

Eukaryotes – General

= “true nucleus”

larger cells (100-500 μm vs 1-5 μm):
→100x’s larger than prokaryotes

only one cell produces all the tasks essential for life
(same as bacteria but much more efficiently since eukaryotes)

compartmentalization
→nucleus, organelles

makes them much more efficient than bacteria

Origin of Eukaryotes

appeared in fossil record about 1.2-1.5BY ago
(2.1 - 2.5 Billion years ago)??? ck

eukaryotic cells probably arose from two processes:

1. **infolding of cell membrane** to form membrane bound nucleus and possibly the endoplasmic reticulum and golgi bodies
2. **endosymbiosis** of other prokaryotes probably produced mitochondria and chloroplasts and possibly the eukaryotic flagellum

evidence:

- there are examples today of such endosymbiosis
- chloroplasts and mitochondria are the size of most bacteria
- chloroplasts and mitochondria have bacterial chromosome (circular ring of DNA)
- they also have bacterial RNA and bacterial enzymes
- and replicate by binary fission as do bacteria

Kingdom Protista – General

~65,000 species described up to 200,000 species probable

simplest eukaryotic organisms

(the other kingdoms are mainly multicellular.)

very efficient cells compared to procaryotic cells

most metabolically diverse group of eucaryotes

(but not more so than bacteria)

diverse group of **organelles** with highly developed **division of labor**

found anywhere there is water or moisture:

freshwaters,

marine environments,

damp soil,

leaf litter,

snow,

ice

important part of **plankton**:

organisms that drift with currents

most **unicellular**, some **colonial**, **filamentous**, some (seaweeds) **multicellular**

multicellular forms with specializations of cells for different functions:

reproduction
photosyn
attachment
reproduction
flotation
etc

autotrophs and heterotrophs

most aerobic

a few lack mitochondria and are anaerobic

Movement

most protists are motile

→ 5 x's faster

(but only ~5x's body length, vs bacteria 10-50x's body length at 50µm/s)

eg. Paramecium 2700 µm/s

eg. Chlamydomonas 200µm/s

use

cilia

flagella

amoeboid motion

gliding

nonmotile

Reproduction and Life Cycles

highly varied reproduction and life cycles

true mitosis and meiosis to produce gametes

reproduce asexually and sexually

asexually:

budding
fission & multiple fission
sexually:
some by conjugation (eg. *Spirogyra*)
some by syngamy
 isogamy = similar gametes
 anisogamy = similar shape but
 one is larger
 oogamy =
 female is larger, nonmotile
 male is smaller, motile
some produce gametes in single celled
gametangium

many have both a **feeding** and a **resistant stage** in
their life cycle

some algae that live in temporary pools

- secrete a gelatinous sheath that swells when soaked in water
- when dry sheath shrinks into a hardened coating that protects cell from completely drying out until next rain

some have alternation of sexual and asexual
generations

200,000 species described

polyphyletic ie. not a natural grouping, some divide protists into 5 or 6 separate kingdoms and 50 phyla

major types of organisms (Note: these are not evolutionary groupings, they are groupings of convenience, and not necessarily the same groupings as in your text, or in other books):

- 1. Algae** (22,000 species + fossils)
mostly single celled, colonial, some multicellular photosynthetic protists, most with cell wall
- 2. Protozoa** (31,000 species + fossils)
mostly single celled or colonial, heterotrophs, non photosynthetic, mostly motile
- 3. Slime Molds** (1,100 species)
mostly complex life cycles
involving amoeba-like stage and fungal spore-like stage, alternating sexual and asexual reproduction, heterotrophs

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

share several animal-like traits:

lack cell wall,
most are motile
heterotrophic nutrition,

animals probably evolved from some kind of protozoan

most are single cell (=solitary)

a few are **colonial**

most are microscopic (3-300 μ m)

have been found in all aquatic environments

form important part of **plankton** (=zooplankton)

some found in terrestrial habitats where moisture is abundant:

sand

soil
decaying organic matter

some are parasitic or symbiotic in animals

most are motile by

cilia

flagella

amoeboid motion (form pseudopodia)

(found in amoebas and some flagellates)

one group is nonmotile and parasitic

can also use cilia or flagella to create water currents
for feeding

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

heterotrophs = feed by:

1. absorbing dissolved organic nutrients
through cell membrane
2. ingest solid particles
through a mouth-like opening (=cytostome)

eat bacteria, algae, other protozoa, etc

some are saprophytic
(=eat decaying organic matter)

3. ingesting solids or liquids

through cell membrane (phagocytosis & pinocytosis)

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”

Life Cycles

- a. most protozoa exist in a single form which feeds and reproduces
- b. some alternate between two stages in their life cycle:

troph = active vegetative feeding form

cyst = more resistant stage,
low metabolic rate
may have wall of cellulose, silica or a chitin-like substance

- c. some parasitic forms have several different stages in more than one host

Reproduction

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 (flagellates)

some split transversely (ciliates)

budding = unequal fission

multiple fission = >2 daughter cells
(some flagellates, sarcodines, most
sporozoans)

sexual: involves some exchange of genes

conjugation = exchange of a few genes
(ciliates only)

syngamy = fusion of gametes

Some “animal-like” groups of Protists:

1. “Amoebas” =several phyla (still uncertain)

2. “Flagellates”

- a. Phylum: Euglenozoa
- b. Phylum: Retortamonada
- c. Phylum: Axostylata
- d. “Choanoflagellates”

3. “Ciliates”

- a. Phylum: Ciliophora (Ciliates)

4. Apicomplexans

- a. Phylum: Apicomplexa

“Amoebas”

probably several phyla that haven't been sorted out yet

amoeba = “to change form”

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

related to changes in consistency of the cytoplasm:

ectoplasm = gel

endoplasm = liquid

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

simplest protozoans →relatively few organelles

may be naked or enclosed within shell or case:

only phylum of protozoan with extensive fossil record

the shell may be composed of materials secreted by cytoplasm or

foreign material embedded in cement like secretion

two most important shelled forms:

radiolaria secrete a silica shell (SiO_2), and
foraminiferans produce calcium carbonate shells (CaCO_3)

reproduce mostly asexually

a few reproduce sexually

Human Impacts:

Human pathogens include:

1. *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

→ direct transmission by kissing, shared utensils

2. *Entamoeba histolytica*

amoebic dysentery

esp tropics and areas of poor sanitation
(5% infection in temperate areas)

humans only reservoir

spread by fecal/oral route

invade intestinal mucosa

feed on RBC's

90% are asymptomatic

can cause ulcerations and profuse bleeding in acute cases

cysts passed in feces

may spread to liver, lungs, brain, etc

2. *Naegleria fowleri*

causes always-fatal primary amoebic meningoencephalitis or
PAM

mature adults seem to be immune

prefers warm waters with a high iron content

may prefer areas where other organisms have been wiped
out by natural or man made disasters (eg Mt. St.
Helens)

“Flagellates”

a. Phylum Euglenozoa

(eg. *Euglena*, *Peranema*, *Phacus*, *Trypanosoma*, *Leishmania*)

cell membrane surrounded by **pellicle**
“stiffens” cell membrane

move using one or a few long **flagella**

some have “sail-like” **undulating membrane**
(also used for food gathering and locomotion)

most are **symbionts** as either **mutualists** or
commensals

eg. such as those in the gut of termites

eg. cow rumen contains 1 M protozoa/ml (100 l of fluid
total)

reproduce by binary fission

some are parasitic

some are human **pathogens**

eg. euglena

eg. Trypanosoma (African Sleeping Sickness)

esp in Africa
20,000 cases/yr (1988)
two hosts:

tsetse fly = definitive host
humans and other animals
intermediate hosts
moves into blood and lymphatic system
affects CNS: personality changes,
behavior changes, headaches, apathy, NM
disorders, sleepiness, emaciation
may result in death from coma,
malnutrition, secondary infections

eg. Chagas disease (*T. cruzi*)

Mexico, Central America, So. America
40-50% of population in So. America
>16 M people infected in S. America
→ 50,000 die each year
only a few cases in extreme SW US
reservoirs: rodents, possums, armadillos
vector: "kissing bug": bites lips, defecates while
feeding and may be rubbed into wound by
scratching bite
most dangerous to children
symptoms somewhat similar to sleeping sickness
may also affects many organs; eg. brain, heart,
intestines

eg. *Leishmania*

zoonosis

especially in equatorial areas
transmitted by phlebotomid (sandfly) vector
injected directly into human host
reproduces inside WBC's
two forms:

cutaneous form:

begins with skin ulcer at site of infection
may recur after healing
may spread to nose, lips, palate, throat
death from bacterial infection

systemic form:

produces high intermittant fever

enlarged spleen, liver and lymph glands
75-90% death rate

b. Phylum: Retortamonada

commensal and parasitic species

no mitochondria or golgi bodies

eg. *Giardia*

pear shaped

diarrhea

humans are final (definitive) host

no intermediate hosts

worldwide distribution

infect upper small intestine

no invasive ability – saprophytic

in large #'s can cause chronic diarrhea,
dehydration

cysts shed in feces

fecal/oral transmission

epidemics associated with contaminated water

c. Phylum: Axostylata

(eg. Trichomonas, termite flagellates)

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

human urogenital tract:

like acidity of female tract

one of most common infections in US
(2.5 M inf/yr: 3-15% US infected)

no cyst form → requires personal contact

occasionally spread in communal baths and mother to child

both male and female infected

esp in promiscuous young women who are already infected with other STD's

~50% are **asymptomatic carriers**

symptoms: women -frothy, smelly green discharge; painful urination

d. “Choanoflagellates”

protists group closest to animals

resemble feeding cells of sponges

found in freshwater and salt water, common

“Ciliates”

Phylum: Ciliophora

The largest most diverse group of single celled 'protozoan' protists

mostly are freeliving

in a wide variety of habitats.

motile by means of **cilia**
= 1000's oarlike projections

produce coordinated movements

fastest of the protozoans

a few are nonmotile: attached to substrate by stalk

use cilia for feeding, not movement

Wide variation in #'s and kinds of organelles:

more than one nucleus,

some **macronucleus** => vegetative chores

micronuclei (up to 80) => sexual reproduction

“**mouth**” and throatlike area,

most feed on microorganisms – have mouthlike

cytostome; opens into a throat; food vacuole forms at end of throat

contractile vacuoles, etc

some fw forms use to remove incoming water

trichocysts

some ciliates can steal chloroplasts from the algae they eat

Reproduction:

asexual: binary fission

sexual: conjugation: portion of micronuclei are exchanged between + and - forms

Human Impacts:

Human Pathogens:

1. *Balantidium coli*

only ciliate that is a human parasite

zoonosis: esp in sheep, cattle, pigs, horses
rare in US

esp in hosts with weakened defenses

can be asymptomatic

causes erosion of intestinal lining

produces nausea, vomiting, bloody diarrhea

“Apicomplexans”

a. Apicomplexa (Sporozoa)

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.

Human Impacts:

Human parasites include:

1. *Plasmodium* (malaria)

single most important disease hazard for
people traveling to foreign lands
(esp. Asia, Africa, Latin America)

worldwide infects 270M and kills 2M/yr

in some parts of world is chronic
relatively rare in US (usually travelers)

4 species, all can infect humans

requires two hosts to complete life cycle:

sexual reprod

occurs in *Anopheles* mosquito

reproduces in salivary glands

asexual reproduction

occurs in humans

concentrates in liver

symptoms: cyclic chills/fever, headache every 3-4 days

if not treat may be self limiting but may be reservoir for up

to 3 years
can produce irreversible damage to liver, spleen, kidneys
and brain
most effective prevention is elimination of mosquito
WHO has been trying to eliminate it but with little success
mosquitoes have developed resistance to insecticides
has developed antibiotic resistance
experimental vaccines being tested
some living in endemic areas have developed
genetic resistance to disease (sickle cell)

2. *Toxoplasma*

zoonosis
cats are main reservoir and definitive host
humans contract by contaminated soil, cat feces (litter box),
infected meat
generally no human-human transfer
asymptomatic in adults
if pregnant can cross placenta and cause retardation,
blindness and convulsions in embryo or newborn

3. *Pneumocystis*

common secondary infection of AIDS victims