Biology lecture

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Biology

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Introduction:

Definition of Biology: is a science concerned with the study of life and living organisms, including their structure, function, growth, evolution, distribution, and taxonomy.

The word biology is derived from Greek origin : bios means life, and logos means science or study. Therefore, Biology is the science of Living Things That is why Biology is sometimes known as Life Science.

Characteristics of life

Living things (any bacterium ,fungus ,plant or animal) can be distinguished from nonliving things (a piece of wood ,metal, stone ….etc.) through their life characteristics , There are certain basic characteristics shared by all living things:

All living organisms: - grow, respire, move, feed, secrete, excrete (waste), reproduce and sensate.

- Living things are sensitive, meaning they are able to respond to stimuli.
- Living things are able to grow, develop, and reproduce.
- All known living things use the hereditary molecule, DNA.

Living things are organized in the microscopic level from atoms up to cells. Atoms are arranged into molecules, then into macromolecules, which make up organelles, which work together to form cells.

Beyond this, cells are organized in higher levels to form entire multicellular organisms. Cells together form tissues, which make up organs, which are part of organ systems, which work together to form an entire organism. Of course, beyond this, organisms form populations which make up parts of an ecosystem. All of the Earth's ecosystems together form the diverse environment that is the earth.

Branches of biology

Biology can be divided in to many divisions such as Botany which deals with the study of plants and Zoology which deals with the study of animals , Bacteriology concerned with studying bacterium.

Morphology deals with form and structure of organisms . such study on the cellular level is known as Cytology, on tissue level it is known as Histology ,the study of gross structure is known as Anatomy, the study of formation and development of embryo is known as Embryology , mycology deals with fungi parasitology deals with parasites , Helminthology deals with worms ,Virology deals with viruses .

Physiology a branch of biology that deals with functions and activities of living matter (organ ,tissue and cells)and physical and chemical phenomena involved .

Ecology a branch of biology that deals with the interrelations of organisms with their environment. Genetics a branch of biology that deals with the heredity and variations of organisms.

Why we study biology

Biology is one of the fundamental sciences that medicine students and other medical professionals need. It teaches different forms of organic life and their interrelated relations with environment and other science.

Biology is a highly relevant science to our lives. We human beings are biological organisms. We learn biology to know how the human body is made, how it works, and what organs are in the body. We must study biology because we must learn about life in our environment.

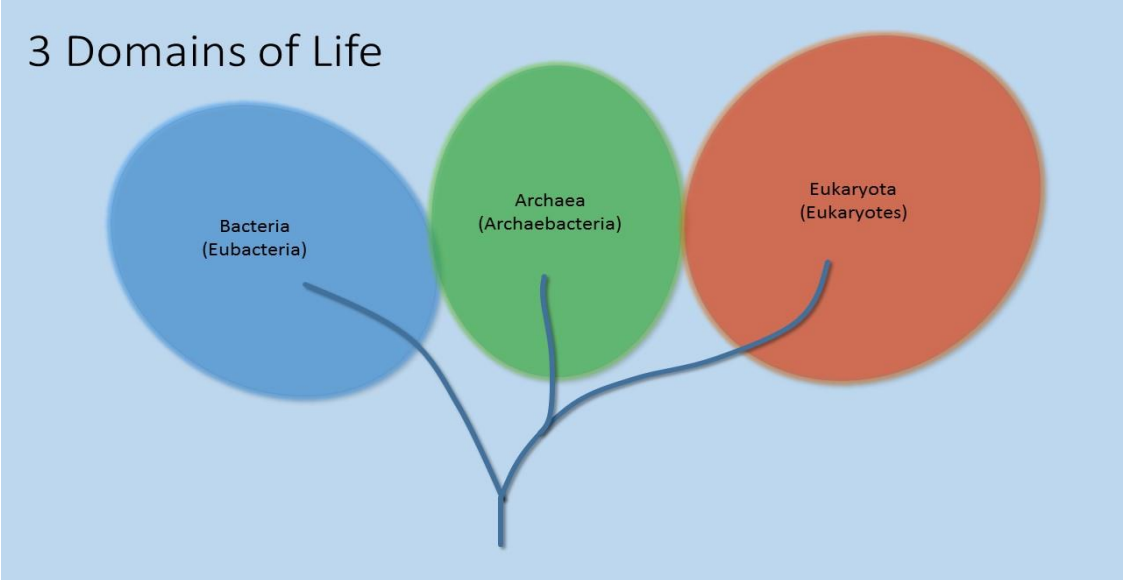
Some important reasons for studying biology have to do with understanding how cells and organisms work. Biology involves the study of life and how plants, humans and animals work. You will better know how your body works. Biology touches your life in many ways every day.

Biology can tell us about the physical makeup of our bodies, which enables us to produce cures and treatments for many diseases , The things biology can also tell us about is plants of major importance and what plants can help our body systems to be healthy. Biology also helps us know the different body systems of different animals and also ourselves. Also biology can help us know more about the organisms in our bodies. Biology can also tell us why animals act the way they do, also why humans act the way we do. This is why biology is important.

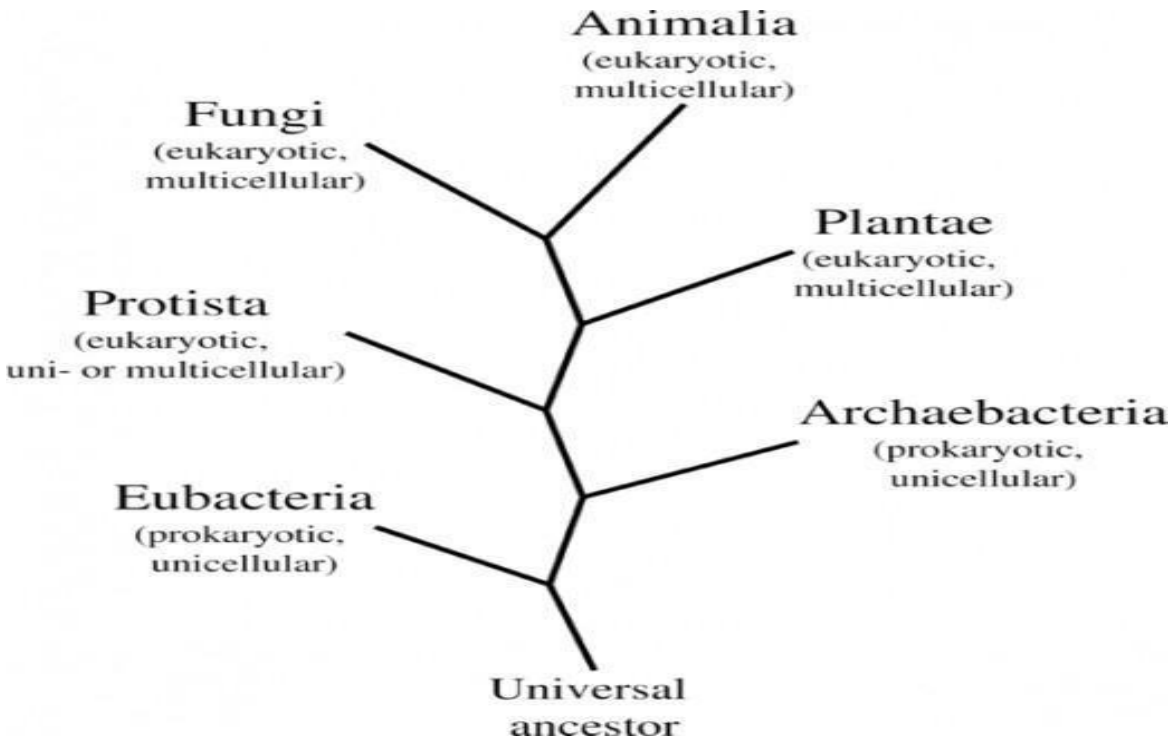
Kingdoms of life

The earliest classification system recognized only two kingdoms : plants and animals but the use of microscope led to discovery of microorganisms , so the two kingdoms system was no longer useful . today the system of classification includes six kingdoms in which two kingdoms of prokaryotes and four kingdoms of eukaryotes.

The organisms are classified in to three domins : Bacteria , Archea and Eukarya .



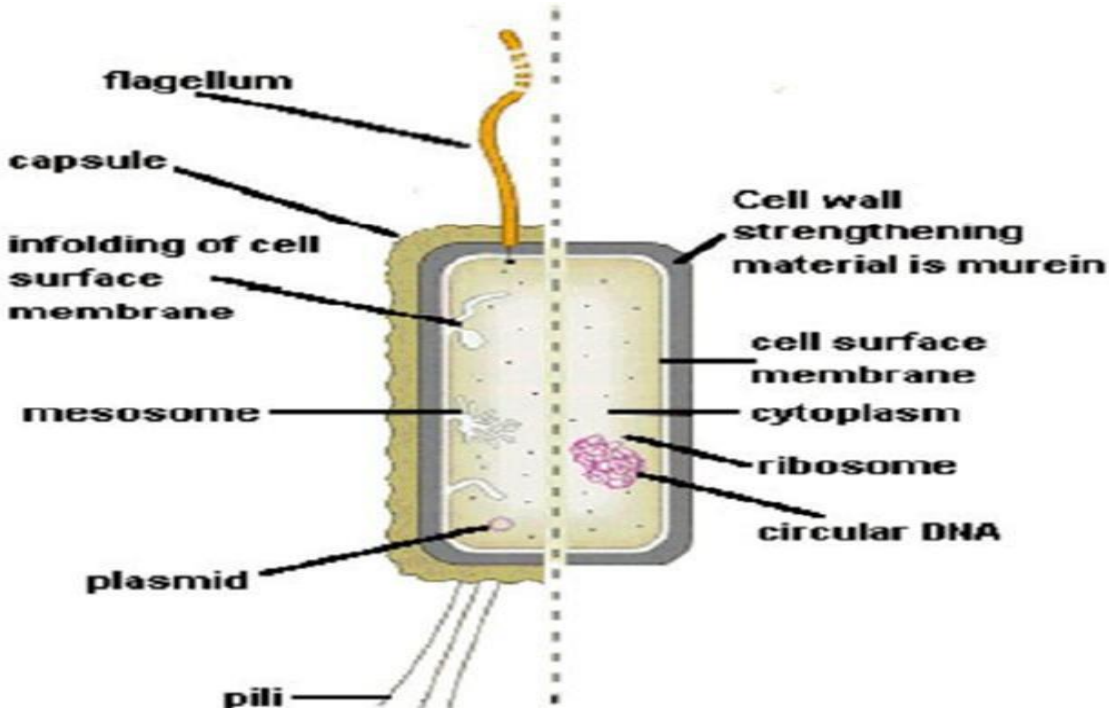
within these domins are six kindgoms od life , these kingdoms are: Archaebacteria, Eubacteria , Protista , Fungi ,Plantae and A nimalia.



Prokaryote vs. Eukaryote

Prokaryotes (pro=before , karyon= nucleus) are single-celled organisms they lack a membrane bounded nucleus and a membrane bounded organelles ,the only membrane in prokaryote cell is the plasma membrane which represent the outer boundry of the cell it self . their genetic material is naked within the cytoplasm , the only type of organelles in prokaryote are Ribosomes .

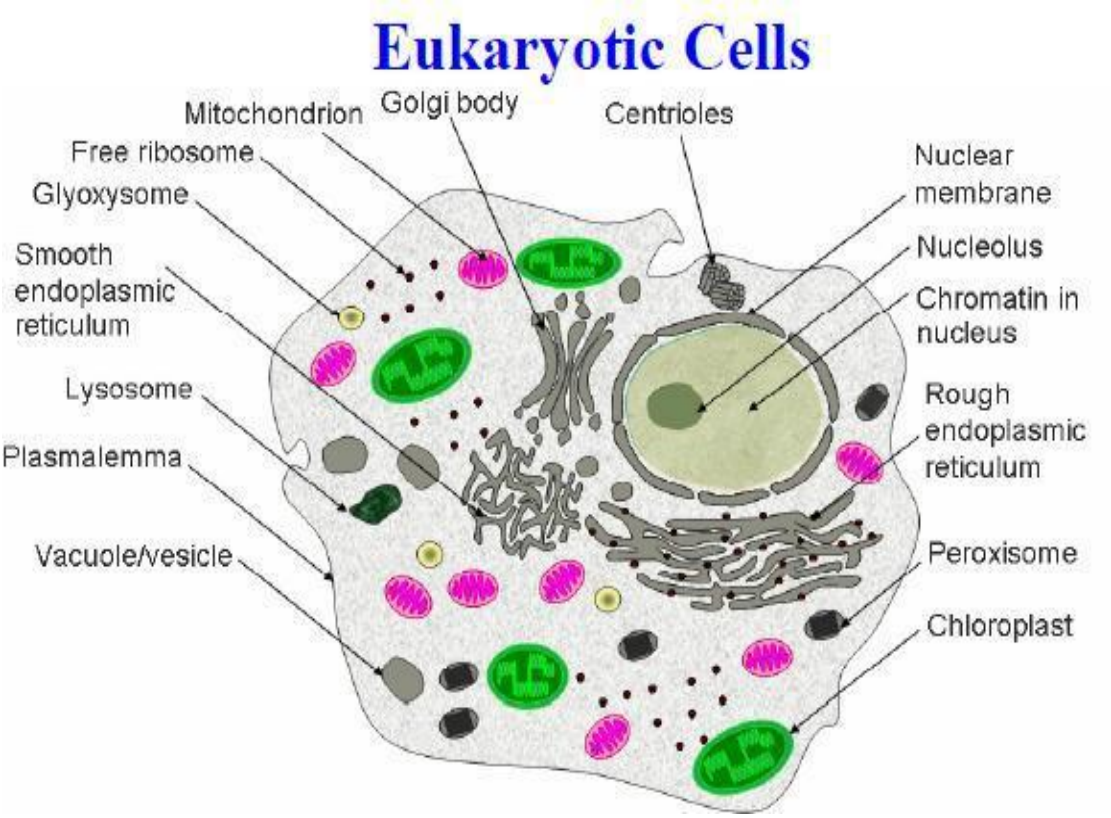
Prokaryote include two kingdoms : Archaebacteria and Eubacteria .



Cytoplasm of prokaryote contains all the enzymes needed for all metabolic reaction since there are no organelles. Ribosomes the smaller (70s) type. Nuclear material is the rgion of cytoplasm that contin DNA . it is not surrounded by a nuclear membrane.DNA always circular and not associated with any protien to form chromosomes.Cell membrane made of phospholipid and protiens like in eukaryotic membrane. Cell wall :made of peptidoglycan (glycoprotien= protien-carbohydrate complex).

Mesosome are tightly folded region of of the cell membrane containing all the membrane bounded protiens required for respiration and photosynthesis .

Eukaryote (Eu=true , karyon=nucleus) are single-celled or multicelled organisms with a defintive nucleus and a membrane bounded organelles , organelles such as mitochondria and chloroplast . these vital organelles invoved in metabolism and energy convertion within the cell .eukaryote included four kingdoms : Protista , Fungi , Plantae and Animalia.



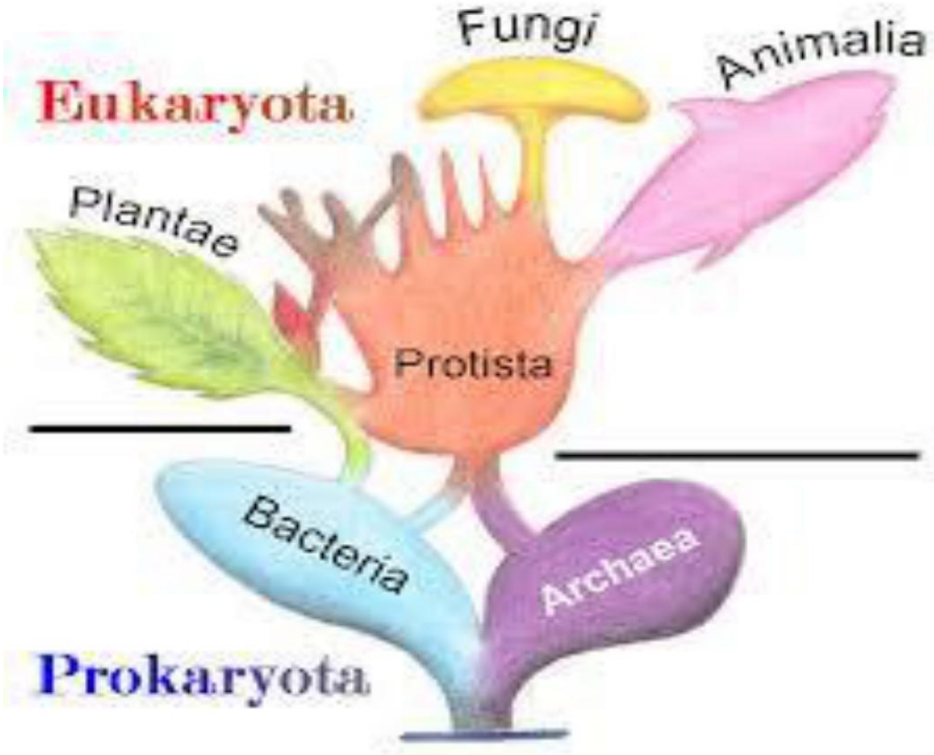
Cell membrane thin layer of phospholipid and protien , it separate the content of cell from the outside environment and control the entry and exit of material. Cytoplasm of eukaryote contain nucleus and all organelles needed by cell to function.

Neucleus: surrounded by double membrane neuclear envelope inside nucleus chomosomes which consists of DAN and protien.

Prokaryotic Cells	Eukaryotic cells
Small cells (< 5 µm)	Larger cells (> 10 µm)
Always unicellular	Often multicellular
No nucleus or any membrane-bound organelles, such as mitochondria	Always have nucleus and other membrane-bound organelles
DNA is circular, without proteins	DNA is linear and associated with proteins to form chromatin
Ribosomes are small (70S)	Ribosomes are large (80S)
No cytoskeleton	Always has a cytoskeleton
Motility by rigid rotating flagellum (made of flagellin)	Motility by flexible waving cilia or flagellae (made of tubulin)
Cell division is by binary fission	Cell division is by mitosis or meiosis
Reproduction is always asexual	Reproduction is asexual or sexual
Huge variety of metabolic pathways	Common metabolic pathways

The Kingdoms of Life

All living things fall into one of three domains which include six kingdoms:



Kingdom Archaebacteria: Prokaryotes, unicellular, that lack a peptidoglycan cell wall, autotrophic or heterotrophic, including the methanogens and extreme halophiles and thermophiles.

Kingdom Eubacteria: Prokaryotic organisms with a peptidoglycan cell wall, autotrophic or heterotrophic, including cyanobacteria, soil bacteria, nitrogen-fixing bacteria, and pathogenic bacteria.

Kingdom Protista: Eukaryotic, primarily unicellular and less are multicellular, autotrophic (photosynthetic) or heterotrophic organisms, such as amoebas ,algae and paramecium.

Kingdom Fungi: Eukaryotic, mostly multicellular , heterotrophic, usually nonmotile organisms, with cell walls of chitin, such as mushrooms.

Kingdom Plantae: Eukaryotic, multicellular, nonmotile, usually terrestrial, photosynthetic organisms, such as trees, grasses, and mosses.

Kingdom Animalia: Eukaryotic, multicellular, motile, heterotrophic organisms, such as sponges, spiders, newts and humans. As more is learned about living things, particularly from the newer evidence that DNA studies provide, scientists will continue to reevaluate the relationships among the kingdoms of life.

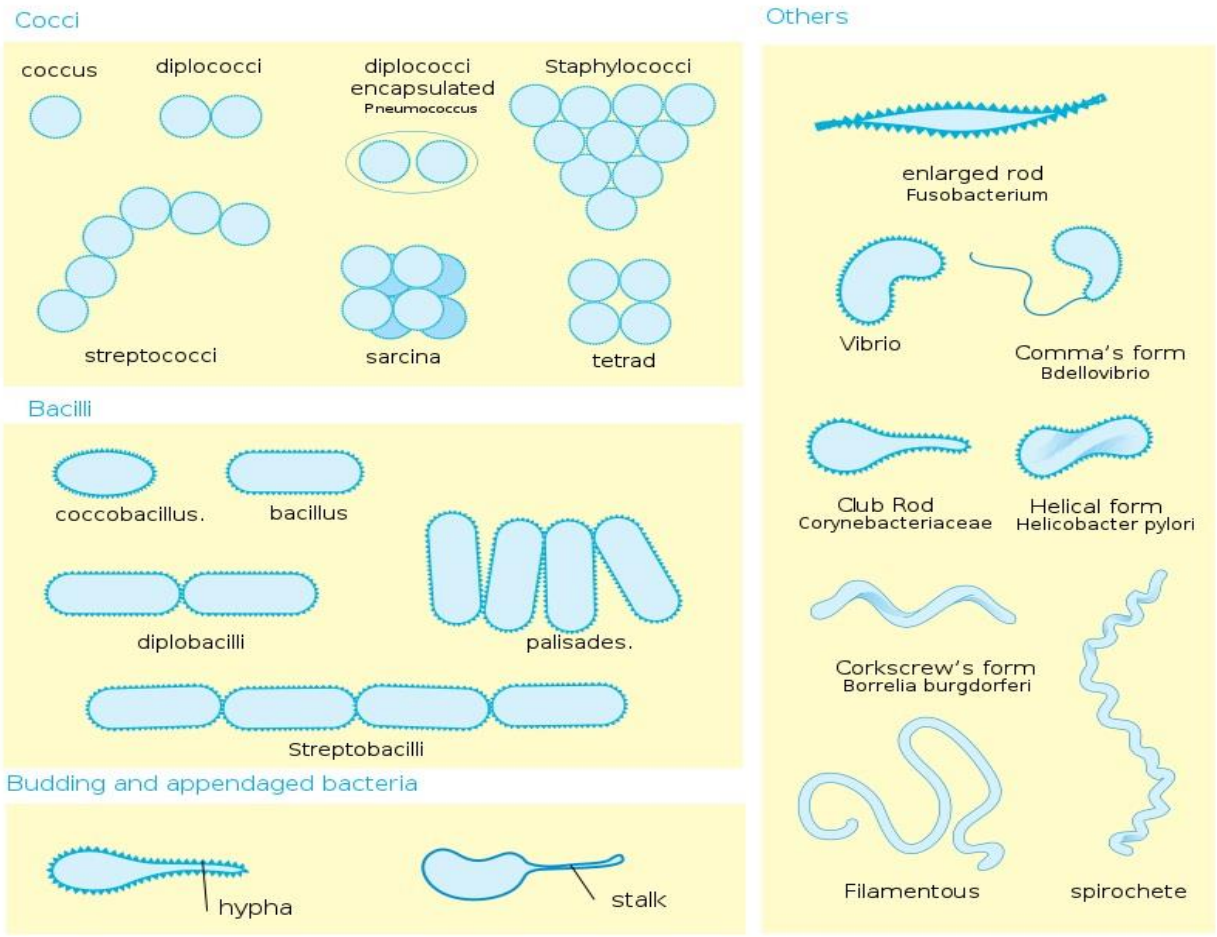
Definition of Bacteria

Bacteria are the oldest, structurally simplest, and the most abundant forms of life on earth. They are also the only organisms with prokaryotic cellular organization.

Bacterial shapes and arrangement

Bacteria are mostly simple in form and exhibit one of three basic structures:

- **Coccus** **- bacillus** **- spiral**



Bacterial structure

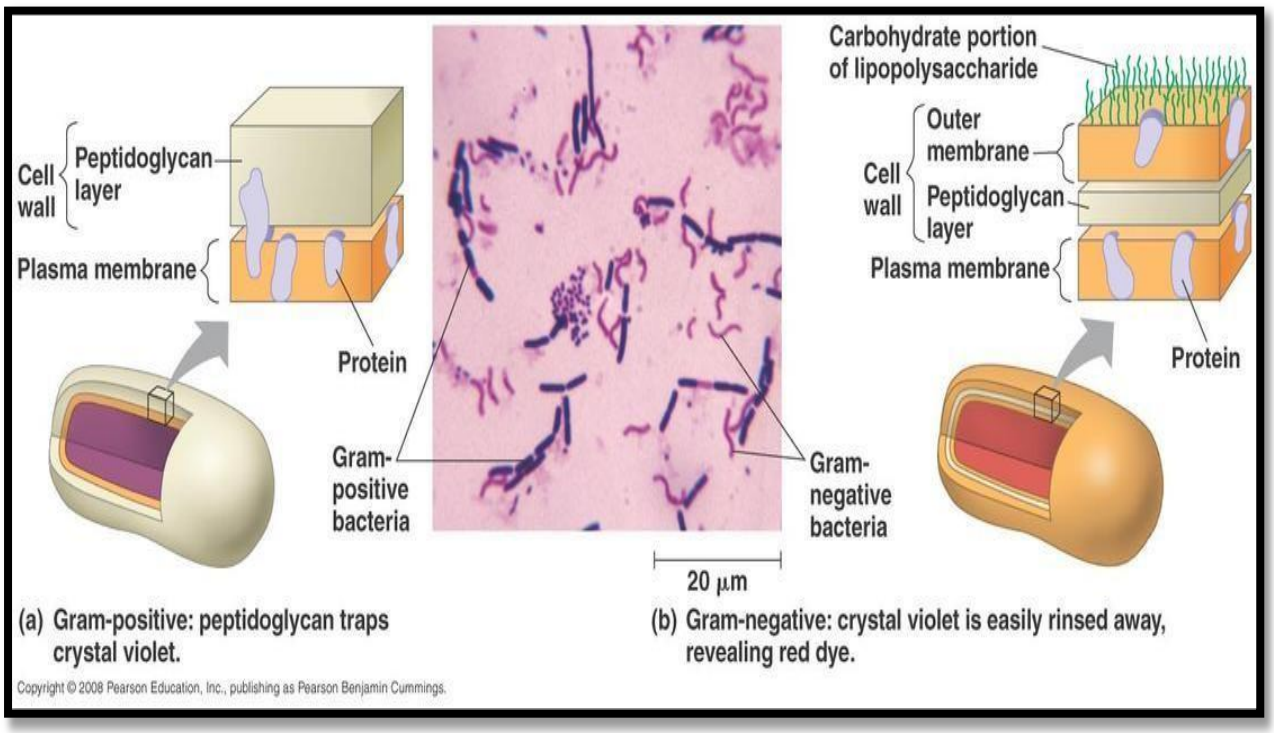
The bacterial cell wall is an important structure because it maintains the shape of the cell and protects the cell from swelling and rupturing. The cell wall usually consists of peptidoglycan .

In some bacteria, the peptidoglycan forms a thick, complex network around the outer surface of the cell. In other bacteria a thin layer of peptidoglycan is found sandwiched between two plasma membranes.

The outer membrane contains large molecules of lipopolysaccharide, lipids with polysaccharide chains attached. These two major types of bacteria can be identified using a staining process called a Gram stain.

Gram-positive bacteria have the thicker peptidoglycan wall and stain a purple color .The more common gram-negative bacteria contain less peptidoglycan and do not retain the purple-colored dye. Gram-negative bacteria stain red.

In some kinds of bacteria , an additional layer consists of polysaccharide ,polypeptides or both called glycocalyx when this layer highly organized and firmly attached to the wall it is called the capsule when less organized loosely attached to the wall it is called slimy layer . this gelatinous layer helps a bacterium to attach to teeth , mucus membrane ,rocks in streams and other interesting surfaces ,it also helps some encapsulated types to resist being engulfed by phagocytic cells of the host .



Many kinds of bacteria have slender, rigid, helical **flagella** (singular, flagellum) composed of the protein flagellin .These flagella range from 3 to 12 μm in length and are very thin only 10 to 20 nm thick . They are anchored in the cell wall and spin, pulling the bacteria through the water like a propeller.

Pili (singular pilus) are other hairlike structures that occur on the cells of some bacteria . They are shorter than bacterial flagella, up to several μm long, and about 7.5 to 10 nm thick. Pili help the bacterial cells attach to appropriate substrates and exchange genetic information.

Bacteria lack nuclei and do not possess the complex chromosomes characteristic of eukaryotes. Instead, their genes are encoded within a single double-stranded ring of DNA that is crammed into one region of the cell known as the nucleoid region. Many bacterial cells also possess small, independently replicating circles of DNA called plasmids . Plasmids contain only a few genes, usually not essential for the cell's survival.

They are best thought of as an excised portion of the bacterial chromosome. Ribosomes: Bacterial ribosomes are smaller than those of eukaryotes and differ in protein.

Bacterial Metabolism

Bacteria have evolved many mechanisms to acquire the energy and nutrients they need for growth and reproduction .

- **Autotrophs**: organisms that obtain their carbon from inorganic CO2. Autotrophs that obtain their energy from sunlight are called photoautotrophs, while those that harvest energy from inorganic chemicals are called chemoautotrophs.
- **Heterotrophs**: organisms that obtain at least some of their carbon from organic molecules like glucose. Heterotrophs that obtain their energy from sunlight are called photoheterotrophs, while those that harvest energy from organic molecules are called chemoheterotrophs.

Metabolic Diversity among Organisms

Nutritional Type	Energy Source	Carbon Source	Example
Photoautotroph	Light	CO_2	Oxygenic: Cyanobacteria plants Anoxygenic: Green, purple bacteria
Photoheterotroph	Light	Organic compounds	Green, purple nonsulfur bacteria
Chemoautotroph	Chemical	CO_2	Iron-oxidizing bacteria
Chemoheterotroph	Chemical	Organic compounds	Fermentative bacteria Animals, protozoa, fungi, bacteria.

Bacterial Reproduction

Most bacteria reproduce by binary fission or by budding (external bud from the parent cell). During binary fission, the single DNA molecule replicates and both copies attach to the cell membrane.

The cell membrane begins to grow between the two DNA molecules. Once the bacterium just about doubles its original size, the cell membrane begins to pinch inward. The cell wall then forms between the two DNA molecules dividing the original cell into two identical daughter cells.

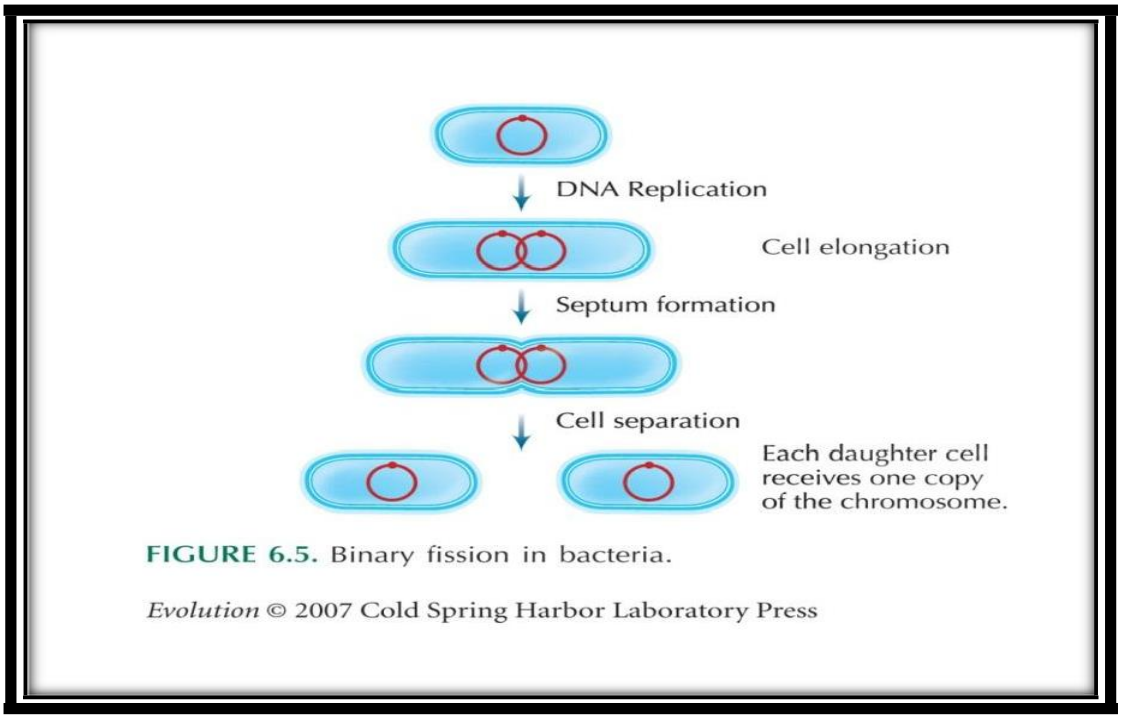


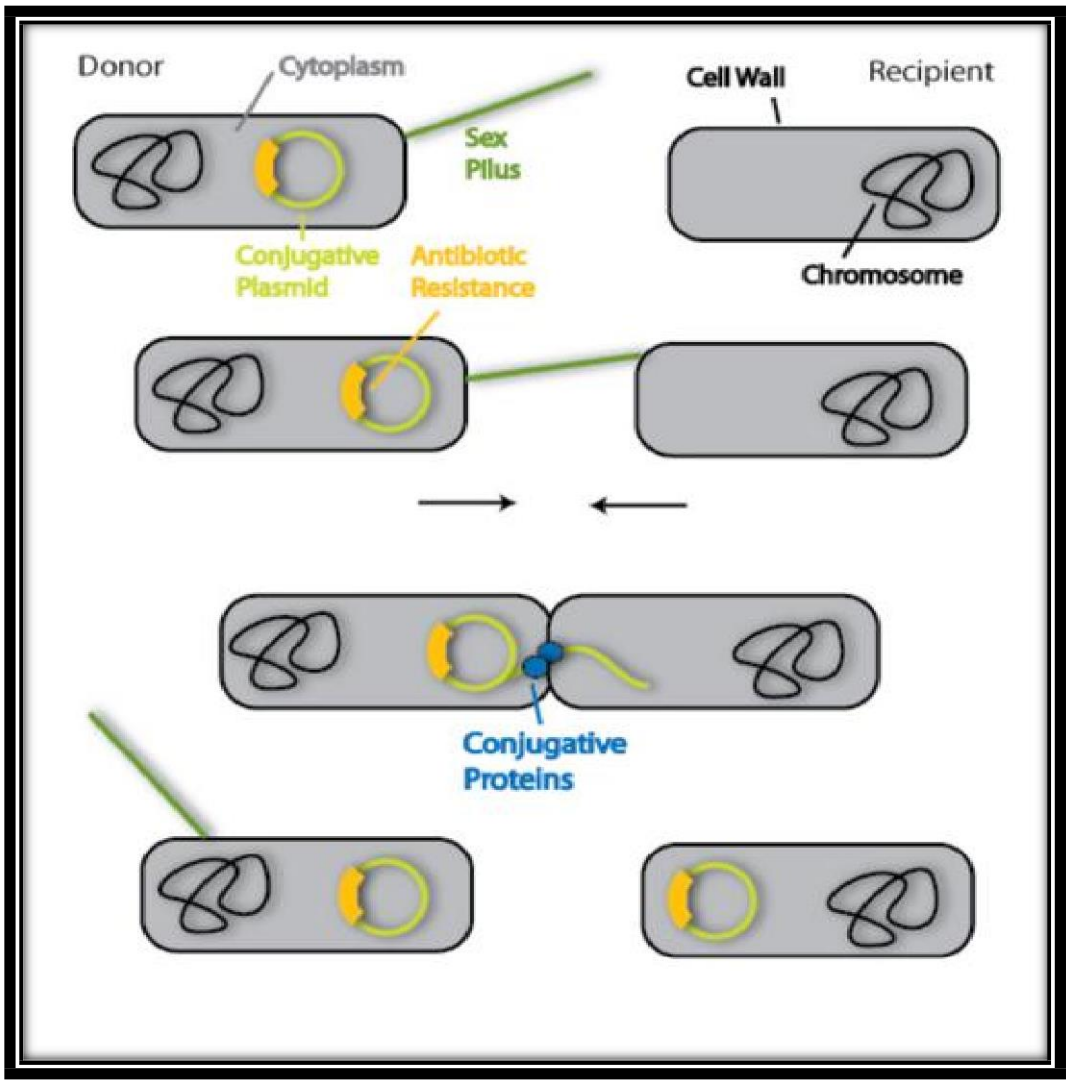
FIGURE 6.5. Binary fission in bacteria.

Binary fission is an effective way for bacteria to reproduce, however it does produce problems. Since the cells produced through this type of reproduction are identical, they are all susceptible to the same types of antibiotics. In order to incorporate some genetic variation, bacteria use a process called recombination. Bacterial recombination can be accomplished through conjugation, transformation, or transduction.

- **Conjugation**

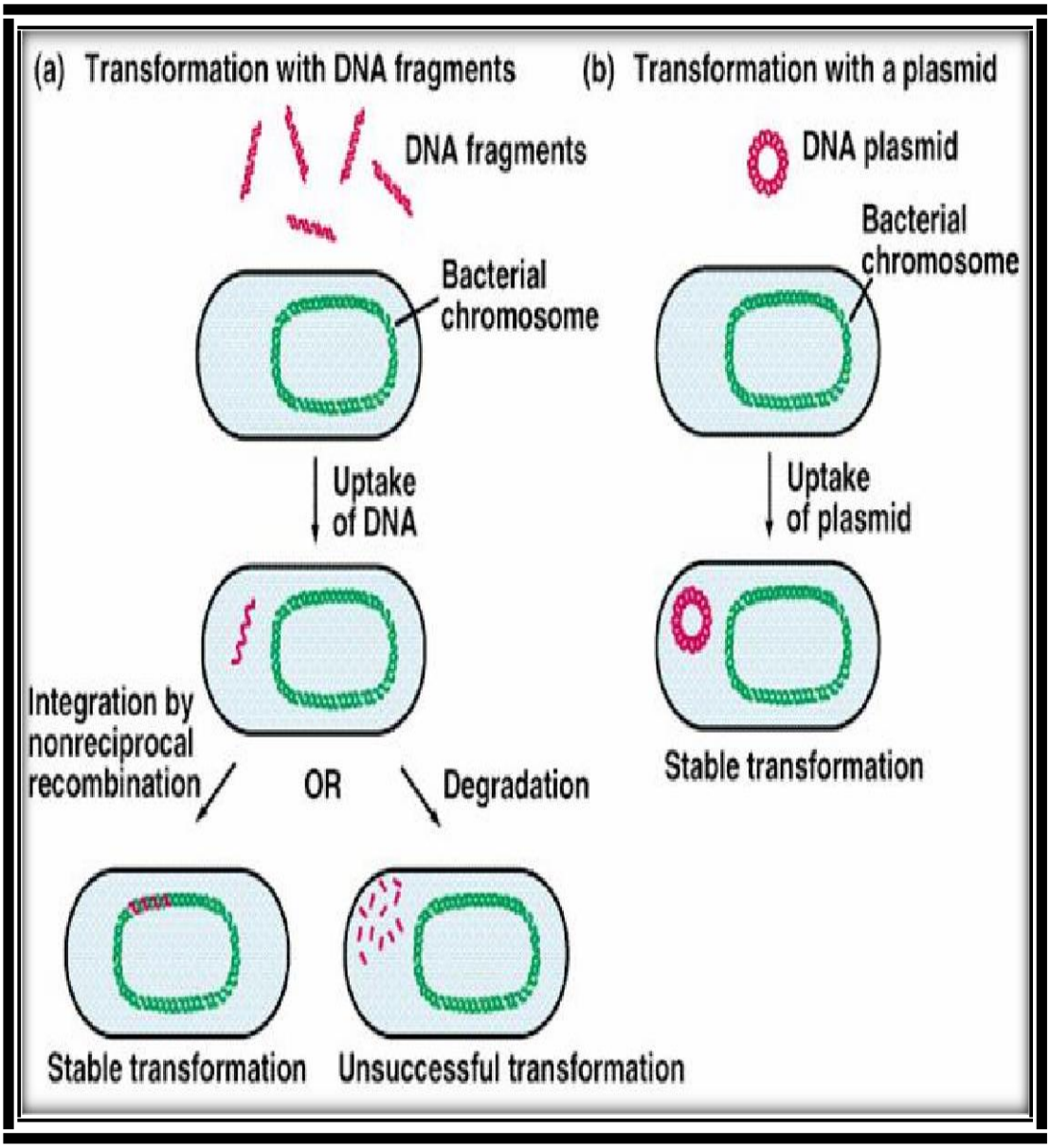
Some bacteria are capable of transferring pieces of their genes to other bacteria that they come in contact with. During conjugation, one bacterium connects itself to another through a protein tube structure called a pilus.

Genes are transferred from one bacterium to the other through this tube.



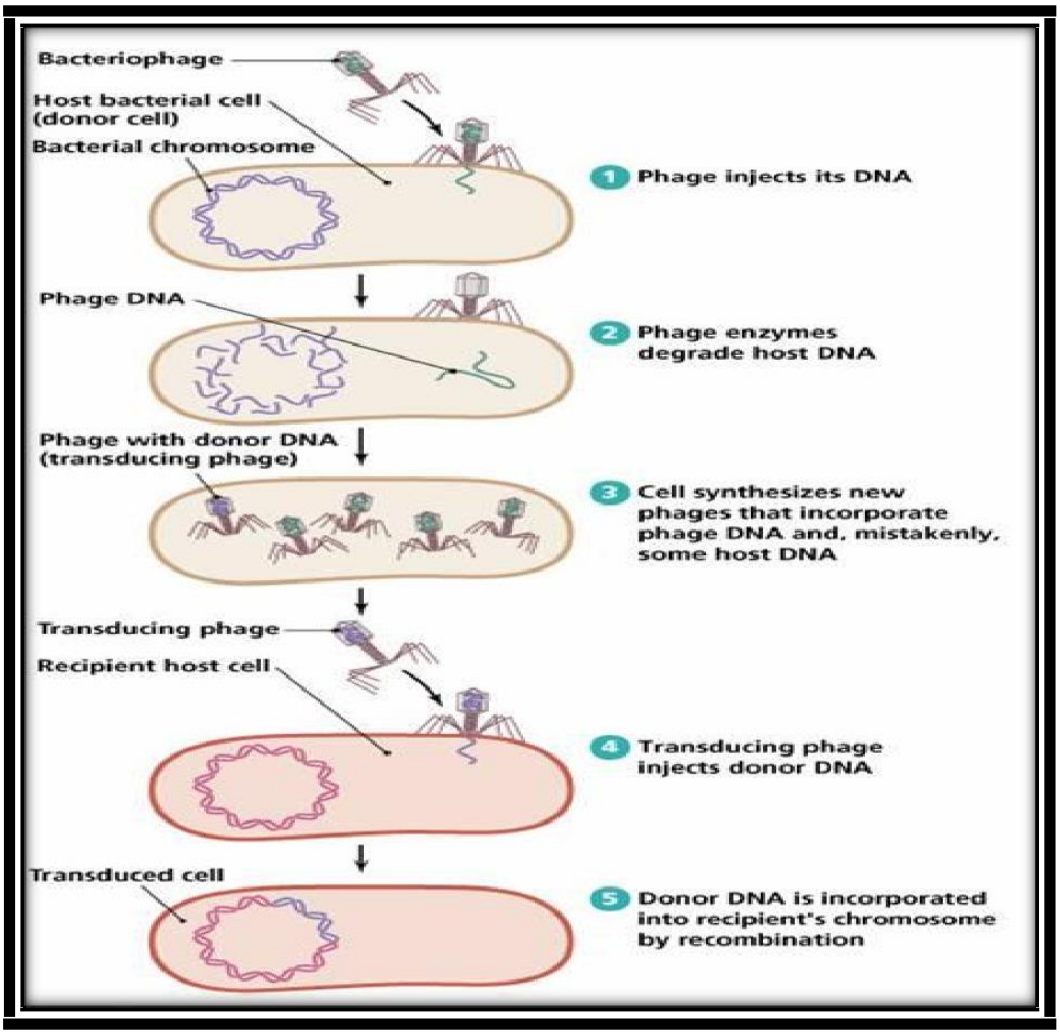
- **Transformation**

Some bacteria are capable of taking up DNA from their environment. These DNA remnants most commonly come from dead bacterial cells. During transformation, the bacterium binds the DNA and transports it across the bacterial cell membrane. The new DNA is then incorporated into the bacterial cell's DNA.



- **Transduction**

Transduction is a type of recombination that involves the exchanging of bacterial DNA through bacteriophages. Bacteriophages are viruses that infect bacteria. There are two types of transduction: generalized and specialized transduction.



Bacteria and disease

Although the great majority of bacteria play a positive role in our life, still there are many bacteria are pathogenic (disease causing) to human ,plant and animal .

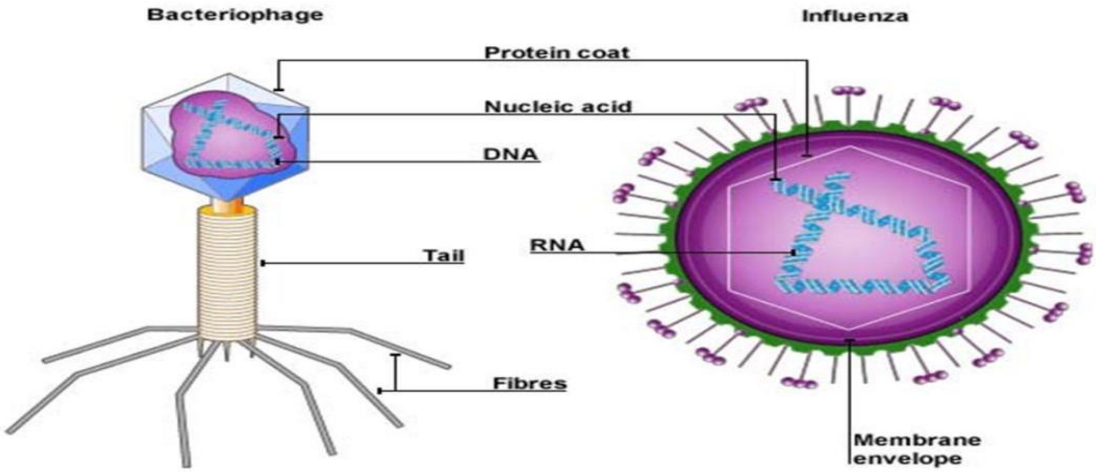
In humans bacteria cause many diseases acquired with consumed food and drinks or through inhalation such : Cholera, Dysentery, Tuberculosis , Bacterial Pneumonia and whooping cough . some bacterial species responsible for some sexually transmitted diseases such as Gonorrhea

,Syphilis which are acquired through sexual intercourse .

Bacteria vary greatly in their pathogenicity (ability to cause disease) virulence (degree of pathogenicity), invasiveness (ability to invade host tissues and fluids) and toxicity (ability to create clinical response due to exotoxins and endotoxins) .

Viruses

A virus (noncellular infectous particle) consists of nucleic acid (either DNA or RNA) ,a protein coat or sheath or capsid (one or more types of protein subunits organized in to a rod like or many side shape) and sometimes an outer envelope (mostly of membrane remnants from a previously infected cell). Virus cannot reproduce it self . it can be reproduce only after its genetic material and few enzymes enter a host cell and subvert the cells biosynthetic machinery.



The size of virus is usually less than 0.3 μm . however ,some viruses form large particle which can be seen under high power light microscope .

Viruses cause many diseases in all living organisms .such as:

Smallpox, Chicken pox, Measles, German measles (Rubella), Viral encephalitis, Mumps, influenza, infectious Hepatitis, Yellow fever, Rabies and AIDS. in addition viruses have been implicated in some cancers and leukemia.

Nearly all viral multiplication cycles include five steps: attachment to suitable host cell, penetration of it , DNA or RNA replication and protein synthesis , assembly of new viral particles and release .

Bacteriophages are a group of viruses that infect bacterial cells .some bacteriophages consists only of DNA and a protein coat.

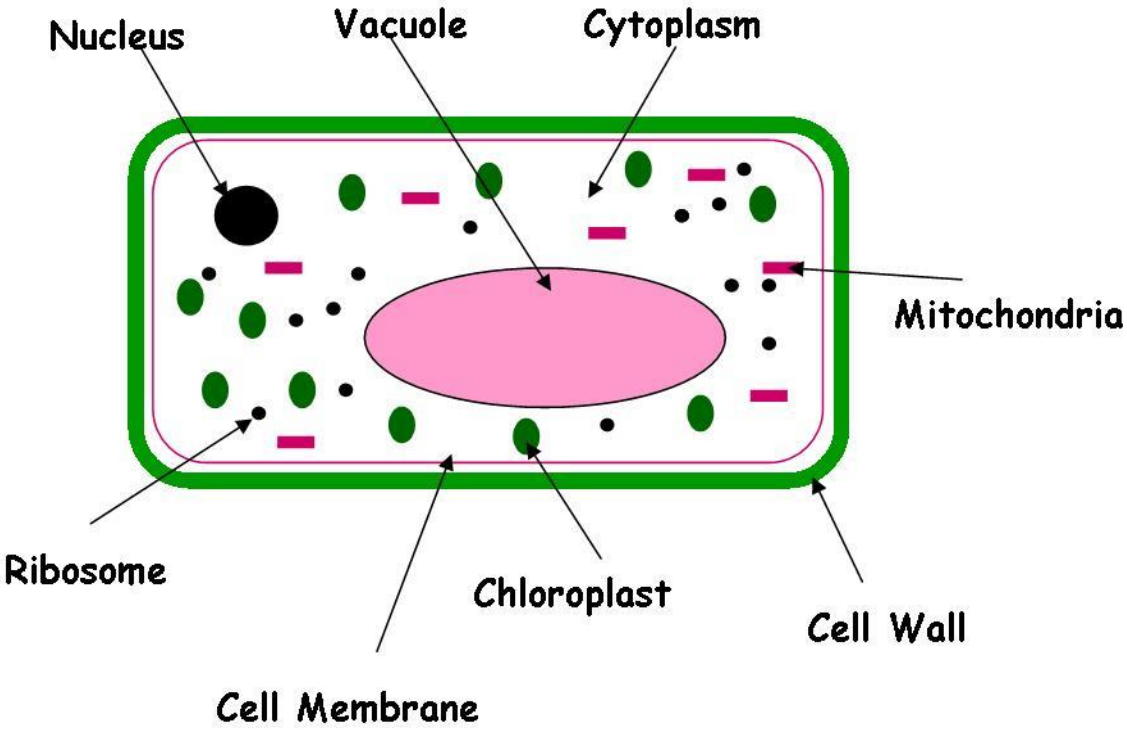
Cell

The cell is the basic structural, functional, and biological unit of all known livingorganisms. Cells are the smallest unit of life that can replicate independently, and are often called the "building blocks of life".

The study of cells is called cell biology.

Cells consist of cytoplasm enclosed within a membrane, which contains many biomolecules such as proteins and nucleic acids.

Organisms can be classified as unicellular (consisting of a single cell; including bacteria) or multicellular (including plants and animals). While the number of cells in plants and animals varies from species to species, humans contain more than 10 trillion cells.



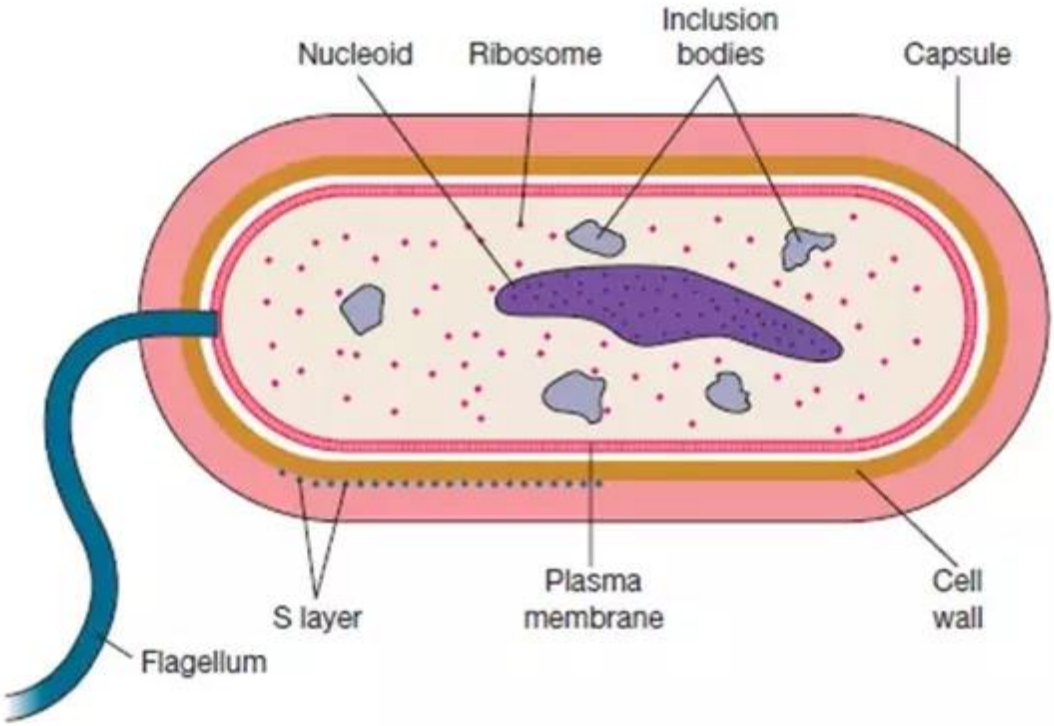
Cell Theory

- All living things are made of cells
- Smallest living unit of structure and function of all organisms is the cell
- All cells arise from preexisting cells (this principle discarded the idea of spontaneous generation)

Types of Cells

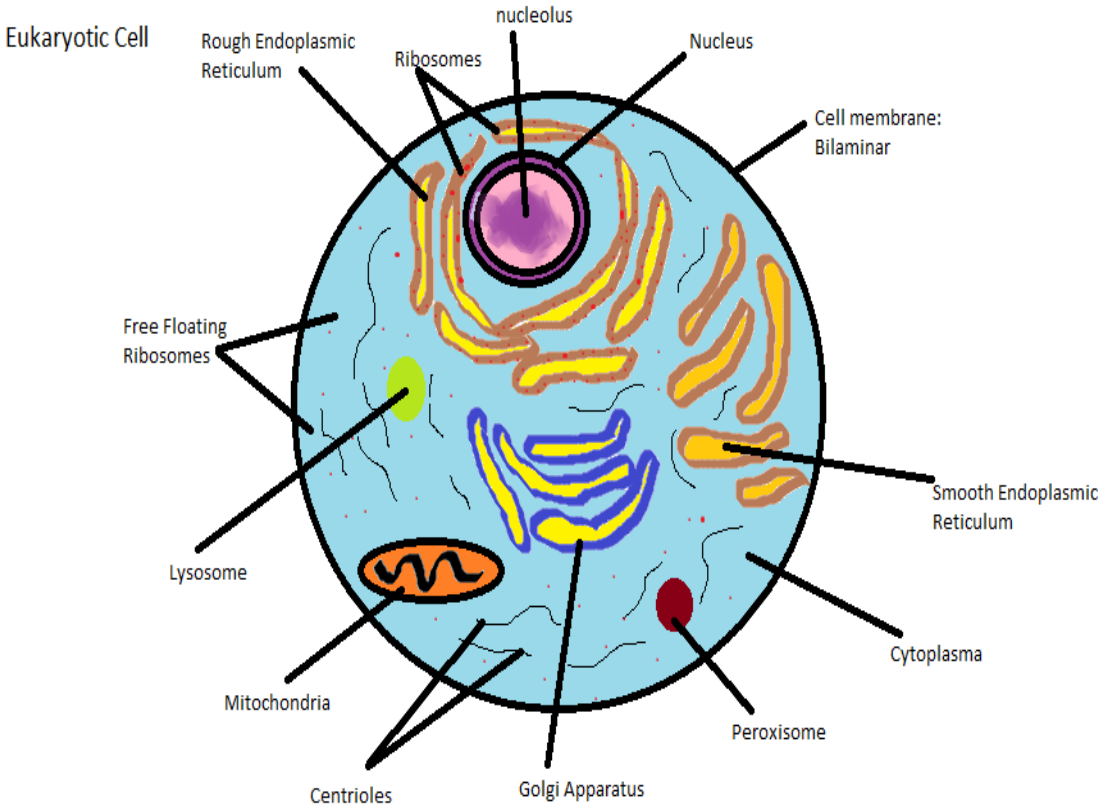
1- Prokaryotic Cells

- The simplest type of cells were the first type of cells that formed on Earth.
- All prokaryotic cells have a cell membrane surrounding the cell, cytoplasm where all of the metabolic processes happen, ribosomes that make proteins, and a circular DNA molecule called a nucleoid where the genetic information is held.
- The majority of prokaryotic cells also have a rigid cell wall that is used for protection.
- All prokaryotic organisms are unicellular, meaning entire organism is only one cell.
- Prokaryotic organisms are asexual, meaning they do not need a partner to reproduce.
- Most reproduce through a process called binary fission where basically the cell just splits in half after copying its DNA. This means that without mutations within the DNA, offspring are identical to their parent.
- Prokaryotic organisms include Archaea and Bacteria.



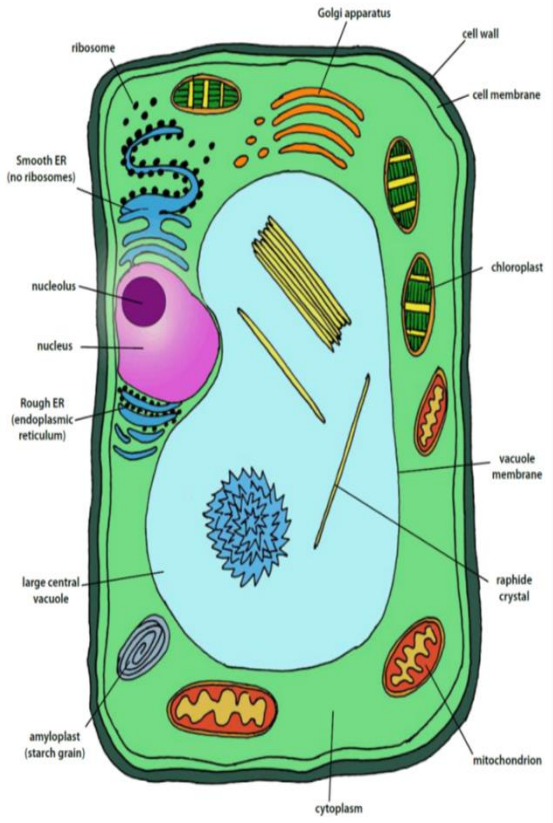
2- Eukaryotic Cells

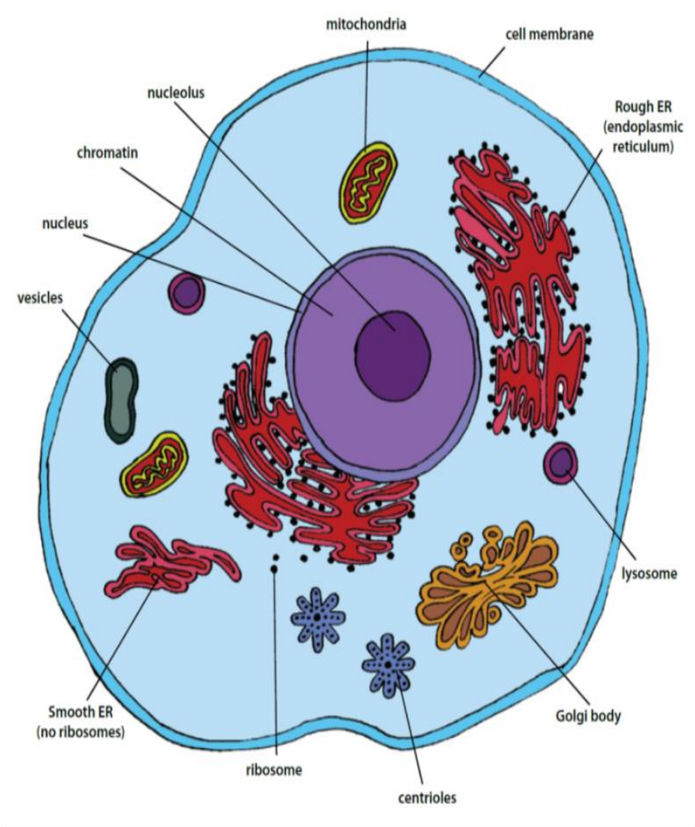
- The other, much more complex, type of cell.
- Like prokaryotic cells, eukaryotic cells have cell membranes, cytoplasm, ribosomes, and DNA.
- There are many more organelles within eukaryotic cells. These include a nucleus to house the DNA, a nucleolus where ribosomes are made, rough endoplasmic reticulum for protein assembly, smooth endoplasmic reticulum for making lipids, Golgi apparatus for sorting and exporting proteins, mitochondria for creating energy, a cytoskeleton for structure and transporting information, and vesicles to move proteins around the cell.
- Cell walls can also be found surrounding some types of eukarotyic cells.
- Most eukaryotic organisms are multicellular. This allows the eukaryotic cells within the organism to become specialized. There are a few unicellular eukaryotes as well.
- Eukaryotes may use either asexual or sexual reproduction depending on the organism's complexity.
- Eukaryotic organisms include all animals, plants, protists, and fungi.



Shapes of cell

1. Squamous: flat, thin, scale-like cells.
2. Spheroid:round to oval cells.
3. Polygonal:irregular angular shapes, with more than 4 sides.
4. Discoid:disc shaped.
5. Cuboidal:squarish.
6. Fusiform (spindle shaped): thick middle with tapered ends.
7. Columnar: taller than wide.
8. Fibrous:long, slender.
9. Stellate: star shape.

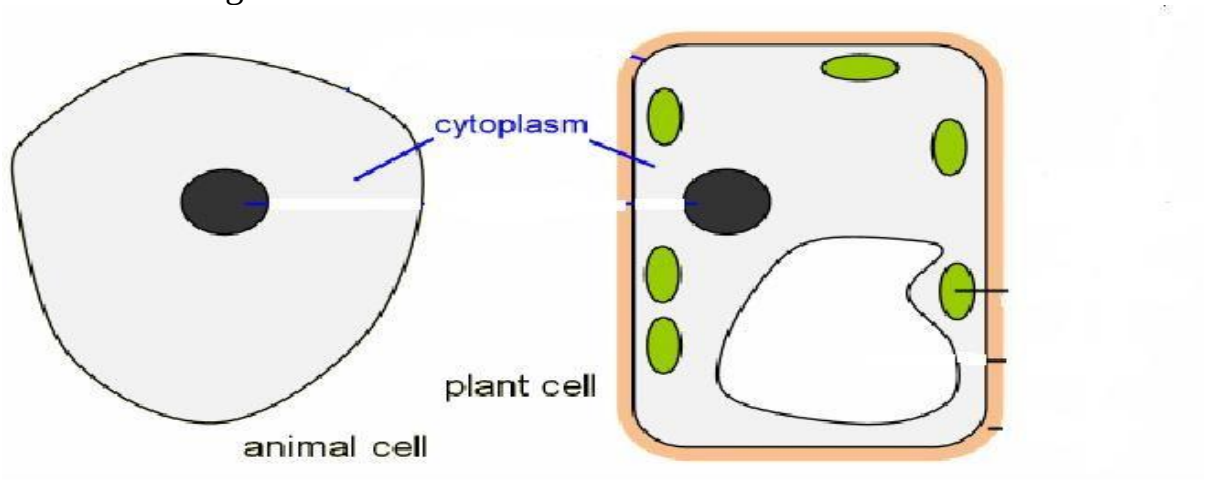




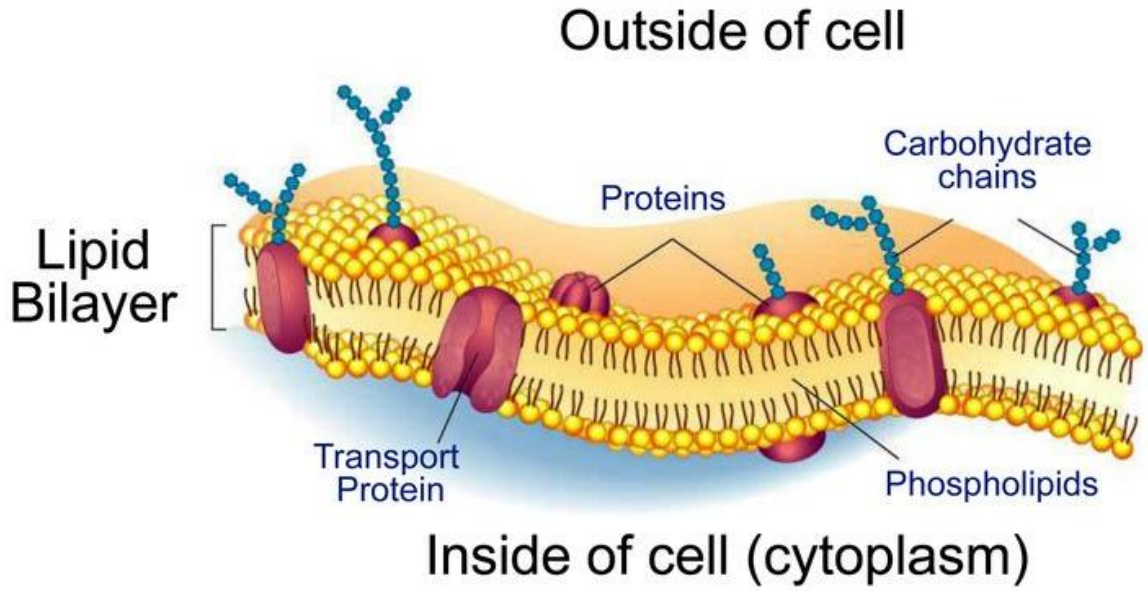
Components of cell

Organelles are tiny structures within cells that perform specialized tasks and are often surrounded by their own membrane. These organelles perform the functions necessary to keep the cell alive. While there are many different types of cellsmaking up an organism, most of these cells contain the same set of organelles.

1. **Cytoplasm**
   - Viscous fluid containing organelles
   - Components of cytoplasm
     - Interconnected filaments & fibers
     - Fluid = cytosol
     - Organelles (not nucleus)
     - Storage substances

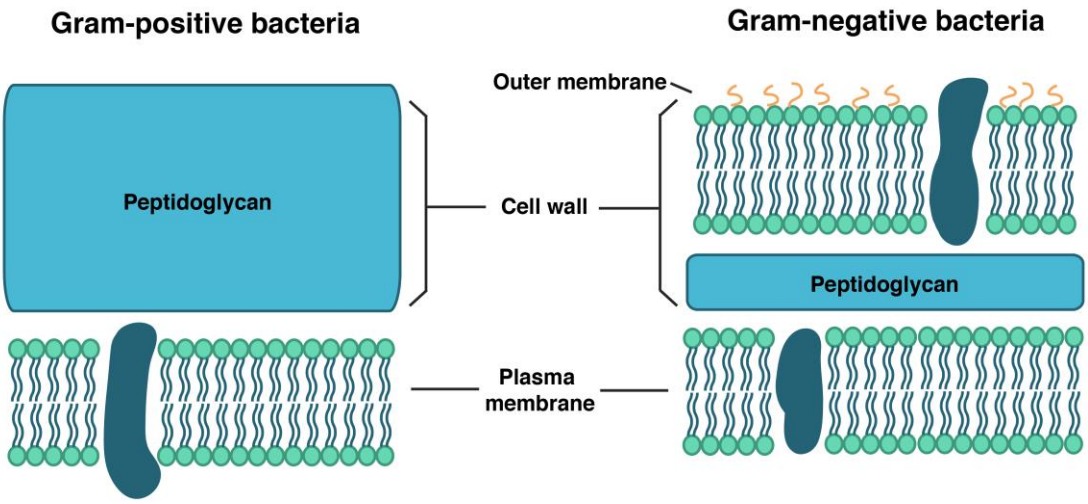


2. **Cell membrane**
   - Outer membrane of cell that controls movement in and out of the cell
   - Double layer of phospholipids & proteins



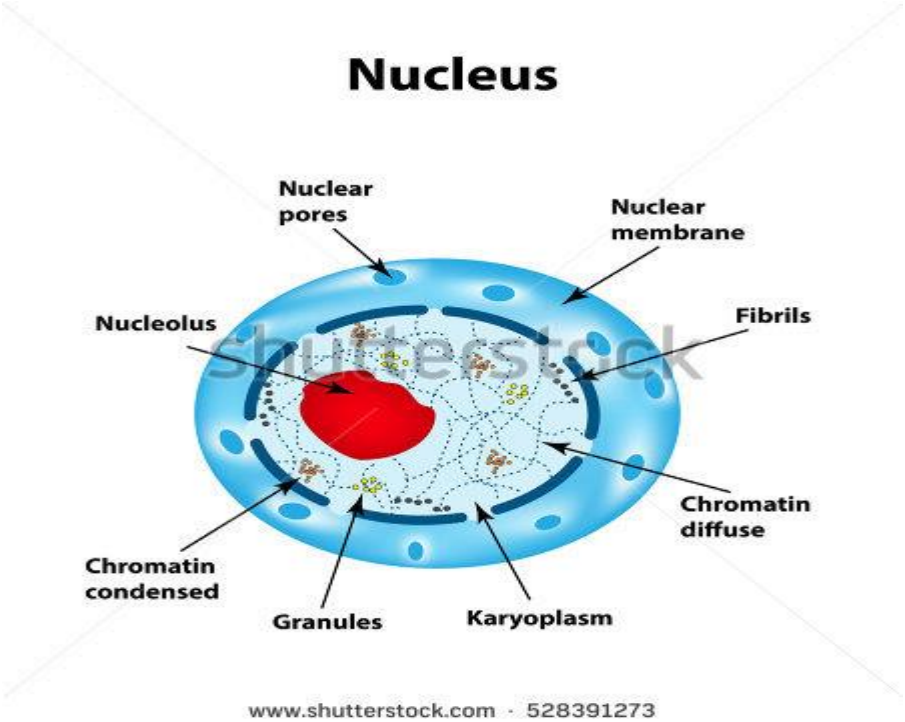
3. Cell wall

- Most commonly found in plant cells & bacteria
- Supports & protects cells
- Plants – mostly cellulose
- Fungi – contain chitin



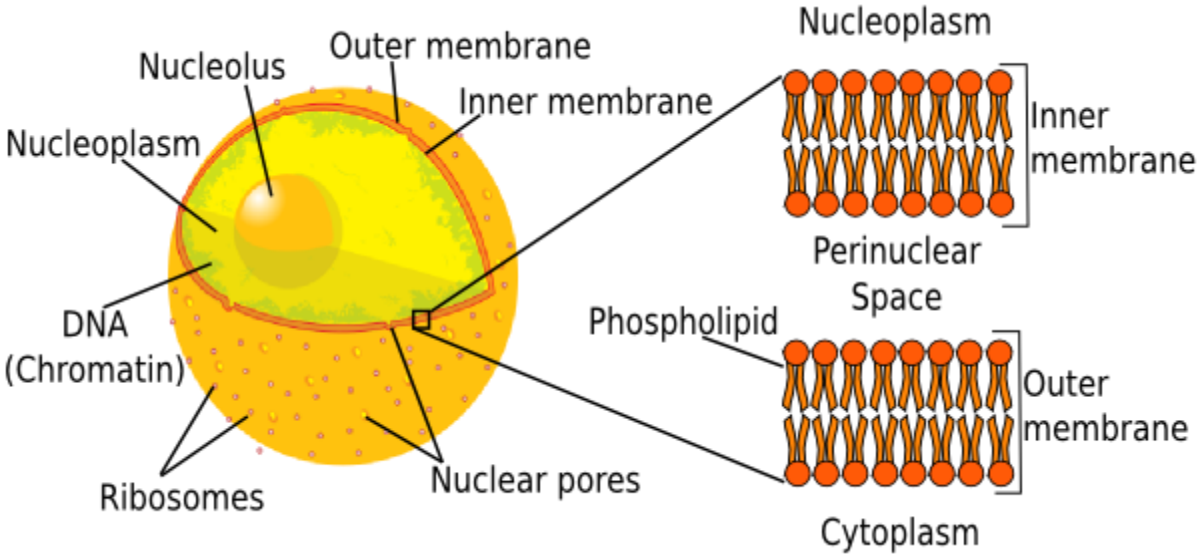
4. Nucleus

- Directs cell activities
- Separated from cytoplasm by nuclear membrane
- Contains genetic material – DNA



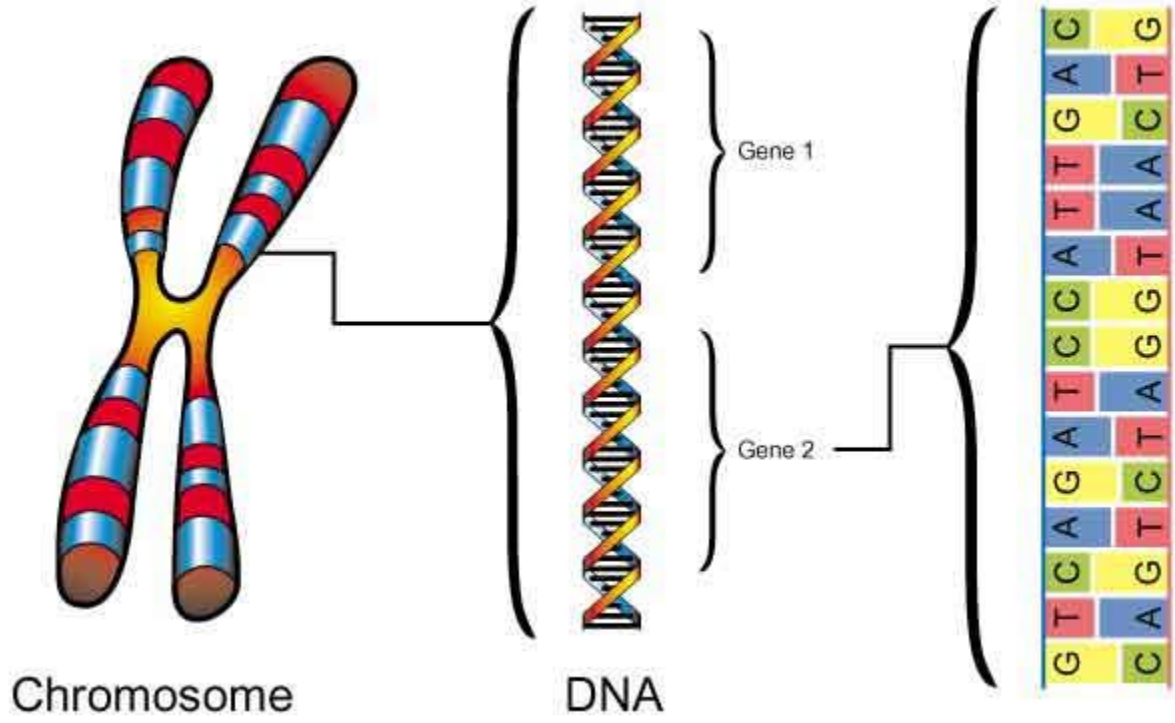
5. Nuclear membrane

- Surrounds nucleus
- Made of two layers
- Openings allow material to enter and leave nucleus



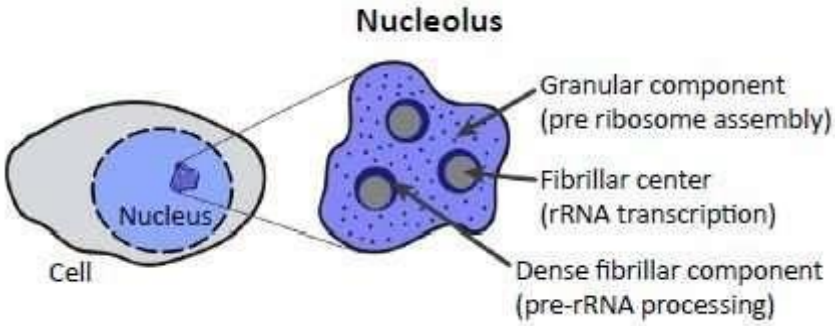
6. Chromosomes

- In nucleus
- Made of DNA
- Contain instructions for traits & characteristics



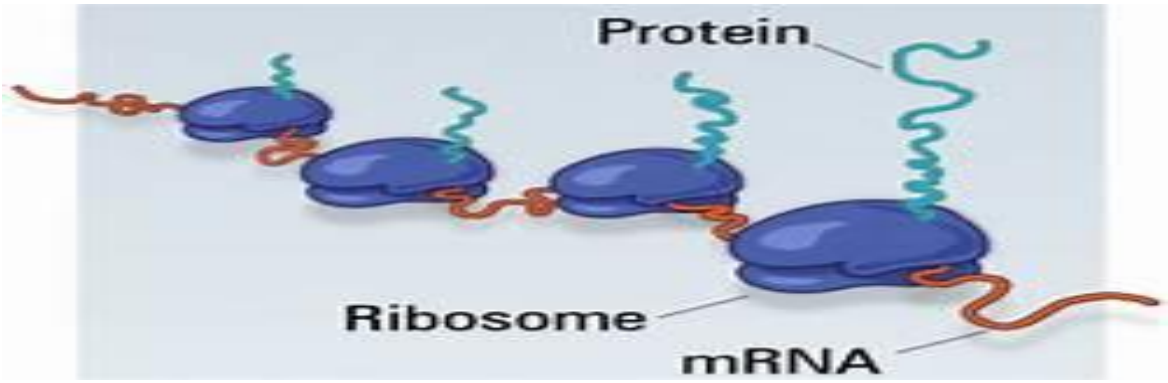
7. Nucleolus

- Inside nucleus
- Most cells have 2 or more
- Directs synthesis of RNA
- Forms ribosomes



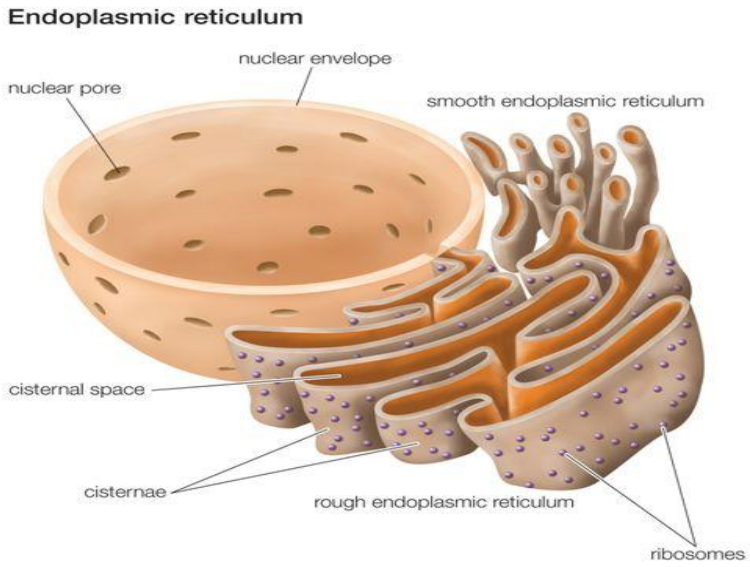
8. Ribosomes

- Each cell contains thousands
- Small dark granules of protein and RNA free in cytosol or on surface of rough ER
- Interpret the genetic code and synthesize polypeptides (Make proteins).



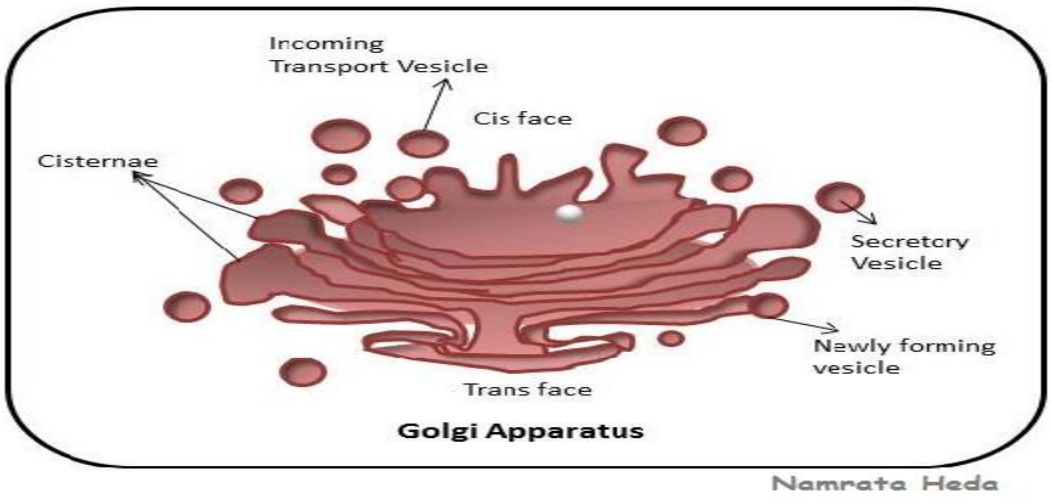
9. Endoplasmic reticulum

- Helps move substances within cells
- Network of interconnected membranes
- Two types:
  - Rough endoplasmic reticulum
  - Smooth endoplasmic reticulum



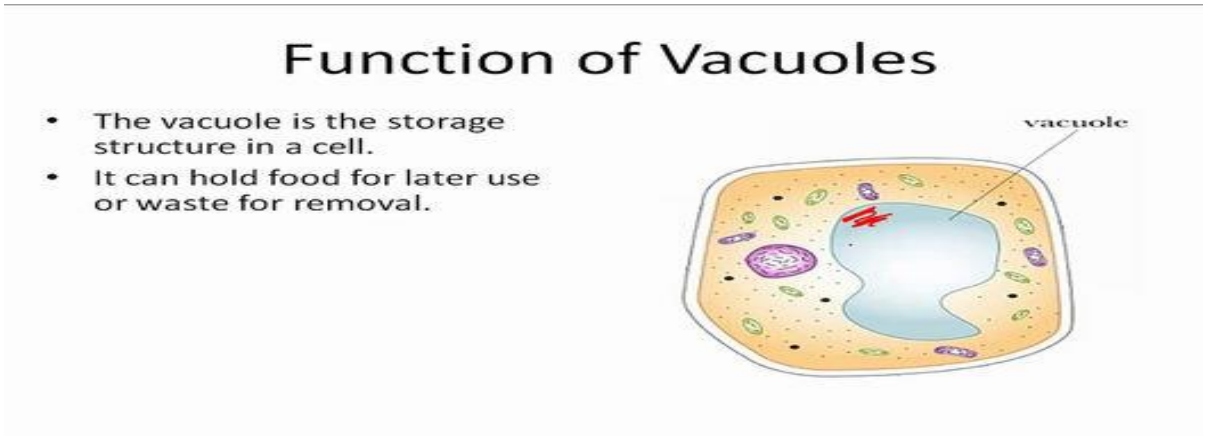
10. Golgi bodies

- Synthesizes CHO's, processes proteins from RER and packages them into golgi vesicles
- Golgi vesicles
  - irregular sacs near golgi complex that bud off cisternae
  - some become lysosomes, some fuse with plasma membrane and some become secretory vesicles.
- Secretory vesicles
  - Store a cell product for later release.



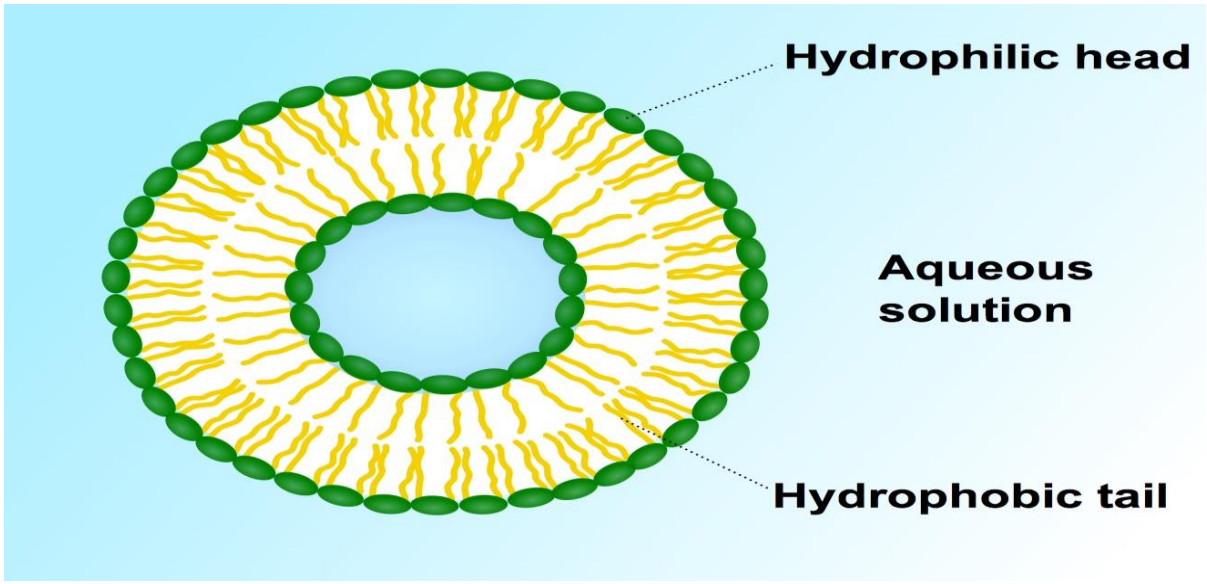
11. Vacuoles

- Membrane bound storage sacs
- More common in plants than animals
- Contents:
  - Water
  - Food
  - Wastes



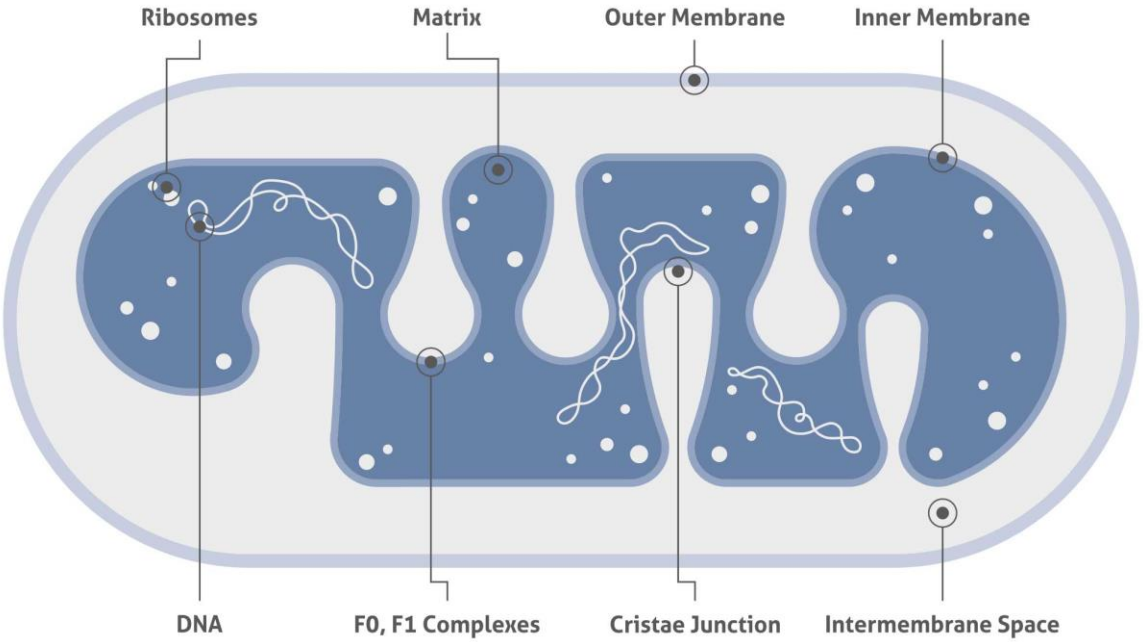
12. Vesicles

- Storage organs found in animal cells.
- These tend to be muchsmaller then plant vacuoles.



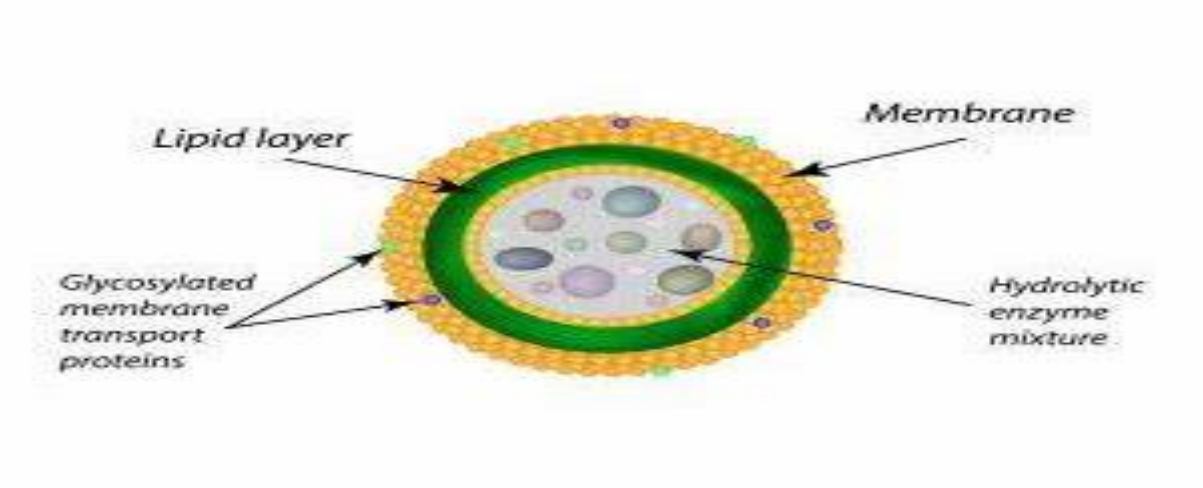
Mitochondria

- Produces energy through chemical reactions – breaking down fats & carbohydrates
- Controls level of water and other materials in cell
- Recycles and decomposes proteins, fats, and carbohydrates



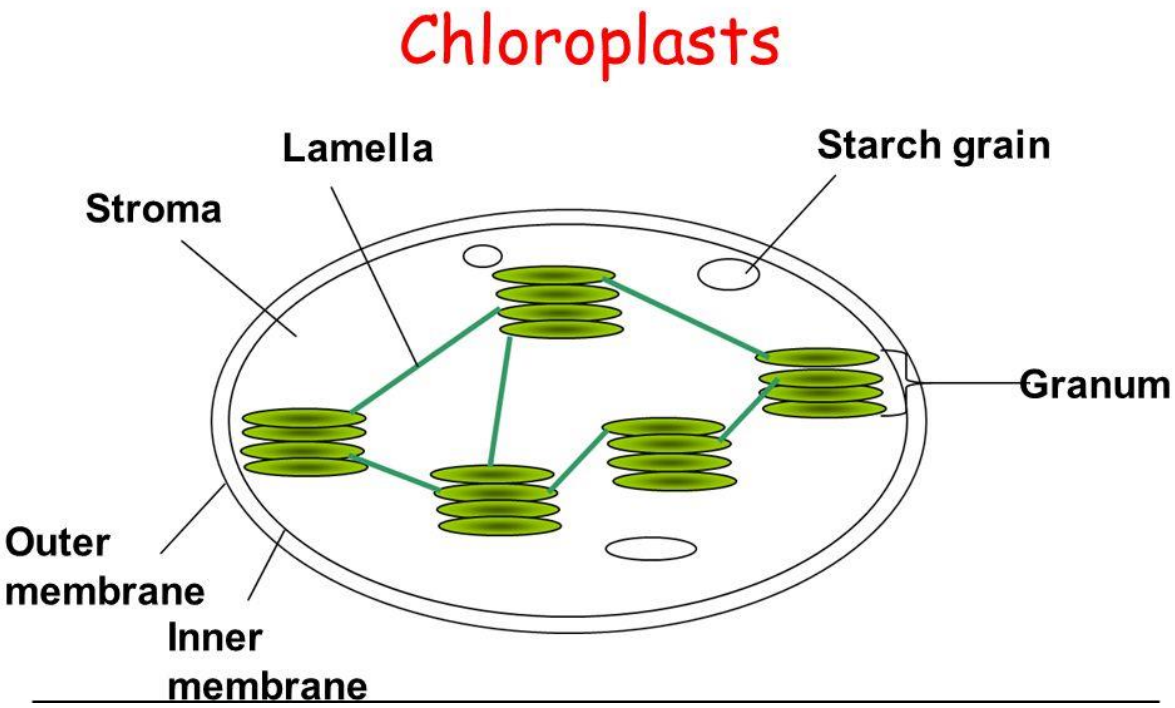
13.Lysosomes

- Package of enzymes in a single unit membrane, variable in shape
- Functions:
  - intracellular digestion - hydrolyze proteins, nucleic acids, complex carbohydrates, phospholipids and other substrates
  - autophagy - the digestion of worn out organelles and mitochondrion
  - autolysis - programmed cell death
  - glucose mobilization - lysosomes in liver cells break down glycogen



14. Chloroplasts

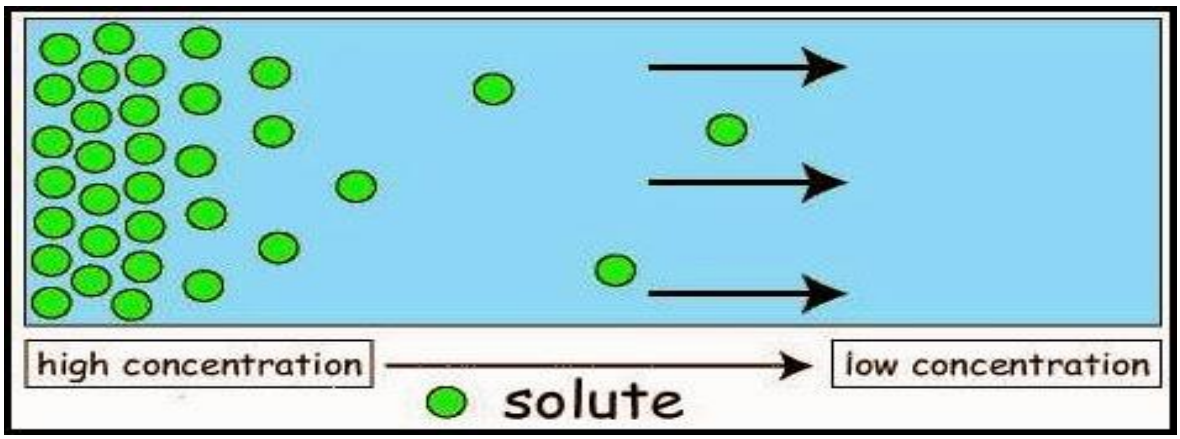
- Usually found in plant cells.
- Contains green chlorophyll.
- Where photosynthesis takes place.



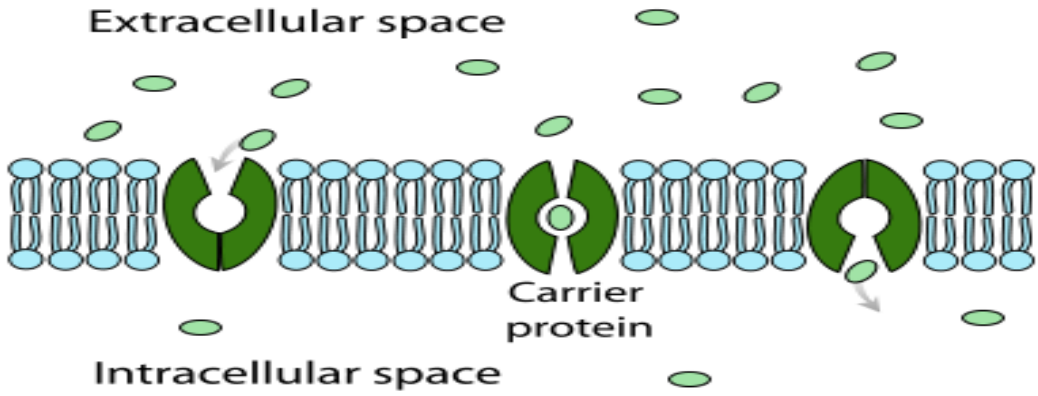
Diffusion, Facilitated Diffusion, Osmosis, and Active Transport

How molecules move through the membrane.

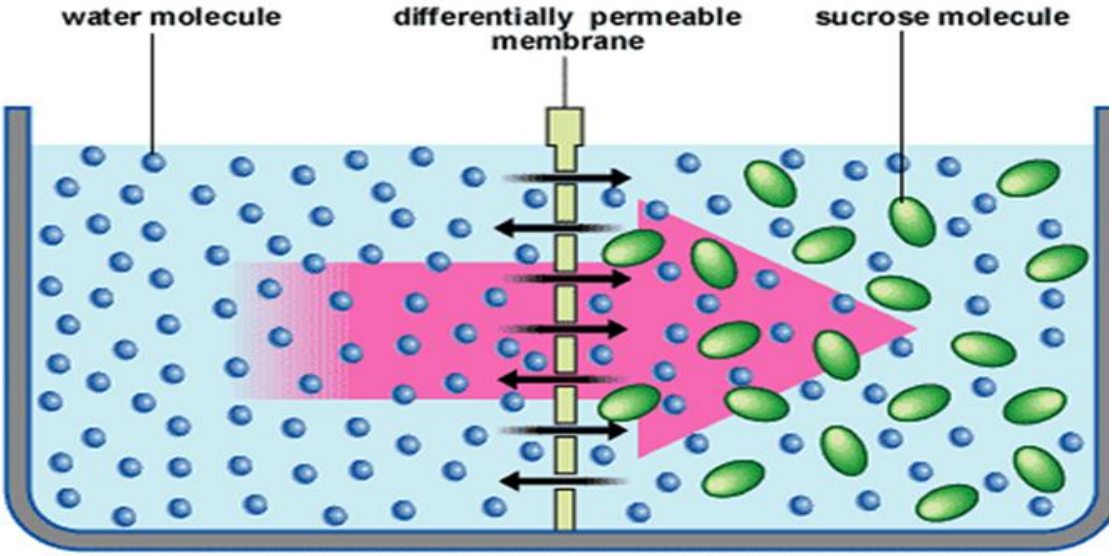
Diffusion is the movement of molecules from an area where the molecule is in high concentration to an area where the molecule is in lower concentration. *A diffusion **animation** is introduced here.* In the animation, the molecules chosen represent a generic molecule (green balls) and carbon dioxide gas (small black and brown three ball structure). The generic molecules being in higher concentration outside of cells will freely diffuse into the cell and carbon dioxide being produced inside the cell due to cellular respiration will increase in concentration inside the cell and diffuse to the outside through the membrane. This allows the cell to obtain nutrients and dispose of carbon dioxide without any energy use. A very fortunate situation for the cell.



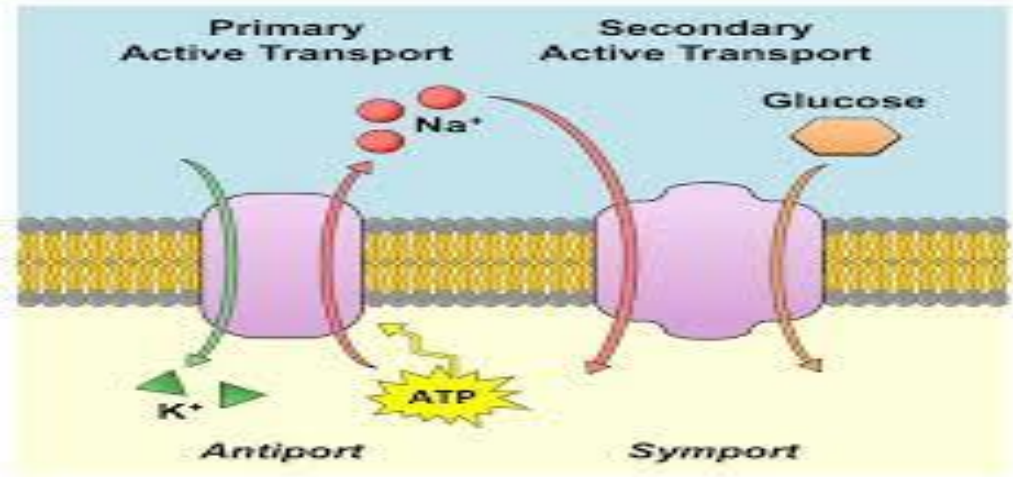
Facilitated diffusion is the movement of a molecule from an area of high concentration to an area of lower concentration with the help of a protein channel or carrier. The generic molecules in the previous animation used a channel protein to enter the cell. In the facilitated diffusion **animation** both amino acids and glucose are shown entering the cell facilitated by a protein carrier. In a cell membrane there would be proteins specific to each molecule and the carriers would not be shared in this way. The animation shows that movement occurs until the concentration of the molecules reaches equilibrium.



Osmosis is the diffusion of water through a semi-permeable membrane. Water moves from an area of high water molecule concentration (and lower solute concentration) to an area of lower water molecule concentration (and higher solute concentration). The osmosis **animation** shows water moving into a cell through a channel. Water molecules can be transported in this way, but can also diffuse directly through the membrane lipid bilayer.



Active transport is the movement of molecules from areas of low concentration to areas where the molecule is found in higher concentration. This movement is not spontaneous and requires ATP energy and a protein carrier. The ATP is used to drive conformational changes in the protein to pump molecules against their concentration gradient. This process occurs continuously in nerve cell membranes with sodium-potassium pumps. The active transport **animation** shows a simplified version of how such a pump operates.



Comparison of the ways molecules move into and out of cells.

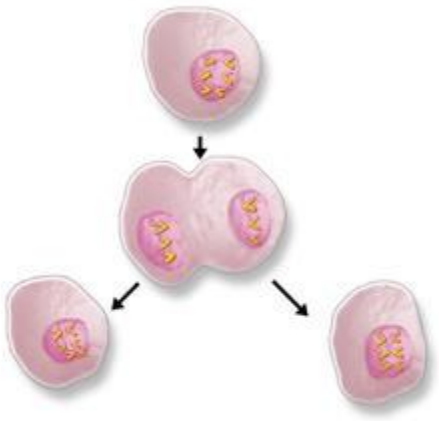
Cell Membrane Transport

Name	Type of Transport	Direction of Movement	Conditions	Energy?	Examples
Diffusion	passive	HIGH to LOW	No membrane, Semipermeable membrane	NO	Water, gases ($0_2$and CO_2), and steroid hormones.
Facilitated Diffusion	passive	HIGH to LOW	Protein Channel	NO	Water, glucose, and amino acids.
Osmosis	passive	HIGH to LOW	Semipermeable membrane	NO	**Water 0nly!**
Active Transport	active	LOW to HIGH	Protein pump and ATP energy	YES	Ions, sugars, and amino acids.

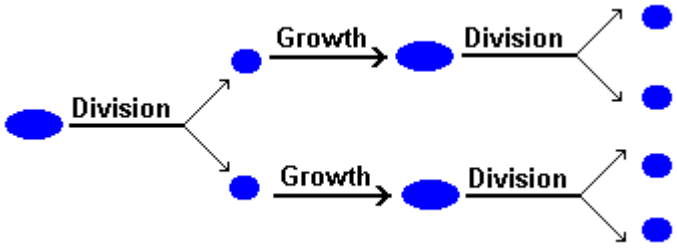
Cytology

Cell cycle, Mitosis and Meiosis

Why do cells divide? There are many reasons for this. Cells absorb and release nutrients threw their membrane. The larger the cell, the harder it is to get rid of all the waste that is produced. So, if there are many small cells (more surface area) rather than one large cell, the waste can be disposed of more readily. The other 3 reasons are critical to the survival of all organisms: Growth, repair and reproduction.

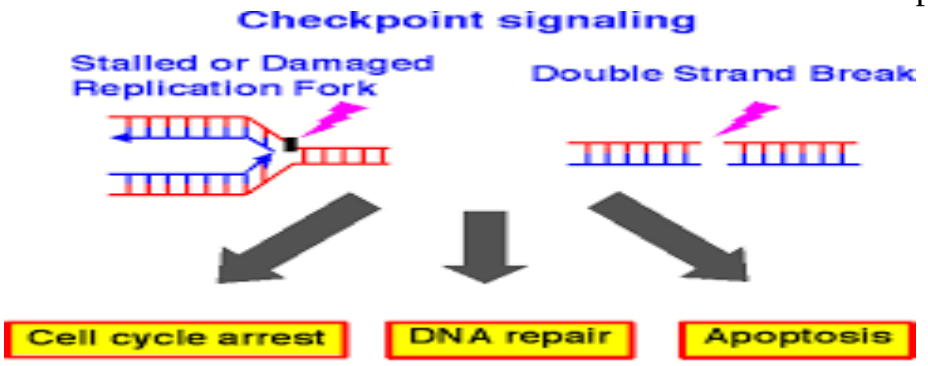


•Growth: This is a result of mitosis. The more cells in an organism, the larger that organism is. Humans start off as one single cell, and by the time they are adults, they have over 10 trillion cells!!! This increase in the number of cells also allows for some of those cells to be specialized for various functions. This is important to the survival of many organisms.

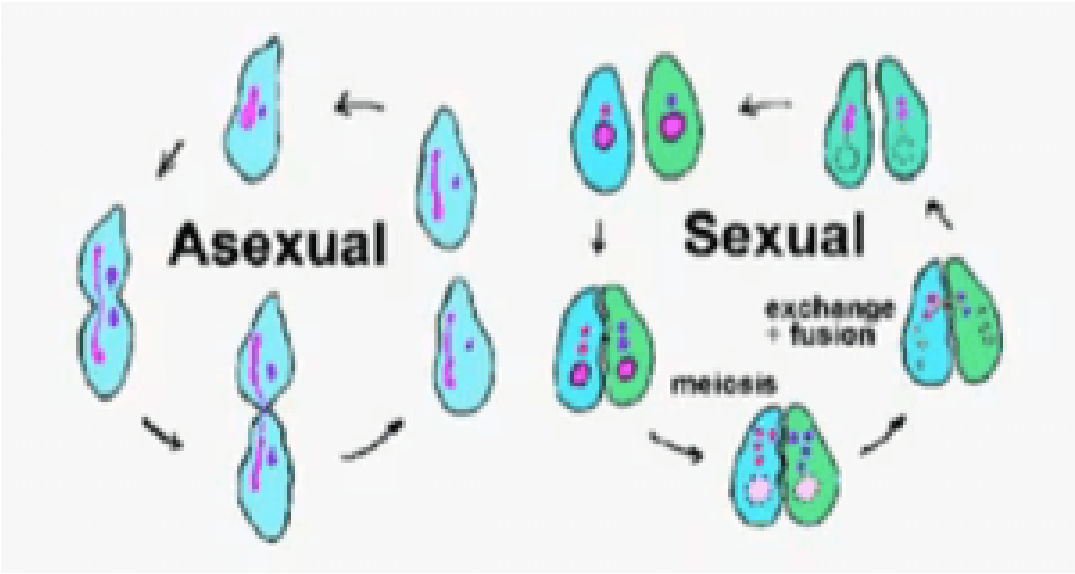


•Repair: This is a result of mitosis. If tissue is damaged, repair is extremely important. With some organism, they are even able to regenerate lost limbs (such as arms or tails). For us, this is important because it can repair skin, blood vessels and bones, for example. This

also replaces cells that have died. You have a “new” skin every 28 days! That means that the old cells died and the new ones took their place.

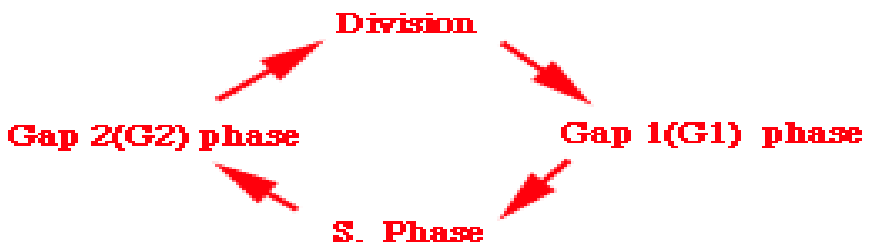


•Reproduction: This is a result of mitosis or meiosis, depending on the type of reproduction. There are two types of reproduction. The first type is asexual reproduction, and this is when there is only one parent. This results from normal cell division. This occurs in bacteria, protests, fungi, some plants and some animals. The offspring are genetically identical to that of the parent. The other type of reproduction is sexual reproduction. This is when the offspring have a combination of both parents DNA.



Cell cycle

How do cells know when to divide? There are hormones in an organism's body that sends signals to the cells to prepare for division when it is needed. This is all part of the cell cycle, which is made up of various phases, beginning at the start of one cell division and ending at the start of another. There are two main parts to this division: Interphase, which is for growth and preparation, and cell division, which includes mitosis and cytokinesis. Interphase occurs between divisions, and is the congest phase in the cell cycle. This usually makes up about 90% of the time spent in the cell cycle. This is not a "resting" period, but time for preparation. This is when the cell grows and prepares for division. There are three stages in interphase. G1 (or gap 1), S (or synthesis(and G2 (or gap 2)



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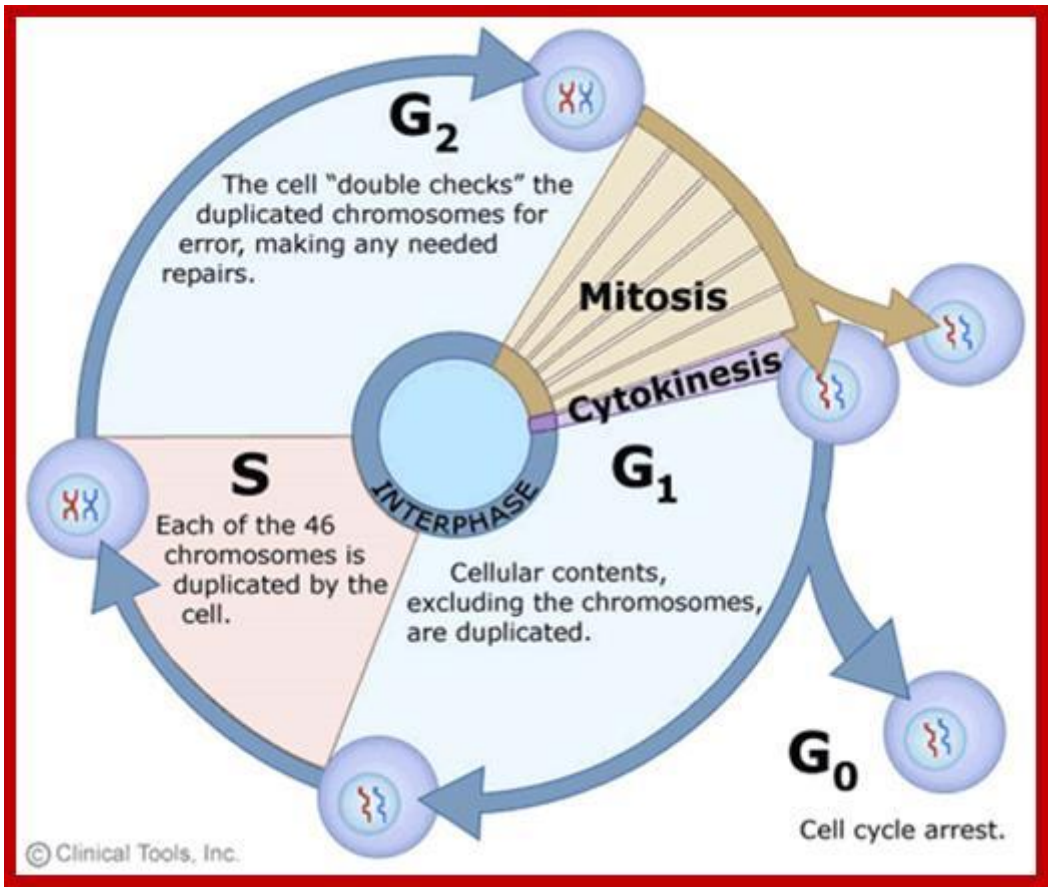
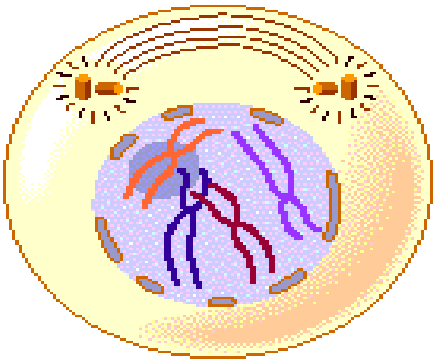
- G1 – this is the period where the cell grows and develops. Since some cells divide more actively than others, the time spent in the G1 phase will vary. There is no division that takes place in this phase. Just growth and development.
- S – This is where the cell is committed to cell division. Inside the nucleus, the chromosomes (including the DNA) begin to replicate, the material makes a copy of itself (more on chromosomes in a minute). This results in two identical copies of chromosomes, called sister chromatids. The two sister chromatids are attached to each other at a point celled the centromere. This replication is important, because it allows there to be two full sets of DNA ineach of the new cells, at the end of the division.
- G2 – Organelles and other material required for cell division are replicated or formed. For example, the centrioles in animal cells replicate themselves, to form 2 pairs.



Cell division includes mitosis and cytokenesis. Mitosis is the portion of the cell cycle when the cells nucleus is replicated and divided into two identical nuclei containing genetically identical material. This type of cell division is for growth, repair and asexual reproduction. Mitosis forms somatic cells, which are also referred to as the cells of the body (having a 2n or diploid number of chromosomes). This is the type of cell division all of the cells in the body do except for those responsible for "sex cell" production.

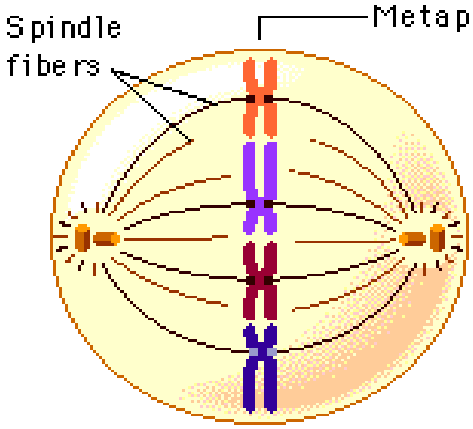
There are 4 main phases in mitosis.

1. Prophase : this is the first stage of mitosis. In this stage the sister chromatids also condense to a visible form. The nuclear envelope also breaks up, exposing the chromosomes. The spindle fibers begin to form, extending from the centrioles. These are made up of microtubules and attach to the centromere of the sister chromatids. The centrioles slowly migrate to opposite sides of the cell.



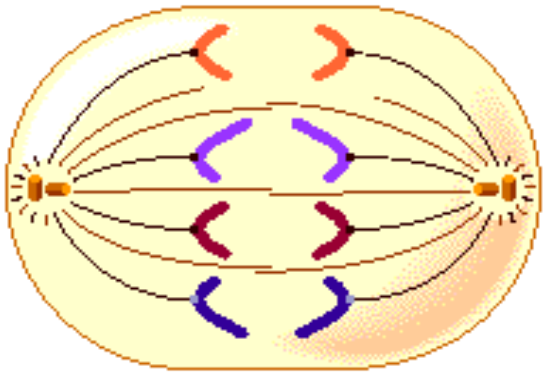
Prophase
The chromosomes appear condensed, and the nuclear envelope is not apparent.

2. Metaphase : this is when the chromosomes are lined up along the metaphase or equatorial plate, an imaginary line in the center of the cell. The chromosomes are moved here with the help of the spindle fibers and the centrioles.



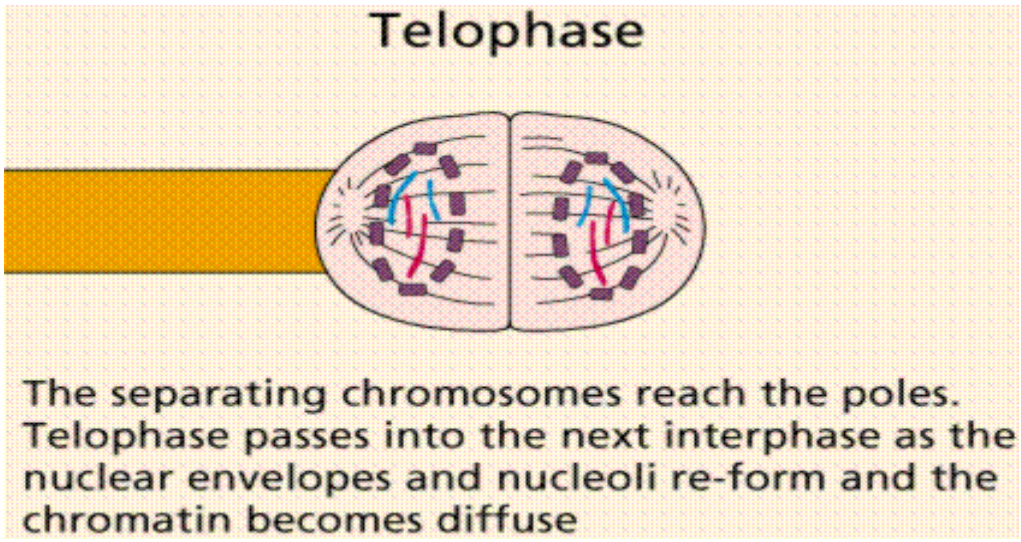
Metaphase
Thick, coiled chromosomes are lined up in the center of the cell on the metaphase plate. Spindle fibers are attached to the chromosomes.

3. Anaphase: The centromere of each chromosome are pulled apart by the spindle fibers, causing the sister chromatids to separate, creating two daughter chromosomes. One of the daughter chromosomes is pulled to one side of the cell, while the other is pulled to the opposite pole.this process is critical, because it ensures that the soon to be daughter cells will each have full, identical sets of chromosomes, also being identical to the parent cell.

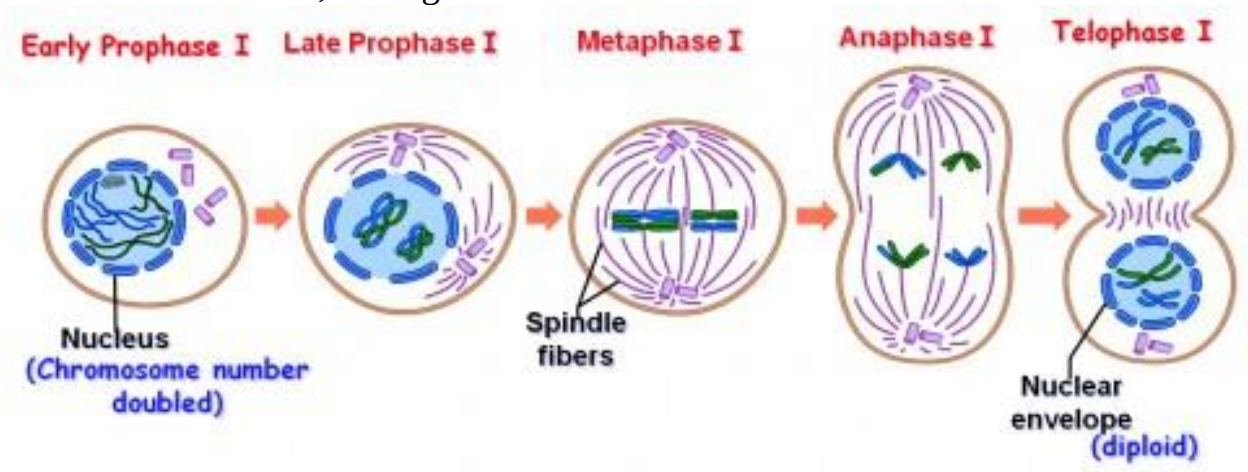


Anaphase
The chromosomes have separated and are moving toward the poles.

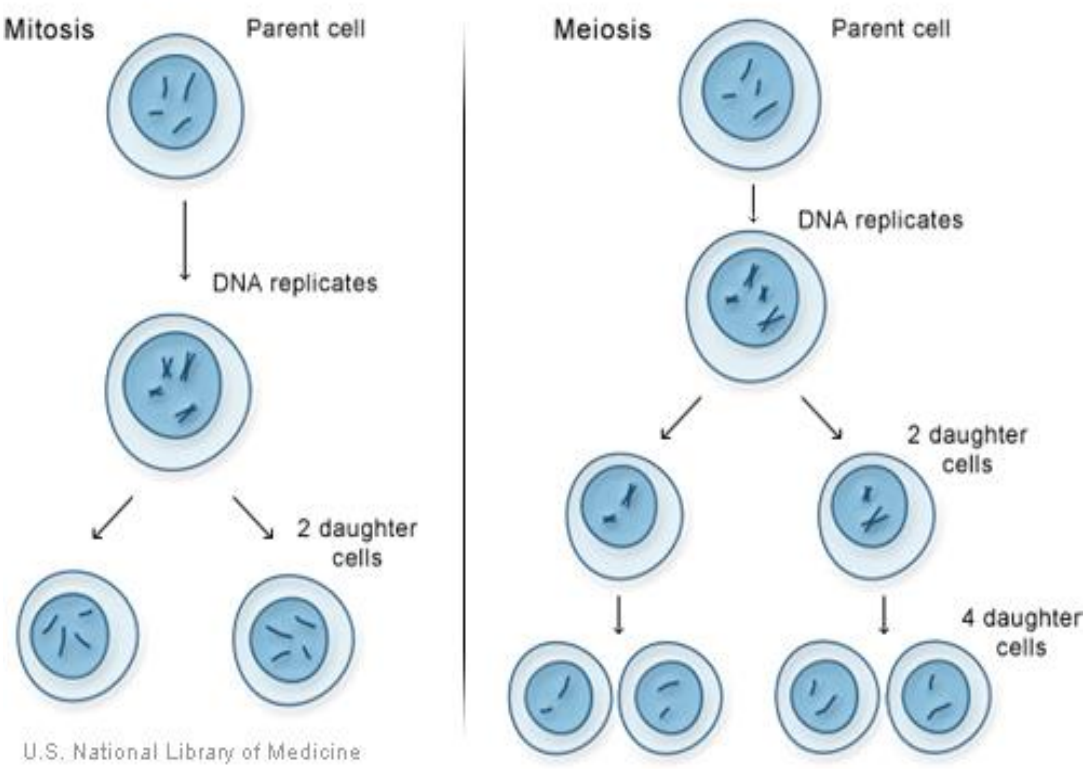
4. Telophase – The new neclei begin to form around the new sets of chromosomes, at each end of the cell. The chromosomes also begin to unravel, back into their loose form. By the end of this phase, the spindle fibers are also dissasembled. At the same time, cytokensis begins, and the cell is "pinched" into two new cells.



As mitosis comes to an end, the two new nuclei must end up in two new cells; this is where cytokenesis comes in. Cytokinesis is when the cell's cytoplasm divides into two, making two new cells called daughter cells. Each of these new cells receives one of the new nuclei, making the daughter cells genetically identical to the parent cell. Animal cells and plant cells complete mitosis and cytokinesis differently. The picture to the right is the while process of mitosis and the beginning of cytokinesis as far as an animal cell is concerned. The cytoplasm "pinches" the cell into two daughter cells, right down the center of the parent cell, until there are two separate daughter cells. However, in plants, a cell plate begins to form along the center of the cell then fuses with the cell membrane and cell wall, cutting the cell into two.



Meiosis is the formation of gametes, performed by reproductive cells only. This will result in a reduction of the chromosome number, forming haploid cells (n). So, unlike mitosis, which produces two daughter cells with identical chromosomes, meiosis produces 4 daughter cells, each with half the number of chromosomes, that are not identical to each other (you will learn why in the next unit). This is again important because it keeps the chromosome number constant over generations, in the adult organism. When the egg (n) and the sperm (n) combine (n + n) in fertilization, the offspring is a diploid cell (2n).



Meiosis I is a 4 step process. The start of this is much like mitosis, the cells have gone through the G1, S and G2 phases, thus the DNA has been replicated and are in the form of sister chromatids, connected at the centromere. The main difference here is that the homologous pairs of chromosomes pair up and then proceed as follows.

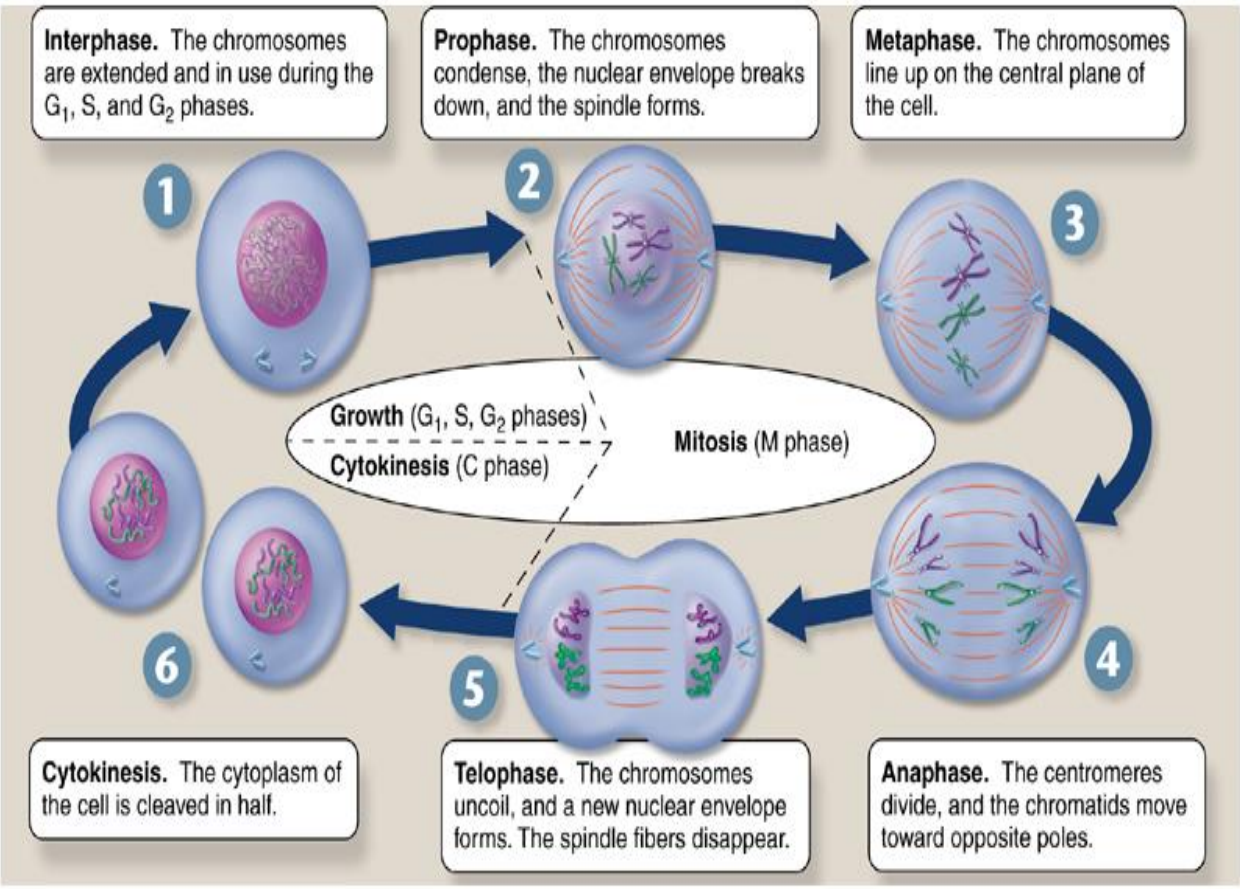
1. Prophase I the chromosomes thicken and are visible under a microscope. The homologous pairs of chromosomes are tangled together and being to move towards the equatorial plate. This means that instead of two sister chromatids like in mitosis, there are now 4 sister chromatids that move together, this is called atetrad. This is also where the nuclear envelope disappears and the spinal fibers begin to form. This is also the phase where crossingover can occur. Due to the way the homologous pairs of chromosomes are tangled together, many times, they "swap" parts of their chromosomes. This is a major source to the addition to the variation between individuals. It is this

variation that allows evolution to act on favorable traits, having those that are more favorable survive and the others die off.

2. Metaphase I is where the homologous pairs are lined up next to each other, along the equatorial plate .

3. Anaphase I : the homologous pairs are now separated, due to the spindle fibers pulling them apart, from the centromere. Each chromosome still has two sister chromatids.

4. Telophase I : the nuclear membrane may or may not reform, depending on the species, but in any case, cytokinesis does occur, resulting in two new cells, each with the haploid number of chromosomes, which are still in the form of sister chromatids.



Meiosis II is what follows after telophase I and cytokinesis. The daughter cells from meiosis I are what go into this phase. The divide again, but this time occurring much the same as mitosis. The only difference is that there are n number of chromosomes rather than 2n, and we end up with a total of 4 daughter cells rather than 2.

Again, since there were two daughter cells produced in meiosis I, and each of them divide again, the result of meiosis is 4 daughter cells, each with n number of chromosomes, which are not identical to the original parent cell or each other. This is done through 4 more steps: prophase II, metaphase II, anaphase II and telophase II,

followed by the final cytokinesis.

Spermatogenesis and Oogenesis :

Meiosis, the process by which gametes are formed, can also be called gametogenesis, literally “creation of gametes.” The specific type of meiosis that forms sperm is called spermatogenesis, while the formation of egg cells, or ova, is called oogenesis. The most important thing you need to remember about both processes is that they occur through meiosis, but there are a few specific distinctions between them.

Spermatogenesis

The male testes have tiny tubules containing diploid cells called spermatogonium that mature to become sperm. The basic function of spermatogenesis is to turn each one of the diploid spermatogonium into four haploid sperm cells. This quadrupling is accomplished through the meiotic cell division .During interphase before meiosis I, the spermatogonium’s 46 single chromosomes are replicated to form 46 pairs of sister chromatids, which then exchange genetic material through synapsis before the first meiotic division. In meiosis II, the two daughter cells go through a second division to yield four cells containing a unique set of 23 single chromosomes that ultimately mature into four sperm cells. Starting at puberty, a male will produce literally millions of sperm every single day for the rest of his life.

Oogenesis

Just like spermatogenesis, oogenesis involves the formation of haploid cells from an original diploid cell, called a primary Oocyte, through meiosis. The female ovaries contain the primary oocytes. There are two major differences between the male and female production of gametes. First of all, Oogenesis only leads to the production of one final ovum, or egg cell, from each primary Oocyte (in contrast to the four sperm that are generated from every spermatogonium). Of the four daughter cells that are produced when the primary oocyte divides meiotically, three come out much smaller than the fourth. These smaller cells, called polar bodies, eventually disintegrate, leaving only the larger ovum as the final product of Oogenesis. The production of one egg cell via Oogenesis normally occurs only once a month, from puberty to menopause.