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

= organisms that drift with currents

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
(ciliates 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

multicellular species

Brown Algae
Red Algae } mostly large **multicellular** species (no true tissues though)

1. <u>Fire Algae</u> (Dinoflagellates, Pyrrophyta)

~1000 sp

unicellular

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 foreward

some are **bioluminescent**
= "burning of the sea" at night

<u>Ecological Importance:</u>

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

eg. red tides in florida and tropical islands

<u>Human Impacts:</u>

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. <u>Diatoms</u> (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**

<u>Human Impact of Diatoms</u>

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
- pesticides
- 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. <u>Coccoliths</u> (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. <u>Euglenas</u> (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. <u>Green Algae</u> (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**

<u>Human Impacts</u>

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 transportationf fuel needs

6. Brown Algae (phaeophyta)

~1500 sp

all multicellular **seaweeds**,

most large seaweeds are in this group

complex 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 slowy 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 camoflage

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. **Algin** (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 thickining agent in toppings, pastry fillings, potato salad, canned foods, gravies, jellies, icings, syrups, candies and puddings

eg. alginates 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. <u>Red Algae</u> (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 chorophyll a and red pigment = phycobilin (more effective at capturing light in deeper water))

food stored as starch

<u>Human Impacts of Red Algae:</u>

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 *Gracilarid* 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 hae 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 º 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**

<u>Life Cycles</u>

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

<u>Reproduction</u>

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 generatons 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. "Flagellates"

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

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 termites

1/3rd to 1/2 of a termites 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

especially 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 its 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 affects 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 hygeine

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)

occasionally 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 molds life it exists as a thin, free-living amoeba-like mass of protoplasm

essentialy a large single cell up to several inches across that

can cover an area of **several square yards** (to 30 g = ~ 1oz)

creep along in **amoeboid** fashion and feeds on decaying organic matter, bacteria and protozoa

it is thick and slimy to the touch

feeds and grows as long as there is food and moisture

some species form extensive growths on lawns, croplands

→ do little, if any, damage

→ may appear in the same locations, year after year as patches of purple, gray, white & cream

some species found on lawn are mistaken for dog vomit

some pet owners find them then rush their dogs to the vet to find out why their pet is sick

eg. ***Fuligo septica*** plasmodium (shades of war of the worlds)

1973 found in Dallas suburb & reported in paper
appeared on lawns as bright yellow masses
spread over large areas
described in paper as a "pulsating yellow blob"
blobs broke apart when sprayed with hose
→but pieces continued to crawl around
caused local panic:
→must be indestructible **aliens from space**
→ or **mutant bacteria** that might take over the earth
excitement soon dissipated once identified

→ 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 produced a hardened resistant **sclerotium** to survive adverse condition

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 has 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

eg. *Saprolegnia* is common parasite of aquarium fish;

causes lesions

sometimes becomes a problem in fish farms

other species infect rotifers, nematodes, arthropods and diatoms

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**

   eg. root rotting fungi, blister rusts, white rusts and downy mildews

   eg. 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 emmigration 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