

Cells

1.1 The Microscope in Cell Studies

Microscopy: is the technical field of using microscopes to view objects that cannot be seen by the naked eye.

For preparing a slide;

- Cut, peel, scrape a very thin layer of cells from the tissue sample to be placed on the slide.
- Use a drop of water on the slide for hydration.
- Use a drop of a suitable indicator such as methylene blue or iodine solution.
- Use a cover slip over the stain to prevent contamination or air bubbles.
- Dry the excess liquid with the edge of a paper towel.

Calibrating a microscope:

- Eyepiece graticule: this is a fine scale that fits inside the eyepiece lens. Its units are arbitrary.
- Stage micrometer: this is a scale fitted onto a cover slip. The size of the divisions is unknown.

An eyepiece graticule and stage micrometer are used to measure the size of an object when viewed under the microscope. Each microscope can vary slightly so needs to be calibrated when used. The calibration is done with the stage micrometer, this is a slide with very accurate scale in micrometer, it is usually in 10 micrometer division so 1 millimeter divided into 100 divisions. The eyepiece graticule is a disc placed in the eyepiece with 100 divisions, this has no scale. To know what the divisions are equal to at each magnification the eyepiece graticule is calibrated to the stage micrometer at each magnification.

Light Microscope:

The light is focused using glass lenses.

Relies on light being able to pass through the specimen.

Regions that absorb more light appear darker in the image.

Magnification = Eyepiece Lens x Objective Lens

Magnification: is how many times bigger the image of a specimen observed is in compared to the actual size of the specimen.

A light microscope has two types of lenses:

- An eyepiece lens which often has a magnification of x10.
- A series of usually 3 objective lenses, each with a different magnification.

- **Calculating Magnification:**

The size of cells is typically measured using the micrometer scale, with cellular structures measured in either micrometers or nanometers.

When doing calculations all measurements must be in the same units. It is best to use the smallest unit of measurement shown in the question.

To convert units, multiply or divide depending if the units are increasing or decreasing.

Magnification does not have units.

To calculate the total magnification the magnification of the eyepiece lens and the objective lens are multiplied together:

Eyepiece lens magnification × Objective lens magnification = total magnification

$$\frac{\text{Image Size}}{\text{Actual Size}} = \frac{\text{Magnification of image} \times \text{length of cell in drawing}}{\text{Length of Cell in Image}}$$

Advantages	Limitations
Easy to use.	Low resolution due to wavelength of light 0.2 um.
Cheap to purchase.	Low magnification (1250 x)
True color but sometimes requires screening.	Specimens are thin; may not be representative.
Could use live specimens.	

Resolution: Is the ability to distinguish between two separate points. If two points cannot be resolved, they will be seen as one point. Richer resolution, greater detail.

Resolving power: Involving power is the ability of a microscope to differentiate between two closes together objects. High resolution means that objects that are closer together can be seen as separate points.

- Resolution of Visible Light: 400nm-700nm.
- The resolution of a light microscope is limited by the wavelength of light.
- As light passed through the specimen it will be refracted.
- The longer the wavelength of light, the more it is diffracted and the more that this diffraction will overlap as the points get closer together.
- Mitochondrion Diameter is around 1000nm which interferes with the wavelength allowing us to see.
- Ribosomes Diameter is around 25nm which does not interfere with the wavelength & does not allow us to see.
- General rule: limited resolution equals half of the wavelength of the radiation used to view the specimen.

- Microscopes using visible light: maximum resolution 200nm.
- Transparent objects need to be stained.

Electron microscopes:

- Uses beams of electrons.
- Instead of light electrons are used.
- Shorter wavelength, so higher resolution.
- Specimens are not directly observed; A computer forms an image based on how many electrons are absorbed by different regions of the specimen.
- Specimen has to be very thin.
- Specimen has to be dead.
- The specimen has to be in a vacuum.
- TEM - transmission electron microscopes:
 - Direct a beam of electrons at the specimen.
 - Creates an image based on the electrons that are absorbed.
 - Focused using Electro magnets.

Advantages	Limitations
Much higher resolution than light microscope 1 nm	Expensive.
Provides detailed images of surface structures.	Extensive training required.
High magnification 500,000x.	Samples must be dead. (Vacuum, Stains)
	Back in white or false color is used.

- SEM- scanning electron microscopes:
 - Direct a beam of electrons at the specimen.
 - Creates an image based on the electrons that are reflected.
 - Focused using Electro magnets.
 - SEM images are usually false colored.

Advantages	Limitations
Much higher resolution than light microscope 1 nm	Expensive.
Provides detailed images of surface structures.	Extensive training required.
High magnification 200,000x.	Samples must be dead. (Vacuum, Stains)
3D image	Back in white or false color is used.
The advantage of SEM microscope is that surface structures can be seen. Also, great depth of field is obtained so that much of the specimen is in focus at the same time and a three-	The disadvantage of the SEM is that it cannot achieve the same resolution as a TEM. Using an SEM, resolution is between 3nm and 20nm.

dimensional appearance is achieved. Such a picture would be impossible to obtain with a light microscope, even using the same magnification and resolution, because you would have to keep focusing up and down with the objective lens to see different parts of the specimen.

Resolution: Electron microscopes: use free electron beams, behave like Electro-magnetic radiation. Have short wavelet and therefore a lot of energy. Suitable: short, negatively charged. 0.5nm.

Resolving power: of an electron microscope is much greater than that of the light microscope, as structures much smaller than wave length of light will interfere with a beam of electrons.

- Electron microscopes have a much larger resolution and magnification than a light microscope as electrons have a much smaller wavelength than visible light. This means that they can be much close together or before the diffractive beams overlap.
- The concept of resolution is why the phospholipid bilayer structure of the cell membrane cannot be observed under a light microscope.
- The width of the phospholipid layer is about 10nm.
- Maximum resolution of a light microscope is 200nm which is half the smallest wavelength of visible light that is 400nm.
- Any points that are separated by a distance less than 200nm such as the 10nm phospholipid layer cannot be observed by a light microscope and therefore will not be distinguishable as separate.

TEM - transmission electron microscopes	SEM- scanning electron microscopes
The beam of electrons is passed through the specimen before being viewed. Only those electrons that are transmitted (pass through the specimen) are seen. This allows us to see thin sections of specimens, and thus to see inside cells.	The electron beam is used to scan the surfaces of structures, and only the reflected beam is observed.

Light Microscopes	Electron microscopes
Light microscopes are used for specimens above 200nm. Light microscope shine light through the specimen, this light is then passed through an objective lens and an eyepiece lens which	Electron microscopes, both scanning and transmission are used for specimens above 0.5 nm. Electron microscopes fire a beam of electrons at the specimens either abroad static beam

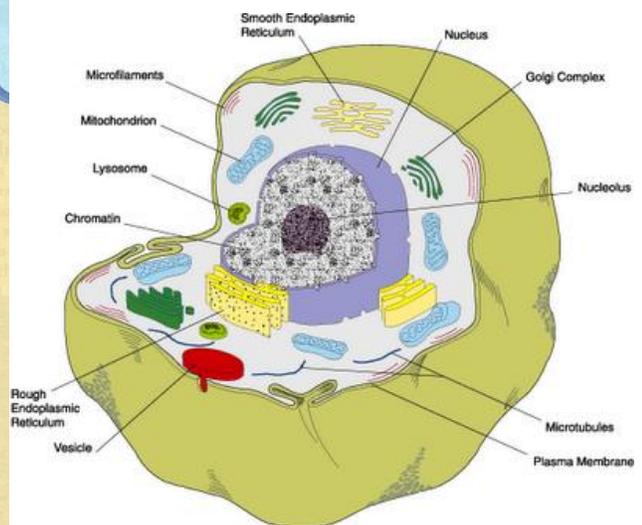
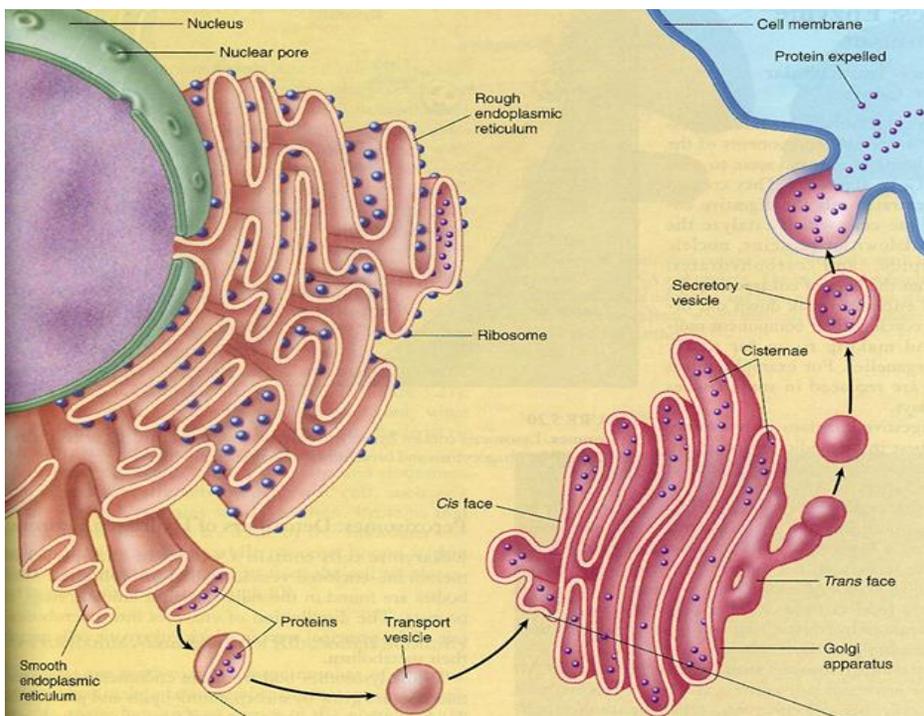
magnifies the specimen to give an image that can be seen by the naked eye. Specimens can be living or dead. Light microscopes are useful for looking at whole cells, small plants, and animal organisms' tissues within organs such as in leaves or skin.

transmission or a small beam that moves across the specimen. The electrons are picked up by the electromagnetic lens which then shows the image. Due to the high frequency of electron waves compared to visible light, the magnification and resolution of an electron microscope is much better than a light microscope. Electron microscopes are useful for looking at organelles, viruses, and DNA as well as looking at the whole cells in more detail. Electron microscopy requires a specimen to be dead; however, this can provide a snapshot in time of what is occurring in a cell. For example, DNA can be seen replicating and chromosome positions within the stages of mitosis are visible.

1.2 Cells as the basic units of living organisms

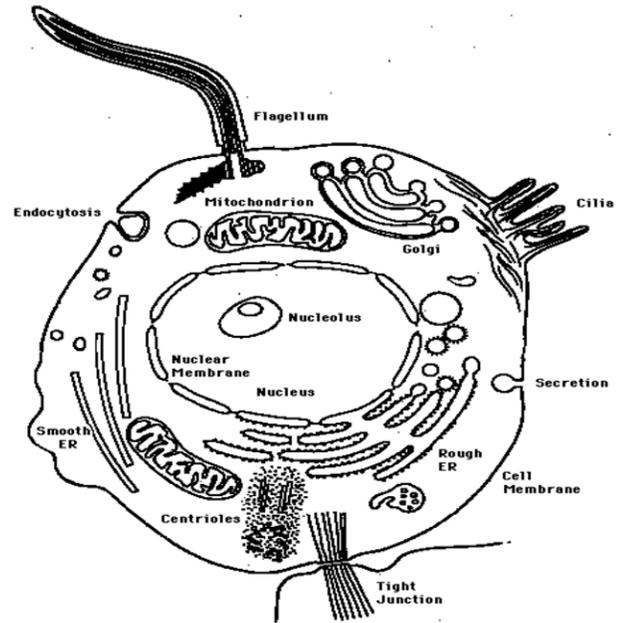
Eukaryotic Cells: are cells that contain a true nucleus. They have membrane-bound organelles & are usually multi-cellular. Eukaryotes can turn into prokaryotes if conditions demand it to do so. This is called "bacterialization". This is also known as "conversion" or "transformation" but this process does not occur in prokaryotes. The

most common components of eukaryotic cells are mitochondria & endoplasmic reticulum.

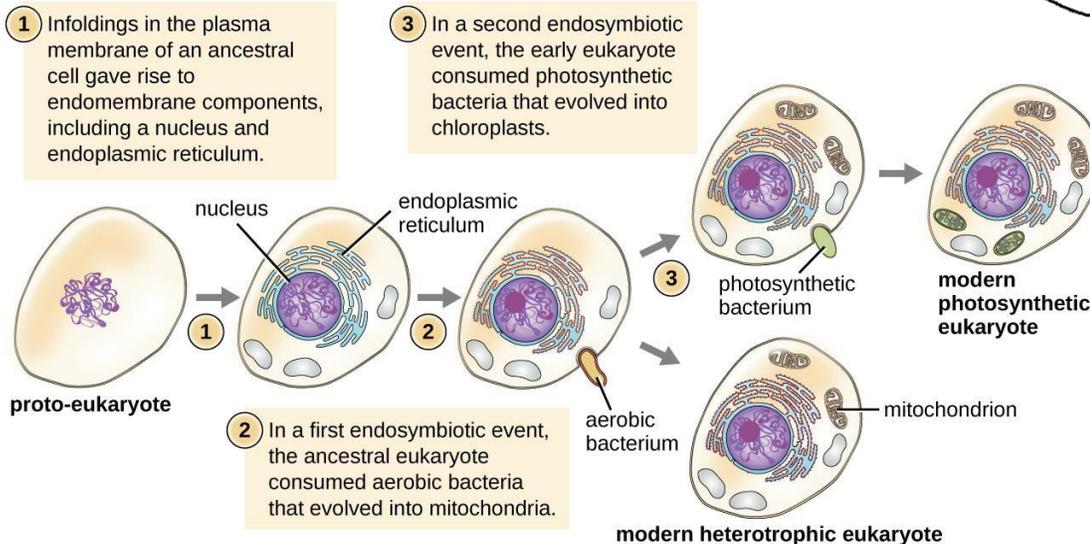


Why compartmentalize?

- Eukaryotic cells are divided into compartments (organelles) by partitions known as membranes.
- They have many different compartments which are separated by double membranes such as nucleus, mitochondria and chloroplasts and single membranes such as the vacuoles and lysosomes.



The Endosymbiotic Theory

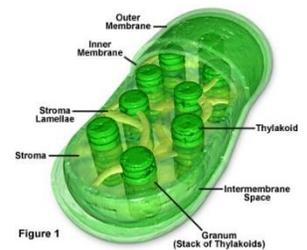


Structures and Function:

- **Mitochondria:** Powerhouse of a cell. Releases energy during respiration. Mitochondria (singular mitochondrion) are relatively large organelles surrounded by a double membrane. They are smaller than the nucleus and chloroplasts, but can be seen with a light microscope. Mitochondria are the site of aerobic respiration within eukaryotic cells. The mitochondrial matrix contains enzymes needed for aerobic respiration. Small, circular pieces of DNA, known as mitochondrial DNA, and ribosomes are also found in the matrix. This allows the production of proteins required for cellular respiration by acting as a site for energy production (ATP). Has a double membrane (smooth outer and folded inner). Inner folds are finger-like and called cristae. Their shape varies. They have their own DNA & a large

surface for cellular metabolism. They produce and contains its own ribosomes (70S type) & can reproduce independently. Liver and muscle cells contain large number of mitochondria. Liver cell can contain as many as 2000.

- Double membrane - outer controls flow of materials in/out and contains a transport protein called porin.
 - Inner membrane is more selective.
 - Cristae - extensions of inner membrane. Increased SA for attachment of enzymes. The inner membrane is folded to form cristae (smoothened folded sheets in the inner membrane of the organelle).
 - Matrix - Semi rigid. Contains protein, lipid and trace DNA. Also, the site of the Krebs cycle.
 - Intermembrane space is the space between the two membranes.
- Small vacuole: Stores water/ waste. These are small and temporary.
 - Cytoplasm: Is a runny jelly-like substance where organelles flow. Anabolic chemical reactions like anaerobic respiration take place.
 - Cytoplasm + nucleus + cell wall makes up the protoplasm.
 - Chloroplast: Contains chlorophyll to capture sunlight. Chloroplasts are larger than mitochondria, and are also surrounded by a double-membrane. Membrane-bound compartments called thylakoids stack together to form structures called grana. Grana are joined together by lamellae (thin and flat thylakoid membranes). Chloroplasts are the sites of photosynthesis. The light dependent stage takes place in the thylakoids, while the light independent stage (Calvin Cycle) takes place in the stroma. Photosynthetic pigments such as chlorophyll are found in the membranes of the thylakoids, where their role is to absorb light energy for photosynthesis. Chloroplasts contain small circular pieces of DNA and ribosomes used to synthesize proteins needed in chloroplast replication and photosynthesis.
 - Nucleus: controls metabolic reactions, cell activity and genetic information in the form of genes made of DNA in chromosomes made of chromatin. It produces mRNA for protein synthesis. It manufactures ribosomal RNA and ribosomes. Present in all eukaryotic cells, the nucleus is a large organelle that is separated from the cytoplasm by a double membrane. The nucleus contains the DNA, which is arranged into chromosomes. Chromosomes contain DNA and proteins, which are collectively referred to as chromatin.
 - Nuclear pores are important channels for allowing mRNA and ribosomes to travel out of the nucleus, as well as allowing enzymes and signalling molecules to move in.



- Nucleolus: The nucleus contains a region known as the nucleolus, which is the site of ribosome production. They vary from 1-5 in a mammalian cell, contains loops of DNA with chromosomes, makes ribosomes.
- Nuclear envelope: The nuclear membrane is known as the nuclear envelope, and contains many pores. It controls substances entering and exiting the nucleus. Substances entering are proteins to make ribosomes, nucleotides (the building blocks of nucleic acids), ATP and some hormones such as Thyroid hormone T3.
- Chromosomes: Chromosomes contain DNA and proteins, which are collectively referred to as chromatin.
- Chromatin: those long, thread-like structures contain genetic information. They control the activities of the cell and are responsible for the repair of worn-out parts. During cell division, the threads condense to form chromosomes. chromosomes in a loosely coiled state made of histone proteins and DNA which is organized into functional units called genes. Controls the cell activity.
- Sap vacuole: The sap is a solution of sugar, salts, minerals, oxygen, carbon dioxide, pigments, enzymes & ions. It is enclosed within the vacuole by a tonoplast. It stores mineral salts. It maintains the plant's rigidity by swelling up and providing additional structural support to cells. Large permanent vacuoles are found in plant cells, where they store cell sap, occupy majority of the cell volume and provide additional structural support to cells allowing them to become rigid. It is a single-membrane called tonoplast with fluid inside. It helps regulate the flow of water by osmosis into & out of the cells.
- Ribosomes: make proteins to make enzymes. Ribosomes are found in the cytoplasm of all cells or as part of the rough endoplasmic reticulum in eukaryotic cells Each ribosome is a complex of ribosomal RNA (rRNA) and proteins 80S ribosomes (composed of 60S and 40S subunits) are found in eukaryotic cells. Smaller, 70S ribosomes (composed of 50S and 30S subunits) are found in prokaryotes, mitochondria and chloroplasts. Ribosomes are the site of translation during protein synthesis. They do not have a membrane & appear as dark granules in the cytoplasm. Bound ribosomes are attached to another organelle called the endoplasmic reticulum and their protein products are shipped out of the cell.
- Cell Surface Membrane: partially permeable layer controlling essential nutrients in and toxic waste substances out of cells. All cells are surrounded by a cell surface membrane and forms the boundary between the cytoplasm and the environment. It separates the inside of cells from their surroundings.

Both eukaryotic and prokaryotic cells have an outer plasma membrane. Cell surface membranes control the exchange of materials between the internal cell environment and the external environment. The membrane is described as being partially permeable as it allows the passage of some substances and not others. Lipid soluble material can move through the membrane via the phospholipid bilayer due to its amphipathic properties. The functions of phospholipids are: to allow lipid soluble molecules to enter and leave the cell. It prevents water soluble molecules entering and leaving the cell & makes the membrane flexible. The phospholipid molecules are arranged in the plasma membrane due to the way they react with water. Because the polar heads of the molecules are hydrophilic, they are arranged so that they are always facing the internal and external fluid environment of the cell. Proteins that are embedded within the membrane are called intrinsic proteins (or integral proteins). Intrinsic proteins may be found in the inner layer or most commonly, spanning the whole membrane, in which case they are known as transmembrane proteins. Typically, a transmembrane protein with hydrophobic regions that completely spans the hydrophobic interior of the membrane. The integral proteins in the plasma membrane penetrate the lipid bilayer from one side to the other. These proteins control the entry and exit of specific molecules from the cell. They also have a hydrophobic and hydrophilic region which helps keep them in place in the membrane. A protein appendage loosely bound to the surface of a membrane and not embedded in the lipid bilayer. The protein molecules are not fixed in one spot of the membrane and they actually float in the fluid phospholipid bilayer or are attached to an integral protein. Peripheral proteins are known as glycoproteins because they have a carbohydrate attached. The function in immune responses and are involved in cell-to-cell recognition. The cell membrane spans a diameter of around 10 nm. However, at very high magnifications, at least $\times 100,000$, it can be seen to have 3 layers, described as trilaminar appearance. This consists of 2 dark lines (heavily stained) either side of a narrow pale interior.

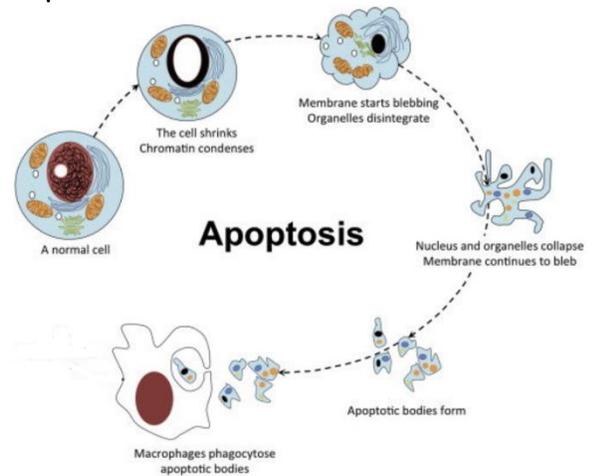
- Endoplasmic reticulum: The endoplasmic reticulum (ER) is made up of a series of membranes that form flattened sacs within the cell cytoplasm. The ER is linked with the nuclear envelope.
 - The smooth endoplasmic reticulum is responsible for lipid synthesis and of steroid hormones such as estrogen and testosterone. The SER does not have ribosomes on the surface. Synthesizes, stores and transports carbohydrates. Fewer of these exist in pancreatic cells.

- The rough endoplasmic reticulum is responsible for the transport and processing of proteins that the ribosomes create. Continuous folds of membrane that are linked with the nuclear envelope. The surface of the RER is covered in 80S ribosomes. Consists of flattened membrane sacs called cisternae. Often located near the nucleus. Pancreatic exocrine cells would have an abundance of these due to the constant production of digestive enzymes.
- Golgi Apparatus: Works together with the endoplasmic reticulum to refine, store, and distribute its products. The Golgi body is often referred to as the Golgi apparatus or the Golgi complex. It consists of a series of flattened sacs of membrane. It can be clearly distinguished from the ER, as it is not connected to other membrane-bound compartments. Its role is to modify proteins & package them into vesicles, produce secretory enzymes, secrete carbohydrates, form lysosomes & modify lipids. However, it has no ribosomes and is often near the plasma membrane. Cisternae are shorter and more curved than those on ER.
- Vesicles: Vesicles are small, membrane-bound sacs used by cells for transport and storage. They can be pinched off the ends of the Golgi body; these are known as Golgi vesicles. They can fuse with the cell surface membrane to allow exocytosis, or bud from the membrane during endocytosis. A single membrane of lipid bilayer with fluid inside.
- Lysosome: Lysosomes are specialized vesicles (membrane-bound sacs) which contain hydrolytic enzymes. Hydrolytic enzymes break down biological molecules;
 - Waste materials, such as worn-out organelles: Molecules can later on be used to make new organelles.
 - Engulfed pathogens during phagocytosis: Breakdown material ingested by phagocytic cells, such as white blood cells.

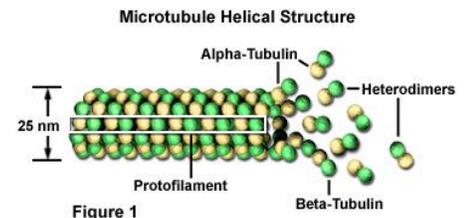
➤ Cell debris during apoptosis (programmed cell death): If the cell is damaged beyond repair, lysosomes can help it to self-destruct in a process called programmed cell death, or apoptosis.

➤ Release enzymes to the outside of the cell to remove harmful materials around the cell boundary. The released enzymes can destroy the cell itself, a process called Autolysis or Autophagy (Cell Suicide).

Many Diseases such as Tay Sachs are caused by lysosomes.



- Centrioles: are hollow fibers made of 2 groups of nine triple microtubules. Two centrioles at right angles to each other form a centrosome, which organizes the spindle fibers during cell division. Centrioles aren't found in flowering plants and fungi.
- Micro-tubules: are hollow tubes made of tubulin protein α and β tubulin proteins combine to form dimers, which are then joined into protofilaments. Thirteen protofilaments in a cylinder make a microtubule. Microtubules make up the cytoskeleton of the cell The cytoskeleton is used to provide support and movement of the cell.
- Cytoskeleton: The cytoskeleton is the skeleton or scaffolding of the cell, but it is also like the muscular system & is able to change the shape of cells in a flash.
- Plasmodesmata: are bridges of cytoplasm between neighboring plant cells. They allow the transfer of substances between plant cells.
- Cilia: are hair-like projections made from microtubules (hollow tubes). They can be found on the surface of some cells where they; allow the movement of substances over the cell surface E.g. ciliated epithelial cells in the airways waft mucus away from the lungs.
- Microvilli: are cell membrane projections that increase the surface area for absorption. Microvilli are found in parts of the body that carry out absorption, e.g. The lining of the small intestine & the kidney tubules.
- Cell Wall: Cellulose maintains shell shape, is hard to digest & requires little maintenance. It produces an internal turgor pressure to push against the cell wall. Being freely permeable to water, the cell becomes inflated and helps support each other without controlling the movement of substances into and



out of cells. Cell walls are outside cell surface membranes and offer structural support to some types of cells. Structural support is provided by the polysaccharide cellulose in plants, and by chitin in fungi. A plant cell wall is arranged in layers and contains cellulose microfibrils, hemicellulose, pectin, lignin, and soluble protein. These components are organized into three major layers: the middle lamella, the primary cell wall, and the secondary cell wall. The secondary cell wall, a thick layer formed inside the primary cell wall after the cell is fully grown. It is not found in all cell types.

- Flagellum: Helps in the movement of bacteria. They contain longer microtubules & contract to provide cell movements for example sperm cells.
- DNA: Controls metabolism by containing instructions needed for an Organism to develop, survive and reproduce.
- Plasmids: Deliver foreign DNA to the bacteria.

Cells: Cells are the basic building block of life. They come from pre-existing cells through cell division i.e. Mitosis. Thus, all cells are constantly regenerating, producing new cells that can replace them once their lifespans are over. Cells, being small, can maximize their surface area to volume ratio, which means small cells have a high surface area to volume ratio and can more efficiently utilize space to input and output materials and hence heat and cool quickly (molecules and ions move across the cell membrane)

- Anabolic Reactions: Create larger molecules from smaller molecules.
- Catabolic reactions: Create smaller molecules from larger molecules.

All cells have an internal structure known as the ultra-structure. 2 types of cells;

- Prokaryotic - bacterial cells like cholera.
- Eukaryotic - epithelial cells of small intestine. Eukaryotic cells have a distinct nucleus and possess membrane bound organelles, and epithelial cells are concerned with absorption and secretion.

Specialized cells: cells become specialized in structures to carry out particular tasks. This is called cell differentiation and is under the control of genes.

1. Root Hair Cells:

- Found just behind the growing tip of the root.
- Single specialized cell of the root epidermis.

2. Xylem Cells:

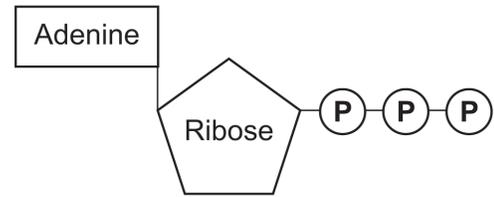
- Dead and hollow cells to allow fast and free movement of water without being used up.
- No top and bottom walls and cells joined end to end to allow free passage of water in a long continuous tube.

- Cells die, walls become impregnated with a thick, woody material called lignin for cell support.
3. Phloem Cells:
 - Dissolved sugar and amino acids can be translocated up and down the stem.
 - Companion cells adjacent to the sieve tubes to provide energy for translocation.
 4. Sperm cells:
 - The head contains genetic information for fertilization and the formation of a zygote.
 - The acrosome contains enzymes so the sperm can penetrate the egg.
 - The midpiece has a mitochondrion that provides energy for the sperm to swim.
 5. Nerve Cells:
 - Extended calls to run to & form different parts of the body to the CNS.
 - Contain extensions to communicate with other nerve cells.
 - Fatty sheath to speed up impulse.
 6. WBC:
 - Recognize foreign cells and provide immunity.
 - Phagocytes: engulf & destroy barter
 - Lymphocytes: produces antibodies
 7. RBC:
 - No nucleus: more hemoglobin can be packed for transport.
 - Biconcave disc shape: high S.A: vol
 - Flexible so you can squeeze.
 8. Muscle cells:
 - Filament to slide & cause contraction
 - Banded appearance
 - Mitochondria provides energy for muscle contraction
 9. Epithelial Cells:
 - Simple squamous epithelial cells form a membrane that allows selective diffusion of materials to pass through.
 - Diffusion helps with filtration, absorption and secretion functions.
 - Sensory reception: Sensory nerve endings that are embedded in epithelial tissue allow your body to receive outside sensory stimuli.

The Structure & Vital Role of ATP

- It is a nucleotide formed by the following components.

- A nitrogenous base - adenine
- Pentose sugar- ribose
- 3 phosphate groups



- Phosphate groups link with ribose in a row.
- The two terminal bonds among phosphates act as high energy bonds. Each of these contain 30.5 kJmol^{-1} .
- This energy is liberated when ATP is subjected to hydrolysis by enzyme ATPase.
- All organisms require a constant supply of energy to maintain their cells and stay alive.
- This energy is required;
 - In anabolic reactions to build larger molecules from smaller molecules.
 - To move substances across the cell membrane in active transport, or to move substances within the cell.
 - Chemical work: ATP supplies energy to synthesis macromolecules and therefore the organism.
 - Transport work: ATP supplied energy needed to pump substances across the plasma membrane.
 - Mechanical Work: ATP supplied energy for cellular movements.
 - Muscle Contraction: When muscle cells contract to move, they convert chemical energy into kinetic energy.
 - Protein synthesis: building large molecules.
 - Growth: building new material.
 - Cell division: when cells divide by mitosis or meiosis, energy is needed for the synthesis of molecules such as DNA.
 - Active Transport: molecules move in & out of cells against the concentration gradient requires an external source of energy from respiration.
 - Homeostasis: maintaining constant body temperature.
 - Passage of Electrical Impulses along neurons: nerve impulses are electrical signals that move along and nerve fibre in and out of nerve cells.
- In all known forms of life, ATP from respiration is used to transfer energy in all energy-requiring processes in cells; this is why ATP is known as the universal energy currency.
- Energy is released from ATP when it is broken down to ADP and inorganic phosphate.

- This process is reversed during respiration to make ATP and maintain a supply of energy.
- Adenosine Triphosphate (ATP) is a nucleotide, & the monomers of DNA & RNA are also nucleotides.

Cells, tissues, organs, organ systems and organisms:

- Cells with similar structures and functions are grouped together to form a tissue.
 - Simple tissue is formed by the same type of cells and exists to fulfill a specific cause
 - For example, muscle tissues bring about movement
 - Epithelium cells, found in the surface of the lungs, make up muscle tissue, too
 - In the trachea, they trap bacteria and produce mucous
 - In the intestines, they absorb food
 - Cartilage in the trachea is made of connective tissue cells, preventing the trachea from collapsing
 - Connective tissue in the lungs is also tissue
 - Complex tissues are formed by different cells with the same function
 - For example, nervous tissue, made up of neurons, is an example of complex tissue.
- Collections of similar tissues working together on a function is an organ.
 - A structure made of different tissues working together to perform one function
 - For example, the stomach, made of different tissues, is an organ
 - The leaf in the plant is meant to perform photosynthesis
- Several organs working together form organ systems.
- Several organ systems work together to form organisms.

Structural Features of Typical Prokaryotic Cells: are cells that do not contain a true nucleus. They do not have membrane-bound organelles & are usually uni-cellular. Eukaryotes can turn into prokaryotes if conditions demand it to do so. Prokaryotic cell is a bacterium. Prokaryotic cells are smaller than eukaryotic cells both in size and number. The most common components of prokaryotic cells are peptidoglycan and cytochrome. Prokaryotic cells use enzymes to process nutrients. Many prokaryotic cells have DNA as their genetic material.

- Animal and plant cells are eukaryotic cells, whereas bacterial cells are prokaryotic.
- Prokaryotes have a cellular structure that is distinct from eukaryotes:

➤ Their genetic material is free in the cytoplasm and is circular. Eukaryotic genetic material is packaged as linear chromosomes in the nucleus.

➤ Prokaryotes lack membrane-bound organelles.

➤ This means that they do not have any internal structures surrounded by membrane, e.g. a nucleus or mitochondria.

➤ They are many times smaller than eukaryotic cells as they are usually 1-5 μm in diameter, while eukaryotic plant cells can be 10-100 μm across.

➤ Their ribosomes are structurally smaller (70S).

➤ Their cell walls are made of peptidoglycan rather than cellulose or chitin.

➤ Asexual reproduction

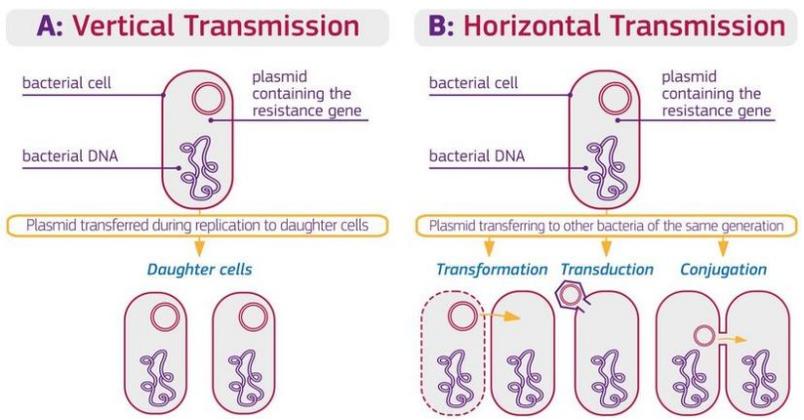
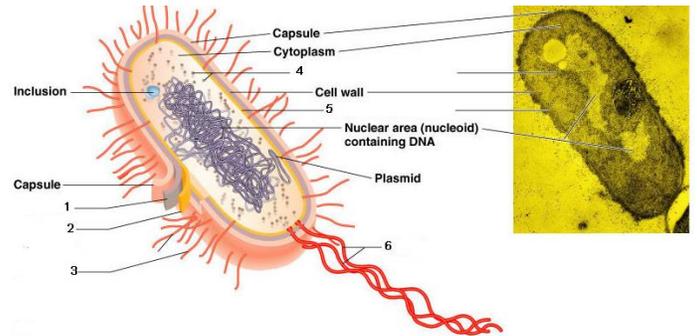
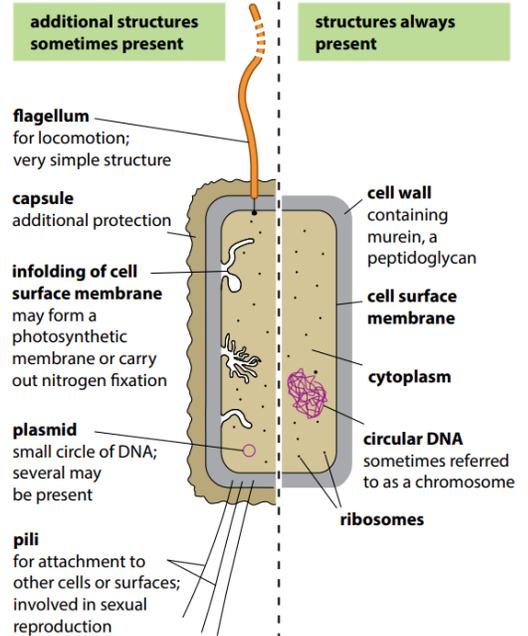
➤ Semiconservative replication
Semiconservative replication describes the mechanism of DNA replication in all known cells. In this process two copies of the original DNA molecule are produced. Each copy contains one original strand and one newly-synthesized strand.

➤ 2 DNA loops attach to membrane.

➤ Membrane elongates and pinches off forming two cells.

➤ Daughter cells are clones (genetically identical).

• Prokaryotes are always unicellular, while eukaryotic animal and plant cells can function together in multicellular organisms.



Bacteria: Bacteria are microscopic, single celled organisms that exist in their millions, in every environment, both inside and outside other organisms.

Types: many types and can be classified by shape.

- Spherical: bacteria shaped like a ball or called cocci and a single bacterium is coccus. E.g. Streptococcus responsible for strep-throat.
- Rod shaped: known as bacilli. Some rod-shaped bacteria are curved. These are known as vibrio. E.g. Bacillus Anthracis or Anthrax.
- Spiral: known as spirilla. If their coli is very tight, they are known as spirochetes. Leptospirosis, Lyme disease and Syphilis are caused by bacteria of this shape.

Structures & Functions: Bacteria are prokaryotes and structure includes;

- Plasmids: small circular DNA strands. A plasmid is a DNA molecule that is separate from, and can replicate independently of, the chromosomal DNA. They are double stranded and, in many cases, circular. Plasmids usually occur naturally in bacteria, but are sometimes found in eukaryotic organisms.
- Genetic material: DNA. this contains all the genetic instructions used in the development and function of the bacterium. It is located inside the cytoplasm.
- Nucleoid Region: DNA in the bacterial cell is generally confined to this central region. Though it isn't bound by a membrane, it is visibly distinct from the rest of the cell interior.
- Cell surface membrane: Controls movement of materials in and out. Role in binary fission. It is found within the cell wall. This generates energy and transports chemicals. The membrane is permeable which means that substances can pass through it.
- Cytoplasm: is the complete interior. No compartments. DNA most visible structure. Its a gelatinous substance inside the plasma membrane that contains genetic material and ribosomes.
- Cell wall: protects and maintains shape. Composed of peptidoglycan (carb-protein). Some have additional layer to adhere to structures (teeth, skin). Though cell wall gives its shape and is located outside the plasma membrane. The cell wall is thicker in some bacteria, called gram positive bacteria.
- Capsule: protective layer found on the outside of the cell in some bacteria.
- Flagellum: The purpose of flagella (singular: flagellum) is motility. Flagella are long appendages which rotate or beat side to side by means of a "motor" located just under the cytoplasmic membrane. Bacteria may have one, a few, or many flagella in different positions on the cell.
- Glycogen Grains: to store food.

- Pilli: These hollow, hairlike structures made of protein allow bacteria to attach to other cells and specialized pili have a role in conjugation.
- Mesosome: site of respiration.

Nutrition:

- Heterotrophic: get energy through consuming organic carbon. Most absorb dead organic matter such as decomposing flesh. Some parasitic bacteria kill their hosts while others help them.
- Autotrophic: make their own food:
 - Photosynthesis: using sun, water and carbon dioxide.
 - Chemosynthesis: using carbon dioxide, water, ammonia, nitrogen and sulfur etc.

Reproduction:

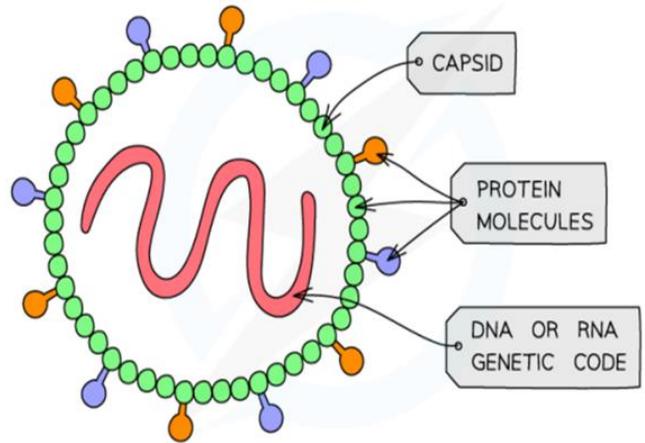
Mainly reproduce by binary fission.

Feature	Prokaryotes	Eukaryotes
Size	0.5 - 5 μm	Up to 100 μm
Genetic Material	Circular chromosomes in the cytoplasm. Not associated with proteins.	Linear chromosomes in the nucleus. Associated with histone proteins.
Cell Division	Binary Fission. No spindle fibers involved.	Mitosis and meiosis. Chromosomes are separated by spindle fibers.
Ribosomes	70S	80S
Organelles	No membrane-bound organelles.	Membrane-bound organelles. E.g. a nucleus, mitochondria, & chloroplasts.
Cell Wall	Made of peptidoglycan.	Made of cellulose in plants & chitin in fungi.

Viruses:

- Viruses are non-cellular particles that infect living cells.
- Virus are microscopic parasites, much smaller than bacteria. Lack the capacity to thrive and reproduce outside a host body.
- Viruses are not cells, and they are not considered to be living organisms, so are referred to as 'particles.'
- They are much smaller than prokaryotic cells, with a diameter of 20-300 nm, which is (about 50 times smaller on average than bacteria).
- Structurally they have
 - A nucleic acid core made of either DNA or RNA.
 - A protein coat called a capsid which is made up of separate protein molecules, each of which is called a capsomere.

- Some viruses have an outer layer called an envelope; this forms from the membrane phospholipids of the host cell in which they were produced.
- Viruses are considered parasitic as they can only reproduce by infecting living cells and using their protein-building machinery to produce new viral particles.
- Viruses use attachment proteins on their surface to bind to and infect their host cells.
- It has a very symmetrical shape.
- The virus DNA or RNA takes over the protein synthesising machinery of the host cell, which then helps to make new virus particles.

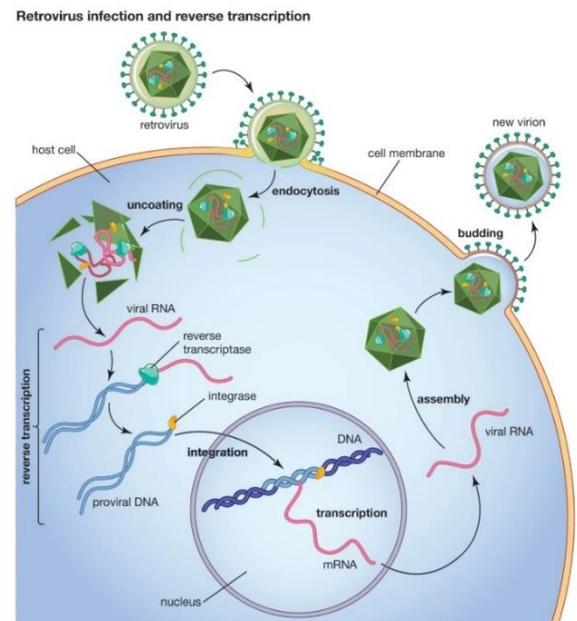


Structure: viruses teeter on the boundaries of what is considered life. On one hand, they contain the key elements that make up all living organisms: the nucleic acid, DNA and RNA. On the other hand viruses lack the capacity to independently breed and act upon the information contained within these nucleic acids.

- Capsid: surround the centre of virion.
- Nucleocapsid: combination of the nucleic acid and the capsid.
- Membrane envelope: surrounds the nucleocapsid.
- Protein spikes: helps viruses attach themselves with the host cell.

How they work?

- First virus needs to attach to the inside of a host's body. Respiratory passages and open wounds can act as a gateway for viruses. Sometimes insects provide the mode of entry. Certain viruses will hitch a ride in an insect saliva and enter a host's body after the insect bites.
- Viruses will then attach themselves to a host's cell surface.
- After a virus binds to the surface of the host cell, it can start to move across the outer covering or membrane of the host cell.



- Once inside, viruses released their genomes and also disrupt or hijack various parts of the cellular machinery. Viral genomes direct host cells to ultimately produce viral protein.

Reproduction:

A minimal virus is a parasite that requires replication in a host cell. The virus cannot reproduce itself outside the hosts because it lacks the complicated machinery that a host cell possesses. The host's cellular machinery allows viruses to produce RNA from their DNA and to build proteins based on the instructions encoded in their RNA.