The **reproductive stage** in the form of a fungus-like fruiting body that produces spores

a. **Feeding stage** (‘plasmodium’):

For most of a slime mold’s life it exists as a thin, free-living amoeba-like mass of protoplasm

- Essentially a large single cell up to several inches across that
- Can cover an area of several square yards
  - (To 30 g = ~ 1 oz)

- Biologists "saved the world!"

b. **Reproductive stage**:

- When food supply dwindles reproduction is initiated

  - It moves out of its normal habitat and goes to a drier, more exposed location to produce a fruiting body
    - Often seen crossing roads, lawns, climbing trees, etc

- Fruiting bodies can also be produced by absence of food, changes in moisture, pH, temperature

- Plasmodium divides into numerous mounds

- Each mound forms cells surrounded by cell walls

  - At this stage the slime mold more closely resembles fungi than amoebas

- Produces multicellular **fruiting body** (= sporangium)

  - Very small (~1-2mm); look like tiny mushrooms
  - Goblets, globes, plumules
  - With or without a stalk
  - Often colored yellow, orange, red
  - Produces very resistant reproductive spores

- Some slime molds can produce a hardened resistant **sclerotium** to survive adverse conditions

New (2010) research indicates that some slime molds show traits usually encountered in more complex organisms:

- Eg. Slime molds can be taught to "run mazes for food"
- Eg. Some slime molds "farm" the bacteria they eat

  - They stop grazing on bacterial while there is still some left
  - Then mix uneaten bacteria into the spores they produce to make a "starter kit" for the next generation

Fossils of this group have the distinction of being the first true fossil that actually shows an organism caught in the act of sexual reproduction (65MY)

**Economic Importance of slime molds**:

1. Slime molds are eaten in Veracruz Mexico:

- Some are collected, fried and eaten by indigenous peoples called "caca de luna"
2. Water Molds

1000 species (~100 genera) described
most primitive group of fungi
molecular evidence suggests that they are a direct link between protists and fungi
some are unicellular, some multicellular
have chitin in cell wall
mostly aquatic, a few are terrestrial
extremely abundant
a teaspoon of water from virtually any freshwater habitat should yield samples
most are saprobes - absorptive
others are parasites of plants, animals and other fungi
most commonly seen as the fuzzy filaments growing on skin or eggs of fish & amphibians
e.g. Saprolegnia is common parasite of aquarium fish;
causes lesions
sometimes becomes a problem in fish farms

Economic Impacts of Water Molds:

1. some (chytrids) are part of the microorganism community in the stomachs of most farm animals and grazing animals
they are anaerobic and produces cellulases to help digest plant material along with other protists and bacteria
therefore all products coming from these animals (beef, milk, dairy products, leather, wool, etc) are in part a product of these protists
2. some are serious plant pathogens
e.g. root rotting fungi, blister rusts, white rusts and downy mildews
e.g. Downy Mildews
infect grapes, lettuce, corn, cabbage and many other crop plants
introduced into France in late 1800's
almost destroyed the wine industry
problem was accidentally solved using copper sulfate and lime

eg. Potato Blight (Phytophthora infestans)
Cause of Irish Potato Famine (1845-7) in Ireland
virtually the entire Irish potato crop was wiped out in one week
> 1 million deaths from starvation
began large scale emigration of Irish to US
within a decade the population of Ireland dropped 50%: 8M -> 4M

eg. other Phytophthora species
have caused widespread destruction of many crops throughout the world:
  pineapples, tomatoes, rubber, onions, strawberries, apples, soybeans, tobacco, citrus

3. Animal Pathogens

a primitive water mold pathogen (Batrachochytrium dendrobatidis (chytrid)) is at least partly responsible for current decline in amphibians around the world
today one third of the worlds 6,000 amphibian species are threatened
  one of largest extinction spasms in vertebrate history
unsure of exact causes of declines:
  possibly caused by acid precip, deforestation, urbanization, climate change
more recently noted deformities pollutants in water
most recently has been tied to worldwide spread of (including in and around central Texas)
the fungus spreads very rapidly;
don't know how it kills frogs
Barton springs salamander and some other amphibians have natural antibiotics in its skin that seem to protect it from the pathogen
2008-probiotic treatment with normal amphibian skin bacterium, Janthinobacterium lividum, seems to protect frogs from the chytrid.
It apparently produces an antibiotic that is deadly to the chytrid.
Treatment is now being tested on wild populations