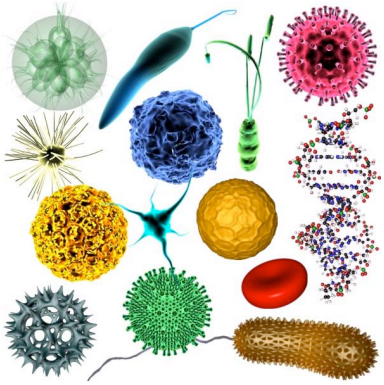
MAJOR GROUPS OF MICROBES

MICROBES



- The term microbe is short for microorganism which means small organism – observed with a microscope
- Over 99% of microbes contribute to the quality of human life
- A small minority cause disease – in humans by sheer numbers or producing powerful toxins
- The major groups of microbes are Archaea bacteria, , algae, fungi, protozoa & viruses
- In terms of numbers, microbes represent most of the diversity of life on Earth and are found in every environment.

BENEFICIAL VS HARMFUL MICROBES

- Most are beneficial (over 99%) contribute to the quality of human life
- They live in every environment on earth
- Microbes are important in ecological systems
- They are important to biogeochemical cycles
- Human digestion depends upon them
- They are important to the food industry and the productions of many products
- Microbes help with wastewater and oil spill cleanup
- A small minority of microbes cause disease

CELLULAR LIFE - All cells have the following:

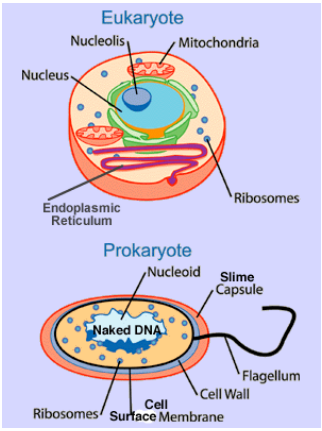
- Has a membrane that separates the cell from the outside world
- Contains a nucleic acid as its genetic material (DNA or RNA)
- Use their genetic material to produce protein – structural or functional as enzymes and hormones
- Are composed of basic chemical as carbohydrates, proteins, fats, nucleic acids, vitamins, & minerals
- Regulate the flow of nutrients and wastes entering and leaving the cell
- Reproduce and are the result of reproduction
- Require a source of energy
- Interact with their environment

ACELLULAR VS CELLULAR

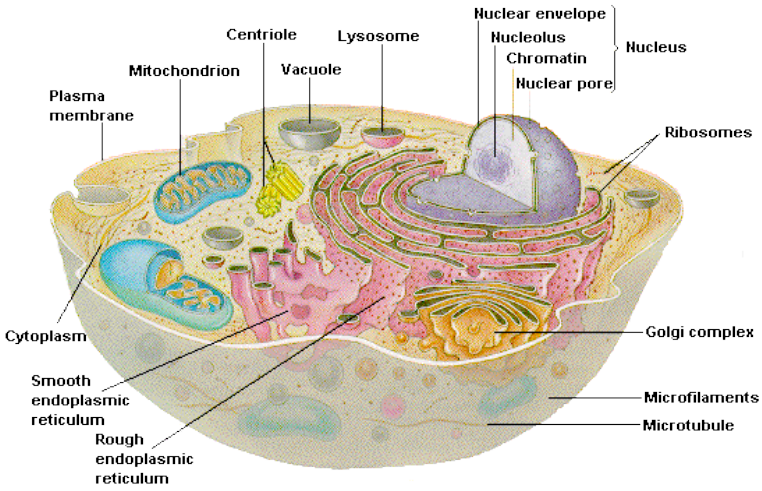
- **Acellular –** Viruses do not have cellular components, nor do they grow or metabolize organic materials. They generally consist of a piece of nucleic acid encased in protein which must use the cellular components of a living cell to reproduce. Prions (**pr**oteinaceous **i**nfectious particles) are infectious agents composed primarily of protein which induce the existing polypeptides in host cells to take on its form.
- **Cellular –** bacteria and Archaea are prokaryotic cells while algae, fungi, and protozoa have eukaryotic cells.

PROKARYOTIC vs EUKARYOTIC CELLS

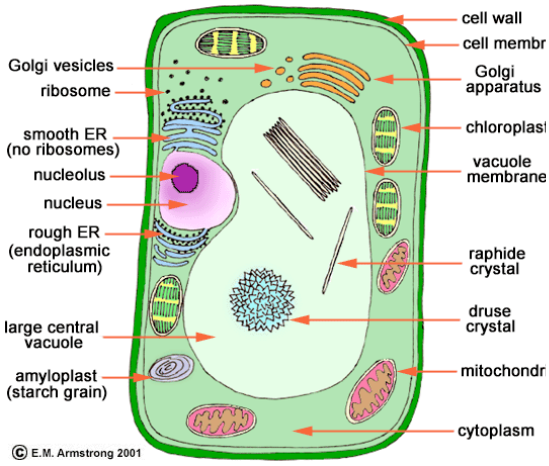
Comparison



- ***Prokaryotic*** – single celled microorganism (archaea and bacteria) with nuclear material but no nuclear membrane or membrane bound organelles



Eukaryotic Animal Cell



Eukaryotic Plant Cell

- ***Eukaryotic*** – most cells – with organized nucleus and membrane bound organelles

  Surface of Cell:
  - **Cell Wall** – commonly found in plants cells – protection & support
  - **Plasma Membrane –** control of substances coming in and out
  - **Cilia -** sweep materials across the cell surface
  - **Flagellum -** enables a cell to propel and move in different directions

  Cytoplasm – between plasma membrane and nucleus – many organelles
  - **Endoplasmic reticulum (ER)** is the passageway for transport of materials within the cell
  - Synthesis of lipids – modification of newly formed polypeptide chains
  - **Ribosomes** are the site of protein synthesis
  - **Golgi apparatus**- Final modification of proteins & lipids Packing of materials for secretion of the cell
  - **Mitochondria** are the site of aerobic cell respiration-ATP production
  - **Lysosomes** contain enzymes to digest ingested material or damaged tissue
  - **Chloroplasts –** store chlorophyll – photosynthesis light reaction
  - **Vacuoles –** storage – increase cell surface area
  - **Centrioles -** organize the spindle fibers during cell division
  - **Cytoskeleton** – cell shape, internal organization, cell movement & locomotion

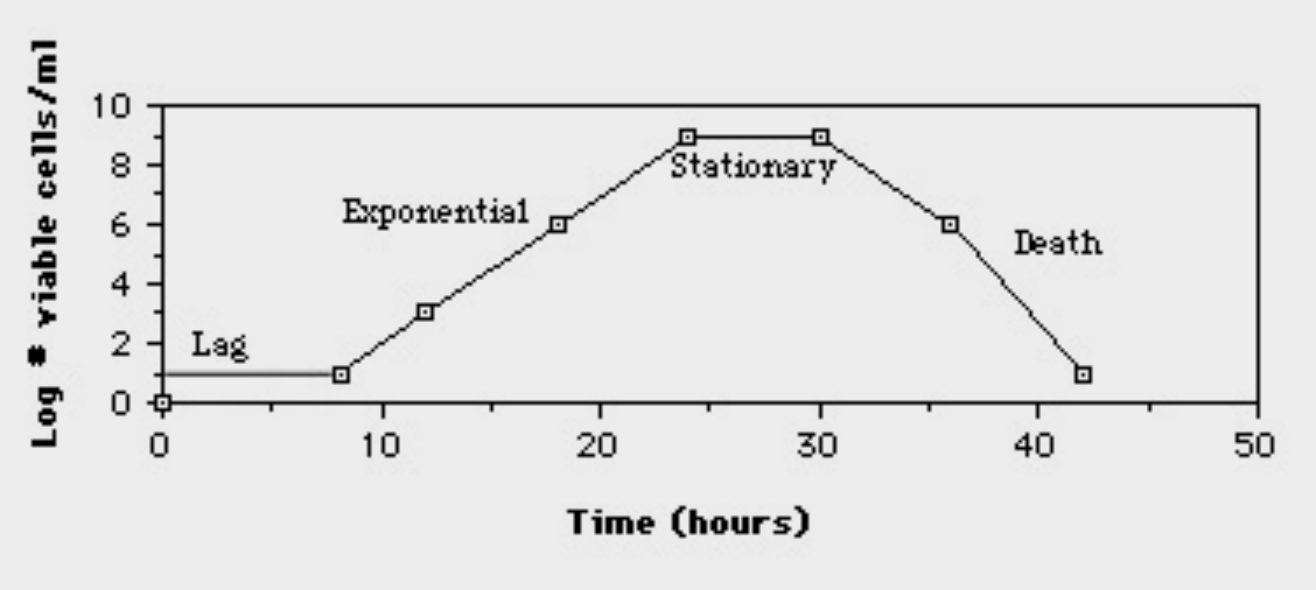
Nucleus: - control center of the cell

- **Nuclear membrane –** membrane around nucleus – controls movement in an out
- **Nucleolus** – assembly of subunits of ribosomes.
- **DNA** - encoding of heredity information
- **RNA** – transcription and translation of DNA coding into proteins

Organelles of Microbial Origin

- Eukaryotic cells are structurally and biochemically more complex than Eukaryotic cells
- There is strong evidence to suggest that Eukaryotic cells came from aggregates of Prokaryotic cells that became interdependent and eventually fused into a single larger cell.
- **Nuclear material –** is found in both Prokaryotic and Eukaryotic cells
- **Mitochondria –** are found in both Prokaryotic and Eukaryotic cells but are smaller in the Prokaryotes. They have DNA similar to that of a Prokaryotic cell and can reproduce independent of the rest of the Eukaryotic cell.
- **Chloroplasts** – also have DNA similar to that of a Prokaryotic cell and can reproduce independent of the rest of the Eukaryotic cell.

MICROBIAL GROWTH CURVE



- **Viable Cells –** living cells
- **Nonviable Cells –** dead cells
- **Phases in Growth Curve**
  - **Lag Phase -** Producing materials needed to reproduce
  - **Exponential Growth Phase -** Rapid growth – number double each generation
  - **Stationary Phase -** Same number of cells dies as are being produced
  - **Death Phase -** Rapid death of cells due to factors as food supply limited, pollution of environment by wastes

CELL RESISTANT TYPES - which allow organisms to survive harsh environmental factors.

Spores – Resistant structures formed by fungi and those formed by bacteria

are termed endospores or bacterial spores. Bacterial spores can exist at extreme environments for centuries.

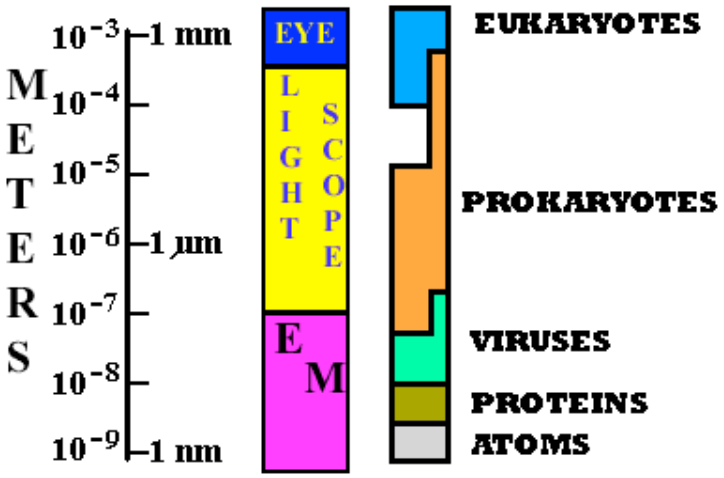
Cysts – Resistant cells formed by some protozoa**.**

RELATIVE SIZE OF MICROBES

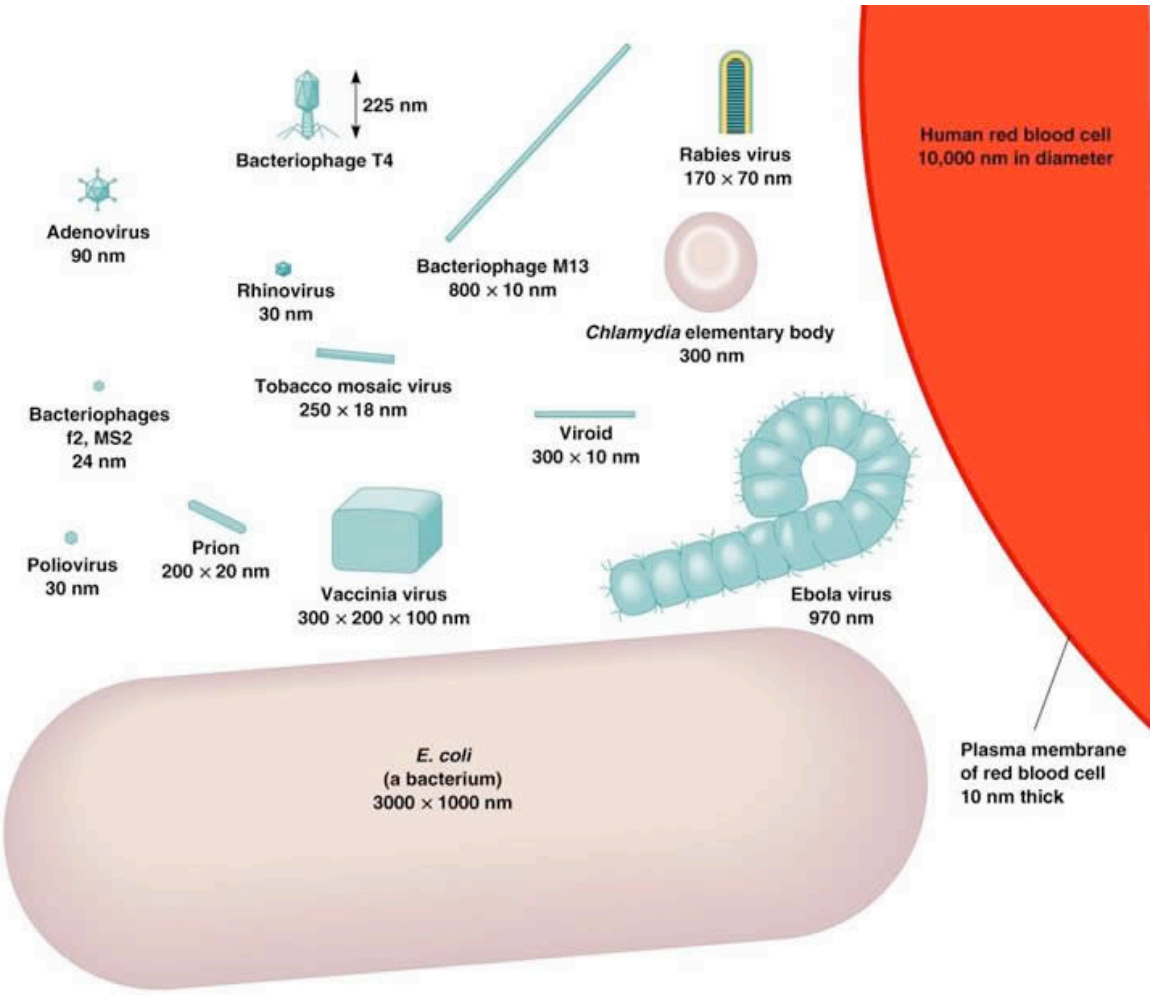
1000 millimeters (mm) = 1 meter (m)

1000 micrometers (µm or mcm) = 1 millimeter (mm)

1000 nanometers (nm) = 1 micrometer (mcm)



Relative Sizes of Viruses and Prions – must be viewed with electron microscopes



MAJOR GROUPS

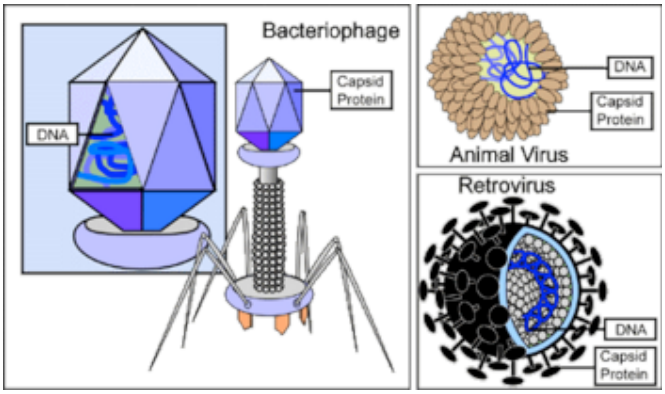
PRIONS - acellular

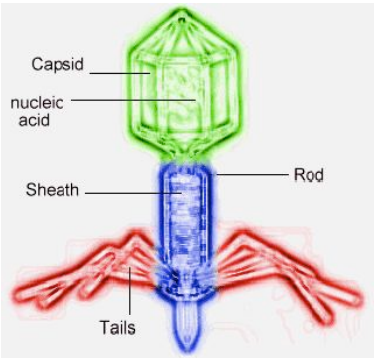
General Characteristics - ultramicroscopic proteinaceous infectious particles

Importance - associated with a number of diseases characterized by loss of motor control, dementia, paralysis, wasting and eventually death

- **Creutzfeld-Jacob disease** (CJD) in humans
- **Gerstmann-Straussler-Scheinker syndrome** (GSS) in humans
- **Alpers syndrome (**in infants),
- **Fatal Familial Insomnia** (FFI) in humans
- **Kuru** in humans
- **Scrapie** in sheep,
- **Bovine Spongiform Encephalopathy** (BSE) or **Mad Cow Disease** in cattle
- **Chronic Wasting Disease** (CWD) in wild ungulates such as Mule deer and elk

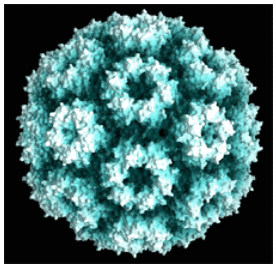
VIRUSES – acellular





General Characteristics

- Are acellular
- Consists of a piece of nucleic acid (DNA or RNA) encased in protein and in some cases a membrane-like envelope
- They come in many shapes
- Are parasites - found anywhere there are cells to infest
- Are small – ranging from 20 – 400 nm
- Exist to reproduce – must take over a suitable host cell
- Uses the cell machinery of the host cell to reproduce



Mode of Transportation – outside of a living cell a viral particle is inactive

Mode of Reproduction – viruses must infest a living cell and use the cellular machinery of the infested cell in order to reproduce. The genetic material can mutate.

Importance of Viruses

- Phage typing of bacteria to help identify bacteria during disease outbreaks
- Source of enzymes
- Pesticides
- Anti-bacterial agents
- Anti-cancer agents
- Gene vectors for protein production and treatment of genetic disorders
- Serve as the infecting agent for a number of diseases

<u>ARCHAEA</u> – prokaryotic

General Characteristics


SEM ~ 5 mcm long

- Are typically smaller than eukaryotic cells
- Similar to bacteria in many characteristics including size and shape – Can have some unusual shapes
- Found in a variety of shapes: coccus, bacillus, spirillium, plate-like and can cluster together: diplo, strepto, staphylo
- Unlike bacteria - Cell walls lack peptidoglycan plus other differences in the chemical composition of many of their structures.
- Origin very old - have been on the planet for billions of years back to the formation of the earth
- Respond to light (phototaxis), food (chemotaxis), temperature (thermotaxis), and to each other (conjugation)
- Some species are **extremophiles** living in extremes of salinity, temperature, and pH and being extremely tolerant to heat, acid, and toxic gases
- May be found in a variety of terrestrial and aquatic environments
- Not known to cause disease

Mode of Movement - move using flagella made of flagellin also have intracellular movement

Modes of Nutrition- photoautotrophic, chemo-autotrophic, photo-heterotrophic and chemo-heterotrophic

Mode of Reproduction - reproduce by cell division: known as binary fission involving one genomic chromosome and replicons...but not by mitosis. They grow very rapidly, dividing every 20 minutes, doubling in both size and number recombination can be achieved by conjugation

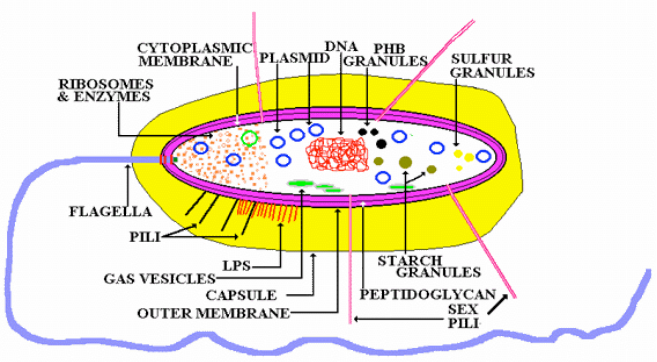
Importance of Archaea

- May contribute up to 20% of earth's biomass
- Some are in extreme habitats in anaerobic environments to produce methane, high salt concentrations or hot acid environments
- Large numbers are found throughout the world's oceans in non-extreme habitats among the plankton community
- Are involved in carbon and nitrogen cycles
- Assist in digestion in the gut
- Used to produce enzymes that function under harsh conditions
- Play a vital role in sewage treatment
- Used in mineral processing to assist in the extraction of ores.
- Involved in mutualism with other organisms to assist in digestion in ruminants and termites
- Involved in commensalism with organisms as around plant roots

<u>BACTERIA</u> – prokaryotic

General Characteristics

- Consist of only one cell – a prokaryotic cell
- Live in all environments – even above boiling point and below freezing point
- Are typically smaller than eukaryotic cells
- Are basically three shapes – spherical , rod, and spiral or helical
- Exist as individuals or cluster together to form pairs, chains, squares, or other groupings
- Some are **photoautotrophic** - make their own food as plants and give off oxygen
- Some are **chemoautotrophic** - synthesize their own food using energy from chemical reactions – important for recycling in nitrogen and sulfur cycles
- Some types are also aerobic – use oxygen for respiration while others are anaerobic
- Some form spores which allow them to survive severe environmental conditions
- Bacterial spores can exist at extreme environments for centuries.



Composite of a bacteria cell

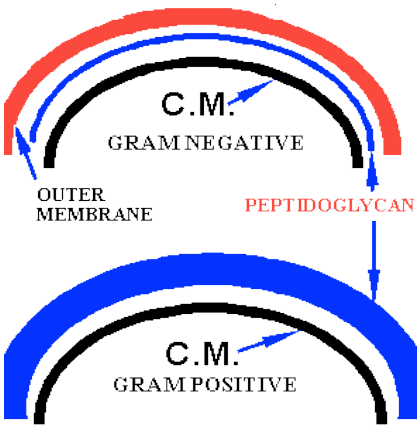
Mode of Transportation - Some have flagella - rotates like a tiny outboard motor, others secrete a slime layer and move over surfaces like slugs, while others are immobile.

Mode of Reproduction - grow to a fixed size then reproduce through binary fission, a form of asexual reproduction, resulting in the formation of two bacterial cells that are genetically identical.

Importance of Bacteria

- Typically 40 million bacteria in a gram of soil and a million bacteria in a milliliter of fresh water
- Cyanobacteria have chlorophyll and carry on photosynthesis – are primary producers and along with algae provide large amounts of oxygen
- Vital in recycling nutrients – decomposers
- In many steps of biogeochemical cycles depending on these
- Used as pesticides
- Used to degrade a variety of organic compounds in waste processing
- Used to clean up oil spills
- Used with yeasts and molds in the preparation of an number of kinds of food
- Important agents for genetic engineering
- Used in industry to produce a number of products
- Can be important agents for disease

GRAM + AND GRAM BACTERIA



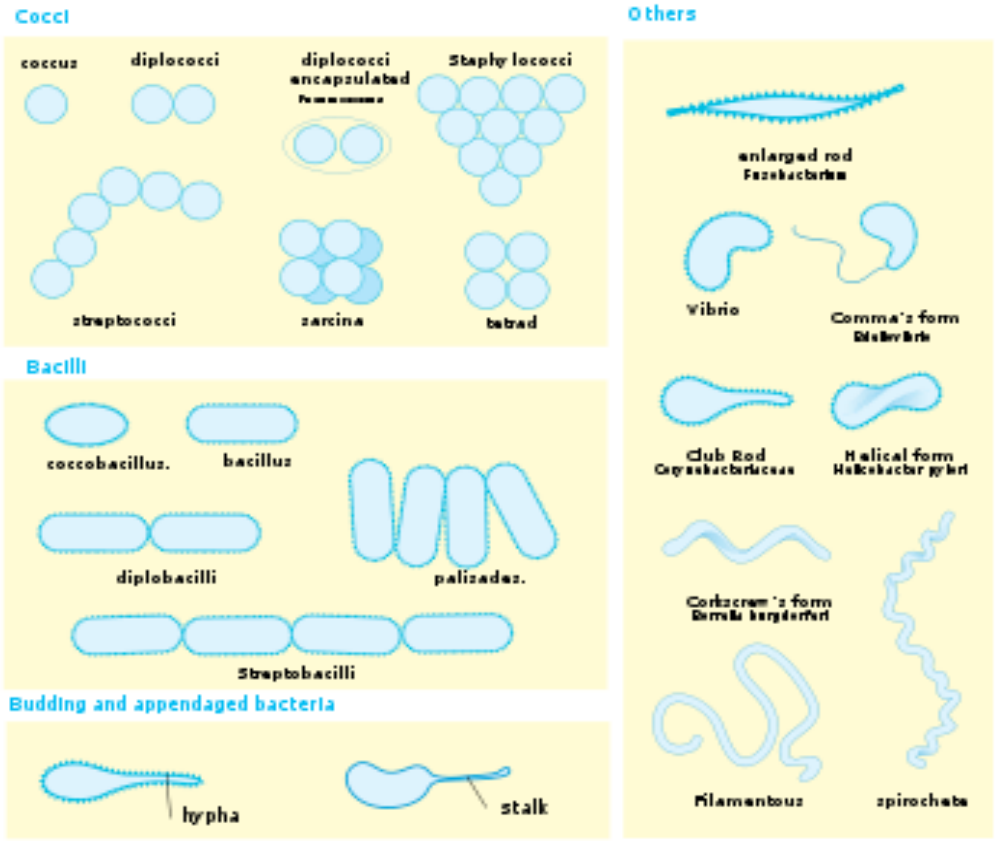
Gram positive bacteria

- stain purple under Gram stain
- have a thick bilayer wall of the polymer peptidoglycan.

Gram negative bacteria

- stain red
- have a thin layer of this polymer and an additional lipopolysaccharide outer layer, LPS,
- often endotoxic - capable of initiating inflammation and cell-mediated immune responses
- e.g., *Salmonella*, *Shigella*, and *Escherichia*.

BACTERIAL SHAPES



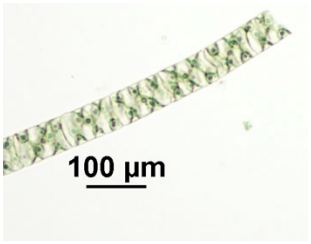
- **bacillus** is rod-shaped
- **coccus** is ball-shaped
- **spirilium** is spiral-shaped
- **vibrio** is comma-shaped
- **cocco-bacillus** is ovoid-shaped
- other combinations

diatoms

ALGAL PROTISTS (ALGAE) – eukaryotic

General Characteristics

- Plant-like occurring as single cells, thread-like filaments, or colonies of various shapes and composition
- Cells, like those of fungi, are surrounded by rigid cell walls.
- Most cell walls made of polysaccharide (cellulose or agar), but some contain quantities of glass (silica dioxide) as with diatoms
- Found in fresh and salt water environments
- Can live on rocks, trees, and in soils with enough moisture
- Some types live inside other organisms
- Photoautotrophs and contain chlorophylls
- Can carry on photosynthesis – produce large amount of oxygen for life on earth
- They are self-feeding (autotrophic) and as producers provide food for other organisms



Spirogyra

- Examples are Diatoms, *Volvox*, *Clamydomonas* , *Spirogyra*

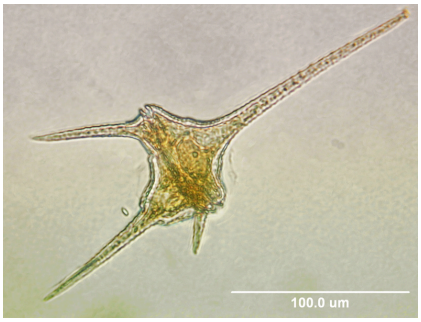
Mode of Transportation – some types of algae have flagellated forms

Mode of Reproduction

- Both sexually and asexually, with asexual reproduction occurring more commonly
- Algae, like fungi, produce asexual spores of various types

Importance of Algae

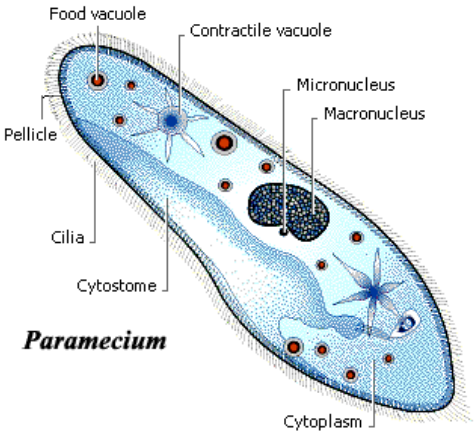
- Play an essential role at the bottom of multiple food chains – major producers
- Algae are nutritious and some kinds serve as food
- With Cyanobacteria produce up to 70% of the oxygen present in the earth's atmosphere
- Some types of algae live inside other organisms and some form symbiotic relationships with fungi in structures called **lichens**.
- **Eutrophication** is an increase in algae populations in a body of water (fresh or salt), and occurs when nutrients are abundant and light intensity is high.
- Algal blooms can use up oxygen in water at night and can kill fish and other organisms living in water
- Dinoflagellates can cause "red tide" while shellfish such as mussels, clams, scallops and oysters feed on dinoflagellates filtered from the water and accumulate neurotoxins in their tissues
- Dinoflagellates ***(Pfiesteria)*** produce potent neurotoxins – contaminate organism that eat them and can cause paralytic shellfish poisoning - threatens both fish and fishermen
- Shells of diatoms – silica – mined to make abrasives
- Algae are used to produce petroleum



dinoflagellate

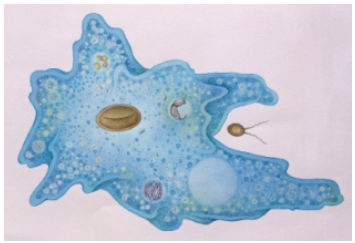
ANIMAL-LIKE PROTISTS (PROTOZOA) – eukaryotic

General Characteristics



- Protozoa means "little animal" – act like tiny animals – Eukaryotic
- Vary greatly in shape and size
- Size varies from 10 to 50 mcm but some are as large as 1000 mcm
- Most prefer a pH near normal (pH of 7)
- Unicellular eukaryotic microorganisms lacking a cell wall
- Some have cells surrounded by hard shells
- Most have a single nucleus
- Some have both a macronucleus and one or more micronuclei.
- Contractile vacuoles may be present to remove excess water
- Heterotrophic - hunt other microbes for food
- Food vacuoles are often observed – obtain large food particles by phagocytosis
- Mainly feed on bacteria, also other protozoa and some algae
- Digest food in digestive organelles
- Some protozoa as Euglena have chlorophyll and can photosynthesize
- Most are found in moist environments as freshwater, salt water and soil
- Most species are aerobic but a few anaerobic species are found in human intestines and animal rumen

Mode of Transportation – Most can move independently



They are organized by mode of transportation

- Ciliates – hair-like cilia (Paramecium)
- Amoebaes – foot-like pseudpods (Amoeba)
- Flagellates – whip-like flagella (Euglena)

Amoeba

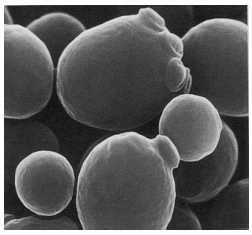
Mode of Reproduction

- They can reproduce by binary fission or multiple fission
- Some produce sexually
- Still others reproduce using a combination of both
- Some types alternate between a free-living vegetative form known as a **trophozoite** and a resting form called a **cyst.**
- The protozoan cyst is like the bacterial spore can resists harsh conditions in the environment.
- Many protozoan parasites are taken into the body in the cyst form.
- In the trophozoite stage, they feed actively

Importance of Protozoa

- Most are not harmful – a few are harmful
- Important as **zooplankton**, the free-floating aquatic organisms of the oceans
- Found at the lower end of many food chains and food webs
- Both herbivores and consumers
- Help control bacterial populations
- Important food source for macro-invertebrates
- Certain protozoa are parasites and can cause dysentery and malaria

FUNGI – eukaryotic


yeast with buds

General Characteristics

- Single celled as **yeast** or multicellular clusters as **molds & mushrooms**
- Cellular level, more like animals than plants
- Cell walls contain chitin
- Heterotrophic - can't synthesize their own food – secrete digestive enzymes into surrounding environment to break down large organic molecules to simple molecules that they can absorb
- Most are aerobic, some are facultative anaerobic (ex. yeast) and some are anaerobic
- Can't tolerate high temperatures but some types can tolerate high sugar concentration, high acid environments, and extremely cold temperatures
- Grow best under conditions that are somewhat acidic – often prefer pH of 5
- Multicellular ones form filament like strands – hyphae
- Cross walls between fungal cells called septa and some species lack these septa as bread mold
- Grow best in slightly acidic environment – can grow in low moisture
- Live in soil, on plants & animals, in fresh & salt water
- One teaspoon of topsoil has about 120,000 fungi

Mode of Transportation

- Non- mobile

Mode of Reproduction

- Sexual and asexual modes of reproduction
- Form sexual and asexual spores
- Yeast form buds for asexual reproduction

Importance of Fungi

- **Baker's yeast** for bread and brewing
- Many fungi are edible and are cultivated worldwide
- Important as decomposers in the ecosystem recycling nutrients
- In symbiotic relation (mutualism) with algae or Cyanobacteria to form lichens
- Form mycorrhizal associations with plant roots which are essential to the growth and health of plants - help absorb phosphorus from the soil
- Some fungi are used as pesticides
- Used as biofertilizers
- Used in the manufacture of dairy products, pharmaceuticals as antibiotics, vitamins, enzymes, vaccines
- Used for Genetic Engineering
- Food Spoilage - Can grow on bread, fruit, cheese, and other foods even when refrigerated
- Ruin ¼ to ½ of fruits & vegetables per year
- Some cause disease in humans, animals and plants
- Major cause of plant diseases