RV Institute of Technology and Management®

2022 Scheme

IV Semester

Course Name: BIOLOGY FOR ENGINEERS, [ECE/CSE]

Course Code: BBOK407/BBOC407

Module-1: INTRODUCTION TO BIOLOGY

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Why Biology for Engineers:

Case study I: Materials-Bio Implants

- **Magnesium alloys**

Magnesium Alloy
- **Cast alloy**
- **Wrought Alloys**

Advantages of Mg alloys:

Low density

High Strength to weight ratio

High damping Capacity

Excellent Machinability

Properties:

Crystal structure: HCP

Density: $1.74 g/cm^3$

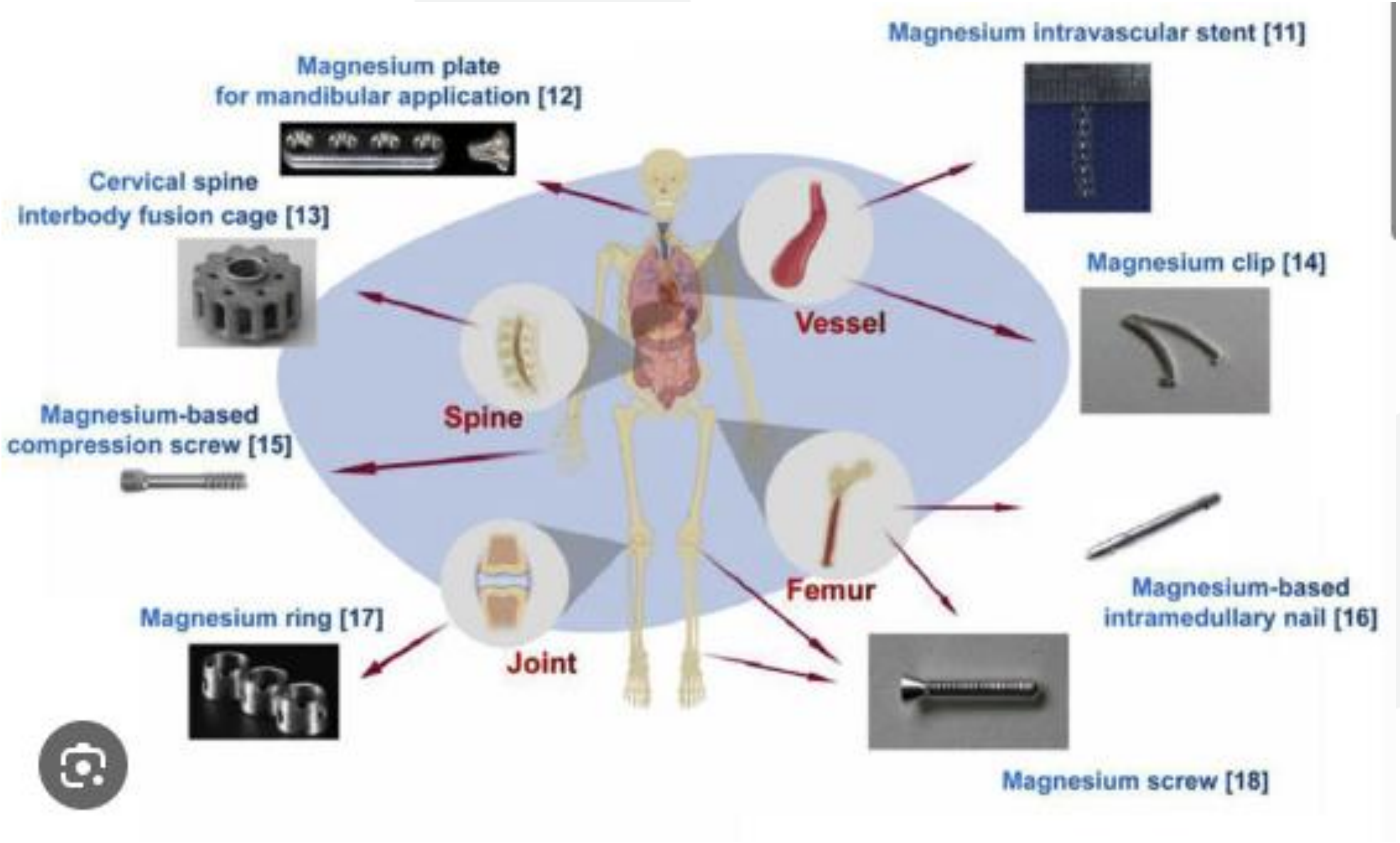
Melting Temperature: 650^oC

Atomic weight: 24.3g/mol

Disadvantages of Mg alloys:

Low mechanical strength and corrosion resistance.

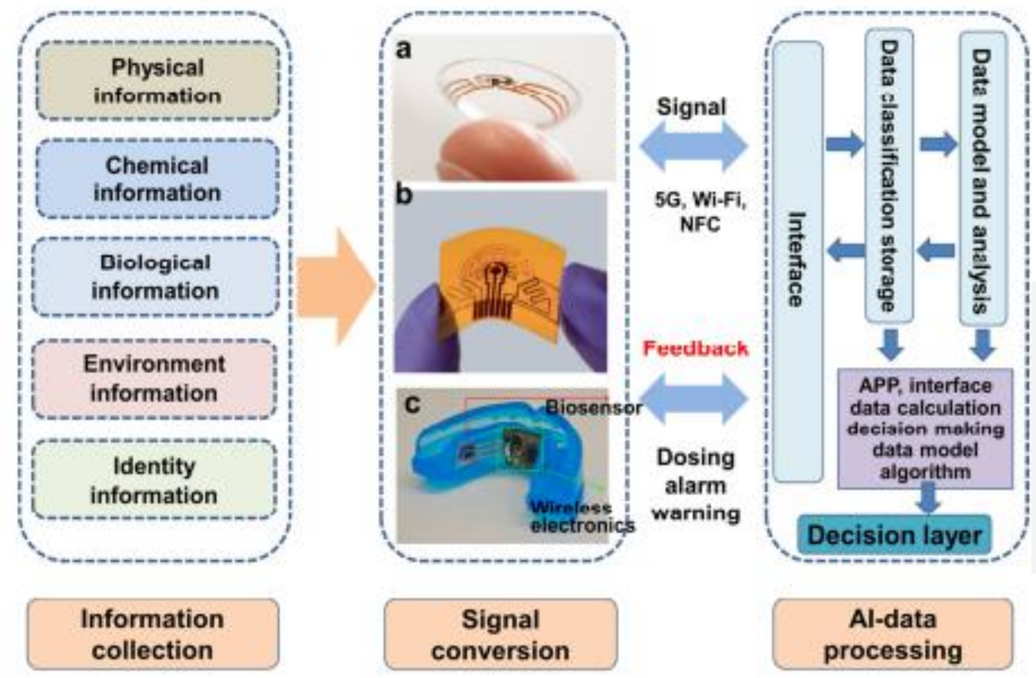
Properties	Mg	Human Bone (generally)
Density (g/cc)	1.74	0.96-1.39
Tensile strength (MPa)	21	60-70
Compressive strength (MPa)	21	106-131
Elasticity (GPa)	44	20-40
Elongation (%)	2-6	0.5-3%
Corrosion rate 2g/m2/d. (static corr)	2	NA


Magnesium plate
for mandibular application [12]
Magnesium intravascular stent [11]
Cervical spine
interbody fusion cage [13]
Magnesium clip [14]
Vessel
Spine
Magnesium-based
compression screw [15]
Femur
Magnesium-based
intramedullary nail [16]
Joint
Magnesium ring [17]
Magnesium screw [18]

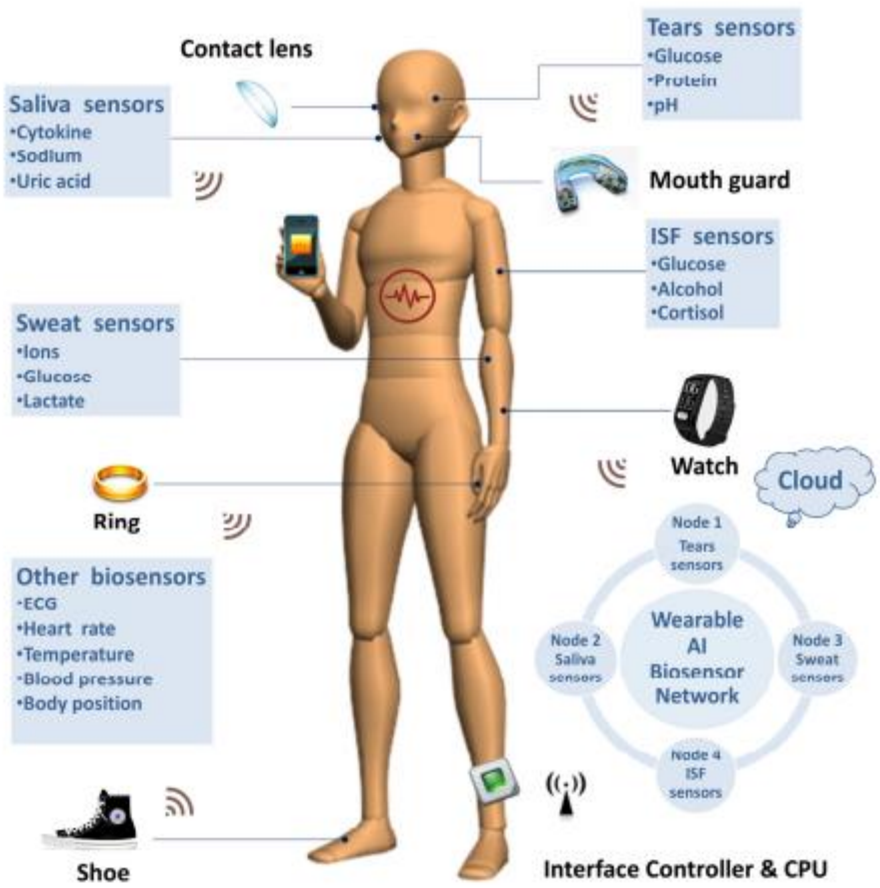

(a)
After expansion
Stents
(b)
MgCa0.8 screw
ZEK100 plate
AE112 nail
1.0 cm
Orthopedic
implants

Case study II: EC and Computer science.

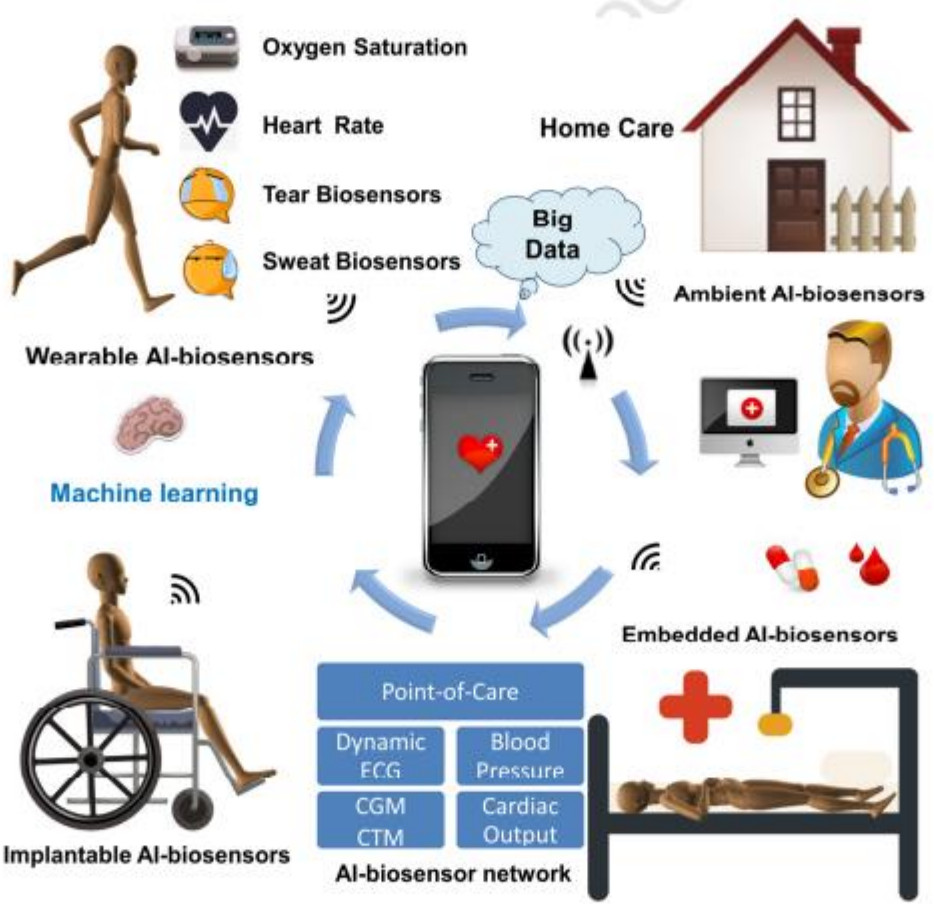
Basic architecture of AI-biosensor networks (AIBN). (a) The contact lens sensor by Google and Novartis. Copyright 2014 Google X. (b) A flexible lab-on-skin patch. Reproduced from Yang et al., 2020 with permission from Copyright 2020 Springer Nature Limited. (c) Mouthguard biosensor integrated with wireless electronics



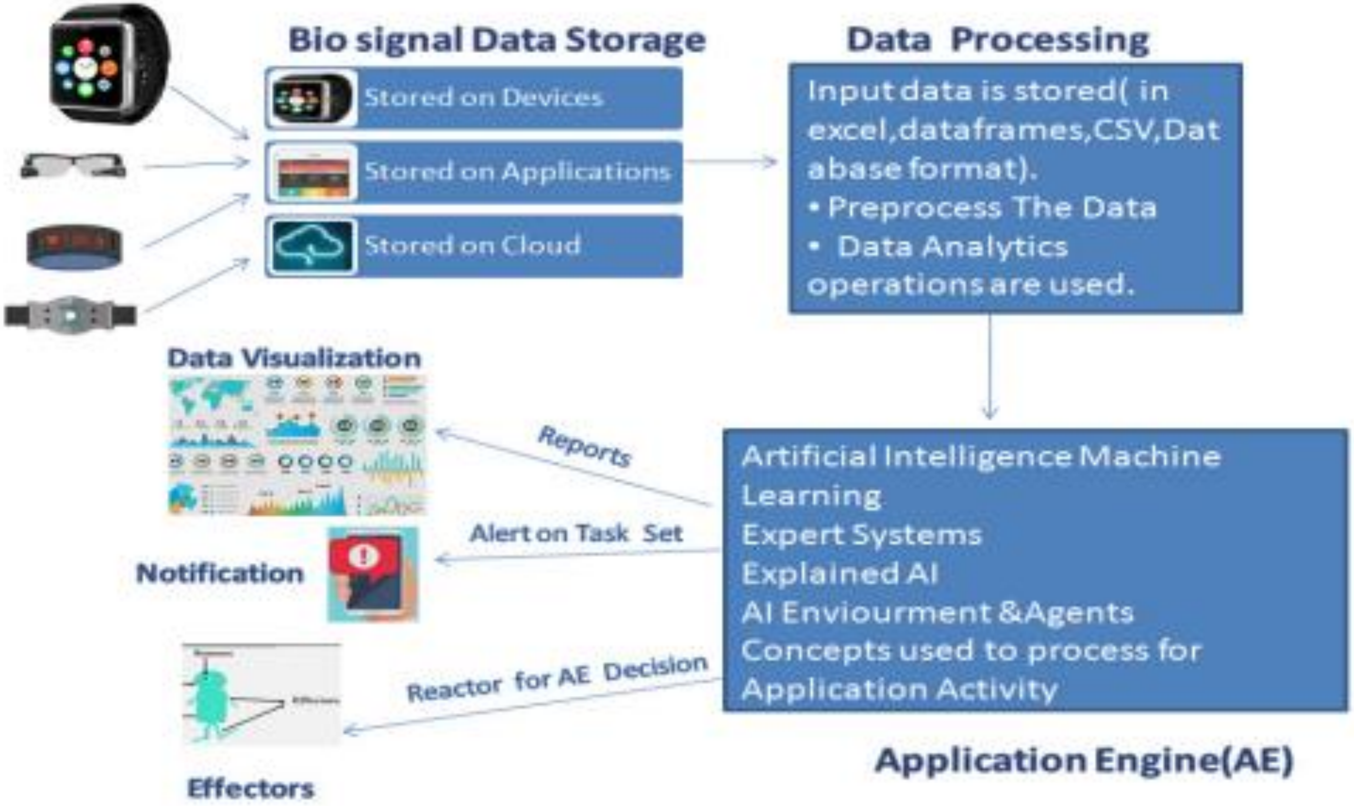
Wearable Biosensors are used to monitor the subject's health using sensors or biomarkers. Bio-sensor devices can be used on the head or inside the oral cavity, or they can take the form of wristbands, **textile devices, ear buds, finger rings, smart watches, skin mounted chips, gloves, or electronic chips**. Different types of sensors, such as
saliva-based sensors
implant sensors,
sweat-based sensors,
tear-based sensors,
arm patches, oral cavity guards, or
foot-mounted sensors are used for **medical health monitoring**.



Representative applications of wearable AI-biosensor networks

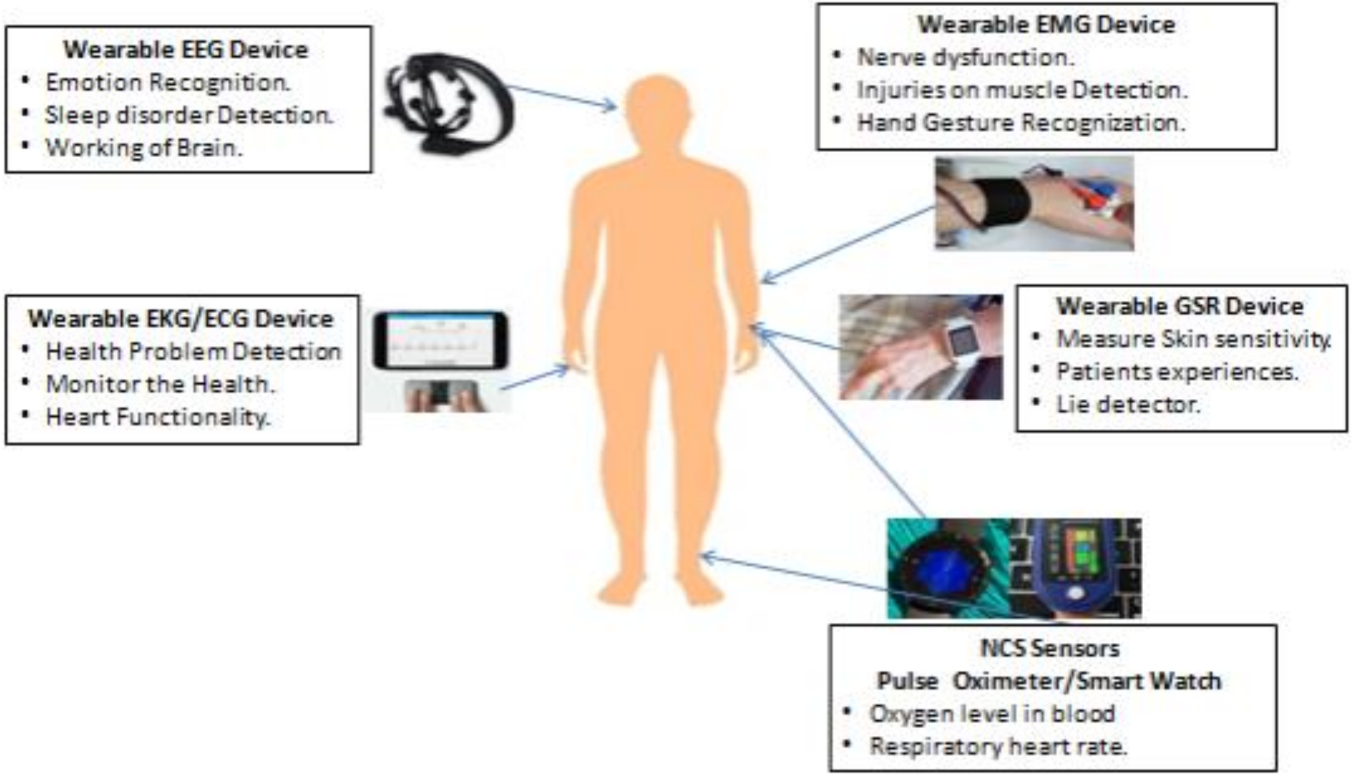


wearable AI-biosensor networks



Architecture diagrams of bio-signals processing environment

Signal Processing is a subfield of electronic engineering that includes sound and images. It is also part of the medical imaging field and is utilized in X-rays, CT scans, and MRI. Digital signal processing is used to denoise the noise of speech signals. **Bio-signals can be measured** in many ways, including by **electrooculogram (EOG), electroencephalogram (EEG), electromyogram (ERG), and electrocardiogram (ECG),** which is an electronic amplifier used to find the difference between input voltages attached to the skin. The magnetic amplifier is a galvanic skin response



Different types of wearable bio-signal devices and utilities.

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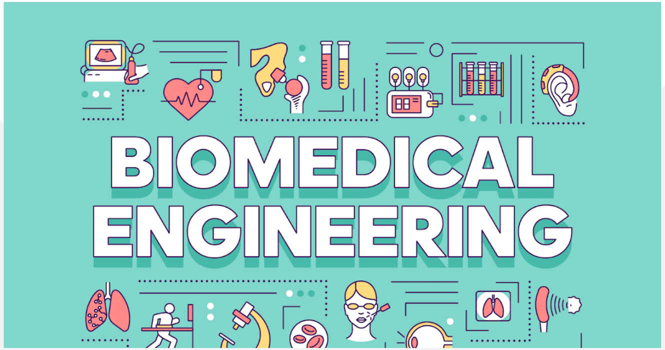
AI Classification Algorithms

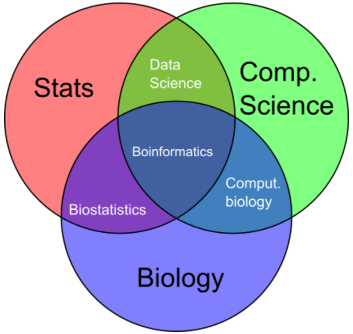
1. Navi Bayes (NAB) Classifier Algorithm
2. Decision Tree Algorithm (DTA)
3. Random Forest Algorithm (RFA)
4. Support Vector Machine (SVM)
5. K-Nearest Neighbor Algorithm
6. Logistic Regression Algorithm
7. AI Clustering Algorithm

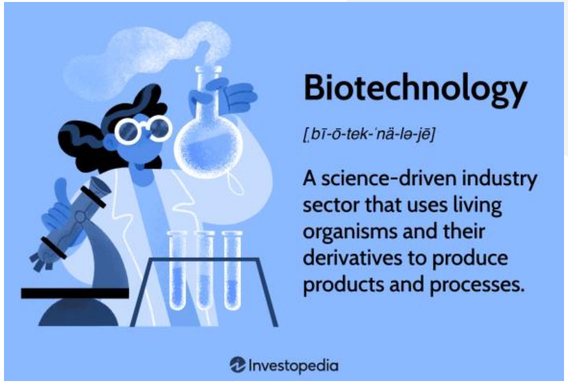
Why Biology for Engineers:

Studying biology can be valuable for engineers for several reasons:

1. **Interdisciplinary Applications:** Many engineering **fields intersect with biology, such as biomedical engineering, bioinformatics, and biotechnology**. Understanding biological principles allows engineers to work on projects that involve the integration of biological and engineering concepts, leading to innovative solutions.







2. **Medical Device Development:** Engineers working on medical devices need a solid understanding of biology to design products that interact seamlessly with the human body. This includes implants, prosthetics, diagnostic devices, and other medical technologies.

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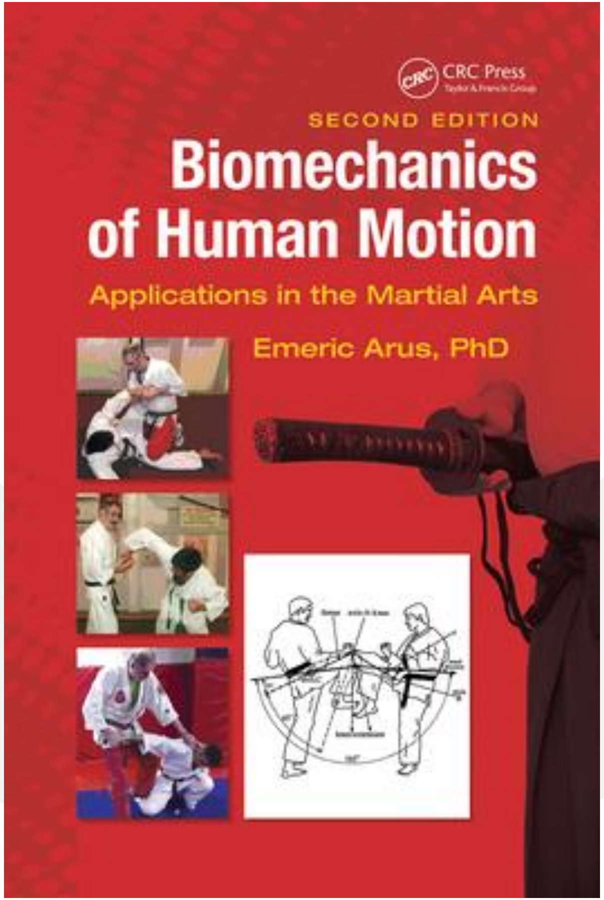
3. **Biomechanics:** Engineers involved in designing products related to **human movement or physiological function (such as sports equipment, ergonomic designs, or rehabilitation devices)** benefit from knowledge of biomechanics and how the human body functions.



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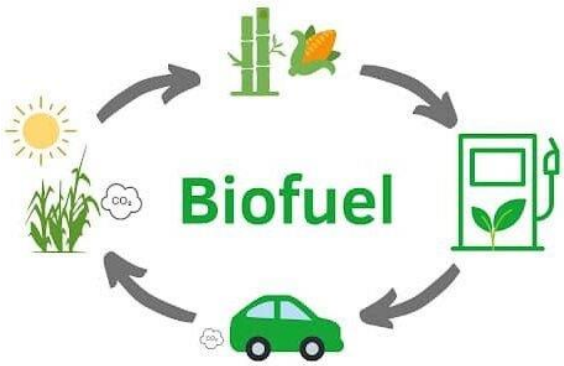
4. **Environmental Engineering:** Biology is crucial for engineers working on **environmental issues.** Understanding **ecosystems, biodiversity, and the impact of engineering projects on the environment** helps in developing sustainable solutions and minimizing ecological damage.

5. **Biochemical Engineering:** In industries such as **pharmaceuticals and biotechnology**, engineers may work on the **production of drugs, vaccines, or biofuels**. A background in biology is essential for understanding the biological processes involved in these applications



6. **Biologically-Inspired Design:** Nature often provides efficient and elegant solutions to complex problems. **Engineers can draw inspiration from biological systems to design more efficient and sustainable technologies**. This approach, known as biomimicry, has led to innovations in various fields.

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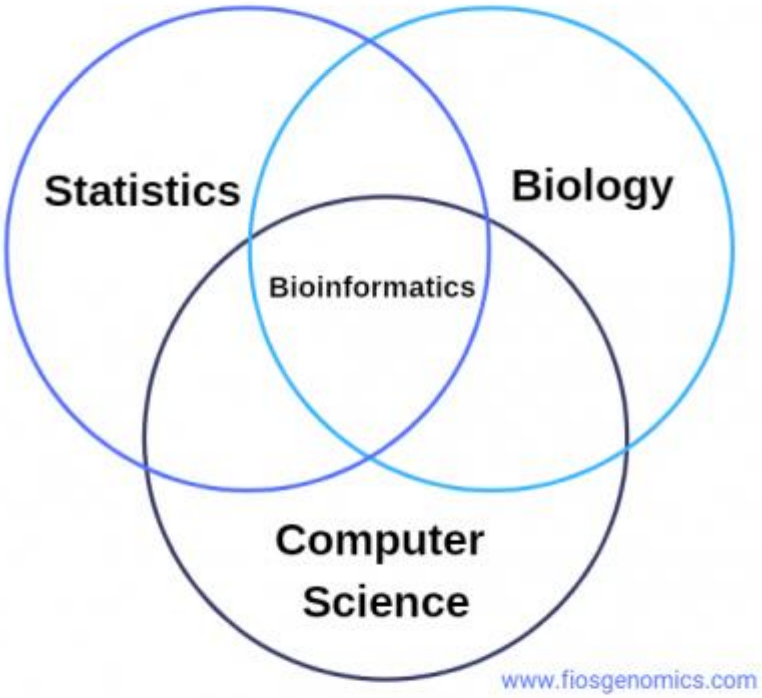
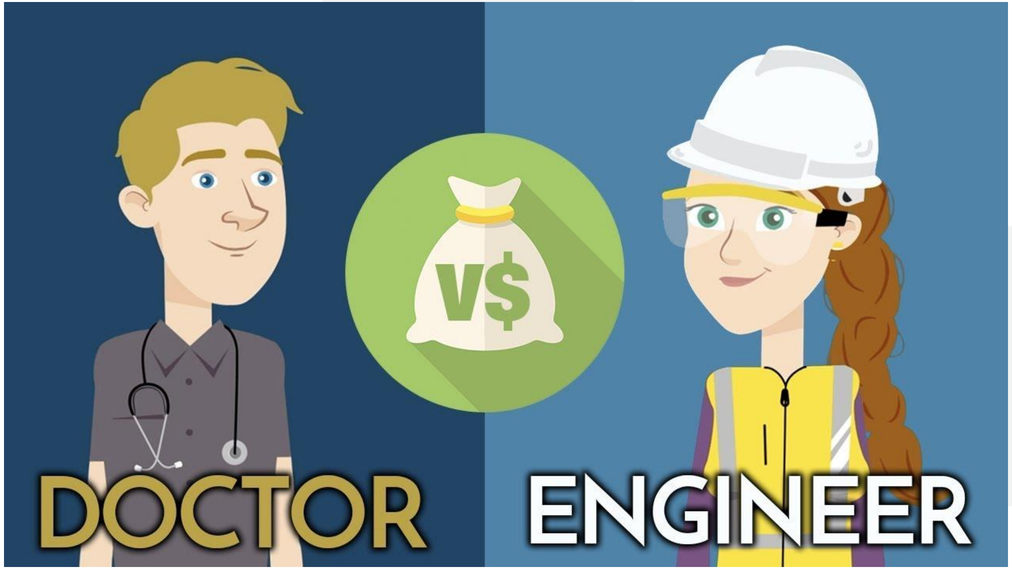
7. **Understanding Living Systems:** For engineers working on projects that involve living organisms, such as **agricultural engineering or bioinformatics, a solid understanding of biology is crucial for effective problem-solving.**



8. **Research Collaboration:** Collaborations between **engineers and biologists are increasingly common in research projects.** Engineers who can communicate effectively with biologists and understand their language are better positioned to contribute meaningfully to interdisciplinary research efforts.



In summary, a foundation in biology enhances the skill set of engineers, enabling them to work on a diverse range of projects, collaborate effectively with professionals in other fields, and contribute to solutions that address complex, real-world challenges.

Module-1

The cell: the basic unit of life, Structure and functions of a cell. The Plant Cell and animal cell, Prokaryotic and Eukaryotic cell, Stem cells and their application.

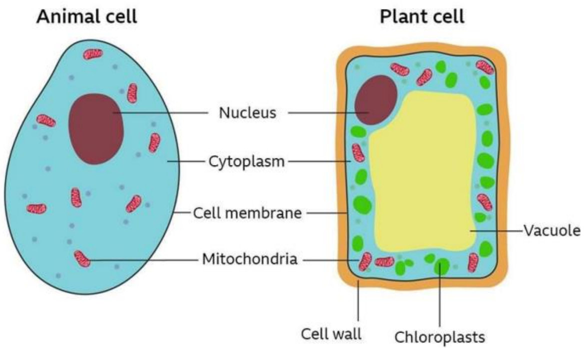
Biomolecules: Properties and functions of Carbohydrates, Nucleic acids, proteins, lipids. Importance of special biomolecules; Enzymes (Classification (with one example each), Properties and functions), vitamins and hormones.

CELLS

A cell is defined as the smallest, basic building blocks of all living things. A cell is the structural and fundamental unit of life.

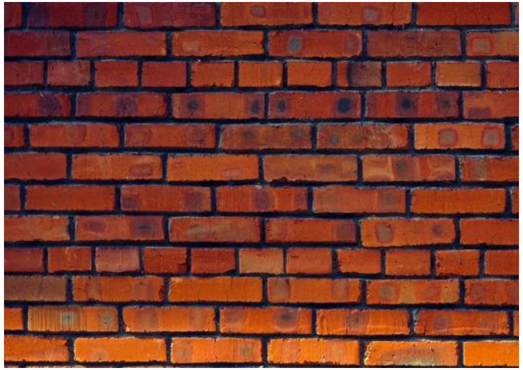
Cells are the **structural, functional, and biological** units of all living beings. A cell can replicate itself independently. Hence, they are known as the **building blocks of life.**

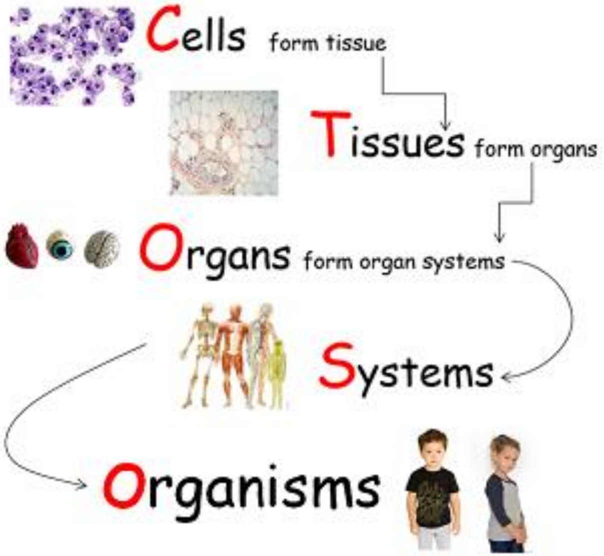
Each cell contains a **fluid** called the **cytoplasm**, which is enclosed by a **membrane**. Also present in the cytoplasm are several **biomolecules like proteins, nucleic acids and lipids**.

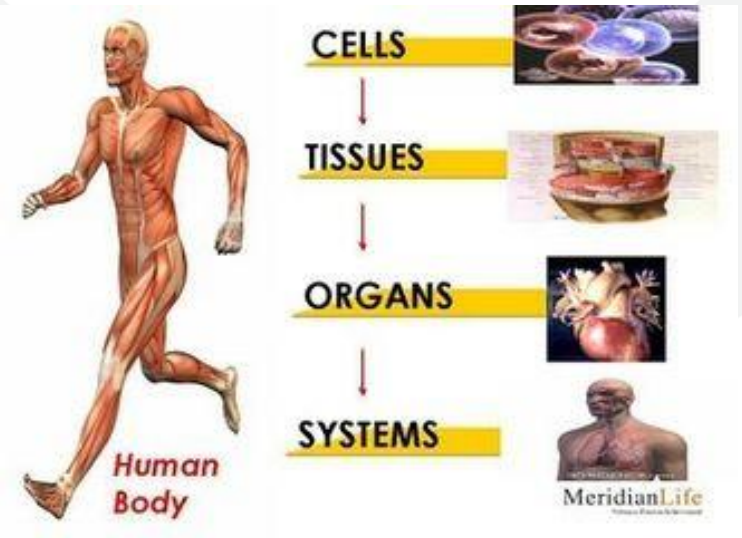


The cell: the basic unit of life

Cells are the **structural, functional and biological** units of all living beings. **A cell can replicate itself independently.** Hence, they are known as the **building blocks of life. Cytology: study of cells &its organelles under microscope.**







Overview of cell

Cell Envelop

<u>Outermost cover</u>
Cell membrane
Plasma membrane
Plasmalema
(plant-cell wall)

Genetic Material

DNA
Prokaryotic-Nucleoid
Eukaryotic-Nucleus

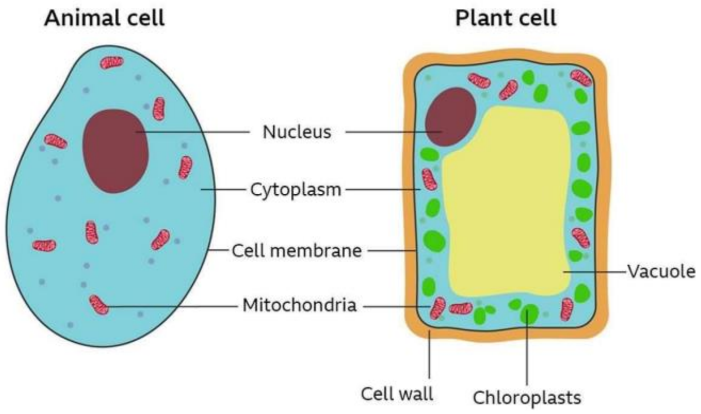
Cytoplasm

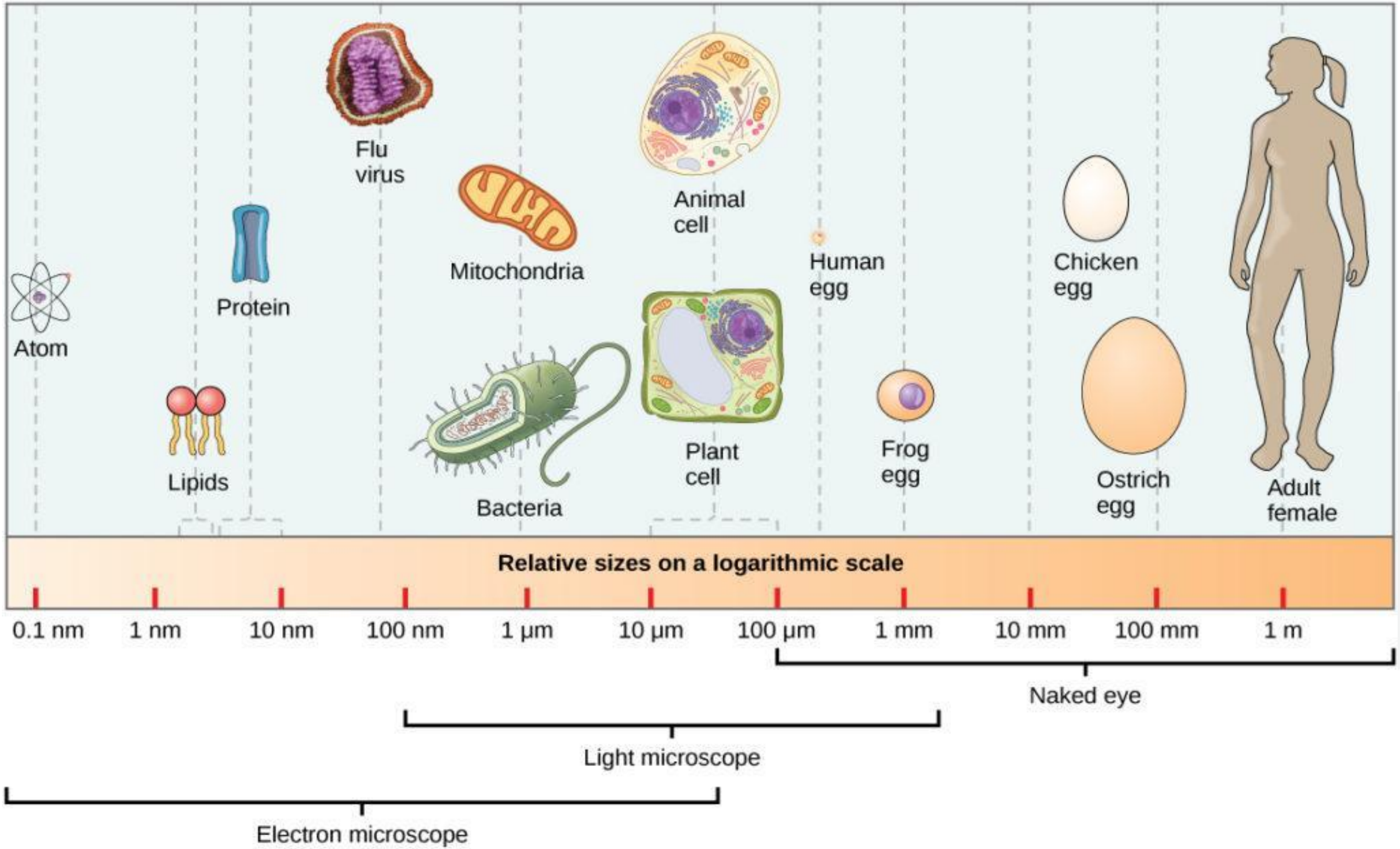
Semi liquid matrix

Membrane less
*Ribosomes
-centrioles (animal)

Single membrane covered
-Endoplasmic reticules
-Golgi Apparatus
-lysosomes
-Micro bodies

Double membrane covered
Mitochondria
Plastid (plant cell)




Flu virus
Animal cell
Mitochondria
Protein
Human egg
Chicken egg
Atom
Lipids
Bacteria
Plant cell
Frog egg
Ostrich egg
Adult female
Relative sizes on a logarithmic scale
0.1 nm
1 nm
10 nm
100 nm
1 µm
10 µm
100 µm
1 mm
10 mm
100 mm
1 m
Naked eye
Light microscope
Electron microscope

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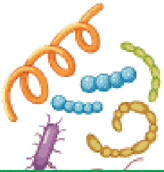
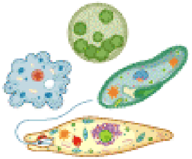
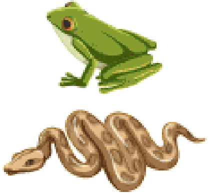
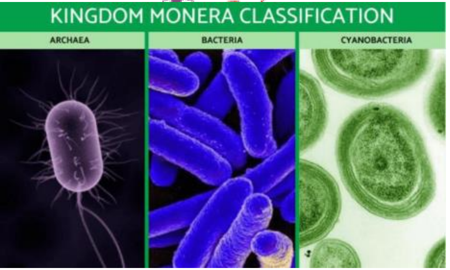
Five kingdom Classification

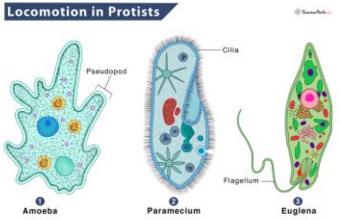
- Monera
- Protists
- Fungi
- Plants
- Animals











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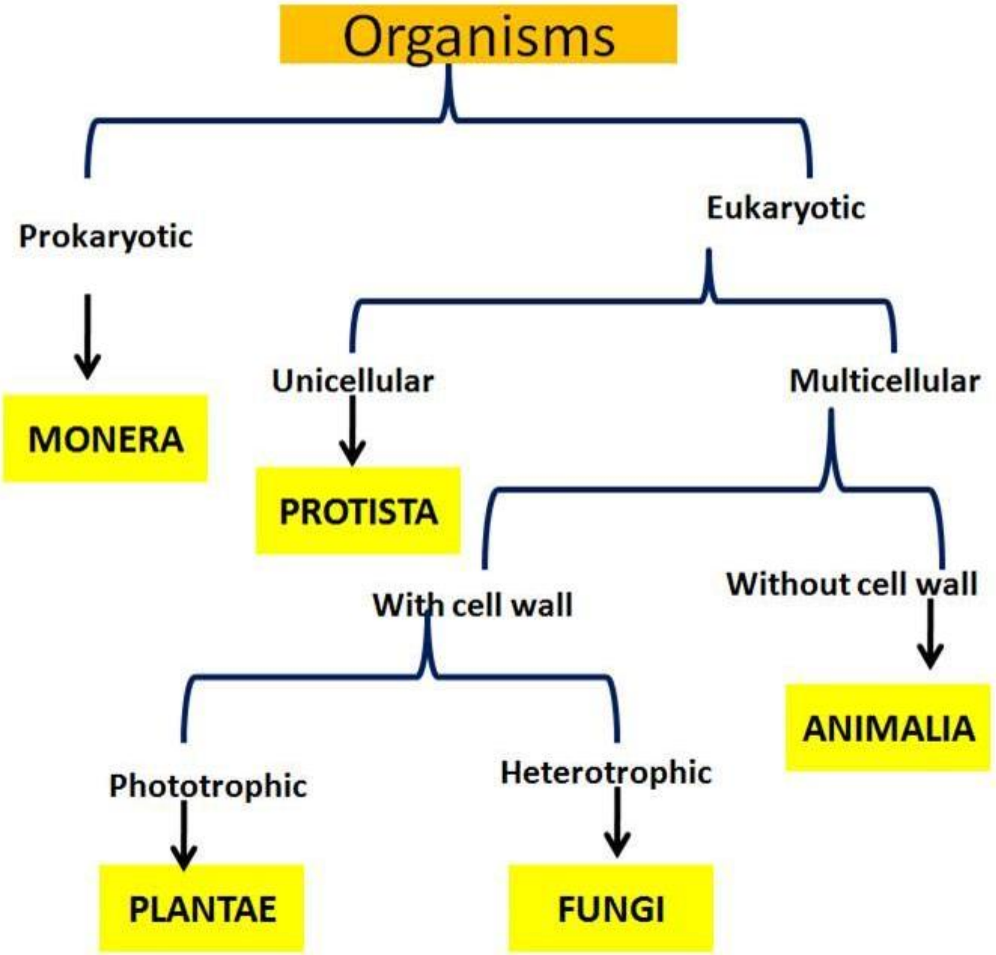
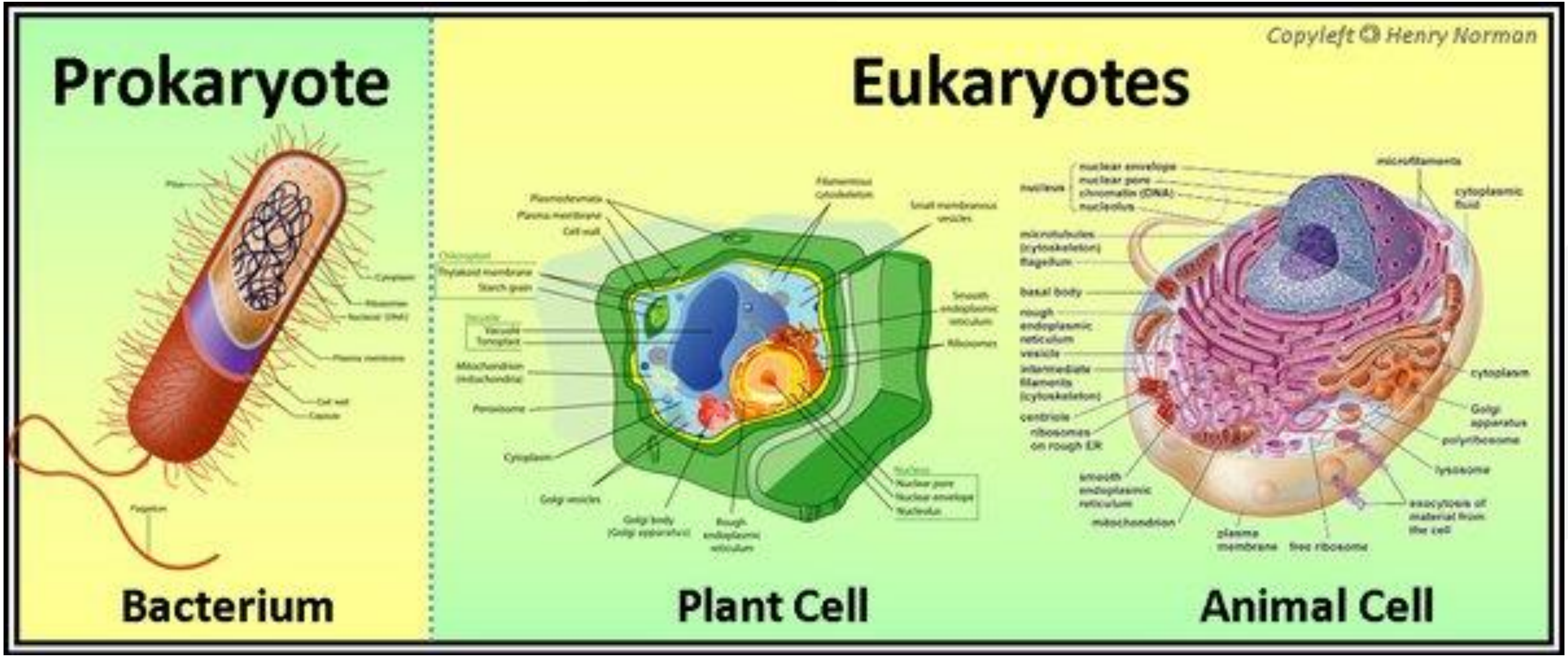
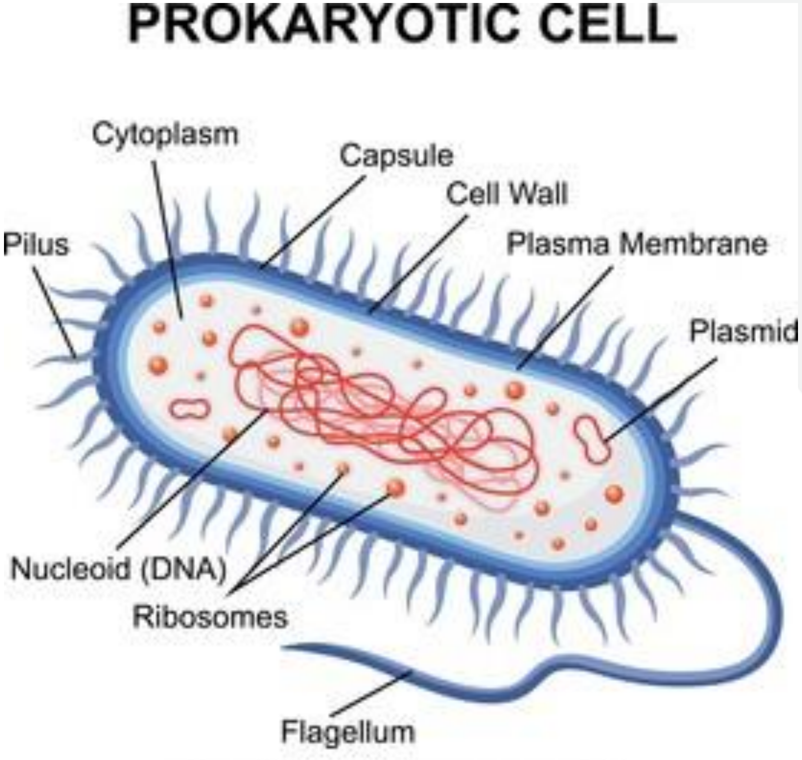
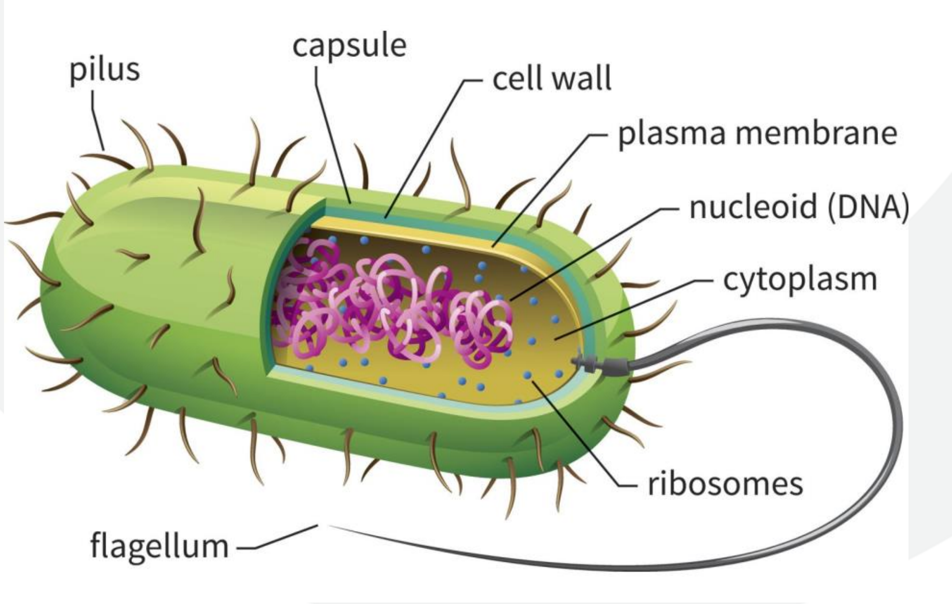


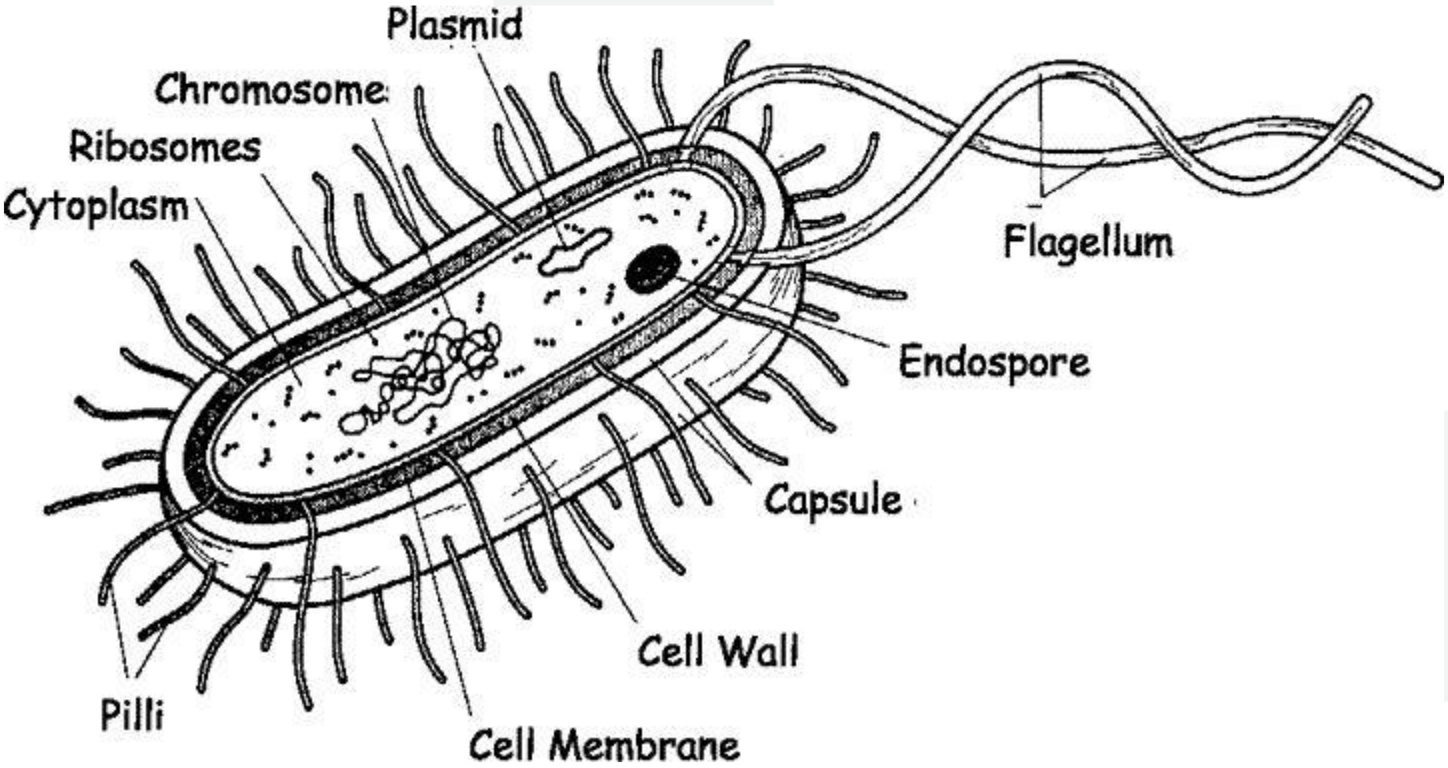


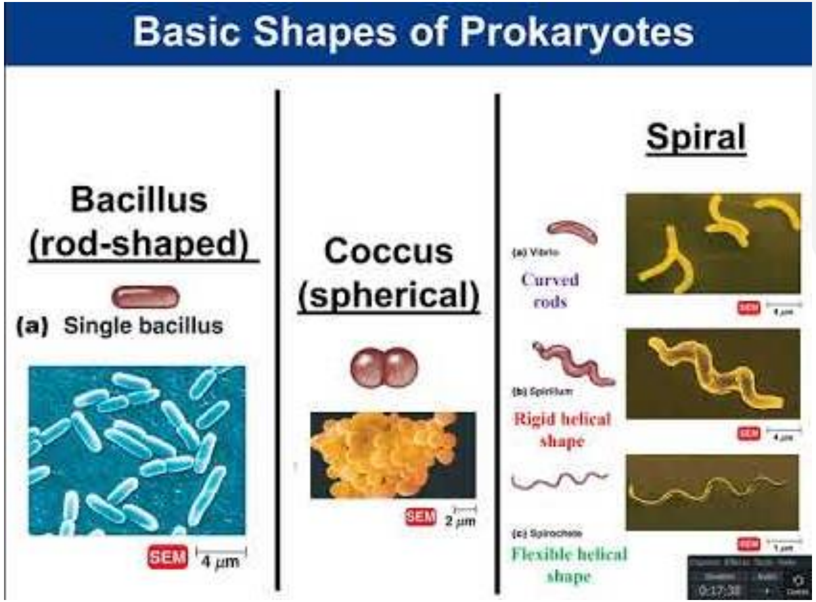
Pro: Blue-green algae, bacteria and mycoplasma.

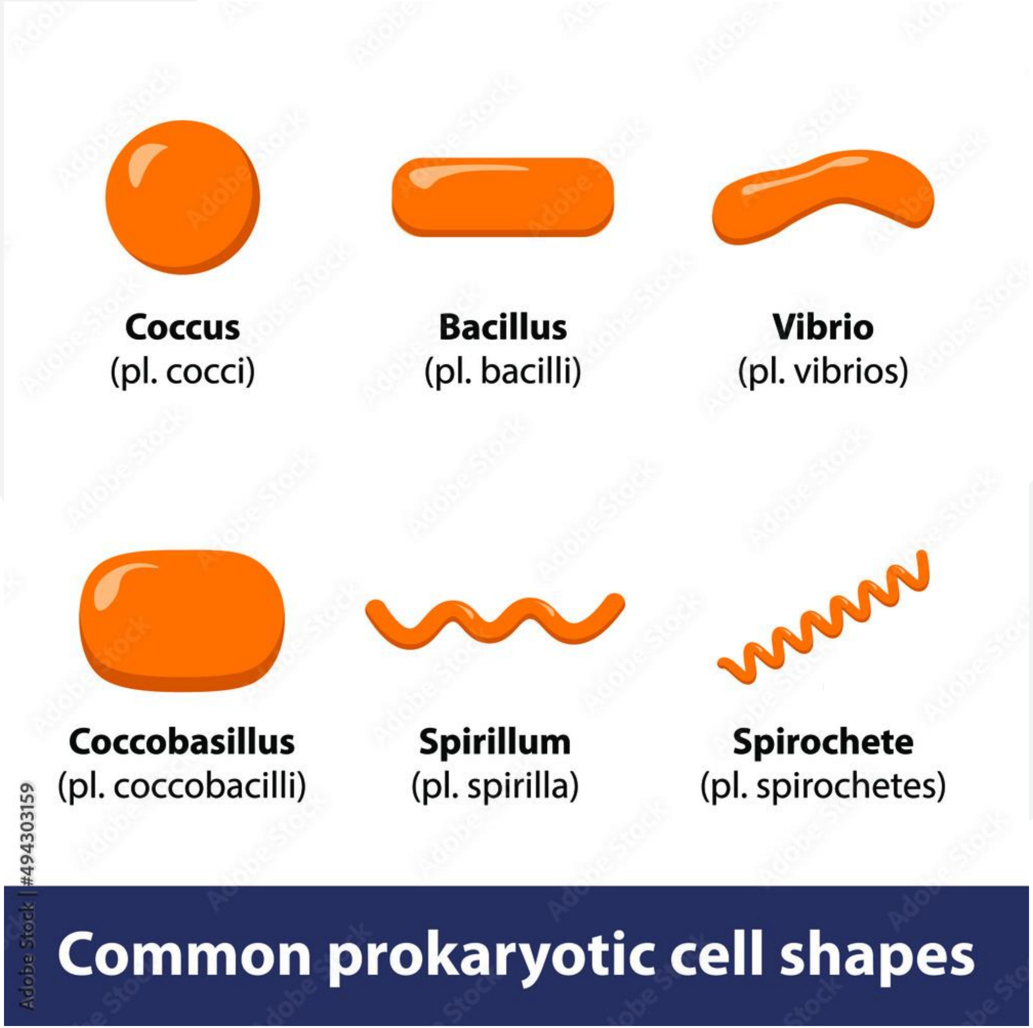

PROKARYOTIC CELL
Cytoplasm
Capsule
Cell Wall
Pilus
Plasma Membrane
Plasmid
Nucleoid (DNA)
Ribosomes
Flagellum


pilus
capsule
cell wall
plasma membrane
nucleoid (DNA)
cytoplasm
ribosomes
flagellum

Prokaryotic cell




Basic Shapes of Prokaryotes
Bacillus
(rod-shaped)
(a) Single bacillus
SEM
4 µm
Coccus
(spherical)
SEM
2 µm
Spiral
Curved
rods
Rigid helical
shape
Flexible helical
shape


Coccus
(pl. cocci)
Bacillus
(pl. bacilli)
Vibrio
(pl. vibrios)
Coccobasillus
(pl. coccobacilli)
Spirillum
(pl. spirilla)
Spirochete
(pl. spirochetes)
Adobe Stock | #494303159
Common prokaryotic cell shapes

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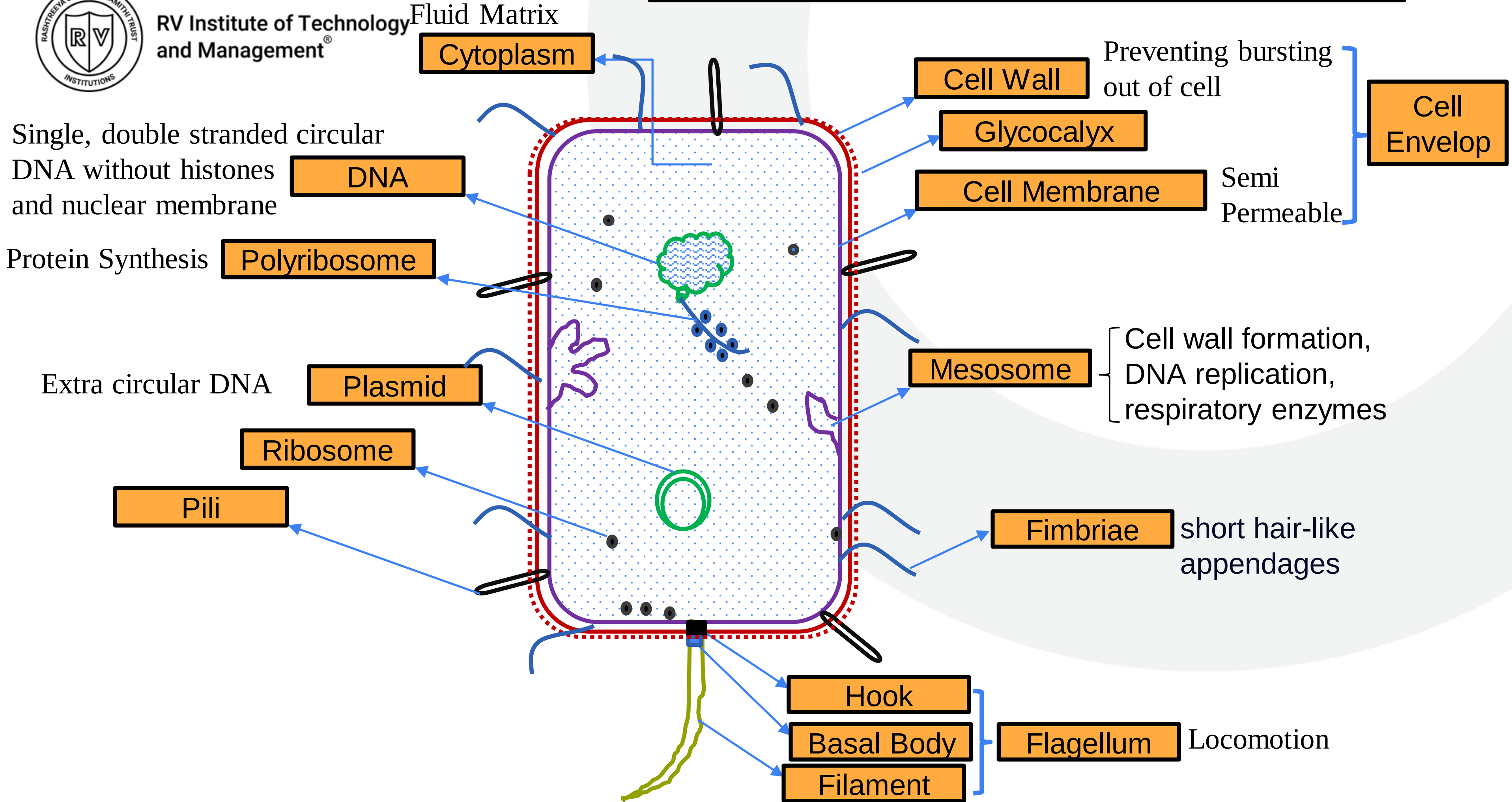
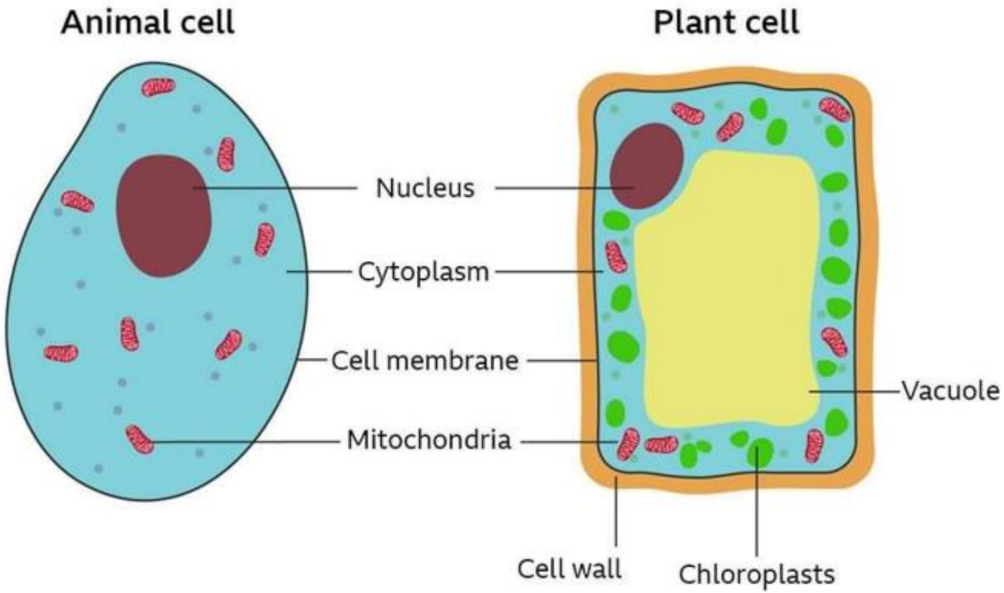
Prokaryotic cell- Bacteria, BGA, Mycoplasma



CELLS

Each cell contains a **fluid** called the **cytoplasm**, which is enclosed by a **membrane**. Also present in the cytoplasm are several **biomolecules like proteins, nucleic acids and lipids**.



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Nucleus

Cells control central

DNA

Endoplasmic Reticulum

Move and store materials Made by the cell

Lysosome

Where digestion of cell nutrients

Cytoplasm

Jelly like fluid

Cell membrane

Made up of a double layer of fatty material.

Mitochondrion

Produces energy for cells

Golgi Complex

Collects and distributes molecules made in cell.

Ribosome

Tiny Protein Producing factories

Storage area-fats and other substance

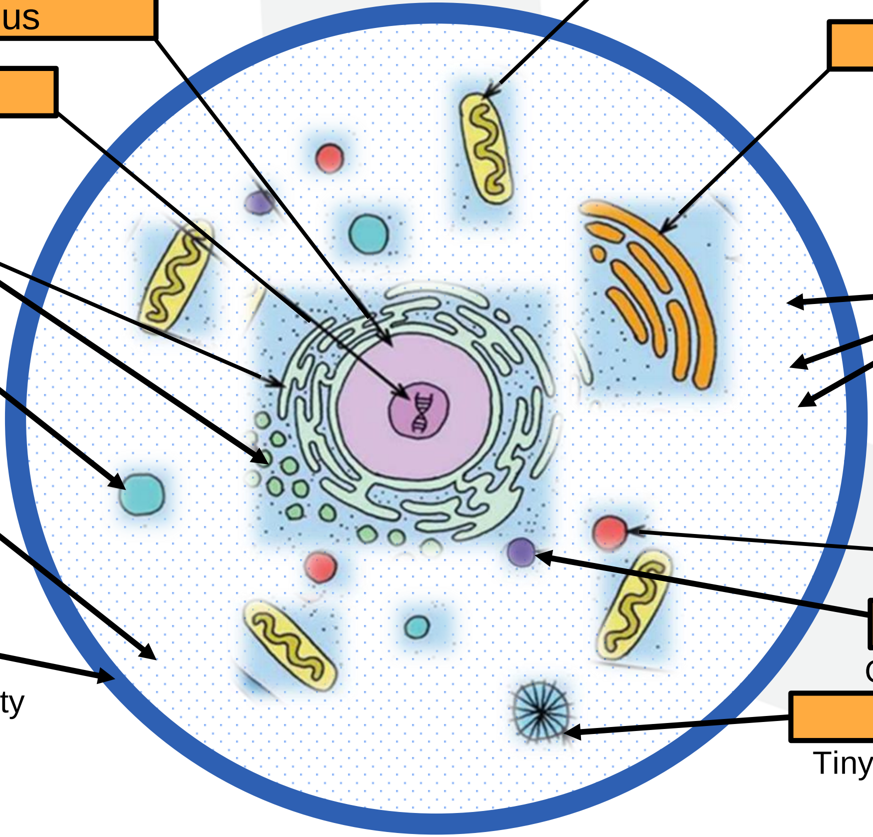
Vocuole

Peroxisome

Contain enzymes

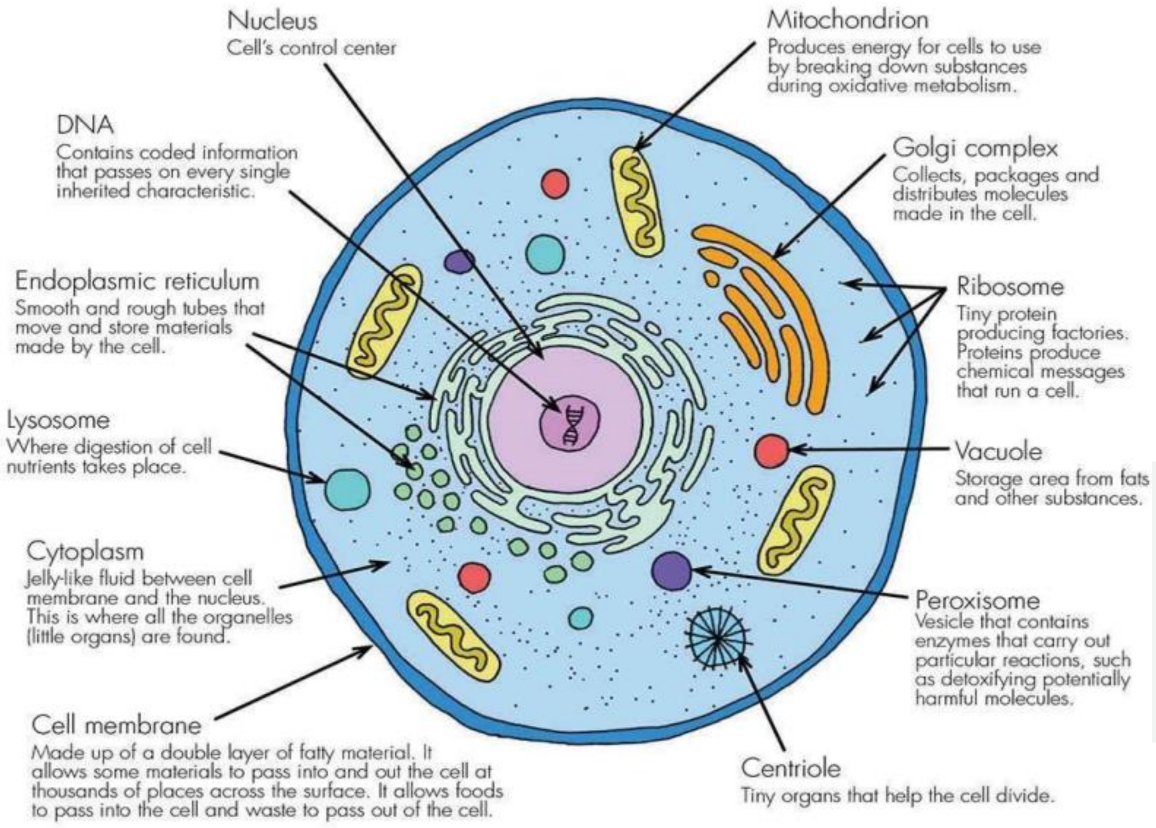
Centriole

Tiny organs that help the cell divide



Animal Cell

Structure and functions of a cell



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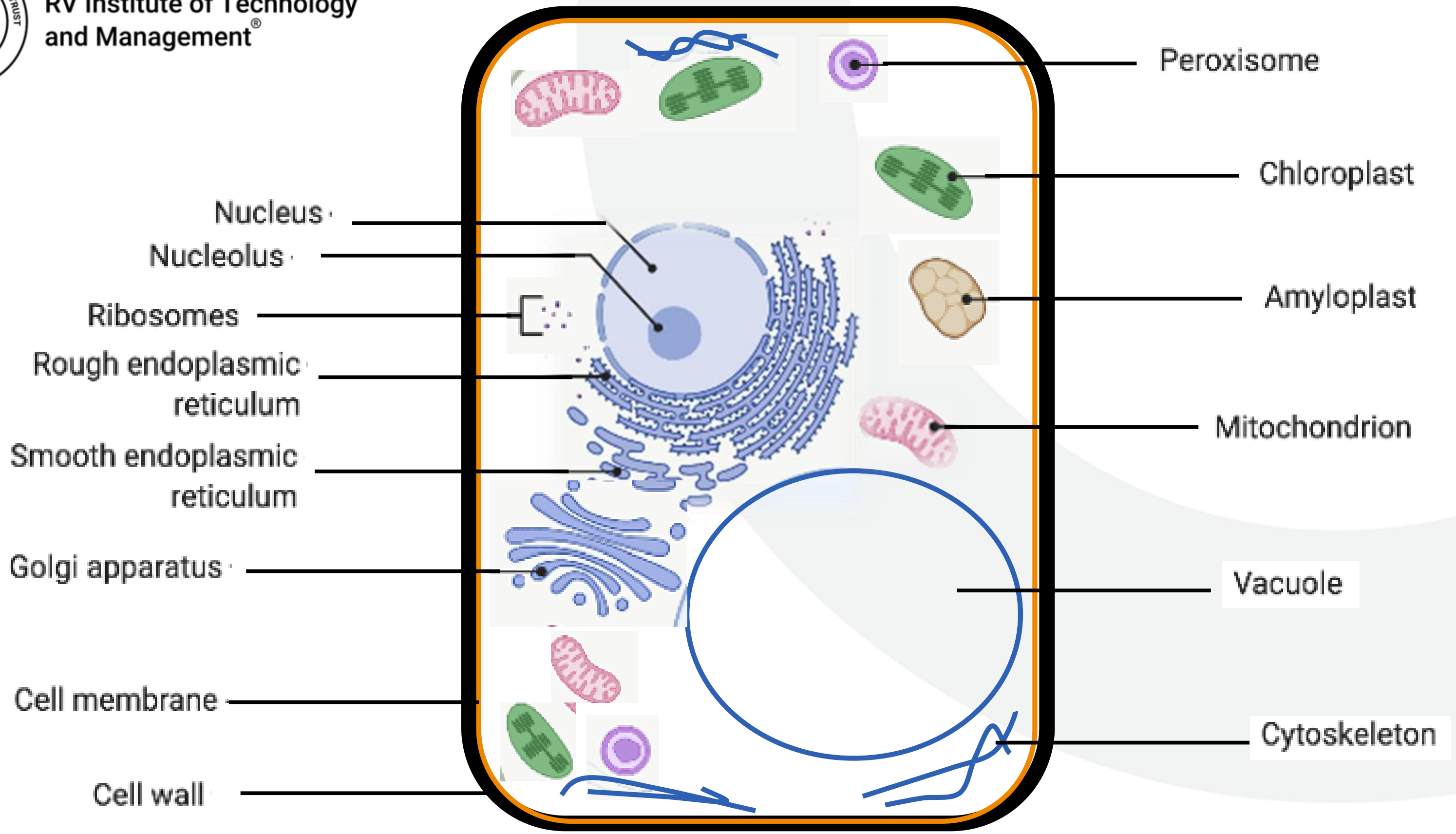

Plant Cell

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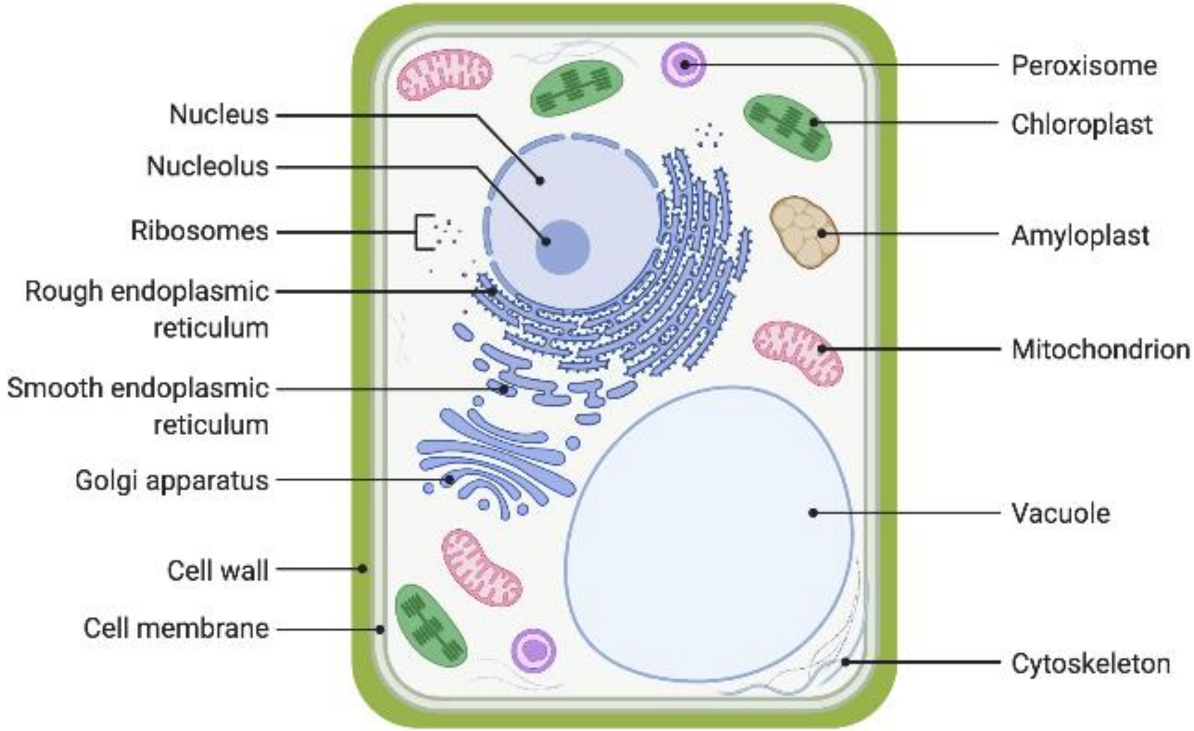
Plant Cell



Comparing prokaryotes and eukaryotes

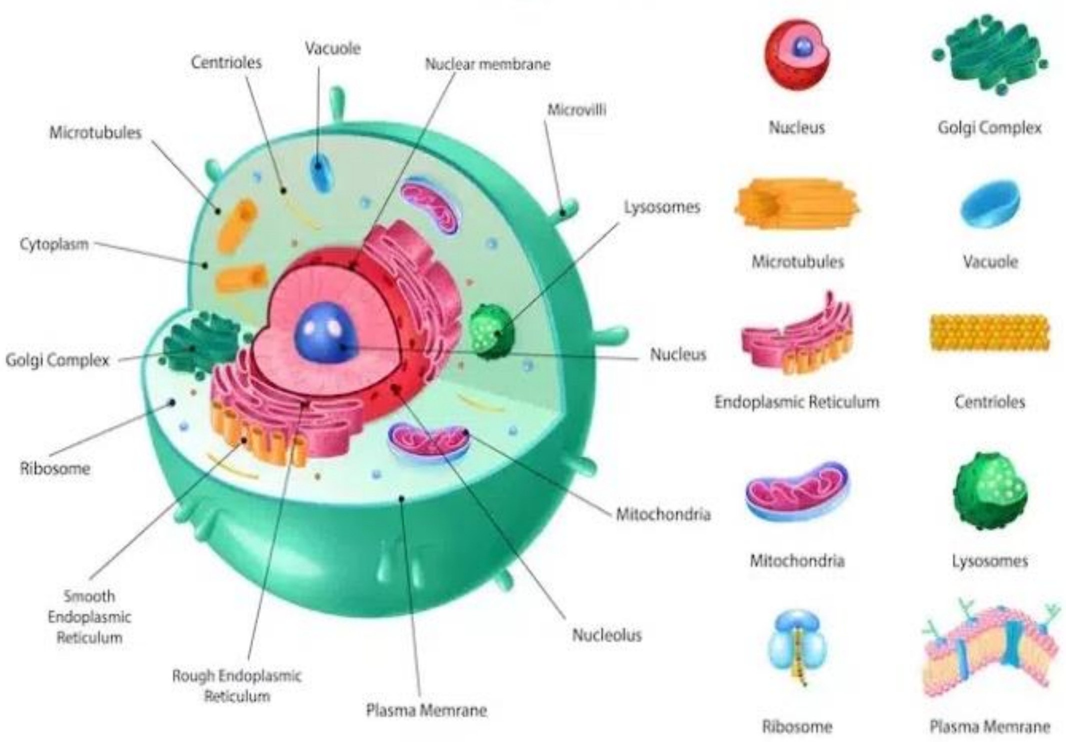
	Prokaryote	Eukaryote
Nucleus	Absent	Present
Membrane-bound organelles	Absent	Present
Cell structure	Unicellular	Mostly multicellular; some unicellular
Cell size	Smaller (0.1-5 μm)	Larger (10-100 μm)
Complexity	Simpler	More complex
DNA Form	Circular	Linear
Examples	Bacteria, archaea	Animals, plants, fungi, protists

Plant Cell Vs Animal cells

Plant cells	Animal cells
The plant cells are larger than animal cells.	Animal cells are usually smaller in size.
The plant cells are rectangular shaped.	Animal cells usually have irregular shapes.
An outer envelope covers the plasma membrane of the plant cell called a cell wall.	Animal cell lacks a cell wall, and the plasma membrane is the outer membrane.
Plastid, a membrane-bound cell organelle, is present in a plant cell.	Except for Eugelena, animal cells lack plastids.
The vacuole in the plant cell is single, large, and centrally located.	Animal cells have numerous vacuoles and are small in size.
Plant cells have many simpler units of Golgi apparatus called dictyosomes.	Animal cells have a single highly complex and prominent Golgi apparatus.
Plant cells lack centrosomes and centrioles.	Animal cells have centrosomes and centrioles.
The number of mitochondria are fewer.	The number of mitochondria are more than that of plant cell.
Plant cells do not have cilia.	Animal cells have cilia.
Lysosomes are very rare in plant cells.	Animal cells have lysosomes.

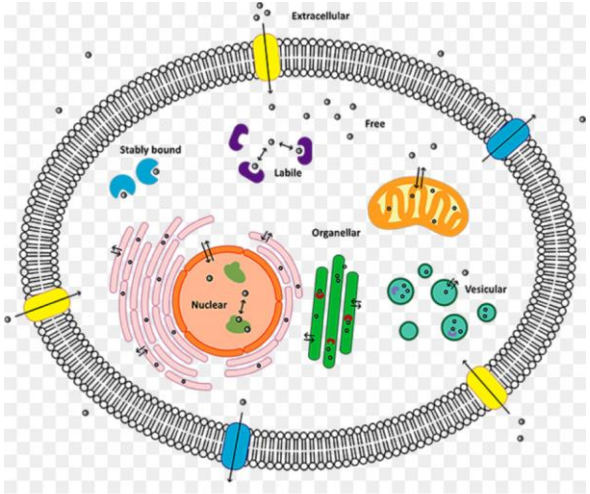
Cell Organelles

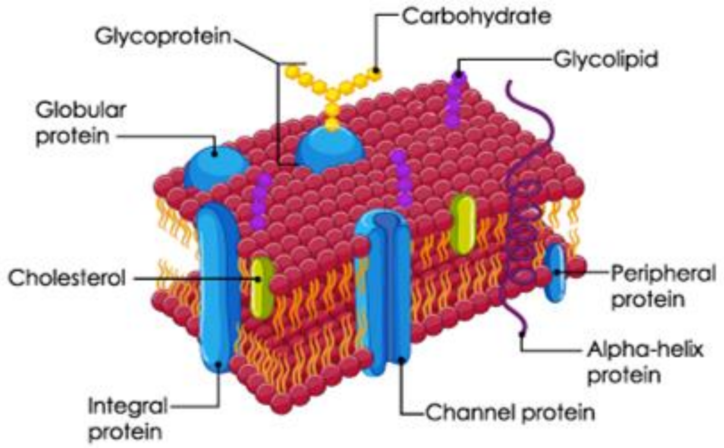
Cells are composed of various cell organelles that perform certain specific functions to carry out life's processes



Cell Membrane

The cell membrane supports and protects the cell. It controls the movement of substances in and out of the cells. It separates the cell from the external environment. The cell membrane is present in all the cells.





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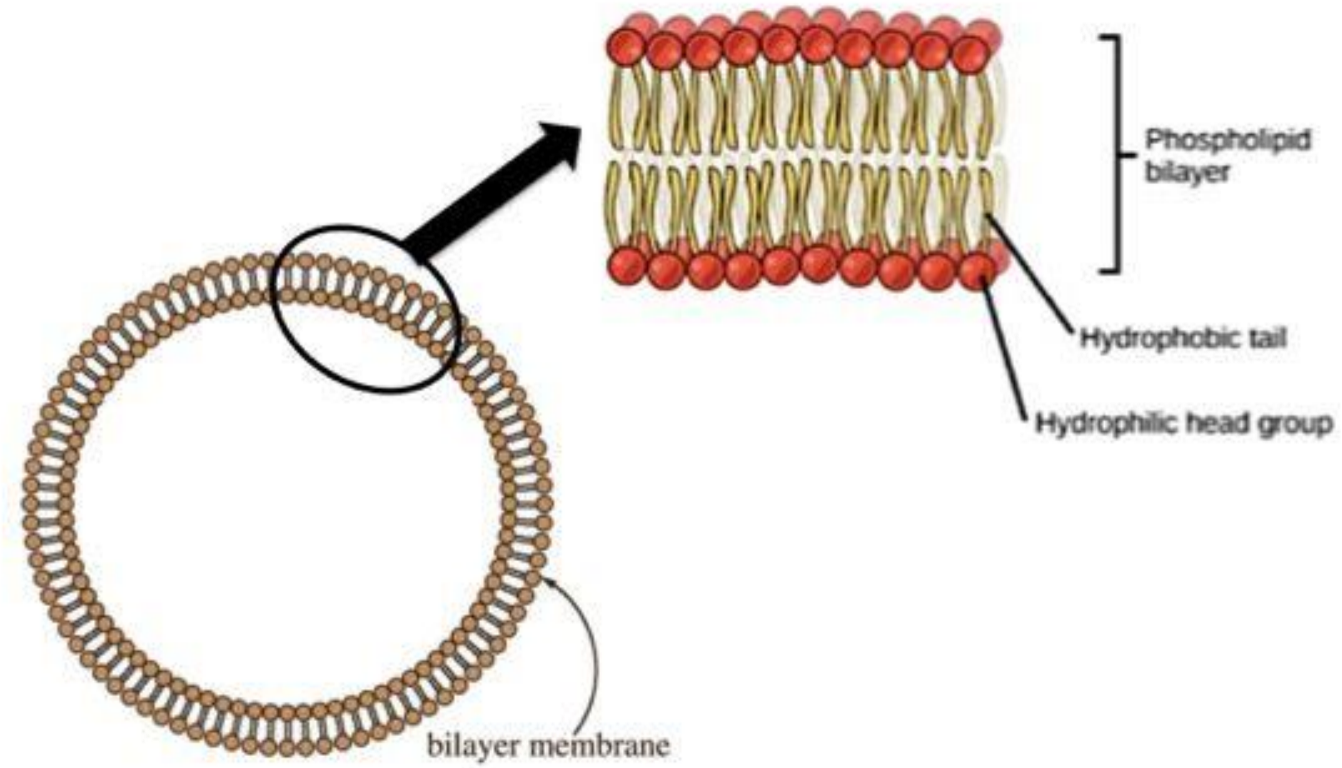
Membrane Structure

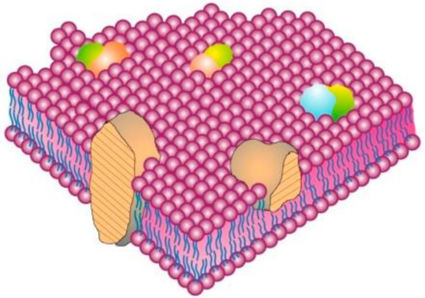


Membrane Structure

1. Lipids (40%) – Phospholipid – Polar head (Hydrophilic) and Non-Polar/tail (Hydrophobic)

2. Protein (52%) – Extrinsic and intrinsic Protein

3. Carbohydrate (8%) / Sugar- Glycolipid, Glycoprotein

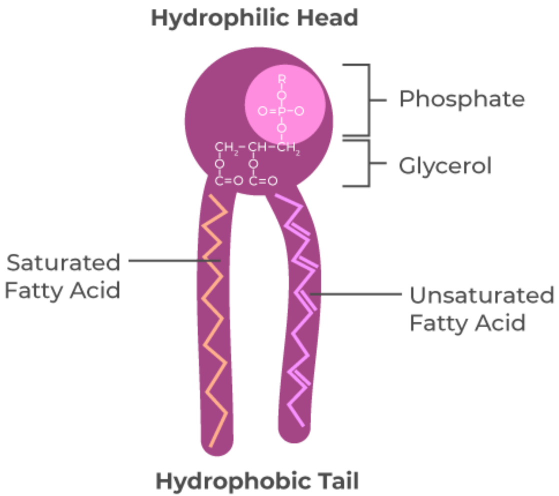


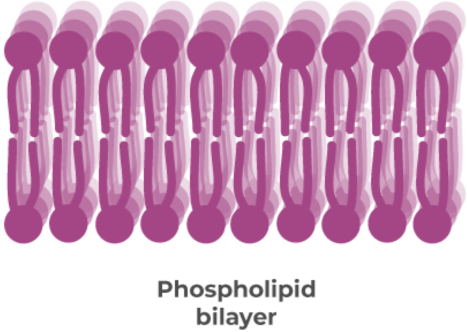
<u>Fluid</u> Mosaic model:

<u>Quasi- Fluid Nature: -Move easily</u>

<u>Membrane-Fluidity</u>

- <u>Cell Growth</u>
- <u>Cell Division</u>
- <u>Cell Repair</u>
- <u>Cell Enlargement</u>





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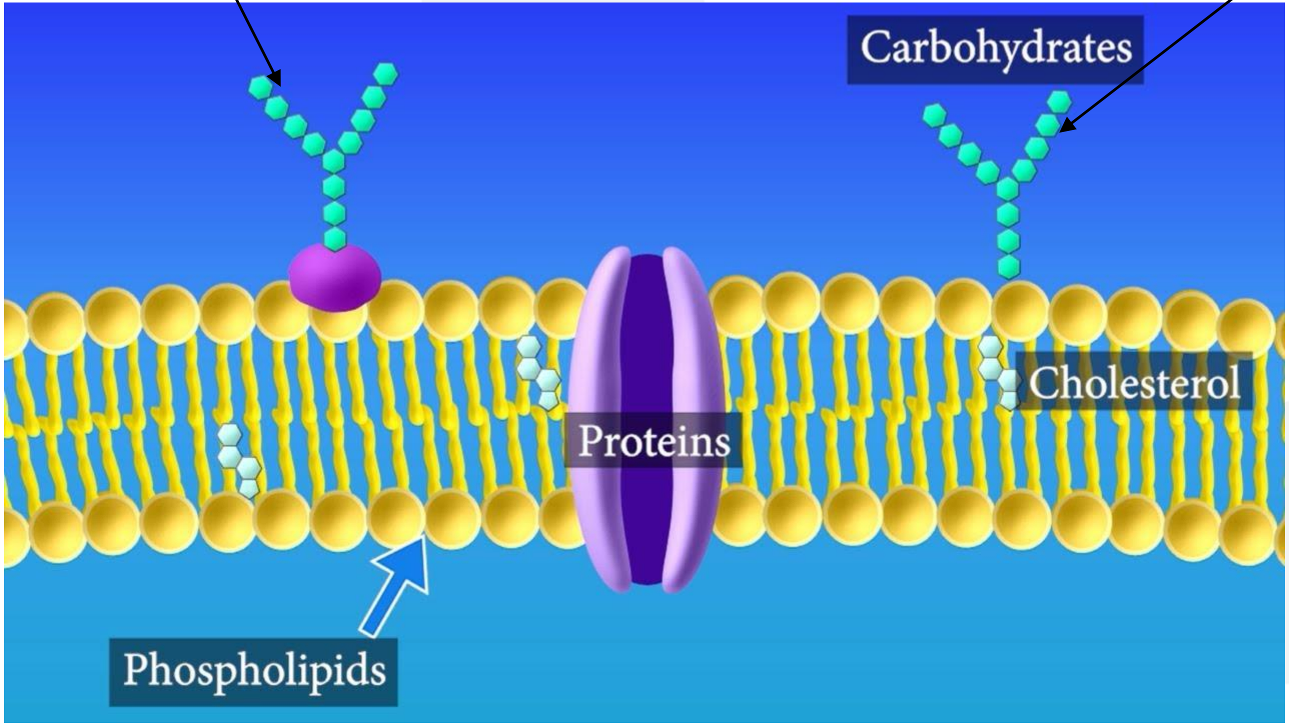
Membrane Structure

Sugar + Protein=Glycoprotein

Sugar + lipid=Glycolipid



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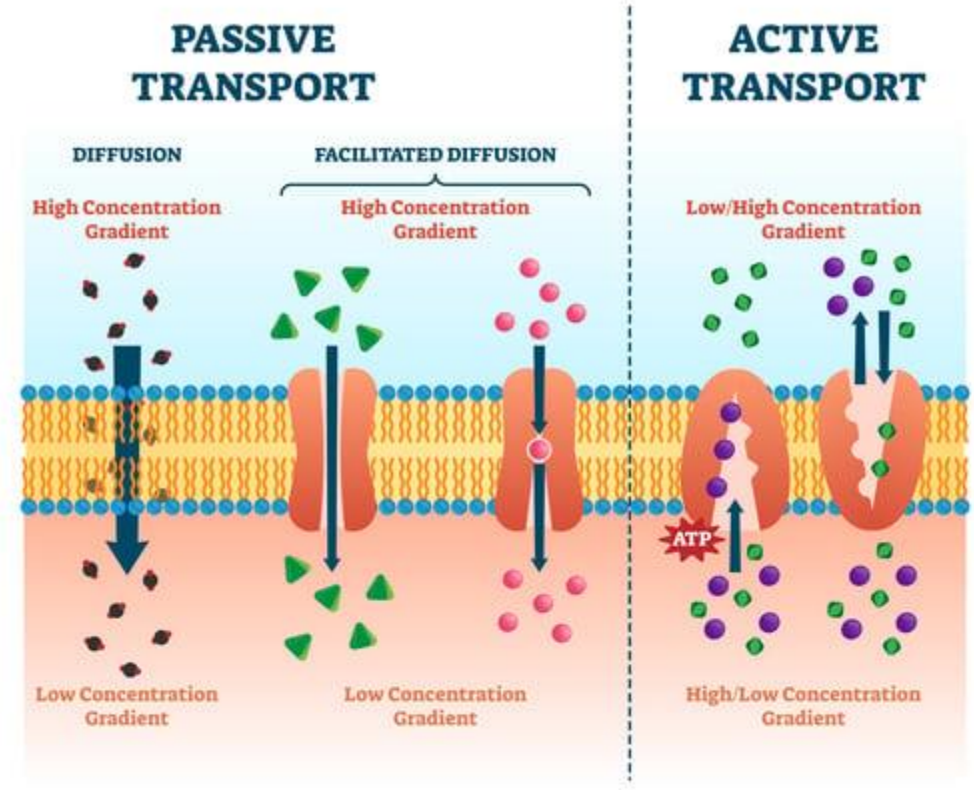
Cell membrane transport

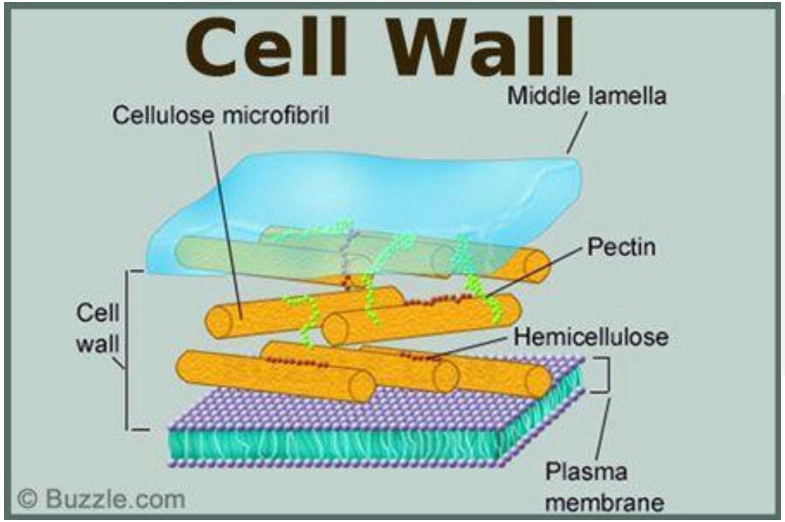
Passive Transport:
Higher Concentration
to
Lower Concentration

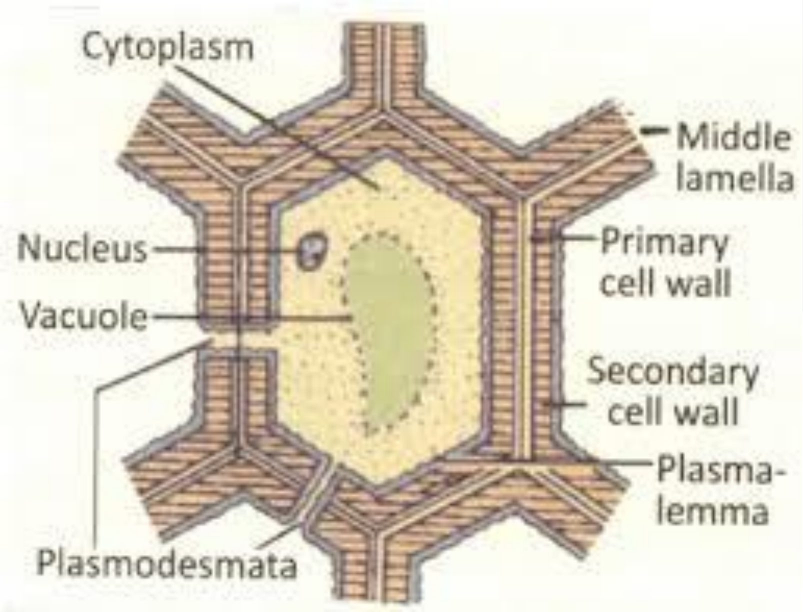
Active Transport:
Lower Concentration
to
Higher Concentration
With ATP

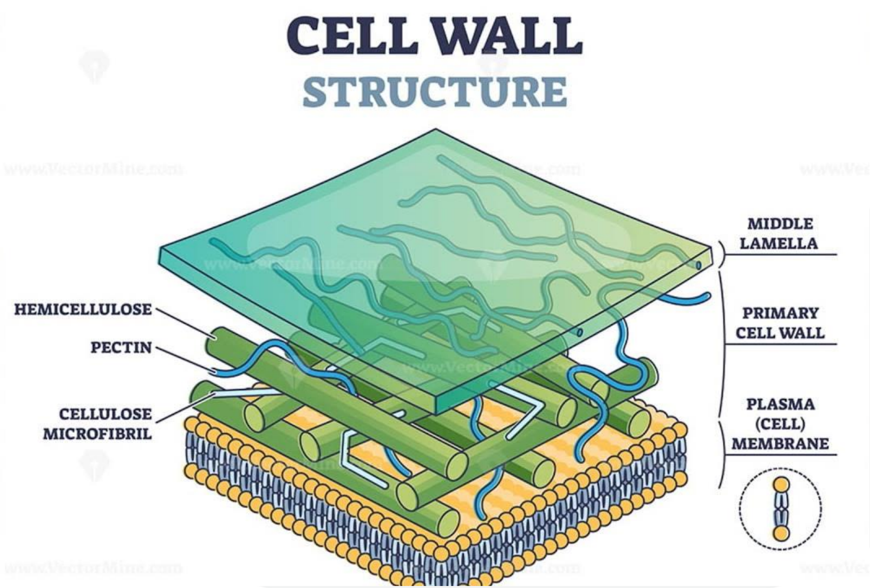


Cell Wall

The cell wall is the most prominent part of the plant's cell structure. It is made up of cellulose, hemicellulose and pectin.- **Rigid, Non-Living, strength and Supportive structure-out side the cell membrane.**

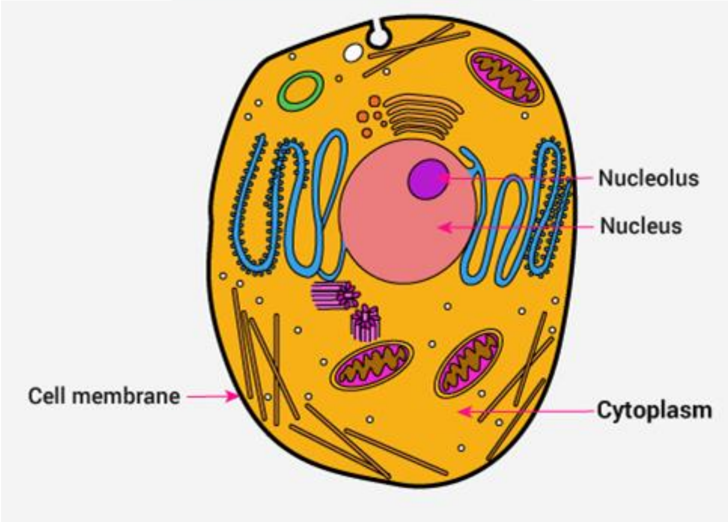



Cytoplasm
Middle lamella
Nucleus
Primary cell wall
Vacuole
Secondary cell wall
Plasma-lemma
Plasmodesmata


CELL WALL
STRUCTURE
MIDDLE LAMELLA
HEMICELLULOSE
PECTIN
PRIMARY CELL WALL
CELLULOSE MICROFIBRIL
PLASMA (CELL) MEMBRANE

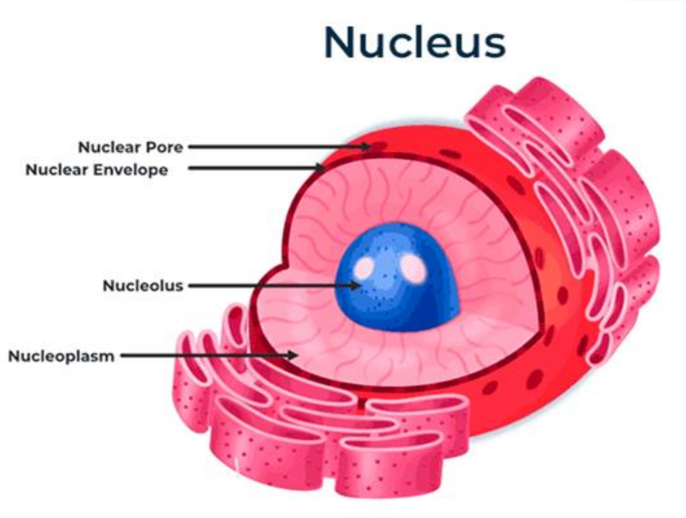
Cytoplasm

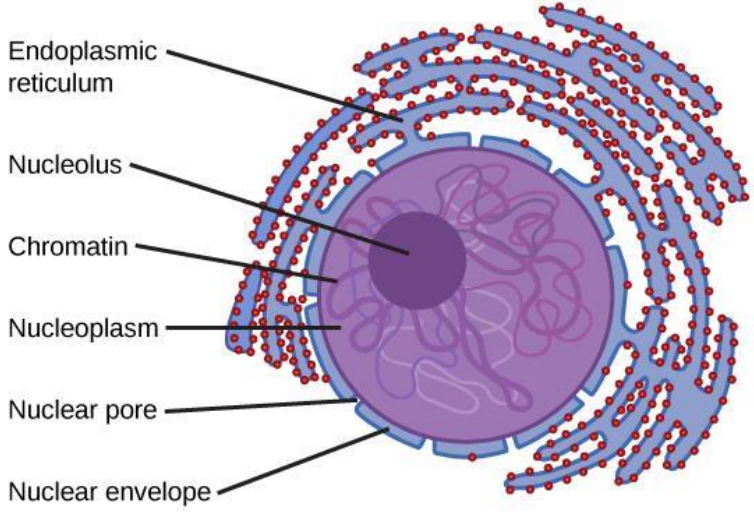
- ✓ The cytoplasm is a thick, clear, jelly-like substance present inside the cell membrane.
- ✓ Most of the chemical reactions within a cell take place in this cytoplasm.
- ✓ The cell organelles such as endoplasmic reticulum, vacuoles, mitochondria, ribosomes, are suspended in this cytoplasm



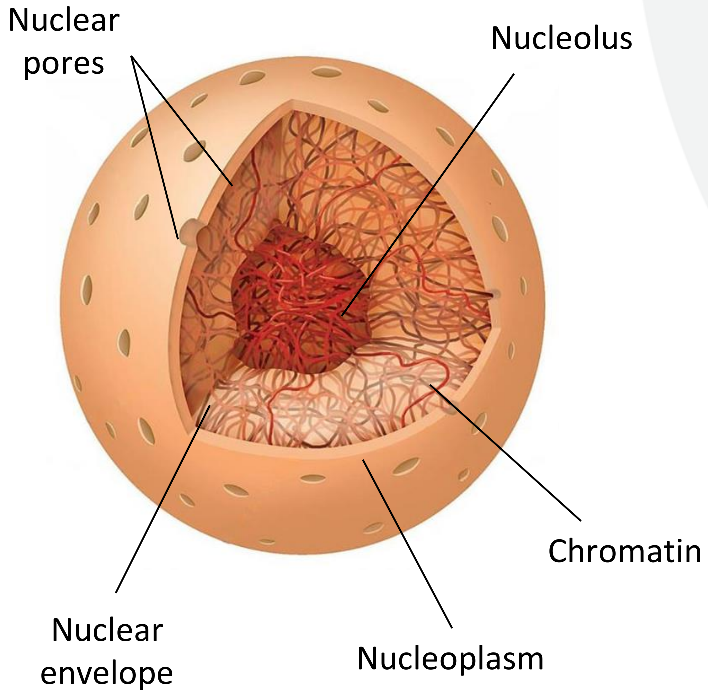
Nucleus

The nucleus contains all the genetic material of the cell. It is circular in shape and dark in color having a double membrane. Nuclear membranes are also selectively permeable. They help in cellular transport. Nuclear pores are present over the nuclear membrane which help in the transport of proteins and transcription factors.





Nucleus



- Nucleus has a double layered covering called nuclear membrane
- Nuclear membrane has pores of diameter about 80-100 nm
- Colourless dense sap present inside the nucleus known as nucleoplasm
- Nucleoplasm contains round shaped nucleolus and network of chromatin fibres
- Fibres are composed of deoxyribonucleic acid (DNA) and protein histone
- These fibres condense to form chromosomes during cell division

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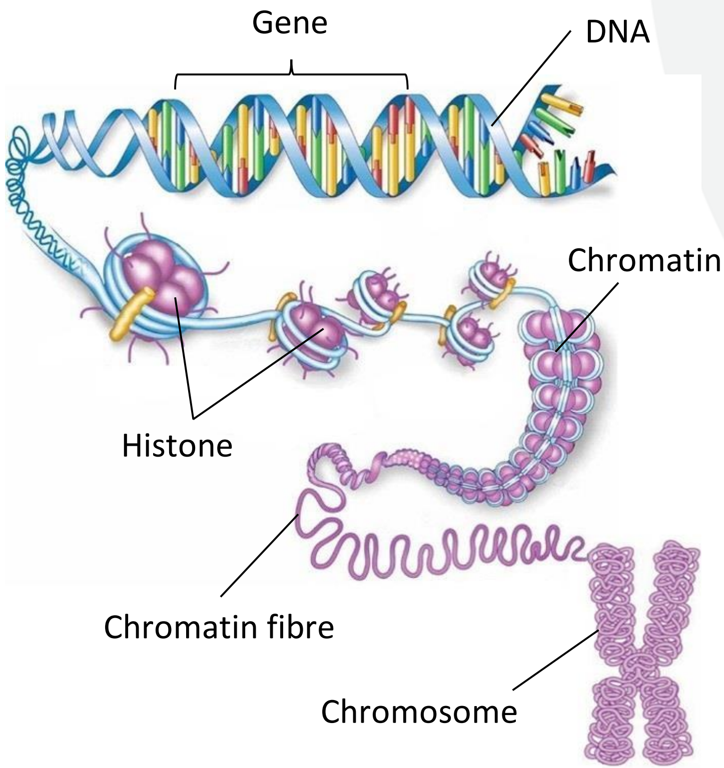
Nucleus



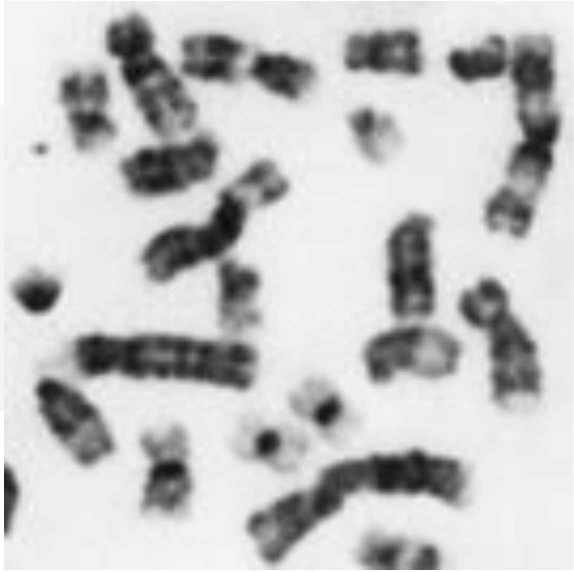
- Chromosomes contain stretches of DNA called genes
- Genes transfer the hereditary information from one generation to the next

Functions:

- Control all the cell activities like metabolism, protein synthesis, growth and cell division
- Nucleolus synthesizes ribonucleic acid (RNA) to constitute ribosomes
- Store hereditary information in genes

Chromosomes: Chromosomes play a crucial role in determining the sex of an individual. Each human cell contains 23 pairs of chromosomes.

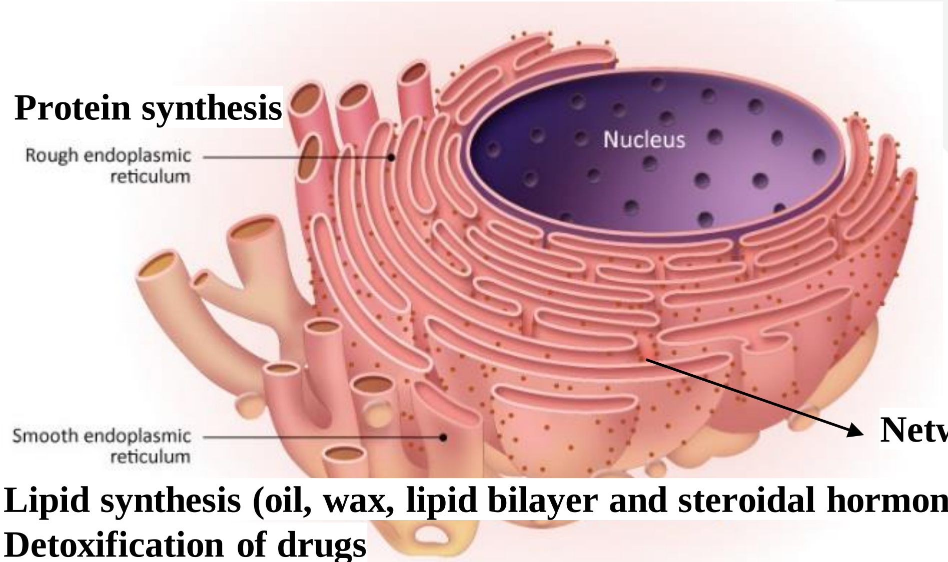
- Placed in nucleus
- Made of DNA
- Contain instructions for traits & characteristics



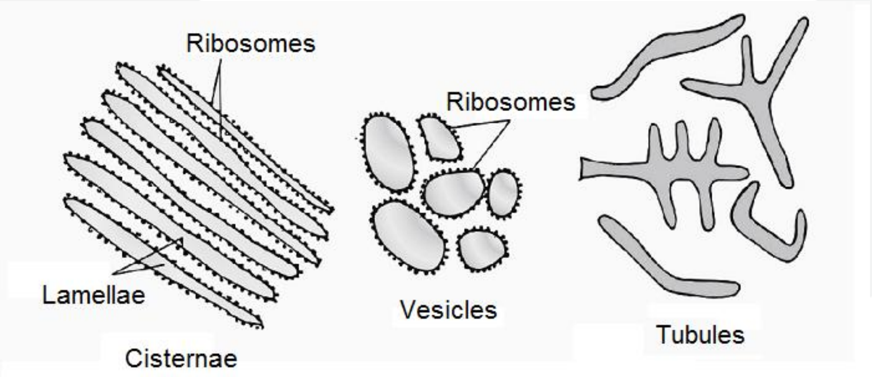
Endoplasmic reticulum:

Endoplasmic reticulum membranes form continuous folds, eventually joining the outer layer of the nuclear membrane . **Except for sperm cells and red blood cells**, the endoplasmic reticulum is observed in every other type of eukaryotic cell.

Protein synthesis



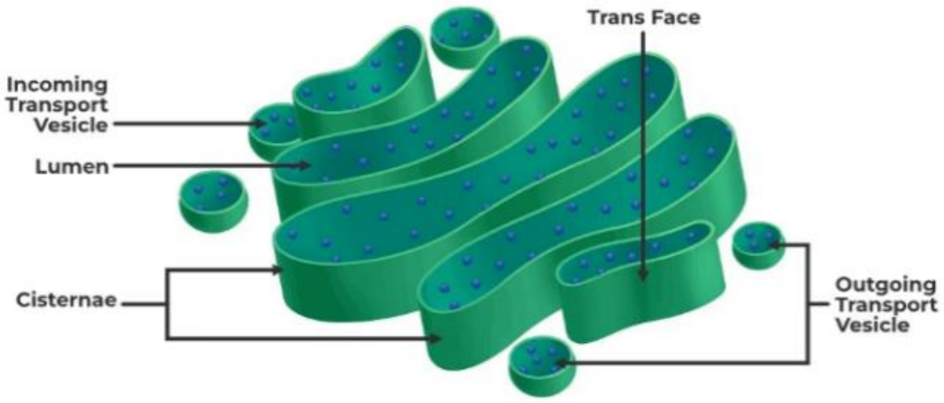
Network of tubules

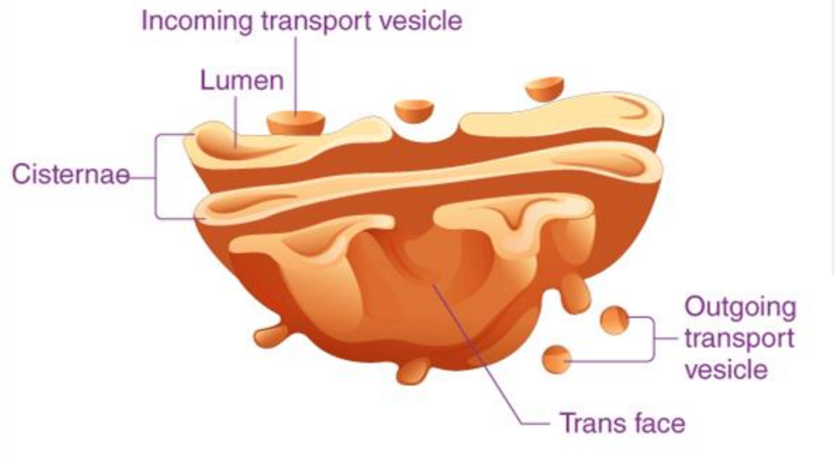


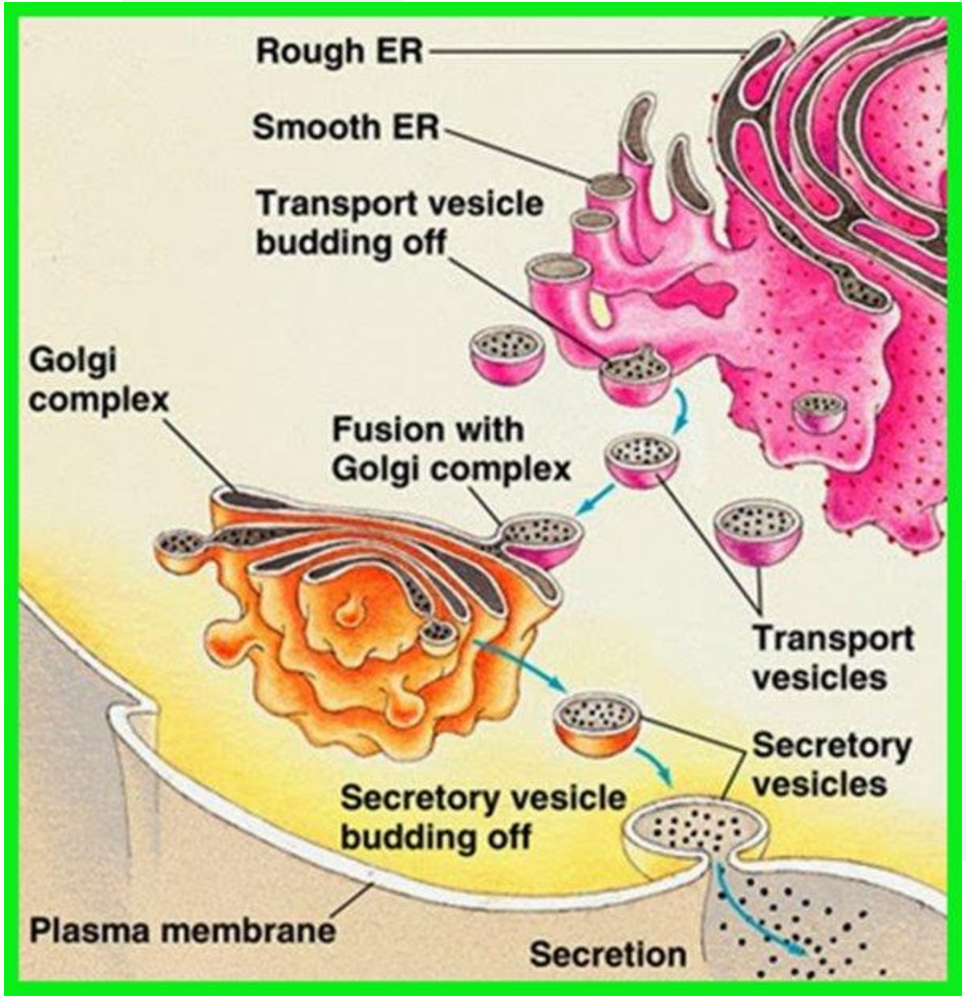
Elements of Endoplasmic Reticulum

Lipid synthesis (oil, wax, lipid bilayer and steroidal hormone)
Detoxification of drugs

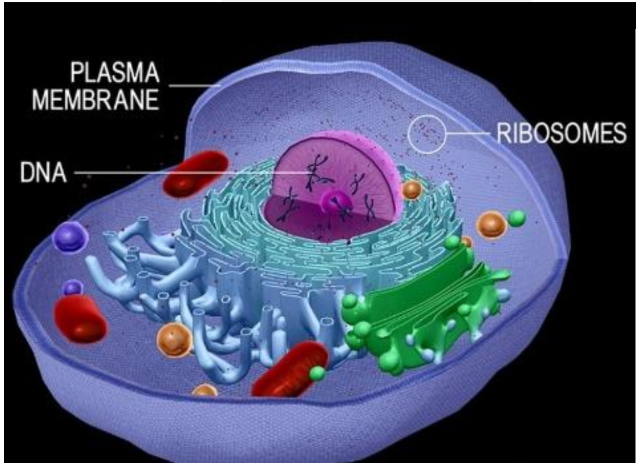
Golgi Bodies: Golgi bodies are called the cell's post office as it is involved in the transportation of materials within the cell. It is a membrane-bound organelle, which is mainly composed of a series of flattened, stacked pouches called cisternae. **This cell organelle is primarily responsible for transporting, modifying, and packaging proteins and lipids to targeted destinations.** Golgi Apparatus is found within the cytoplasm of a cell and is present in both plant and animal cells.

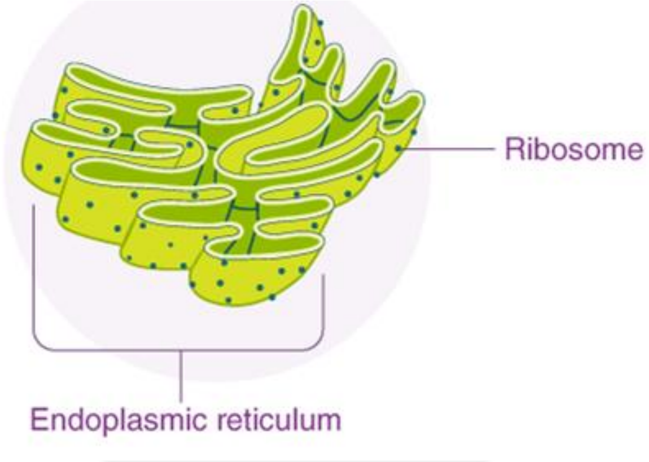




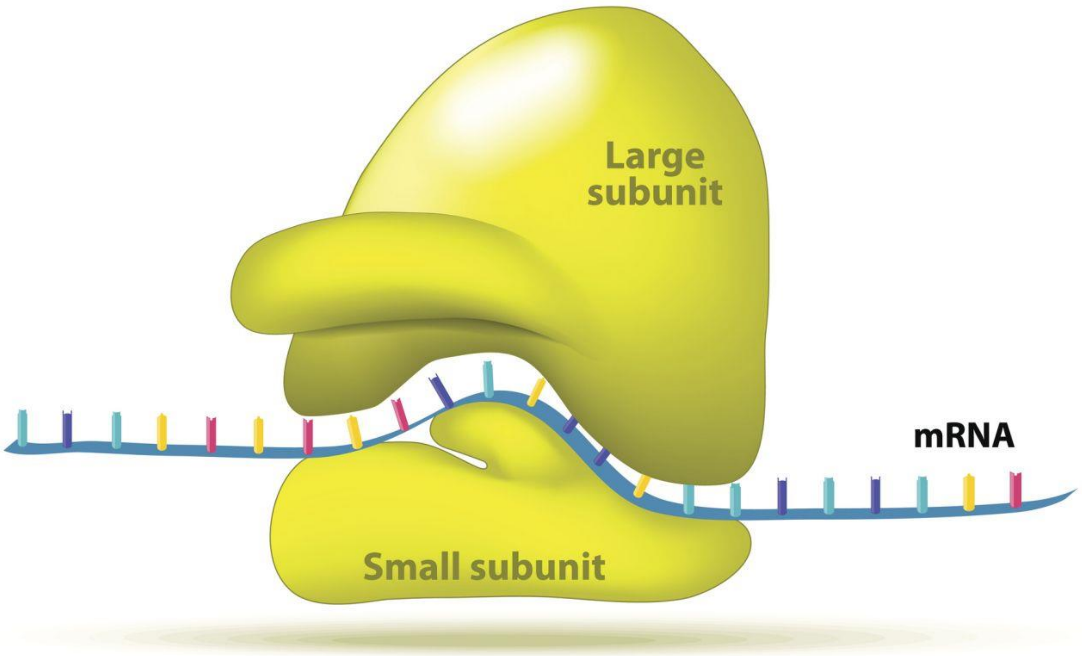

Rough ER
Smooth ER
Transport vesicle
budding off
Golgi
complex
Fusion with
Golgi complex
Transport
vesicles
Secretory
vesicles
Secretory vesicle
budding off
Plasma membrane
Secretion

Ribosome: Ribosomes are the protein synthesizers of the cell. (structures that combine amino acids to create proteins.)-**Membrane less organelles. Structure: rRNA+ Protein=Ribosome**





RIBOSOME

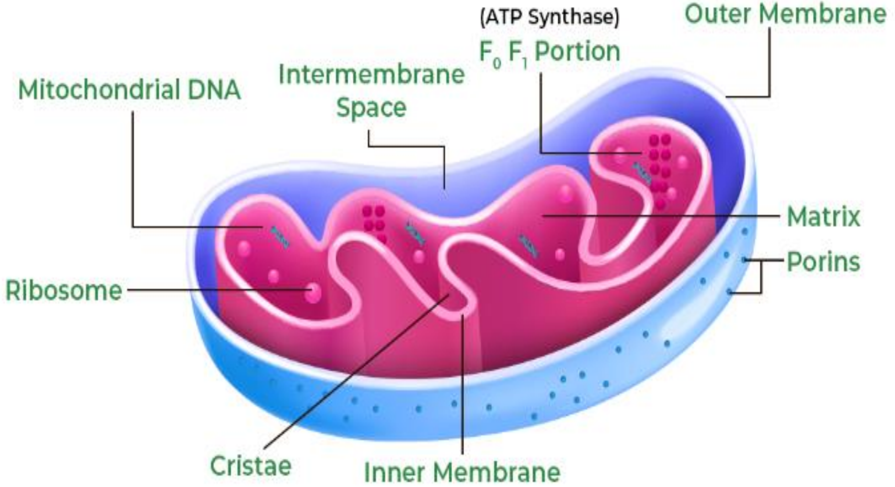


Mitochondria: Mitochondria are called the powerhouses of the cell as they produce energy-rich molecules for the cell. The mitochondrial genome is inherited maternally in several organisms. It is a double membrane-bound, sausage-shaped organelle, found in almost all eukaryotic cells.

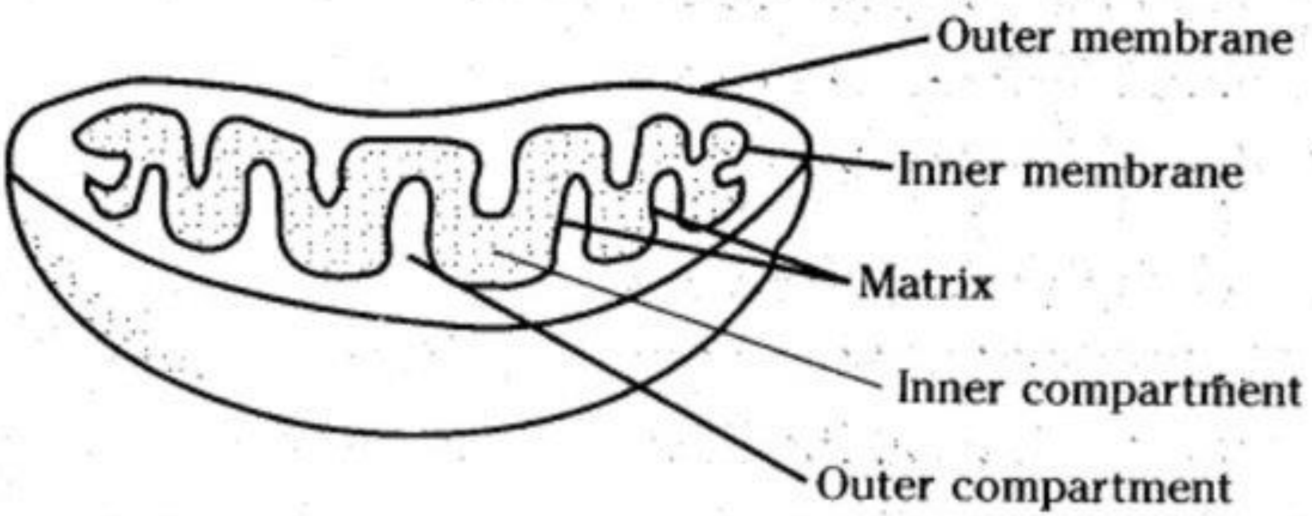
- It is called so because it produces ATP – the cell's energy currency.
- Produces energy through chemical reactions – breaking down fats & carbohydrates
- Controls level of water and other materials in cell
- Recycles and decomposes proteins, fats, and carbohydrates

ATP-Adenosine triphosphate

Permeable membrane



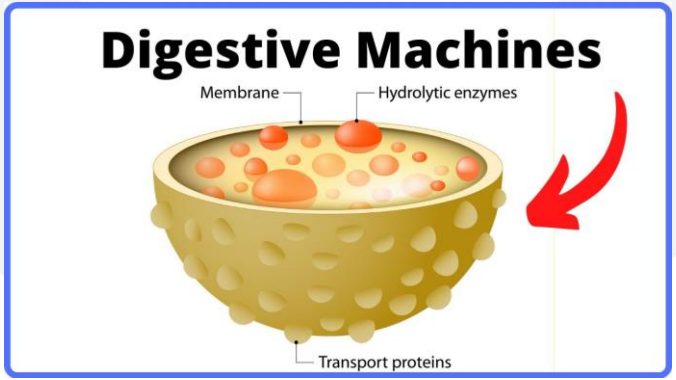
Selectively Permeable membrane

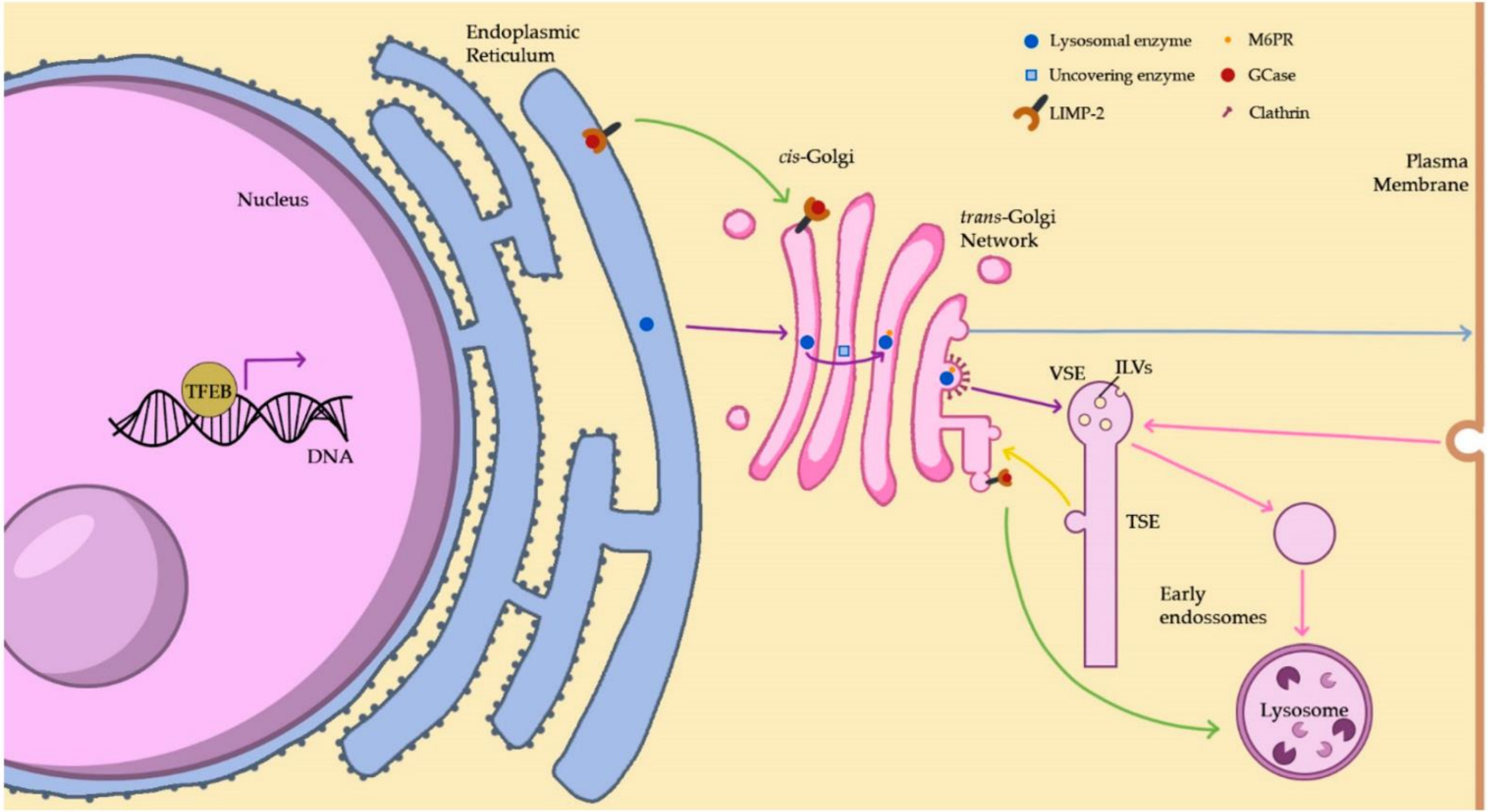


Structure of mitochondria

Lysosomes: Lysosomes protect the cell by engulfing the foreign bodies entering the cell and help in cell renewal.
-Digestive enzymes.

- Digestive 'plant' for proteins, fats, and carbohydrates
- Transports undigested material to cell membrane for removal
- Cell breaks down if lysosome explodes

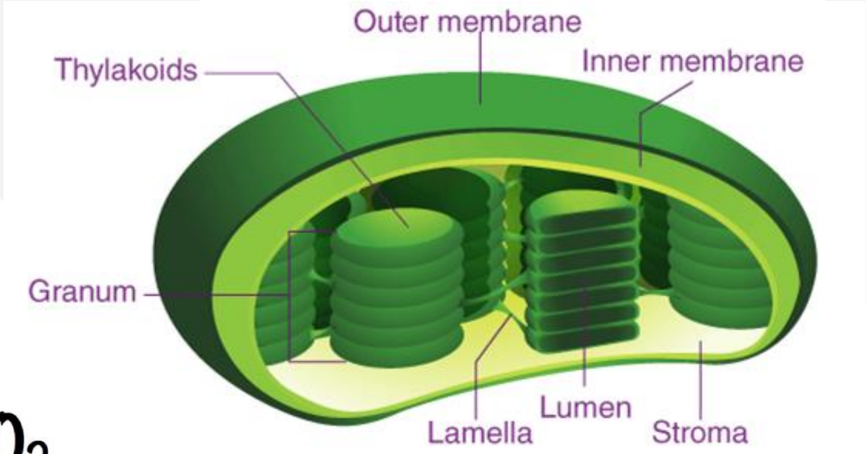



Endoplasmic
Reticulum
Lysosomal enzyme
M6PR
Uncovering enzyme
GCase
LIMP-2
Clathrin
cis-Golgi
Plasma
Membrane
Nucleus
trans-Golgi
Network
TFEB
DNA
VSE
ILVs
TSE
Early
endossomes
Lysosome

Chloroplast: Chloroplasts are the primary organelles for photosynthesis. It contains the pigment called chlorophyll.

Chloroplasts are double membrane-bound organelles, which usually vary in their shape – from a disc shape to spherical, discoid, oval and ribbon.

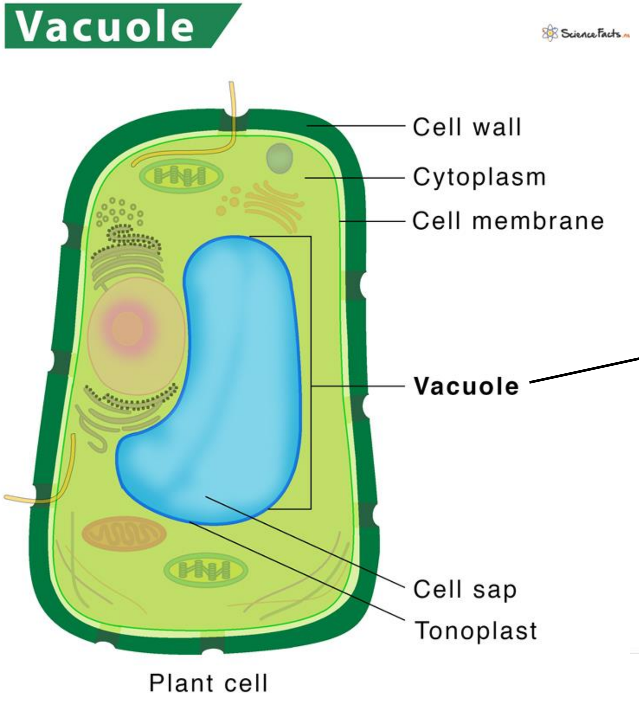
- Usually found in plant cells
- Contains green chlorophyll
- Where photosynthesis takes place

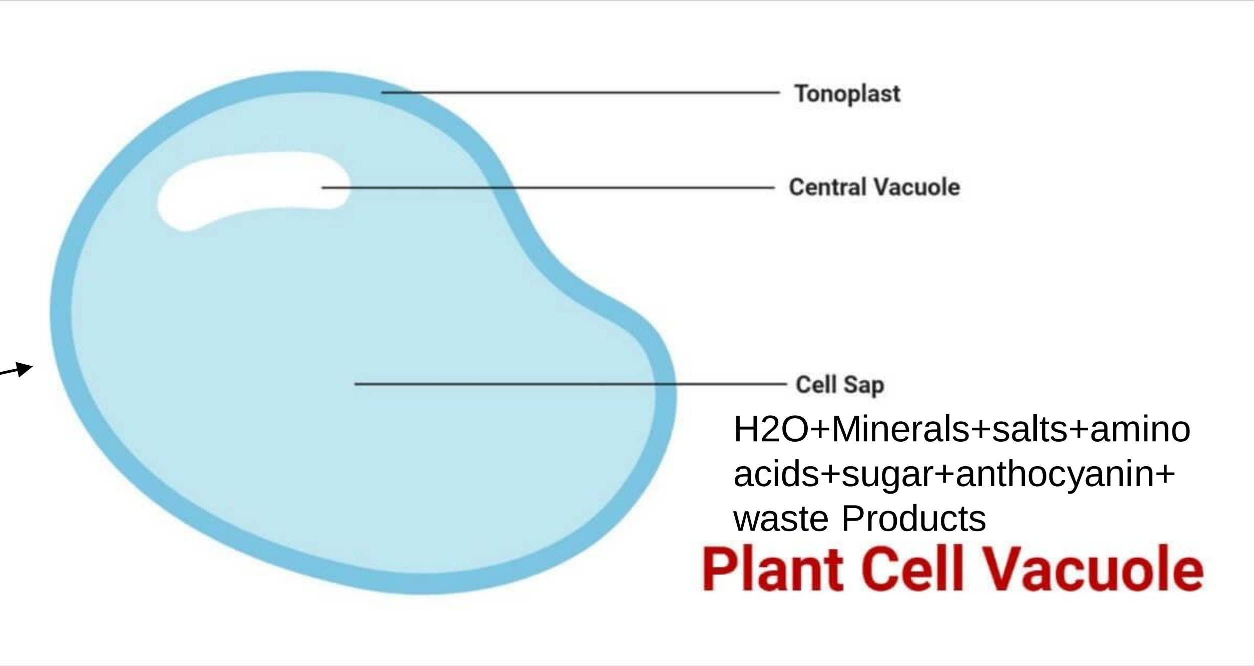


$$6CO_2 + 6H_2O \xrightarrow[\text{Sunlight}]{\text{Chlorophyll}} C_6H_{12}O_6 + 6O_2$$

Vacuoles: Vacuoles are mostly defined as storage bubbles of irregular shapes which are found in cells. They are fluid-filled organelles enclosed by a membrane

- Membrane-bound sacs for storage, digestion, and waste removal
- Store food, water, and other waste materials in the cell.
- Contains water solution
- Help plants maintain shape





H_2O+Minerals+salts+amino acids+sugar+anthocyanin+ waste Products

Functions of Cell

A cell performs major functions essential for the growth and development of an organism. Important functions of cell are as follows:

i) Provides Support and Structure

All the organisms are made up of cells. They form the structural basis of all the organisms. The cell wall and the cell membrane are the main components that function to provide support and structure to the organism. For eg., the skin is made up of a large number of cells. Xylem present in the vascular plants is made of cells that provide structural support to the plants.

ii) Facilitate Growth Mitosis

In the process of mitosis, the parent cell divides into the daughter cells. Thus, the cells multiply and facilitate the growth in an organism.

Functions of Cell

iii)Allows Transport of Substances

Various nutrients are imported by the cells to carry out various chemical processes going on inside the cells. The waste produced by the chemical processes is eliminated from the cells by active and passive transport. Small molecules such as oxygen, carbon dioxide, and ethanol diffuse across the cell membrane along the concentration gradient. This is known as passive transport. The larger molecules diffuse across the cell membrane through active transport where the cells require a lot of energy to transport the substances.

Functions of Cell

iv)Energy Production

Cells require energy to carry out various chemical processes. This energy is produced by the cells through a process called photosynthesis in plants and respiration in animals.

v) Aids in Reproduction

A cell aids in reproduction through the processes called mitosis and meiosis. Mitosis is termed as the asexual reproduction where the parent cell divides to form daughter cells. Meiosis causes the daughter cells to be genetically different from the parent cells.

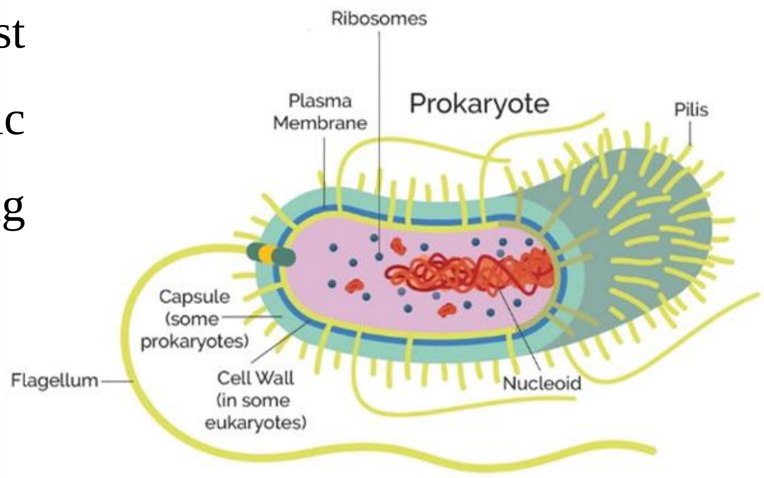
Types of Cell

Cells vary in their shape, size as well as functions.

Based on the presence or absence of a membrane bound nucleus and other organelles, organisms are classified as **Eukaryotes** or **Prokaryotes**.

Prokaryotes Cells

Prokaryotes are unicellular organisms that lack membrane-bound structures, the most noteworthy of which is the nucleus. Prokaryotic cells tend to be small, simple cells, measuring around 0.1-5 μm in diameter.



In prokaryotic cells, **DNA bundles together in a region called the nucleoid**. Prokaryotes can be split into two domains, bacteria and archaea.

Prokaryotic cell features

- Nucleoid: A central region of the cell that contains its DNA.
- Ribosome: Ribosomes are responsible for protein synthesis.
- Cell wall: The cell wall provides structure and protection from the outside environment. Most bacteria have a rigid cell wall made from carbohydrates and proteins called peptidoglycans.
- Cell membrane: Every prokaryote has a cell membrane, also known as the plasma membrane, that separates the cell from the outside environment.

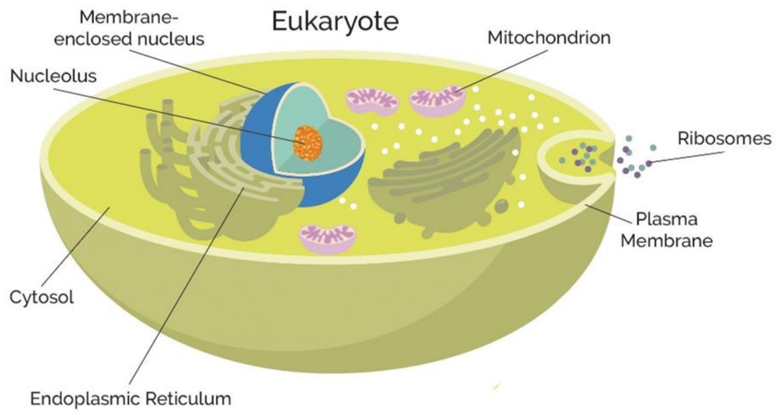
Prokaryotic cell features

- Capsule: Some bacteria have a layer of carbohydrates that surrounds the cell wall called the capsule. The capsule helps the bacterium attach to surfaces.
- Fimbriae: Fimbriae are thin, hair-like structures that help with cellular attachment.
- Pili: Pili are rod-shaped structures involved in multiple roles, including attachment and DNA transfer.
- Flagella: Flagella are thin, tail-like structures that assist in movement.

Eukaryote Cell

Eukaryotes are organisms whose cells have a nucleus and other organelles enclosed by a plasma membrane. Organelles are internal structures responsible for a variety of functions, such as energy production and protein synthesis.

Eukaryotic cells are large (around 10-100 μm) and complex. While most eukaryotes are multicellular organisms, there are some single-cell eukaryotes.



Eukaryote cell features

- Nucleus: The nucleus stores the genetic information in chromatin form.
- Nucleolus: Found inside of the nucleus, the nucleolus is the part of eukaryotic cells where ribosomal RNA is produced.
- Plasma membrane: The plasma membrane is a phospholipid bilayer that surrounds the entire cell and encompasses the organelles within.
- Cytoskeleton or cell wall: The cytoskeleton or cell wall provides structure, allows for cell movement, and plays a role in cell division.
- Ribosomes: Ribosomes are responsible for protein synthesis.
- Mitochondria: Mitochondria, also known as the powerhouses of the cell, are responsible for energy production.

Eukaryote cell features

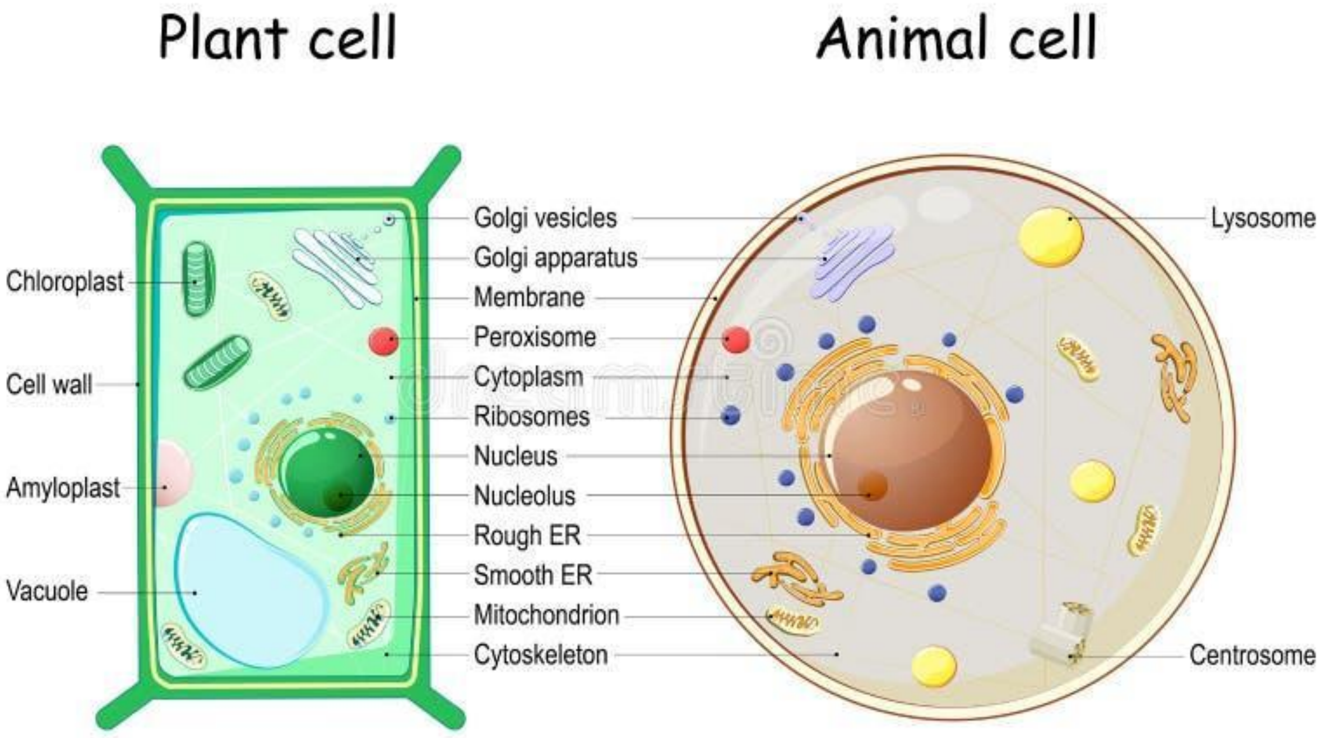
- Cytoplasm: The cytoplasm is the region of the cell between the nuclear envelope and plasma membrane.
- Cytosol: Cytosol is a gel-like substance within the cell that contains the organelles.
- Endoplasmic reticulum: The endoplasmic reticulum is an organelle dedicated to protein maturation and transportation.
- Vesicles and vacuoles: Vesicles and vacuoles are membrane-bound sacs involved in transportation and storage.
- Other common organelles found in many, but not all, eukaryotes include the Golgi apparatus, chloroplasts and lysosomes.
- **Examples of eukaryotes**

Animals, plants, fungi, algae and protozoans are all eukaryotes.

Comparing prokaryotes and eukaryotes

Similarity: All cells, whether prokaryotic or eukaryotic, share these four features:

1. DNA
2. Plasma membrane
3. Cytoplasm
4. Ribosomes

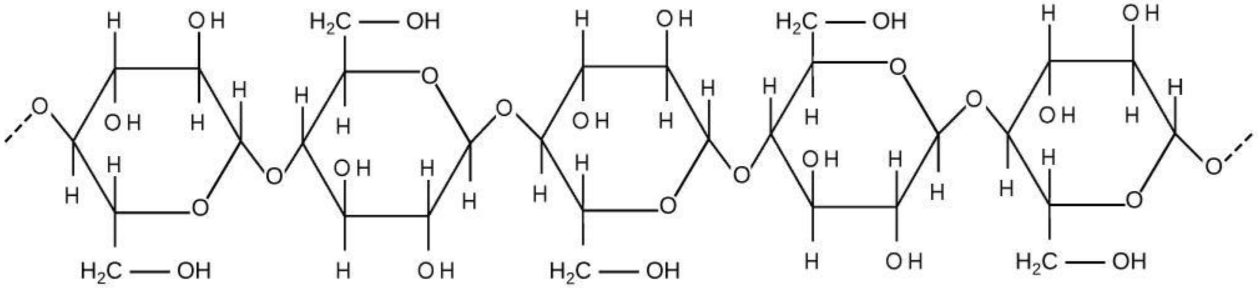

Plant cell
Animal cell
Chloroplast
Cell wall
Amyloplast
Vacuole
Golgi vesicles
Golgi apparatus
Membrane
Peroxisome
Cytoplasm
Ribosomes
Nucleus
Nucleolus
Rough ER
Smooth ER
Mitochondrion
Cytoskeleton
Lysosome
Centrosome

The Plant Cell and animal cell

The cells of plants and animals are both eukaryotic, meaning that they have a membrane-bound nucleus. However, there are some major differences between the two types of cells. For example, plant cells typically have larger vacuoles than animal cells. Plant cells also have cell walls made of cellulose, while animal cells do not. Additionally, plant cells can undergo photosynthesis to produce their food, while animal cells cannot.

Plant Cell

A plant cell is a type of eukaryotic cell that is unique in several ways. For starters, plant cells have a cell wall made of cellulose. This cell wall provides structural support and protection for the plant cell. Additionally, plant cells have large vacuoles that help to store water and other materials. Finally, many plant cells can undergo photosynthesis, a process in which the plant cell produces its food.



Animal Cell

Animal cells are also eukaryotic cells, but they differ from plant cells in a few key ways. Animal cells do not have a cell wall made of cellulose. Instead, their cell walls are made of a different type of protein. Additionally, animal cells have smaller vacuoles than plant cells. Finally, animal cells cannot undergo photosynthesis.

Stem cells

Stem cells are cells that do not yet have a specific role and can become almost any cell that is required. They can also regenerate damaged tissue under the right conditions.

Stem cells are undifferentiated cells that can turn into specific cells, as the body needs them.

Stem cells are special human cells that can develop into many different types of cells, from muscle cells to brain cells.

Stem cells also have the ability to repair damaged cells. These cells have strong healing power. They can evolve into any type of cell. Research on stem cells is going on, and it is believed that stem cell therapies can cure ailments like paralysis and Alzheimer’s as well.

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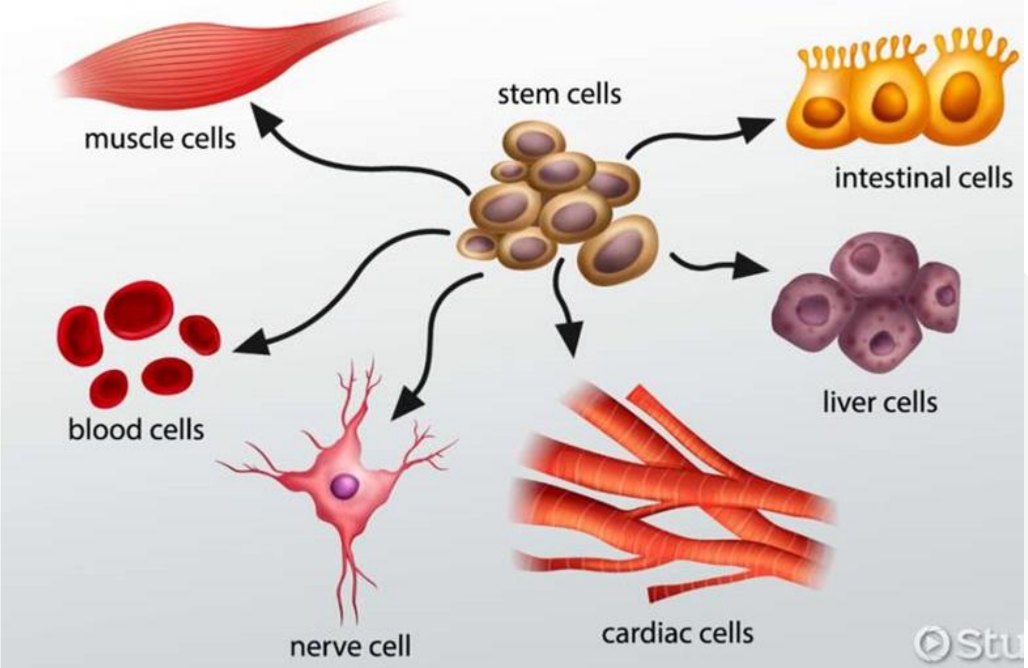
Stem cells



Types of Stem cells

- Embryonic Stem Cells
- Adult Stem Cells
- Induced Pluripotent Stem Cells
- Mesenchymal stem cells

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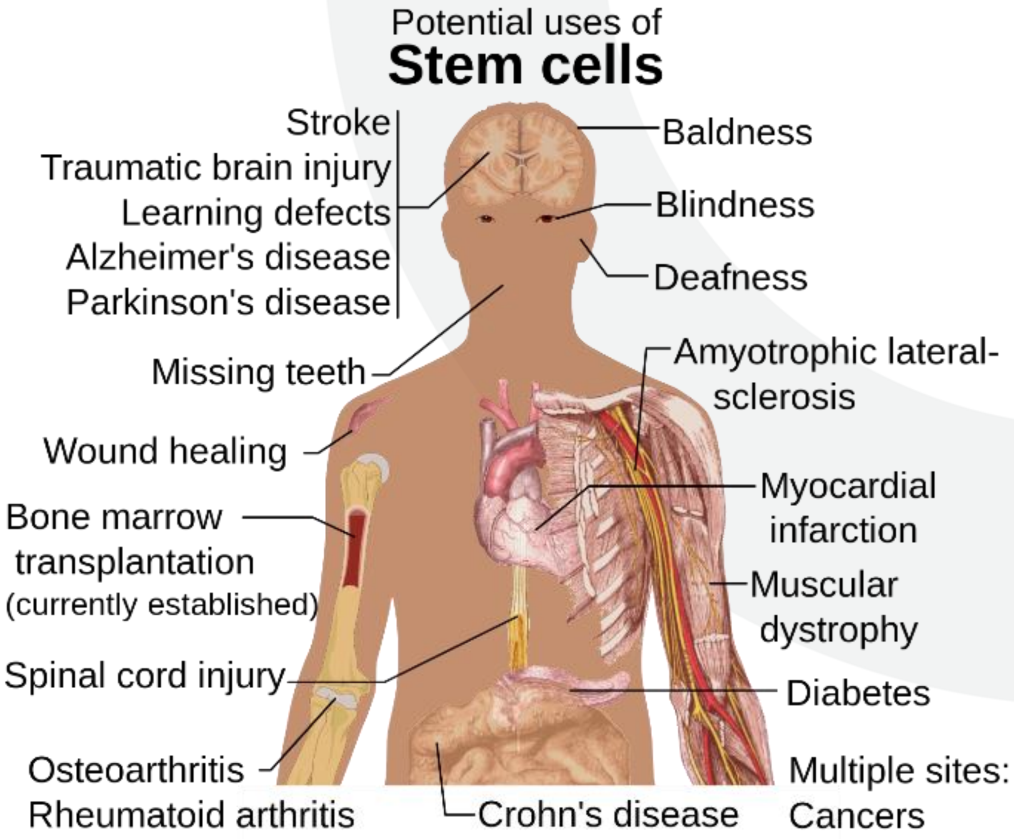
1.Embryonic Stem Cells (ESCs):

1. These stem cells are derived from embryos at a very early stage of development, typically within the first five days after fertilization.
2. Embryonic stem cells are pluripotent, meaning they can differentiate into any cell type in the body.
3. Applications: Research on embryonic stem cells has the potential to provide insights into developmental biology, disease modeling, and regenerative medicine. They could be used to replace damaged tissues or organs in conditions such as spinal cord injury, diabetes, and heart disease.

2.Adult Stem Cells (also called Somatic or Tissue-Specific Stem Cells):

1. These stem cells are found in small numbers in various tissues and organs throughout the body, such as bone marrow, skin, and brain.
2. Adult stem cells are multipotent, meaning they can differentiate into a limited range of cell types related to the tissue or organ where they are found.
3. Applications: Adult stem cells play a crucial role in maintaining and repairing tissues throughout life. They are being studied for their potential in regenerative medicine, particularly in treatments for conditions such as leukemia, lymphoma, and certain genetic disorders.

Applications of Stem Cells



Applications of Stem Cells

- **Tissue Regeneration**

This is the most important application of stem cells. The stem cells can be used to grow a specific type of tissue or organ. This can be helpful in kidney and liver transplants. The doctors have already used the stem cells from beneath the epidermis to develop skin tissue that can repair severe burns or other injuries by tissue grafting.

- **Treatment of Cardiovascular Disease**

A team of researchers have developed blood vessels in mice using human stem cells. Within two weeks of implantation, the blood vessels formed their network and were as efficient as the natural vessels.

Applications of Stem Cells

- **Treatment of Brain Diseases**

Stem cells can also treat diseases such as Parkinson’s disease and Alzheimer’s. These can help to replenish the damaged brain cells. Researchers have tried to differentiate embryonic stem cells into these types of cells and make it possible to treat diseases.

- **Blood Disease Treatment**

The adult hematopoietic stem cells are used to treat cancers, sickle cell anaemia, and other immunodeficiency diseases. These stem cells can be used to produce red blood cells and white blood cells in the body.

Sources of Stem Cells

Stem Cells originate from different parts of the body. Adult stem cells can be found in specific tissues in the human body. Matured cells are specialized to conduct various functions. Generally, these cells can develop the kind of cells found in tissues where they reside.

Embryonic Stem Cells are derived from 5-day-old blastocysts that develop into embryos and are pluripotent in nature. These cells can develop any type of cell and tissue in the body. These cells have the potential to regenerate all the cells and tissues that have been lost because of any kind of injury or disease.

Biomolecules

Biomolecules are the most essential organic molecules, **which are involved in the maintenance and metabolic processes of living organisms.** These non-living molecules are the actual foot-soldiers of the battle of sustenance of life. They range from small molecules such as primary and secondary metabolites and hormones to large macromolecules like proteins, nucleic acids, carbohydrates, lipids etc.

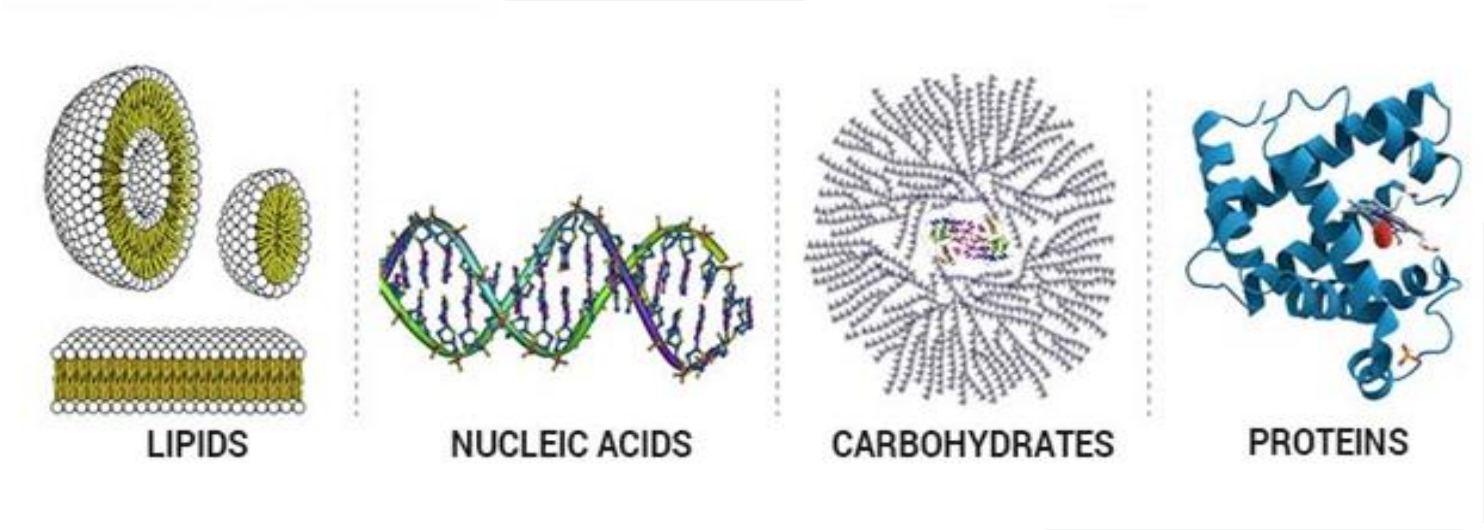
Biomolecules:

- Carbohydrates
- Nucleic acids
- Proteins
- Lipids.

Special biomolecules;

- Enzymes, Vitamins and Hormones.

Types of Biomolecules



Carbohydrates

Carbohydrates are chemically defined as **polyhydroxy aldehydes or ketones** or compounds which produce them on hydrolysis. In layman's terms, we acknowledge **carbohydrates as sugars** or substances that taste sweet.

They are collectively called as **saccharides** (Greek: sakcharon = sugar). Depending on the number of constituting sugar units obtained upon hydrolysis, they are classified as **monosaccharides (1 unit), oligosaccharides (2-10 units) and polysaccharides (more than 10 units).**

They have multiple functions' viz. they're the most abundant dietary source of energy; they are structurally very important for many living organisms as they form a **major structural component,** e.g. cellulose is an important structural fibre for plants. Carbohydrates are macronutrients and are one of the three main ways by which our body obtains its energy.

Glucose

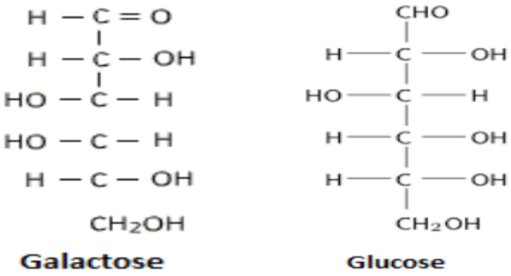
CH_2O — Empirical formula

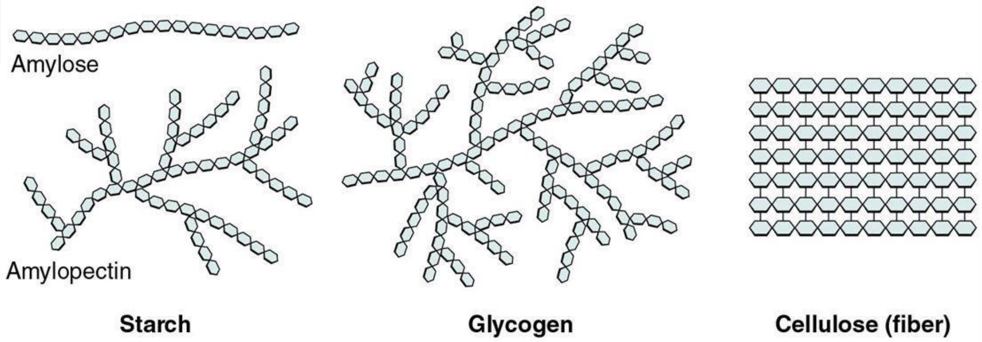
$C_6H_{12}O_6$ — Molecular formula

Carbohydrates food

Classification of Carbohydrates

- Simple Carbohydrates (Monosaccharides, Disaccharides and Oligosaccharides)
- Complex Carbohydrates (Polysaccharides)





Simple

Complex

Classification of Carbohydrates

Monosaccharides
- Glucose
- Fructose
- Galactose

Disaccharides
- Sucrose = G+F
- Lactose = G+Gal
- Maltose = G+G

Polysaccharides
- Starch
- Glycogen
- Cellulose
- Dextrin
- Pectine

Functions of Carbohydrates

- Carbohydrates are known as one of the basic components of food, including sugars, starch, and fibre which are abundantly found in grains, fruits and milk products.
- Carbohydrates are also **known as starch, simple sugars, complex carbohydrates** and so on.
- It is also involved in fat metabolism and prevents ketosis.
- Inhibits the breakdown of proteins for energy as they are the primary source of energy.
- An enzyme by name amylase assists in the breakdown of starch into glucose, finally to produce energy for metabolism.

FUNCTIONS OF CARBOHYDRATES

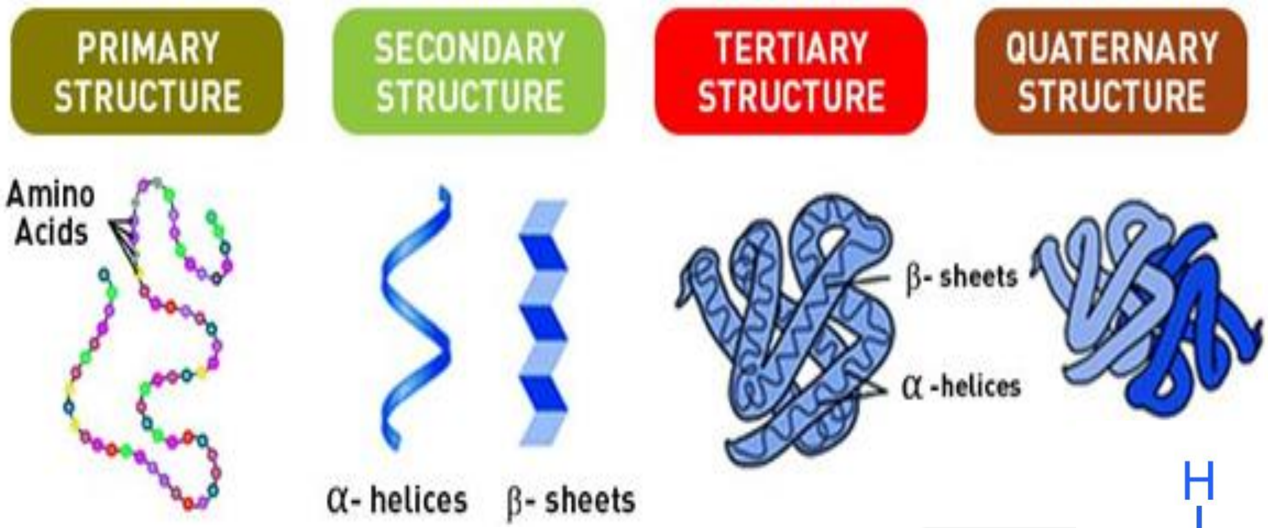
- Carbohydrates have following major functions in our body:-

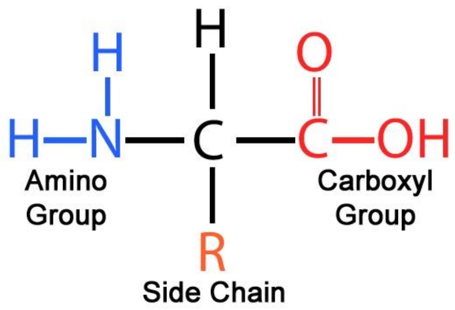
a) Blood sugars and insulin.
b) Provides energy.
c) Triggers hunger and fullness.
d) Mood.
e) Digestion.
f) Brain functionality.
g) Weight.

Proteins

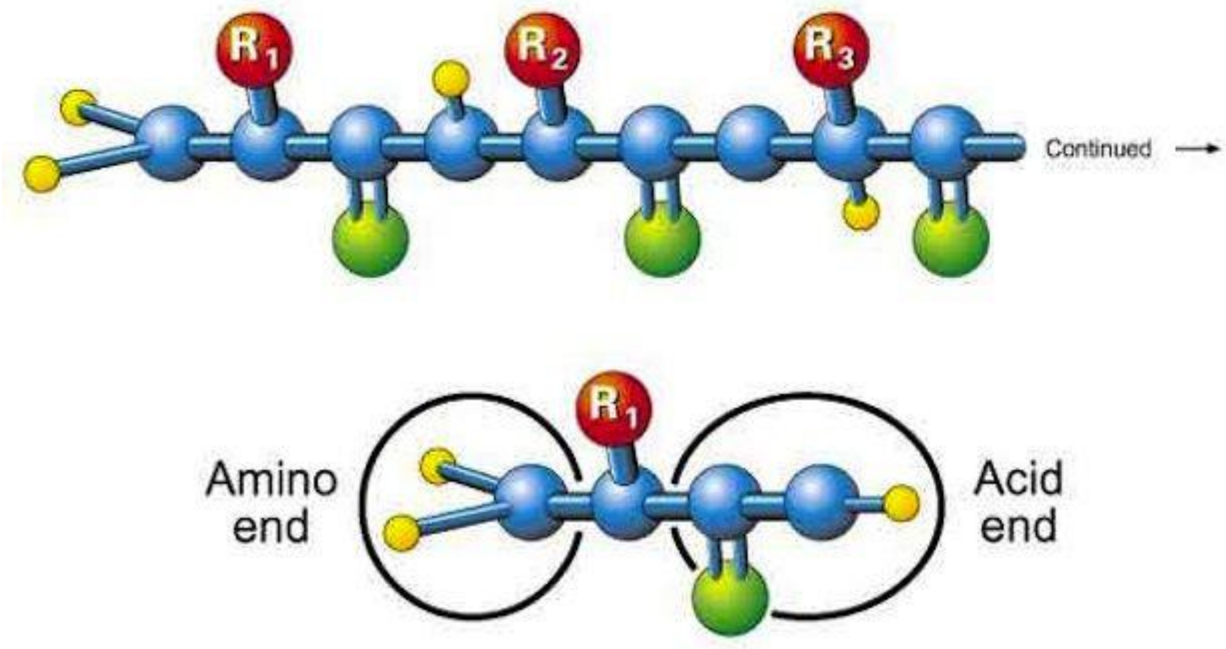
Proteins are another class of indispensable biomolecules, which make up around 50per cent of the cellular dry weight. **Proteins are polymers of amino acids** arranged in the form **of polypeptide chains**. The structure of proteins is classified as **primary, secondary, tertiary and quaternary in some cases**. These structures are based on the **level of complexity of the folding of a polypeptide chain**. Proteins play both structural and dynamic roles. Myosin is the protein that allows movement by contraction of muscles. Most enzymes are proteinaceous in nature.

Protein Structure





Amino Acid Chain (Protein)



Functions of Proteins

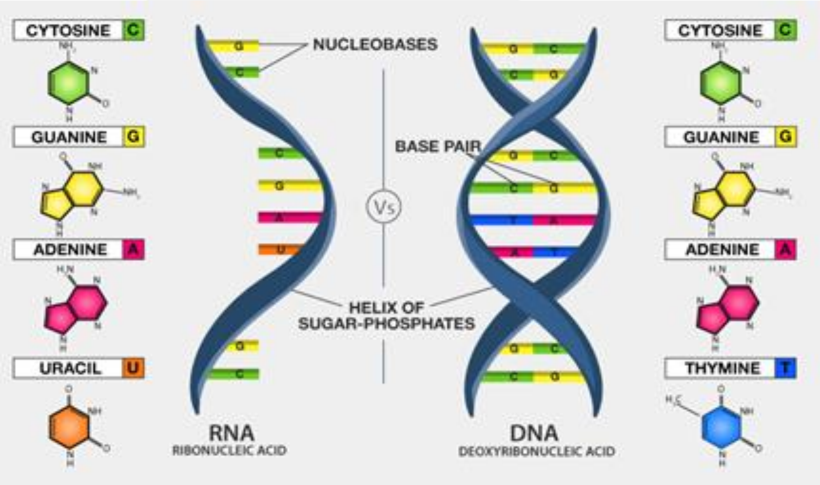
- Protein is vital in the maintenance of body tissue, including development and repair.
- Protein is the major source of energy.
- Protein is involved in the creation of some hormones, help control body functions that involve the interaction of several organs and help regulate cell growth.
- Protein produces enzymes that increase the rate of chemical reactions in the body.

Functions of Proteins

Aspect	Functions of Proteins in Human Body	Examples
Storage	Legume Storage, albumin, and proteins.	Supplies food during the early stage of the seedling or embryo.
Hormone Signalling	Counterpart activities of different body parts.	Glucagon and Insulin.
Transport	It transport substances throughout the body through lump or blood cells.	Hemoglobin.
Contraction	To carry out muscle contraction.	Myosin.
Digestive Enzyme	Breaks down nutrients present in the food into smaller portions so that it can be easily absorbed	Pepsin, Amylase, and Lipase

Nucleic Acids

Nucleic acids refer to the genetic material found in the cell that carries all the hereditary information from parents to progeny. There are two types of nucleic acids namely, **deoxyribonucleic acid (DNA) and ribonucleic acid (RNA).** The main function of nucleic acid is **the transfer of genetic information and synthesis of proteins by processes known as translation and transcription.**

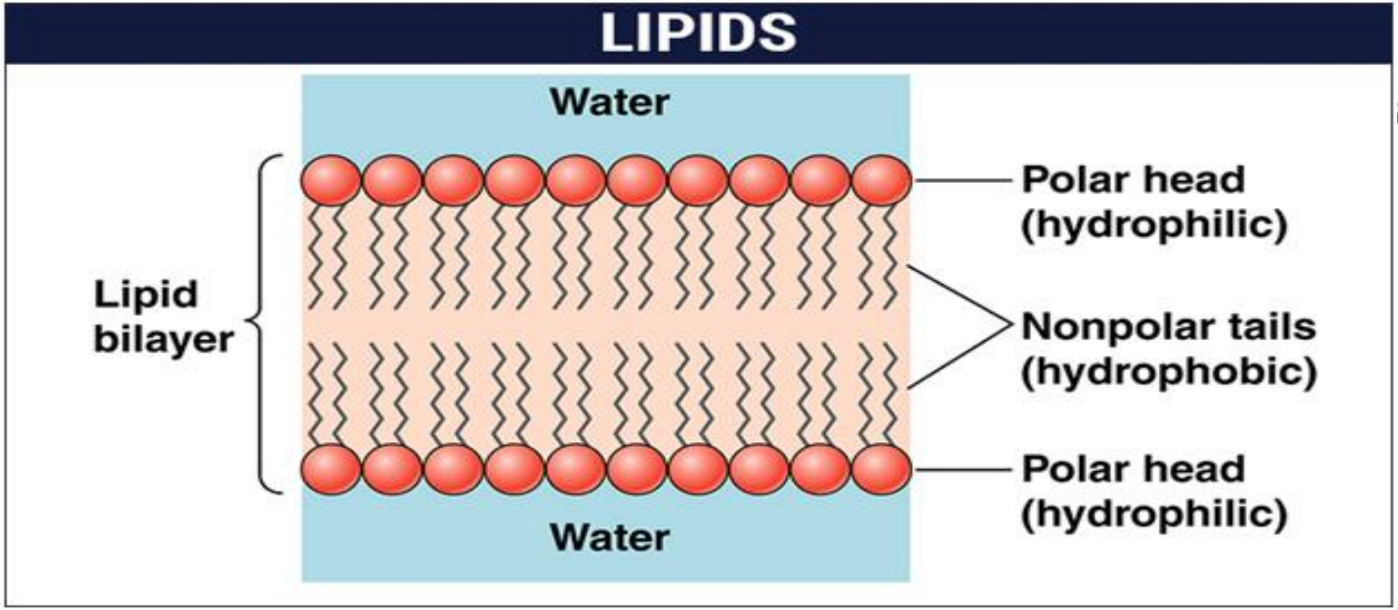


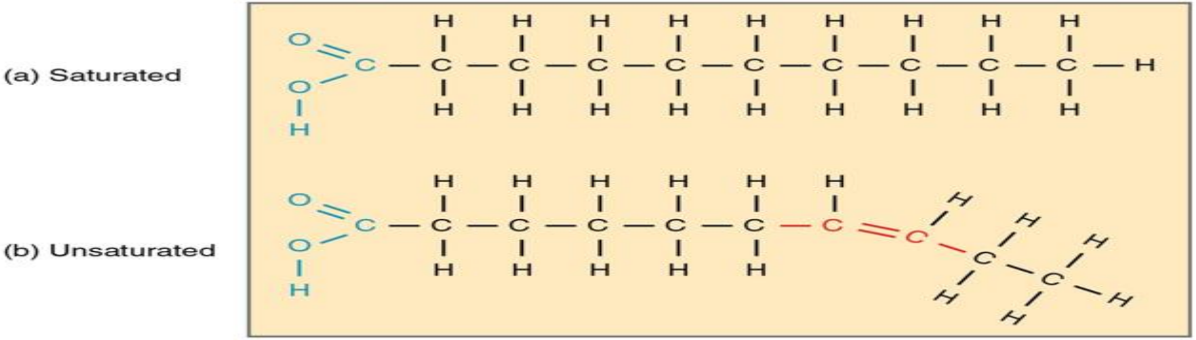
Functions of nucleic acids

- DNA is the chemical basis of heredity
- Reserve bank of genetic information
- Responsible for maintaining the identity of different species of organisms over millions of years
- Cellular function is under the control of DNA
- The basic information pathway
- DNA directs the synthesis of RNA, which in turn directs protein synthesis

Lipids

Lipids are organic substances that **are insoluble in water, soluble in organic solvents,** are related to **fatty acids** and are utilized by the living cell. They include **fats, waxes, sterols, fat-soluble vitamins, mono-, di- or triglycerides, phospholipids,** etc. Unlike carbohydrates, proteins, and nucleic acids, lipids are **not polymeric molecules.** Lipids play a great role in the cellular structure and are the chief source of energy.





Lipid Structure – Saturated and Unsaturated Fatty Acids

Properties of Lipids

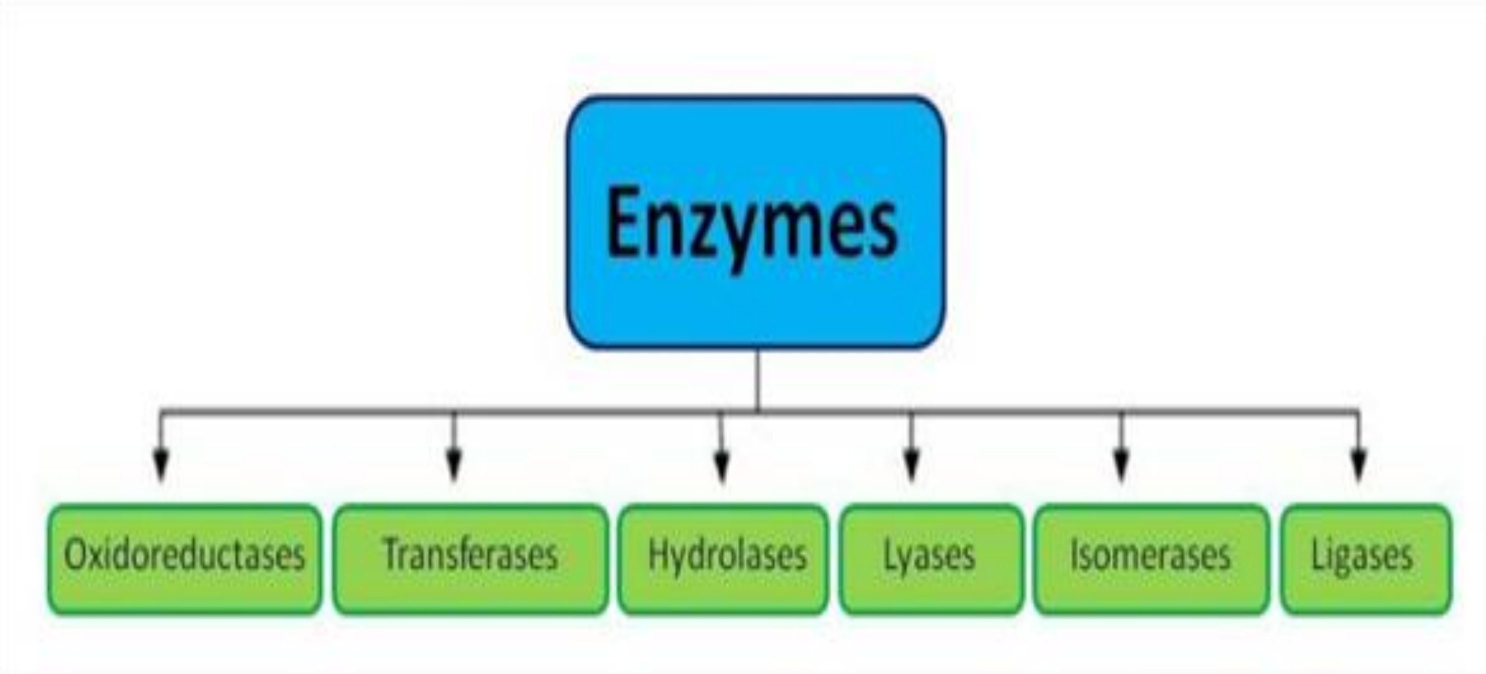
- Lipids are oily or greasy nonpolar molecules, stored in the adipose tissue of the body.
- Lipids are a heterogeneous group of compounds, mainly composed of hydrocarbon chains.
- Lipids are energy-rich organic molecules, which provide energy for different life processes.
- Lipids are a class of compounds characterised by their solubility in nonpolar solvents and insolubility in water.
- Lipids are significant in biological systems as they form a mechanical barrier dividing a cell from the external environment known as the cell membrane.

Lipids Functions

1. Precursors of hormone
2. It helps in digestion
3. It provides store of energy
4. It provides metabolic fuel
5. This is part of cell membrane

Enzyme

Enzymes are a linear chain of amino acids, which give rise to a three-dimensional structure. The sequence of amino acids specifies the structure, which in turn identifies the **catalytic activity of the enzyme.** Upon heating, the enzyme's structure denatures, resulting in a loss of enzyme activity, which typically is associated with temperature.



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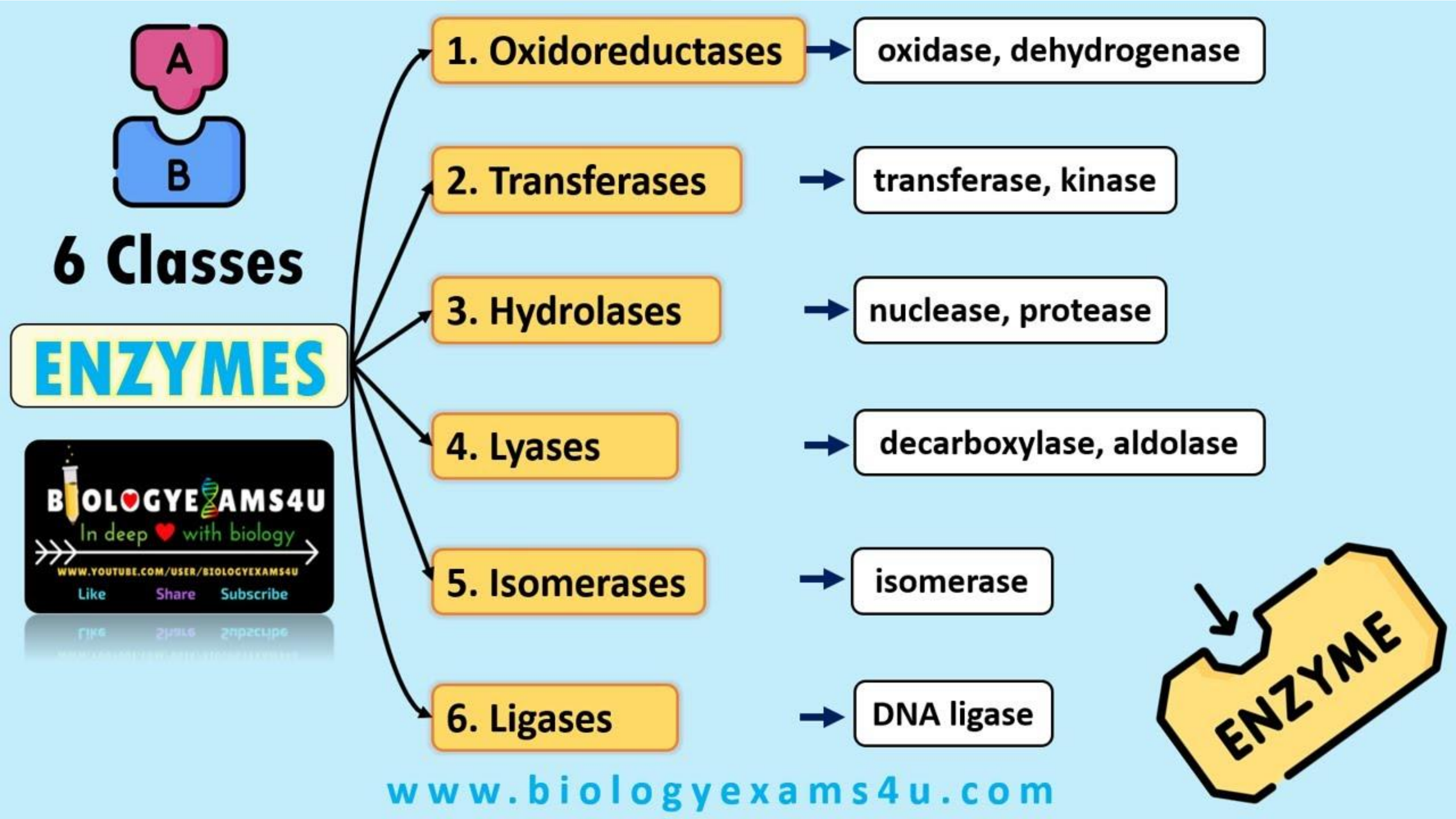
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6 Classes
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1. Oxidoreductases
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2. Transferases
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3. Hydrolases
nuclease, protease
4. Lyases
decarboxylase, aldolase
5. Isomerases
isomerase
6. Ligases
DNA ligase
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Classification of Enzymes:

Enzymes are classified into several categories based on their structure, function, and the type of reaction they catalyze. Here are the main types:

1.Oxidoreductases: These enzymes catalyze oxidation-reduction reactions, involving the transfer of electrons between molecules. Example: Alcohol dehydrogenase, which converts alcohol to aldehyde or ketone.

2.Transferases: Transferases catalyze the transfer of functional groups (e.g., methyl, phosphate, or amino groups) between molecules. Example: Kinases, which transfer phosphate groups from ATP to specific substrates.

3.Hydrolases: Hydrolases catalyze the hydrolysis of bonds by adding water molecules. Example: Lipase, which hydrolyzes lipids into fatty acids and glycerol.

4.Lyases: Lyases catalyze the removal of groups from substrates by mechanisms other than hydrolysis or oxidation. Example: Decarboxylases, which remove carboxyl groups from substrates, often as part of decarboxylation reactions.

5.Isomerases: Isomerases catalyze the rearrangement of atoms within molecules to form isomeric forms. Example: Triose phosphate isomerase, which interconverts dihydroxyacetone phosphate and glyceraldehyde 3-phosphate in glycolysis.

6.Ligases (synthetases): Ligases catalyze the joining of two molecules, often coupled with the hydrolysis of ATP or other high-energy molecules. Example: DNA ligase, which joins DNA strands together by catalyzing the formation of phosphodiester bonds.

Properties of Enzymes:

1. **Specificity:** Enzymes exhibit specificity toward their substrates, meaning they catalyze specific reactions with specific substrates.
2. **Efficiency:** Enzymes can greatly accelerate reaction rates, often by millions to billions of times, compared to the same reactions without enzyme catalysis.
3. **Regulation:** Enzyme activity can be regulated by various mechanisms, including allosteric regulation, covalent modification, and gene expression.
4. **Temperature and pH Sensitivity:** Enzymes have optimal temperature and pH ranges at which they function most efficiently. Outside these ranges, enzyme activity decreases.
5. **Cofactors and Coenzymes:** Many enzymes require non-protein molecules called cofactors or coenzymes to function properly. These molecules often assist in catalysis by providing chemical groups or facilitating substrate binding.

Functions of Enzymes:

1.**Metabolism:** Enzymes are key players in metabolic pathways, facilitating the conversion of substrates into products and the synthesis of complex molecules.

2.**Digestion:** Enzymes such as amylase, lipase, and protease catalyze the breakdown of carbohydrates, lipids, and proteins, respectively, during digestion.

3.**DNA Replication and Repair:** Enzymes like DNA polymerase and DNA ligase are involved in DNA replication and repair processes, ensuring the accurate transmission of genetic information.

4.**Cell Signaling:** Enzymes participate in cell signaling pathways by catalyzing reactions that generate signaling molecules or modulate the activity of signaling proteins. **the process by which a cell interacts with itself, other cells, and the environment**

5.**Detoxification:** Enzymes in the liver and other organs catalyze reactions involved in the detoxification and elimination of harmful substances from the body.

Vitamin

A vitamin is an organic molecule other than proteins, carbs, and lipids **required for normal growth, nutrition, and health**. Vitamins are not utilised to make cells or as a source of energy, but they work as essential catalysts in biological processes, and their lack causes major health disorders.

Required for proper functioning of the body and maintainting health condition.

Types Of Vitamins

Vitamins are segregated into two broad categories, namely

- Fat-soluble vitamins
- Water-soluble vitamins

There are **4 fat-soluble and 9 water-soluble vitamins** required for the **proper functioning of the body.** Let’s discuss these two types in detail.

Fat-soluble vitamins

Vitamins that are soluble in **lipids or body fats are known as fat-soluble vitamins**. The human body absorbs these substances through the intestinal tract with the help of dietary fat. These vitamins are then stored in the fatty tissues or liver. Fat-soluble vitamins can be stored in our systems for a long time.

The four fat-soluble vitamins are as follows:

- Vitamin A (retinol)
- Vitamin K (phylloquinone)
- Vitamin D (calciferol)
- Vitamin E (alpha-tocopherol).

Fat-Soluble Vitamins:

1. **Vitamin A (Retinol):**
   1. **Functions:** Essential for vision, immune function, reproduction, and cellular communication.
   2. **Sources:** Liver, fish liver oils, dairy products, eggs, and orange/yellow fruits and vegetables.
2. **Vitamin D (Calciferol):**
   1. **Functions:** Facilitates calcium absorption and bone mineralization, supports immune function, and regulates cell growth.
   2. **Sources:** Sunlight exposure, fatty fish (e.g., salmon, mackerel), fortified dairy products, and egg yolks.
3. **Vitamin E (Tocopherol):**
   1. **Functions:** Acts as an antioxidant, protecting cell membranes from oxidative damage, and supports immune function and skin health.
   2. **Sources:** Nuts, seeds, vegetable oils (e.g., wheat germ oil, sunflower oil), and green leafy vegetables.
4. **Vitamin K (Phylloquinone, Menaquinone):**
   1. **Functions:** Essential for blood clotting, bone metabolism, and cell growth.
   2. **Sources:** Green leafy vegetables (e.g., spinach, kale), broccoli, Brussels sprouts, and vegetable oils.

Water-soluble vitamins

Water-soluble vitamins, unlike fat-soluble vitamins, **cannot be stored in the body for extended periods. Following consumption, these vitamins are eliminated through urine regularly**. This is why water-soluble vitamins must be consumed more regularly than fat-soluble vitamins. The water-soluble vitamins are as follows:

Vitamin B1, Vitamin B6, Vitamin B7. Vitamin B3, Vitamin B9, Vitamin B12, Vitamin C

Vitamin B2, Vitamin B5

Water-Soluble Vitamins:

1. **Vitamin B1 (Thiamine):**
    1. **Functions:** Plays a key role in energy metabolism, nerve function, and carbohydrate metabolism.
    2. **Sources:** Whole grains, pork, legumes, nuts, and seeds.
2. **Vitamin B2 (Riboflavin):**
    1. **Functions:** Required for energy production, cellular growth and development, and antioxidant activity.
    2. **Sources:** Dairy products, lean meats, eggs, green leafy vegetables, and enriched cereals.
3. **Vitamin B3 (Niacin):**
    1. **Functions:** Involved in energy metabolism, DNA repair, and cell signaling.
    2. **Sources:** Meat, poultry, fish, nuts, legumes, and enriched cereals.
4. **Vitamin B5 (Pantothenic Acid):**
    1. **Functions:** Essential for energy metabolism and the synthesis of essential molecules like fatty acids, cholesterol, and steroid hormones.
    2. **Sources:** Meat, poultry, fish, whole grains, eggs, and vegetables.

5. Vitamin B6 (Pyridoxine):

1. **Functions:** Involved in amino acid metabolism, neurotransmitter synthesis, and hemoglobin synthesis.
2. **Sources:** Meat, fish, poultry, bananas, potatoes, and fortified cereals.

6. Vitamin B7 (Biotin):

1. **Functions:** Plays a role in fatty acid synthesis, gluconeogenesis, and maintaining healthy hair, skin, and nails.
2. **Sources:** Egg yolks, liver, nuts, seeds, and certain vegetables.

7. Vitamin B9 (Folate, Folic Acid):

1. **Functions:** Essential for DNA synthesis, cell division, and the formation of red blood cells.
2. **Sources:** Leafy green vegetables, legumes, liver, fortified grains, and citrus fruits.

8. Vitamin B12 (Cobalamin):

1. **Functions:** Required for DNA synthesis, red blood cell formation, neurological function, and energy metabolism.
2. **Sources:** Animal products (e.g., meat, fish, eggs, dairy), fortified cereals, and nutritional yeast (for vegetarians/vegans).

9. Vitamin C (Ascorbic Acid):

1. **Functions:** Acts as an antioxidant, supports immune function, collagen synthesis, wound healing, and iron absorption.
2. **Sources:** Citrus fruits (e.g., oranges, lemons), berries, kiwi, tomatoes, peppers, and green leafy vegetables.

Hormones

Hormones are chemicals that essentially function as messengers of the body. These chemicals are **secreted by special glands known as the endocrine glands.** These endocrine glands are **distributed throughout the body**. These messengers control many **physiological functions as well as psychological health**. They are also quite important in maintaining homeostasis in the body.

Homeostasis is defined as a self-regulating process by which a living organism can maintain internal stability while adjusting to changing external conditions.

Types of Hormones

To regulate various functions, different types of hormones are produced in the body. They are classified as follows:

- **Peptide Hormones-** hormones that are made of small chains of amino acids.
- **Steroid Hormones -** a group of hormones derived from cholesterol that act as chemical messengers in the body

Functions of Hormones

- Food metabolism.
- Growth and development.
- Controlling thirst and hunger.
- Maintaining body temperature.
- Regulating mood and cognitive functions.
- Initiating and maintaining sexual development and reproduction.

1. **Peptide Hormones:**
   1. **Description:** Peptide hormones are composed of amino acids and are synthesized as prohormones, which are later cleaved to form active hormones.
   2. **Examples:**
      1. Insulin (pancreas): Regulates blood glucose levels by promoting glucose uptake by cells and glycogen synthesis.
      2. Growth hormone (pituitary gland): Stimulates growth, cell reproduction, and regeneration in humans and other animals.
      3. Oxytocin (pituitary gland): Regulates uterine contractions during childbirth and stimulates milk ejection during breastfeeding.

1.Steroid Hormones:

1. **Description:** Steroid hormones are derived from cholesterol and are lipid-soluble. They can diffuse across cell membranes and exert their effects by binding to intracellular receptors.
2. **Examples:**
    1. Estrogen (ovaries): Regulates the development of secondary sexual characteristics in females and plays a role in the menstrual cycle and pregnancy.
    2. Testosterone (testes): Responsible for the development of male secondary sexual characteristics and sperm production.
    3. Cortisol (adrenal glands): Regulates metabolism, immune function, and the body's response to stress.

2.Amino Acid-Derived Hormones:

1. **Description:** Amino acid-derived hormones are derived from amino acids, primarily tyrosine and tryptophan.
2. **Examples:**
    1. Thyroxine (T4) and Triiodothyronine (T3) (thyroid gland): Regulate metabolism, growth, and development by controlling the body's metabolic rate.

Based on Function:

1.Endocrine Hormones:

1. **Description:** Endocrine hormones are released directly into the bloodstream by endocrine glands and travel to target tissues to exert their effects.
2. **Examples:** Insulin, cortisol, growth hormone, thyroid hormones.

2.Paracrine Hormones:

1. **Description:** Paracrine hormones act locally on neighboring cells without entering the bloodstream.
2. **Examples:** Histamine (released by mast cells to mediate inflammation), prostaglandins (regulate inflammation, blood flow, and smooth muscle contraction).

3.Autocrine Hormones:

1. **Description:** Autocrine hormones act on the same cells that produce them, influencing their own activity.
2. **Examples:** Various growth factors involved in cell proliferation and differentiation.

4.Neurohormones:

1. **Description:** Neurohormones are released by neurons and act as hormones, traveling through the bloodstream to distant target tissues.
2. **Examples:** Vasopressin (antidiuretic hormone) and oxytocin (both produced by the hypothalamus and released by the posterior pituitary gland).

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