ATME College of Engineering

Biology for Engineers BBOC407

MODULE-1
CELL BASIC UNIT OF LIFE

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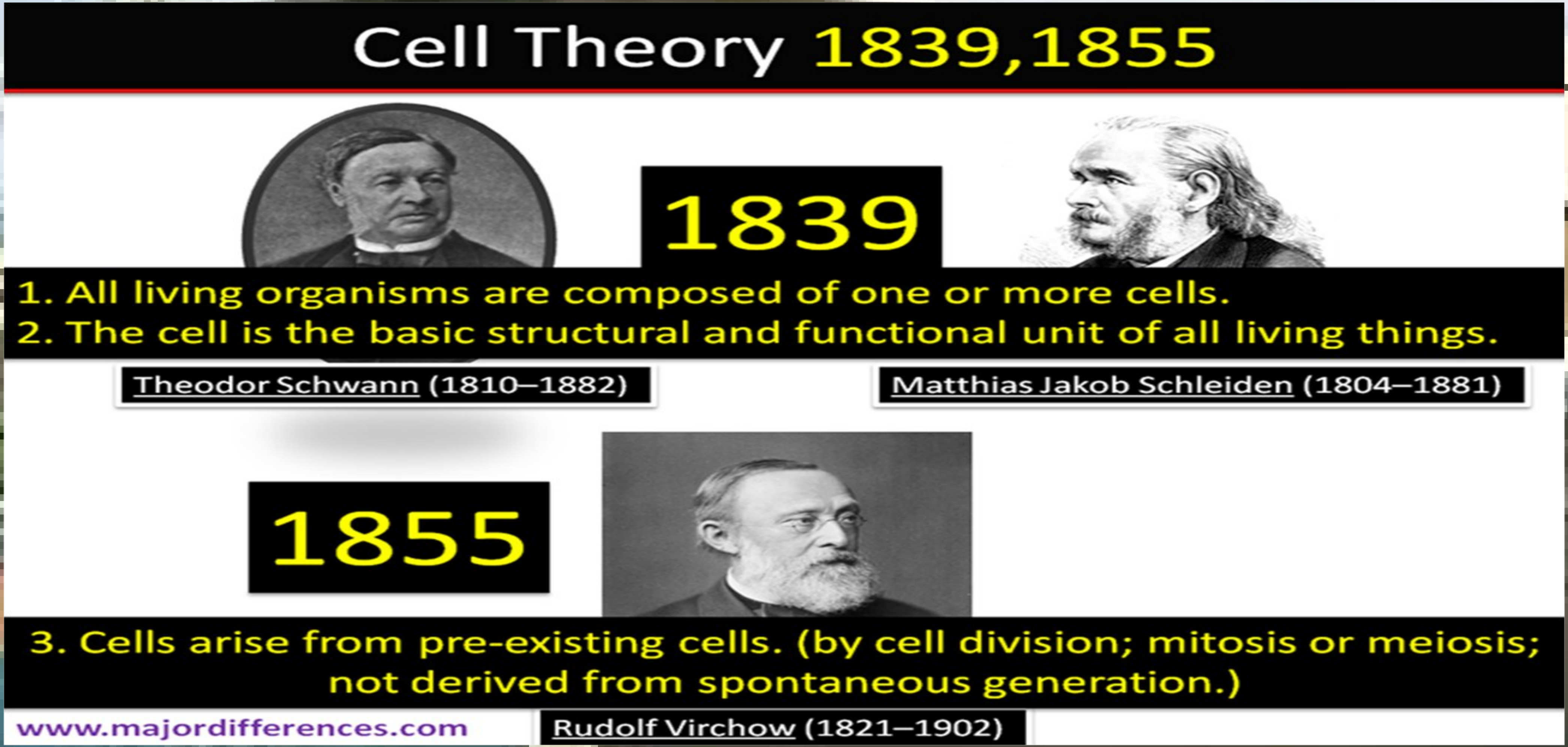
The Cell

- A cell is the smallest and basic form of life.
- In all life forms, including bacteria, plants, animals, and humans, the cell is defined as the most basic structural and functional unit.
- Robert Hooke, in 1665, for the first time, identified the honeycomb-like dead cell walls in a cork.
- Later, Antonie van Leeuwenhoek (1674) observed the first living cells (bacteria/protozoa), while Robert Brown (1831) identified the nucleus

The Cell Theory



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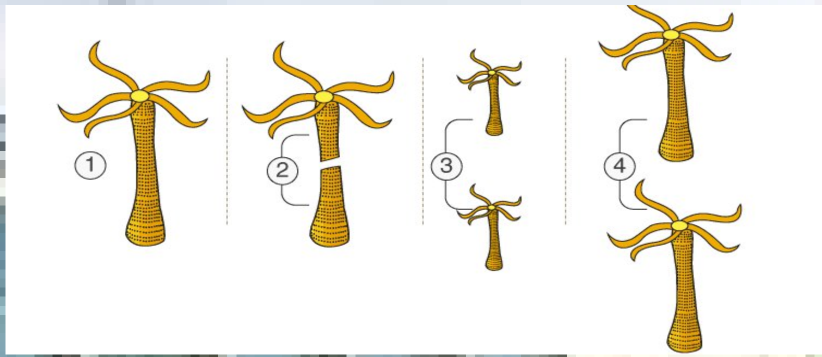
Types of Cell



Cells are like factories with different labourers and departments that work towards a common objective. Various types of cells perform different functions. Based on cellular structure, there are two types of cells:

- **Prokaryotic**
- **Eukaryotic**

Prokaryotes:

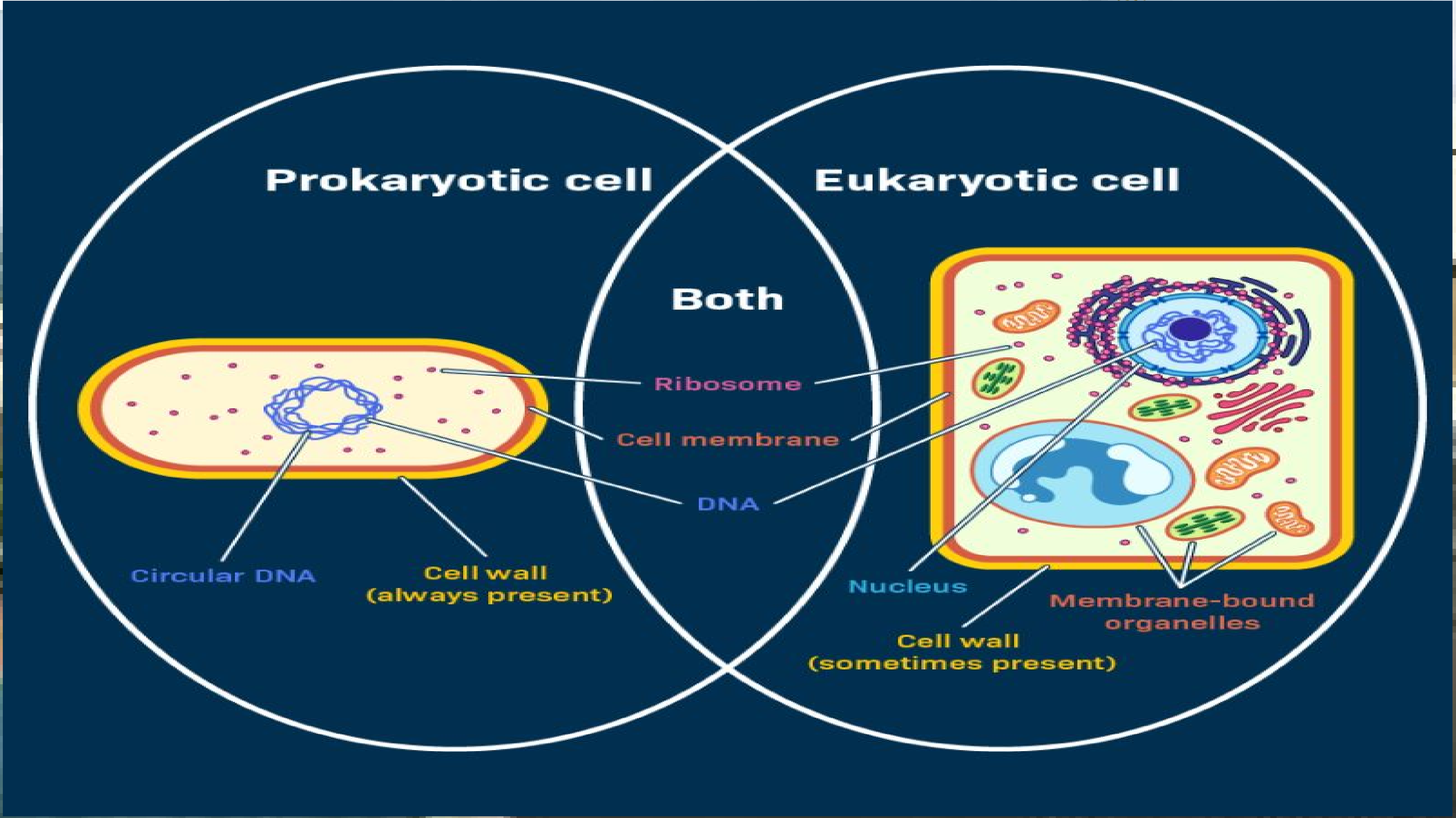
- ***Prokaryotic cells don't have a true nucleus***. Instead, some prokaryotes, such as bacteria, have a region within the cell where the genetic material is freely suspended. This region is called the nucleoid. Ex. Bacteria
- The cell size ranges from **0.1 to 0.5 µm** in diameter.
- They lack membrane-bound organelles.
- They posses 70S type of Ribosomes
- The hereditary material is circular DNA.
- Mode of reproduction is simple.

Types of Cell

Eukaryotic Cells:

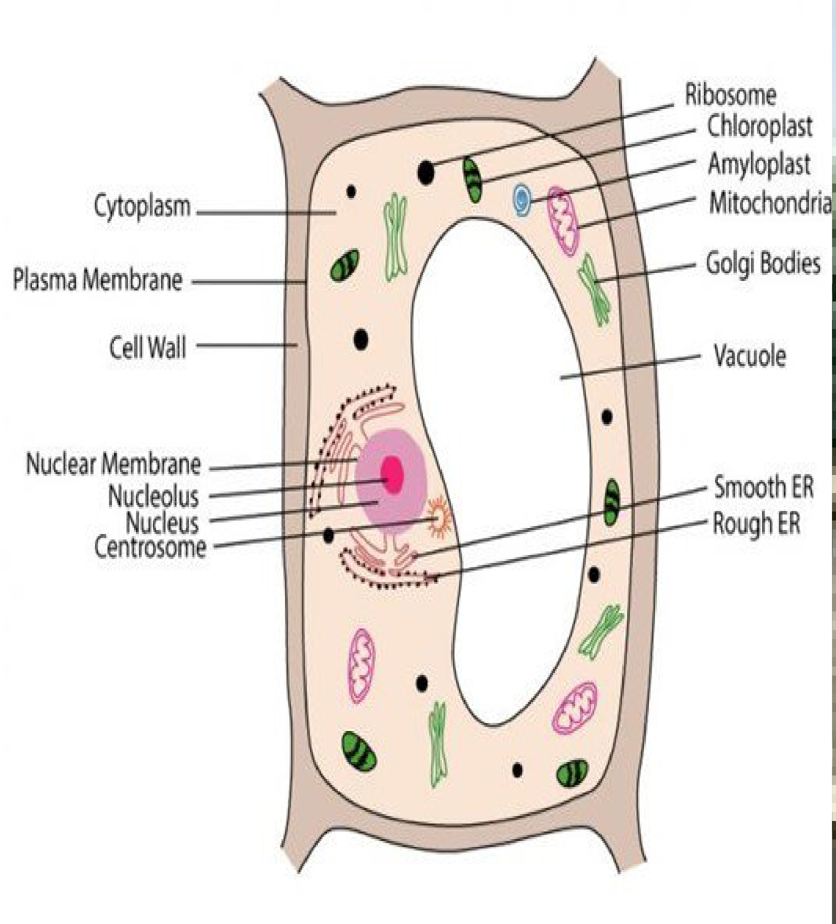
- Eukaryotic cells are characterised by a **true nucleus, which means the nucleus is bounded by a nuclear envelope.**
- The size of the cells ranges between **10–100 µm in diameter**.
- This broad category involves **plants, fungi, and animals**.
- They includes membrane bound organelles in them.
- They posses 80 S type of Ribosomes.
- Mode of reproduction complex
- Eukaryotes can reproduce both in **mitosis and through meiosis**.
  - In mitosis, one cell divides to supply two genetically identical cells.
  - In meiosis, DNA replication is followed by cellular division to produce four haploid daughter cells.

Prokaryotic vs. Eukaryotic Cells


Prokaryotic cell
Eukaryotic cell
Both
Ribosome
Cell membrane
DNA
Circular DNA
Cell wall
(always present)
Nucleus
Membrane-bound
organelles
Cell wall
(sometimes present)

Plant Cell

- Plant cells are a type of **eukaryotic cell.**
- The **organelles** present in plant cells differ from those in other **eukaryotic cells.**
- The major difference in the plant cell is that the plant cell contains a **rigid cell wall** around its plasma membrane.
- **Cell Wall:** Plant cells are surrounded by a rigid cell wall composed of cellulose, which provides structural support and protection and also gives **shape** to the cell.
- **Cell Membrane:** Just inside the cell wall is the cell membrane, a semipermeable membrane that controls the movement of substances in and out of the cell.
- **Ribosomes: Ribosomes are the site of protein synthesis** in the cell, where they translate mRNA into proteins.



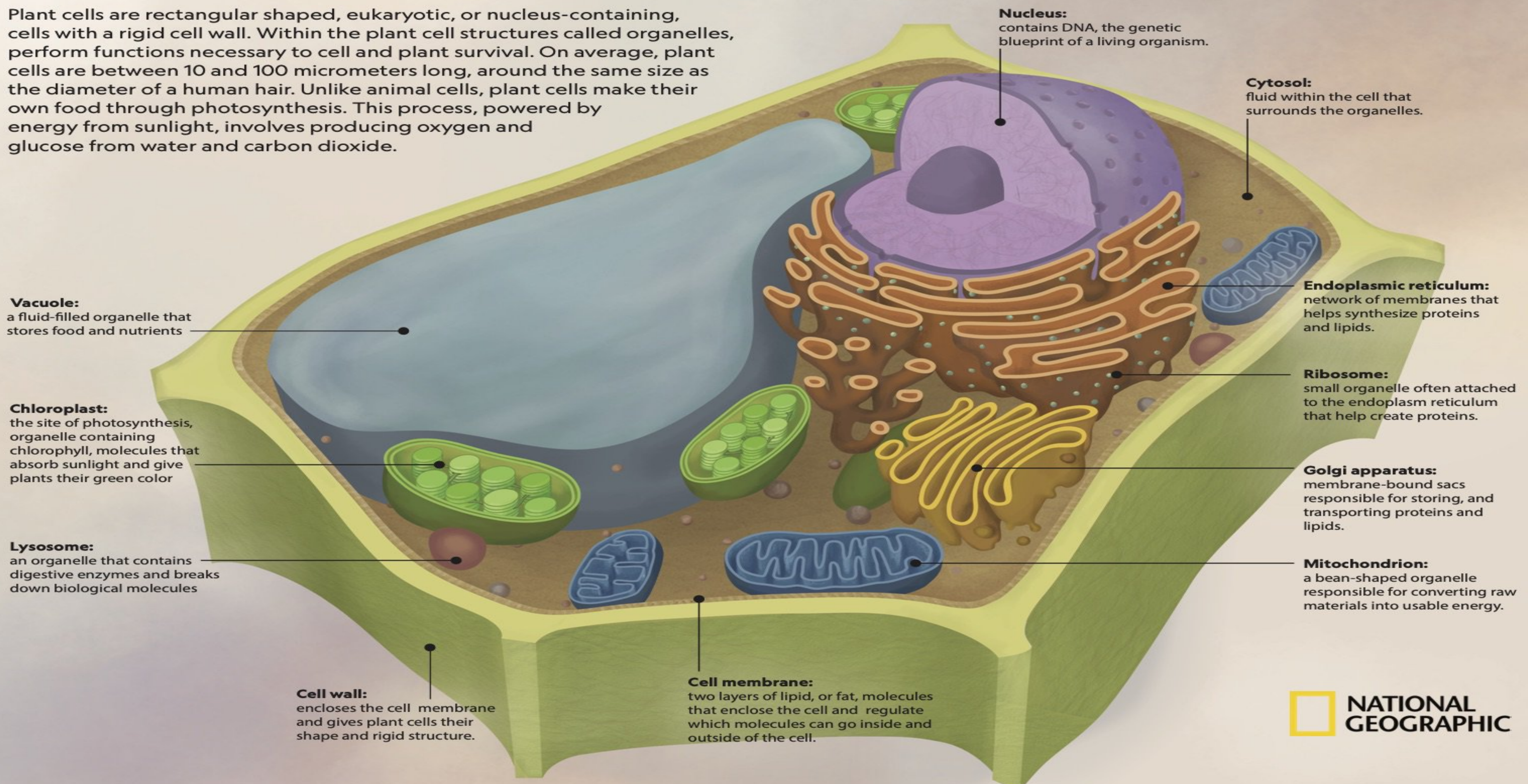
Plant Cell

Structure of Plant Cell:

- **Cytoplasm:** The cytoplasm is a jelly-like substance that fills the cell and contains **various organelles.**
- **Nucleus:** The nucleus is the control centre of the cell, containing the cell's **DNA** and directing the cell's activities.
- **Mitochondria:** Mitochondria are the powerhouses of the cell, responsible for generating energy through cellular respiration.
- **Chloroplasts:** Chloroplasts are organelles that contain chlorophyll, allowing plants to perform photosynthesis and convert light energy into chemical energy.
- **Vacuole:** Plant cells typically have a large central vacuole filled with fluid, which helps maintain **turgor pressure** and stores nutrients and waste products.
- **Endoplasmic Reticulum (ER):** The ER is a network of membranes that assists in **the production, processing, and transport of proteins and lipids.**
- **Golgi Apparatus:** The Golgi apparatus **processes and packages proteins and lipids produced by the ER** for transport to other parts of the cell or for secretion.

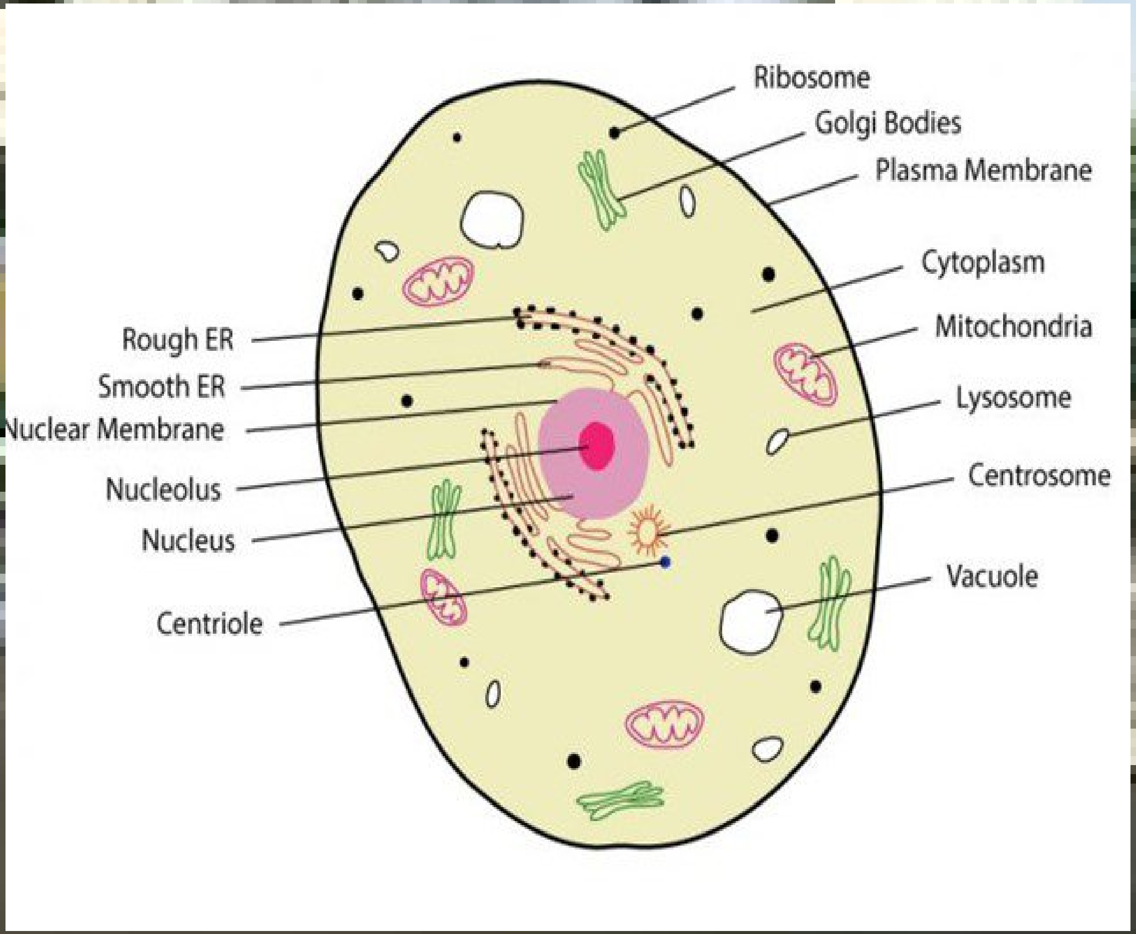
PLANT CELL

Plant cells are rectangular shaped, eukaryotic, or nucleus-containing, cells with a rigid cell wall. Within the plant cell structures called organelles, perform functions necessary to cell and plant survival. On average, plant cells are between 10 and 100 micrometers long, around the same size as the diameter of a human hair. Unlike animal cells, plant cells make their own food through photosynthesis. This process, powered by energy from sunlight, involves producing oxygen and glucose from water and carbon dioxide.



Animal Cell

- An animal cell is a typical eukaryotic cell with a membrane-bound nucleus, with the presence of DNA inside the nucleus.
- Unlike the eukaryotic cells of plants, animal cells do not have a cell wall.
- They comprise **other organelles** and **cellular structures** that carry out specific functions necessary for the cell to function properly.
- The main difference between the animal and plant cells is that the animal cell **is not able to make their own food.** There are trillions of cells in the animal body, and each one is different depending on the function and type.
- Most animal cells have at least three main parts: **nucleus, cell membrane, and cytoplasm.**



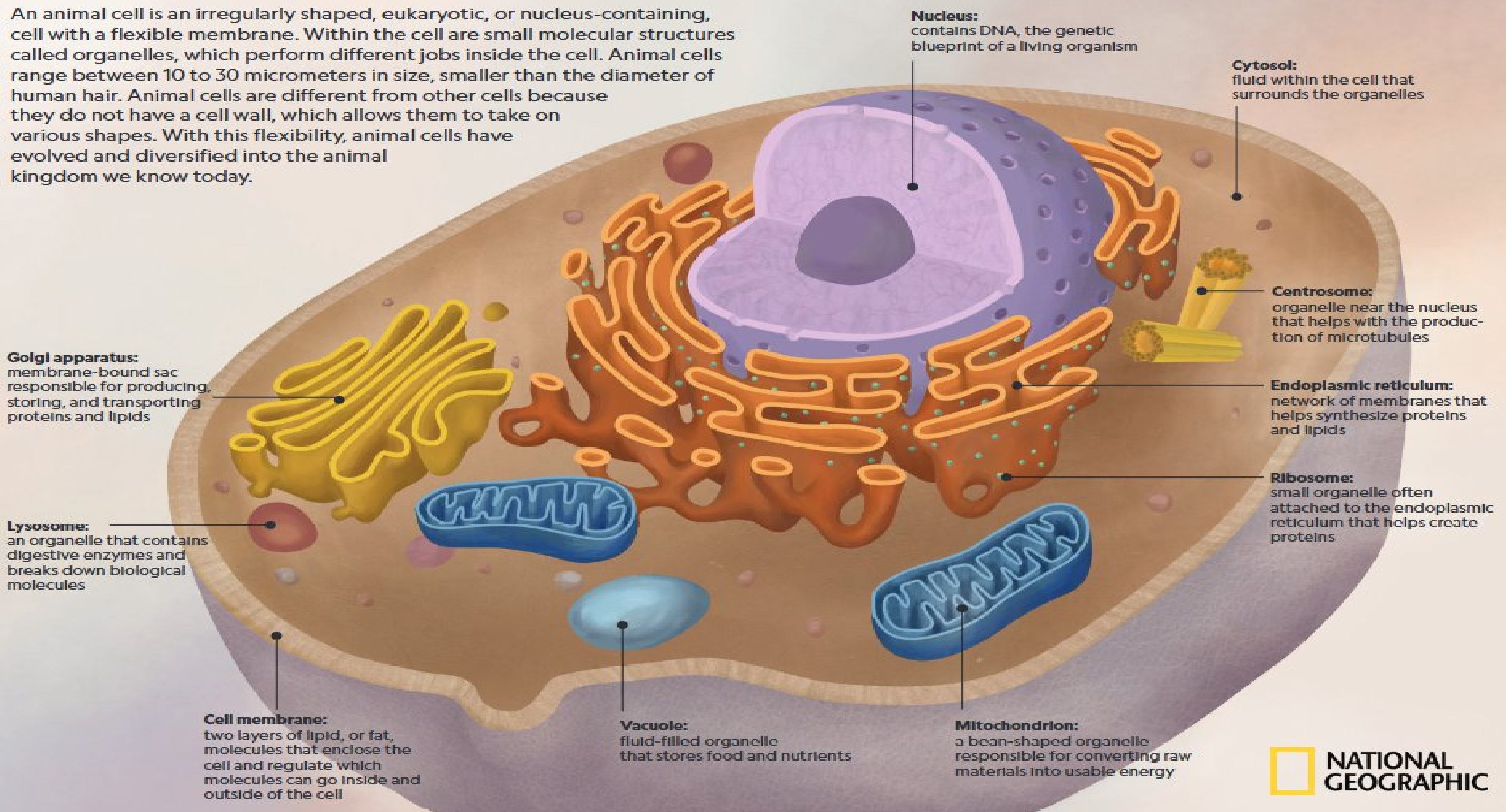
Animal Cell

Structure of animal Cell:

- **Cell Membrane:** A thin, flexible barrier that surrounds the cell, regulating what enters and exits the cell.
- **Nucleus:** The control center of the cell, containing the cell's DNA and directing the cell's activities.
- **Cytoplasm:** A jelly-like substance that fills the cell and supports the organelles.
- **Mitochondria:** Organelles that generate energy for the cell through cellular respiration.
- **Endoplasmic Reticulum (ER):** A network of membranes that aids in the production of proteins and lipids.
- **Golgi Apparatus:** A stack of membrane-bound vesicles that processes, packages, and distributes proteins and lipids.
- **Ribosomes:** Structures that synthesize proteins.
- **Lysosomes:** Organelles that contain digestive enzymes to break down waste materials and cellular debris.

ANIMAL CELL

An animal cell is an irregularly shaped, eukaryotic, or nucleus-containing, cell with a flexible membrane. Within the cell are small molecular structures called organelles, which perform different jobs inside the cell. Animal cells range between 10 to 30 micrometers in size, smaller than the diameter of human hair. Animal cells are different from other cells because they do not have a cell wall, which allows them to take on various shapes. With this flexibility, animal cells have evolved and diversified into the animal kingdom we know today.



Feature	Plant Cells	Animal Cells
Cell Wall	The cell wall is present in plant cells and is made up of cellulose. The cell wall is the outermost layer of plant cells.	It Is absent In the animal Cell.
Shape	They have a definite and rigid shape	They exist in round and irregular shapes.
Chloroplast	Chloroplasts are present in plant cells that make their own food.	Chloroplast absent in animal cell
Centriole	Plant cells lack centrioles	Animal cells contain paired, barrel-shaped centrioles within a centrosome, which act as primary microtubule organizing centers to organize spindle fibers during mitosis.
Nucleus	It is present in peripheral region and controls the functioning of cells.	It is present in the centre and controls the functioning of cells.
Vacuole	Plant cells feature a single, large central vacuole (occupying up to 90% of volume) that maintains turgor pressure and structure	Animal cells possess multiple, smaller, temporary vacuoles used for storage, waste disposal, or endocytosis.

Feature	Plant Cells	Animal Cells
Storage Material	Strach is the storage material	Glycogen is the storage material.
Mode of Nutrition	It is autotrophic – Means they can synthesise their own food	The mode of nutrition is heterotrophic. which means they cannot synthesize their own nutrients.
Golgi Apparatus	Plant cells contain numerous, smaller Golgi stacks known as dictyosomes scattered throughout the cytoplasm	Animal cells typically possess a single, large, and highly complex Golgi apparatus located near the nucleus.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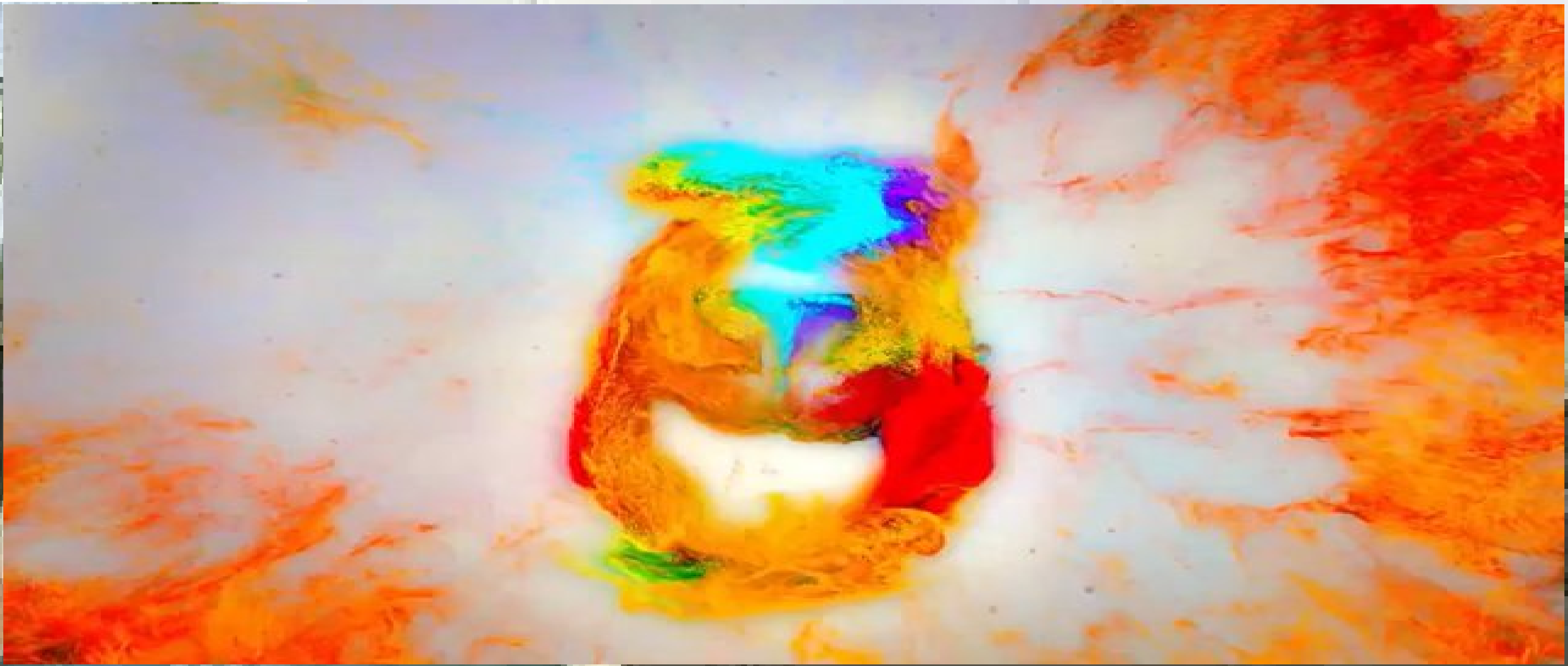
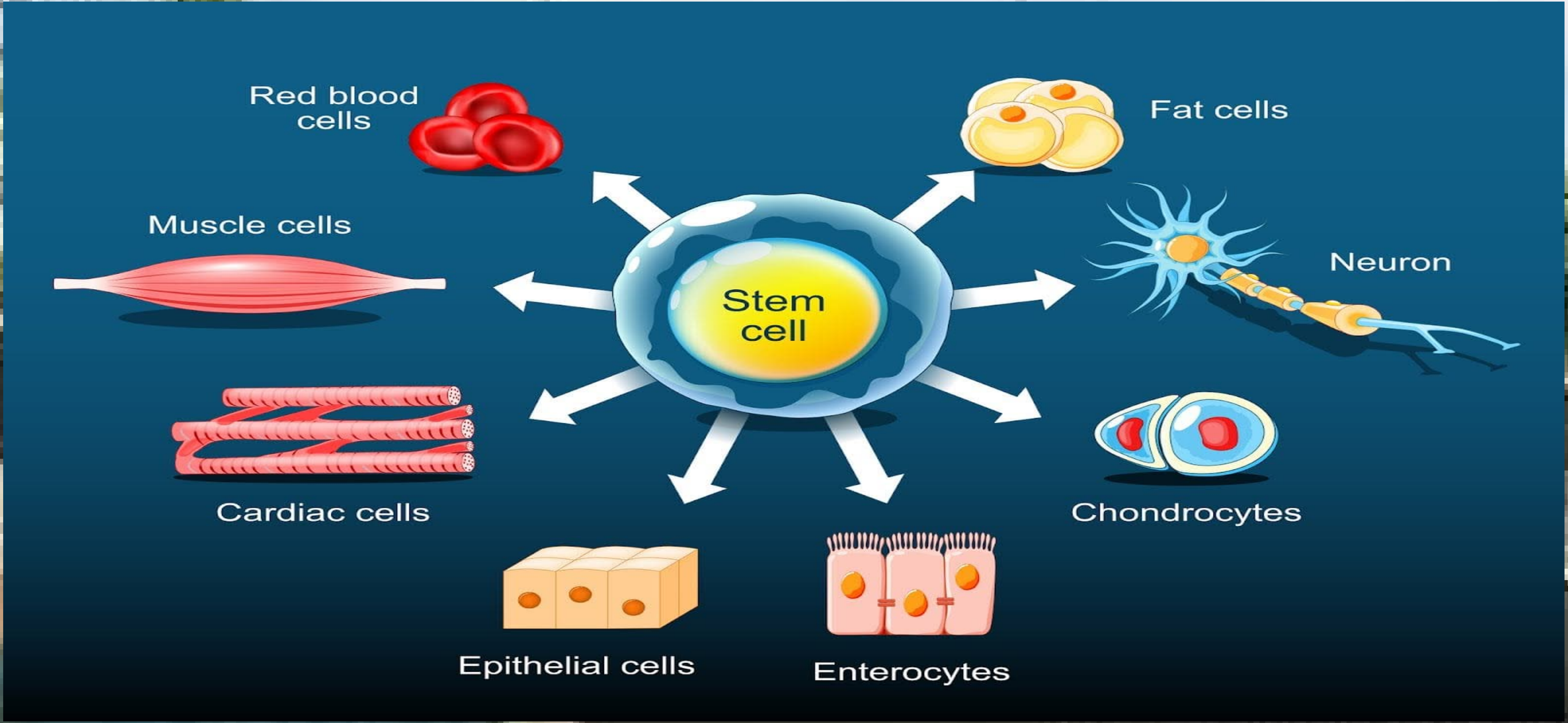
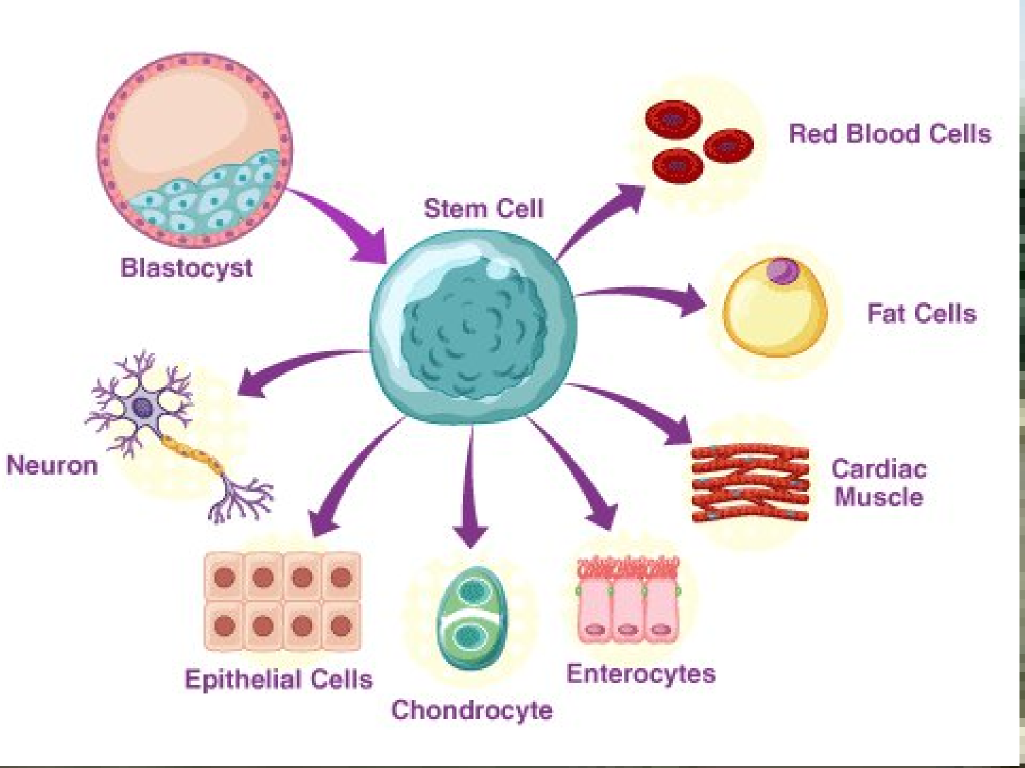



Red blood cells
Fat cells
Muscle cells
Neuron
Stem cell
Cardiac cells
Chondrocytes
Epithelial cells
Enterocytes

Stem Cells

- In multicellular organisms, stem cells are partially differentiated cells that can **change into various types of cells.**
- Stem cells have remarkable potential to develop into many different cell types in the body during early life and growth.
- They serve as a **sort of repair system for the body**, dividing essentially without limit to replenish other cells.
- When a stem cell divides, each new cell has the potential either to **remain a stem cell or become another type of cell** with a more specialized function, such as a muscle cell, a red blood cell, or a brain cell.
- The stem cells can be used to repair or **regenerate damaged or diseased cells.** These cells can develop into any kind of cell.

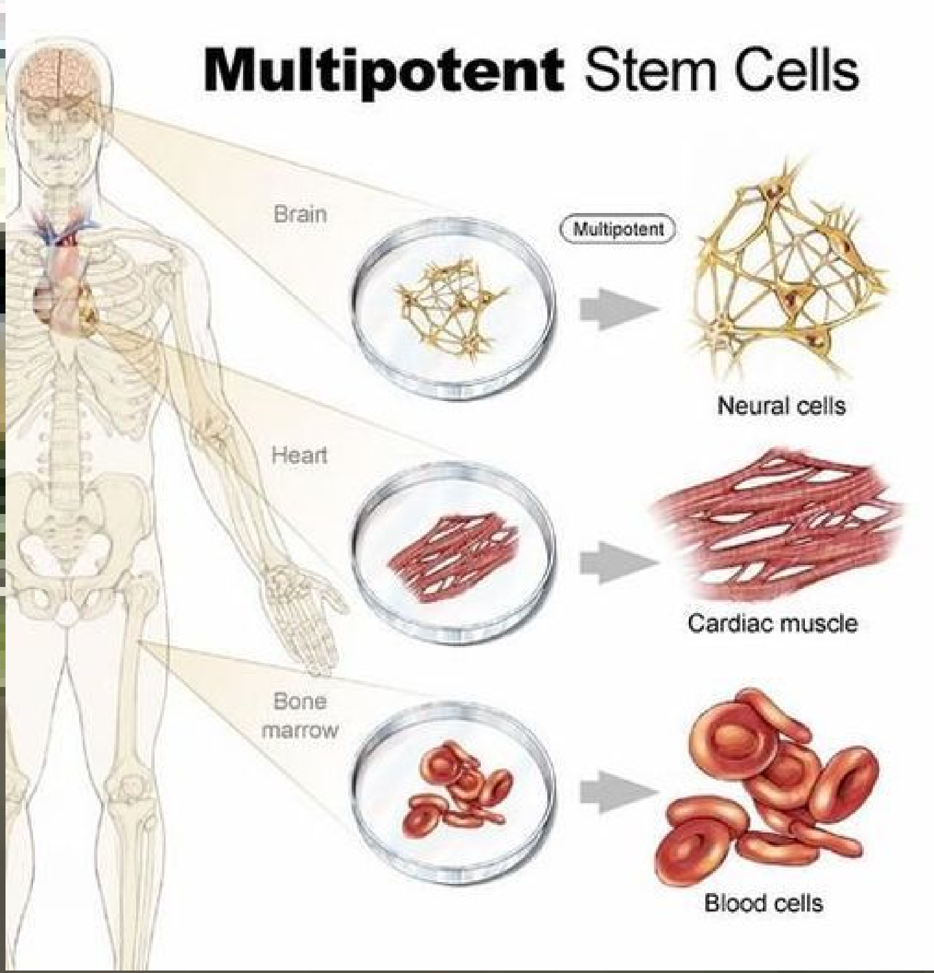


Stem Cells

Stem cells are categorized into two main types based on their source and potential:

1. **Adult stem cells**

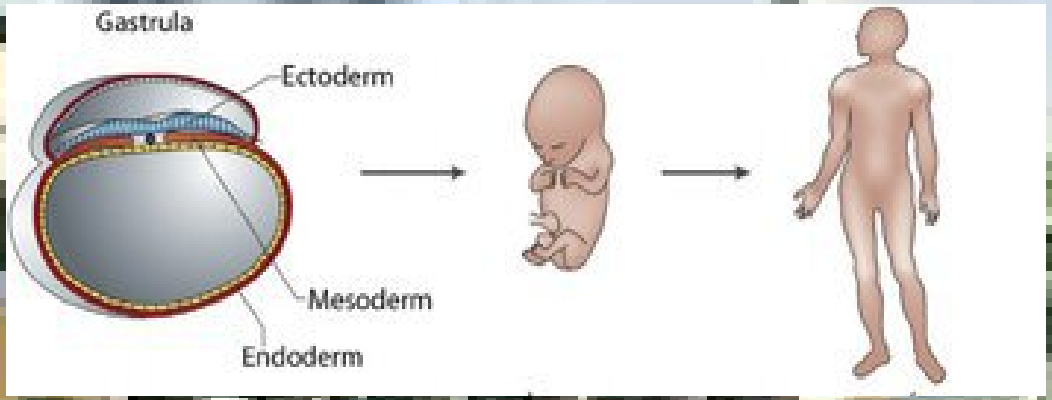
- Also known as **somatic or tissue-specific** stem cells, are found in **various tissues** and **organs throughout the body**. They are multipotent, meaning they can differentiate into a limited range of cell types.
- **These stem cells are acquired from fully-grown adult organs** and tissues found in differentiated tissues (bone marrow and brain). They can fix and supplant the harmed tissues in the area where they are located.

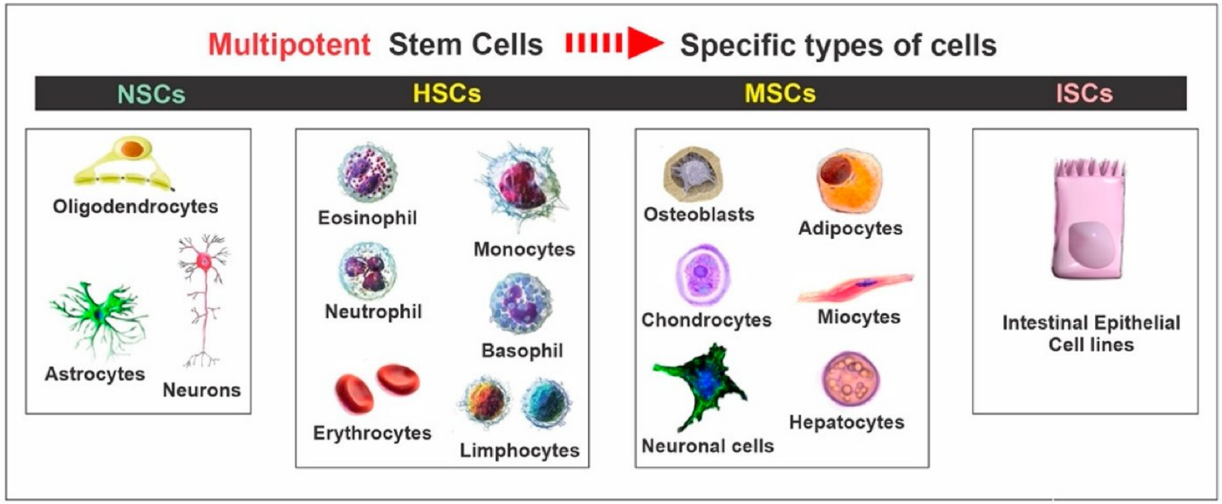


Stem Cells

2. Embryonic stem cells (ESCs)

- are derived from embryos. They are pluripotent, meaning they **can give rise to all cell types in the body.**
- The **pluripotent cells** play a vital role in developing the **fetus.** Thus, these stem cells are found only during the embryonic stage and are termed embryonic stem cells. These cells can differentiate into any type of cell.





Adult Stem Cells	Embryonic Stem Cells
Adult stem cells are undifferentiated stem cells in differentiated organs/tissues.	Embryonic stem cells are found during the early blastocyst stage.
They are multipotent. It means they can develop only into closely related cell types.	They are pluripotent. Hence, they can develop into any cell.

Classification and applications of Stem Cells

Classification : on the basis of potency or plasticity

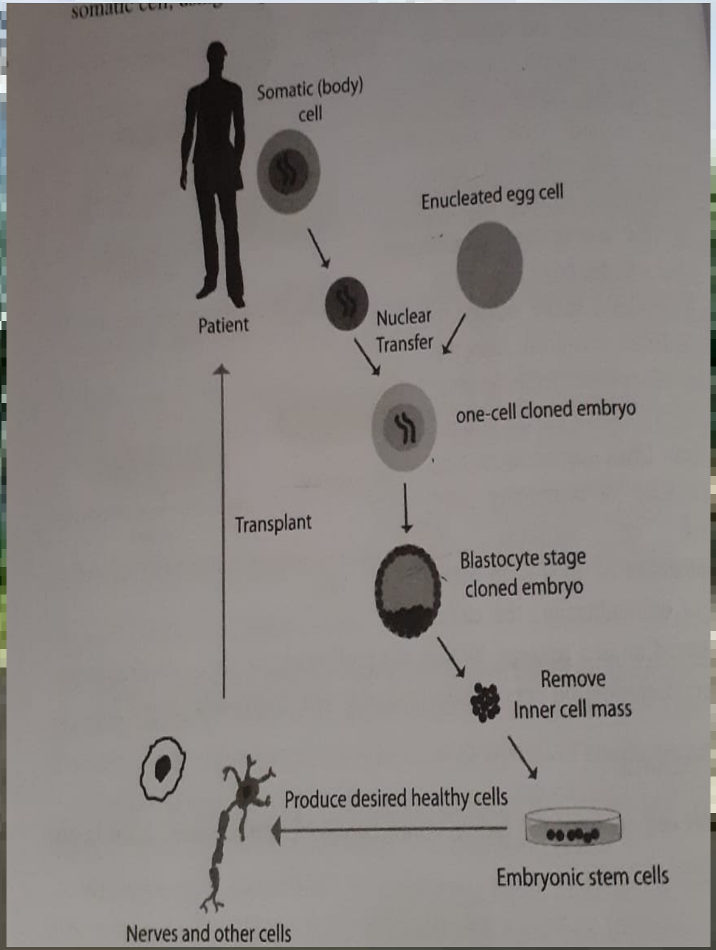
a) **Unipotent** : they can form only one type of specialized cell. E.g., brain stem cells differentiate into only brain cell.

b) **Multipotent** : stem cells can form multiple types of cells. E.g., mesenchymal cells can give rise to osteoblast, adipocytes, chondrocytes, myocytes and neural cells.

c) **Pluripotent** : they can differentiate into almost all types of cells. E.g., ICM of trophoblast.

Applications of stem cells :

a) **Therapeutic cloning** : It involves extracting the nucleus or a cell and putting those into an egg which has been enucleated, then egg is allowed to divide and grow.



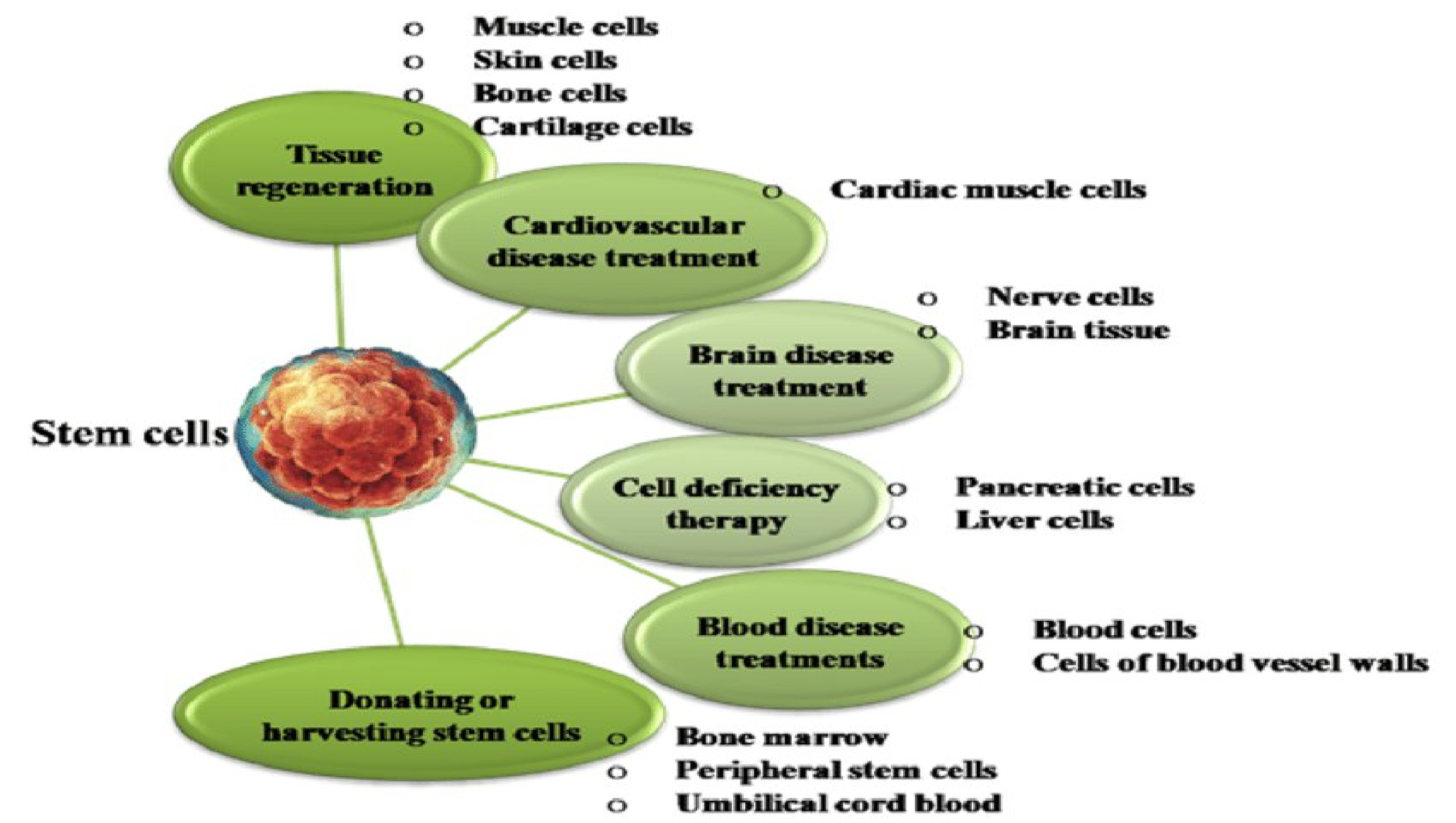
Applications of stem cells

b) **Regenerative medicine**: It is the process of creating functional tissues to repair or replace tissue or organ function lost due to damage or congenital defects.

E.g., Parkinson's disease: a CNS degenerative disorder due to a lack of a chemical called dopamine; to cure this disease, patients are injected with stem cells to multiply nerve cells that release dopamine.

c) **Gene therapy**: It is the insertion of genes into an individual's cells and tissues to treat disease.

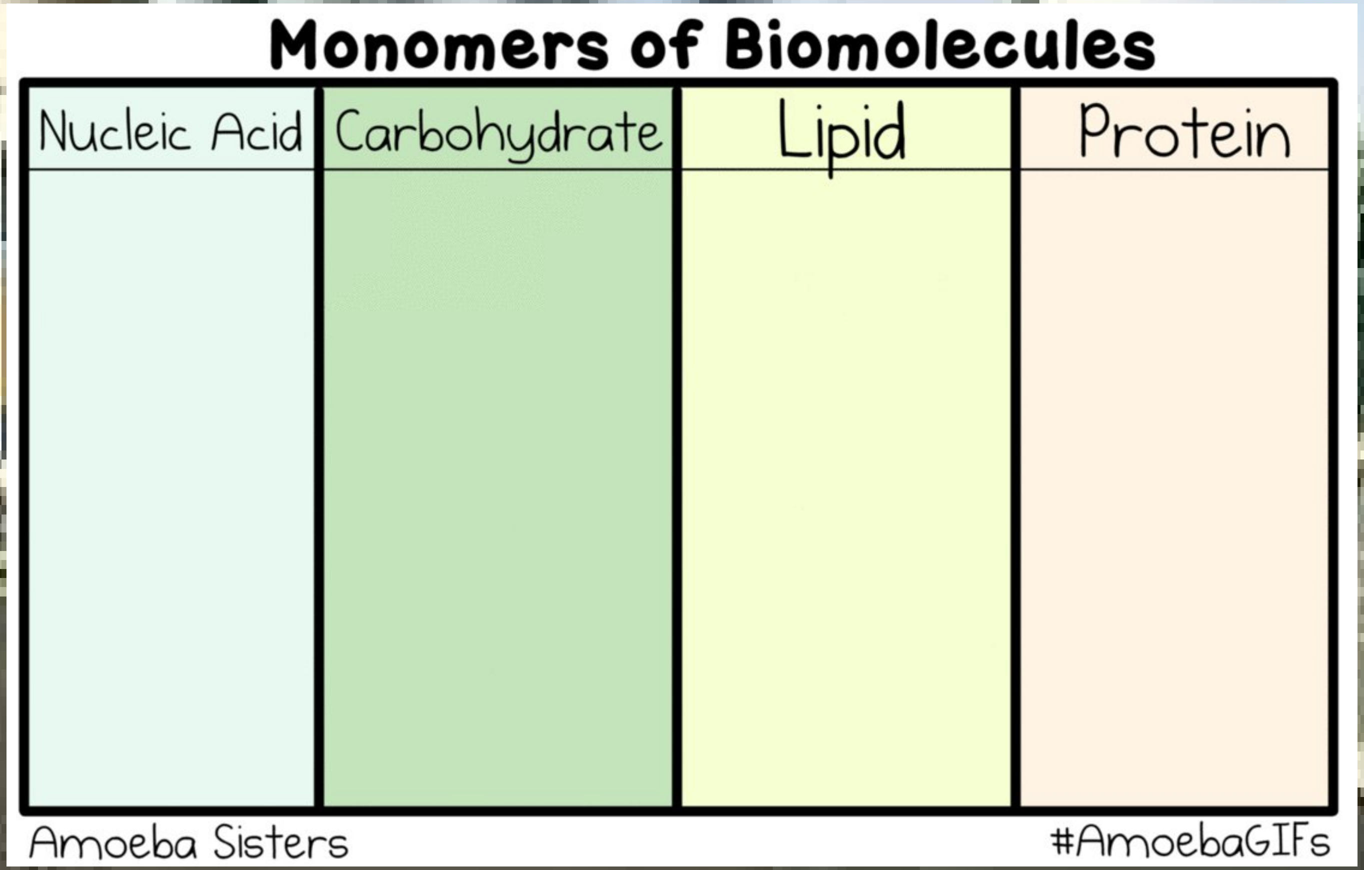
- It is majorly focused on cancer, infectious diseases, heart disease, inadequate blood flow to limbs and arthritis.
- **Strategies for gene therapy**
- Directly infuse the gene into a person by viral-mediated transfer.
- The second one involves the use of living cells to deliver therapeutic transgenes into the body.



Muscle cells
Skin cells
Bone cells
Cartilage cells
Tissue regeneration
Cardiovascular disease treatment
Cardiac muscle cells
Nerve cells
Brain tissue
Brain disease treatment
Stem cells
Cell deficiency therapy
Pancreatic cells
Liver cells
Blood disease treatments
Blood cells
Cells of blood vessel walls
Donating or harvesting stem cells
Bone marrow
Peripheral stem cells
Umbilical cord blood

BIOMOLECULES

- Biomolecules are biological molecules produced by the cells of the living organism. They are critical for life as it help organisms to carry out basic biological processes.
- Biomolecules are the most essential organic molecules, which are involved in the maintenance and metabolic processes of living organisms.
- The large molecules necessary for life that are built from smaller organic molecules are called biological macromolecules.



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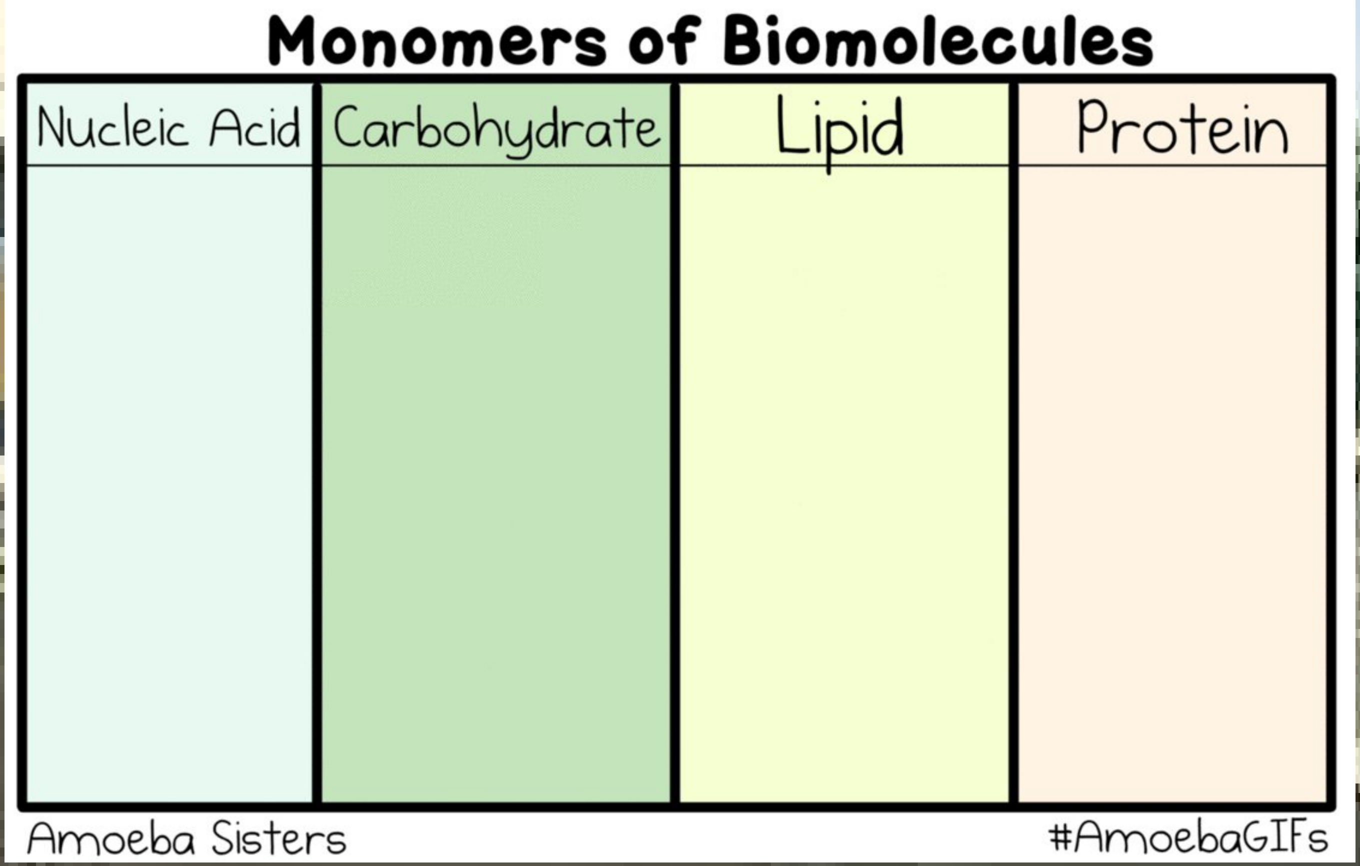
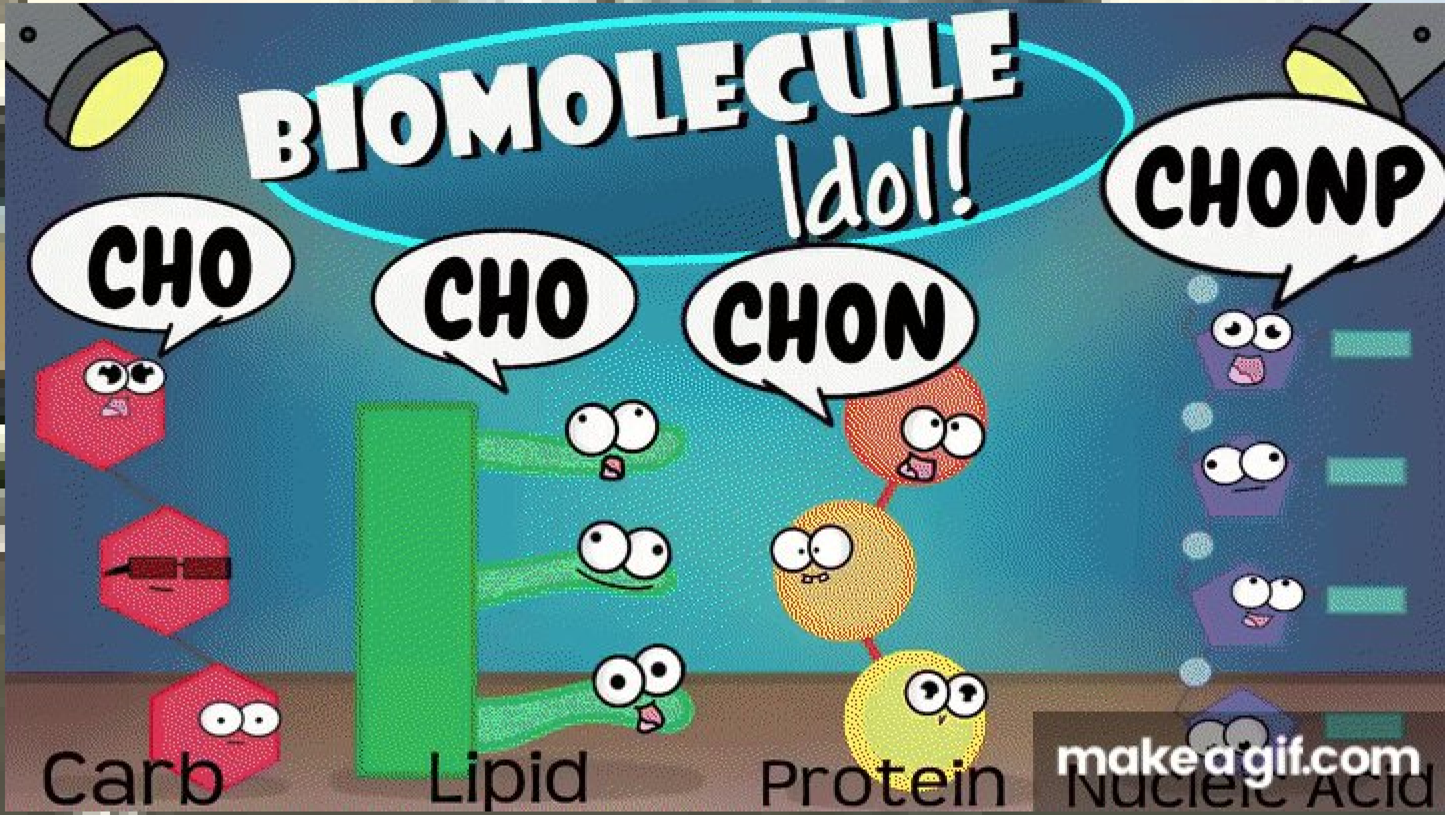
BIOMOLECULES

- **Biological macromolecule:** A large, organic molecule such as carbohydrates, lipids, proteins, and nucleic acids.
- **Monomer:** A molecule that is a building block for larger molecules (polymers). For example, an amino acid acts as the building blocks for proteins.
- **Polymer:** A large molecule made of repeating subunits (monomers). For example, a carbohydrate is a polymer that is made of repeating monosaccharides.



BIOMOLECULES

- There are four major classes of biological macromolecules **(carbohydrates, lipids, proteins, and nucleic acids),** and each is an important component of the cell and **performs a wide array of functions**.
- Combined, these molecules make up the majority of a cell's mass.
- Biological macromolecules are organic, meaning that they contain carbon. In addition, they may contain hydrogen, oxygen, nitrogen, phosphorus, sulfur, and additional minor elements.



BIOMOLECULES

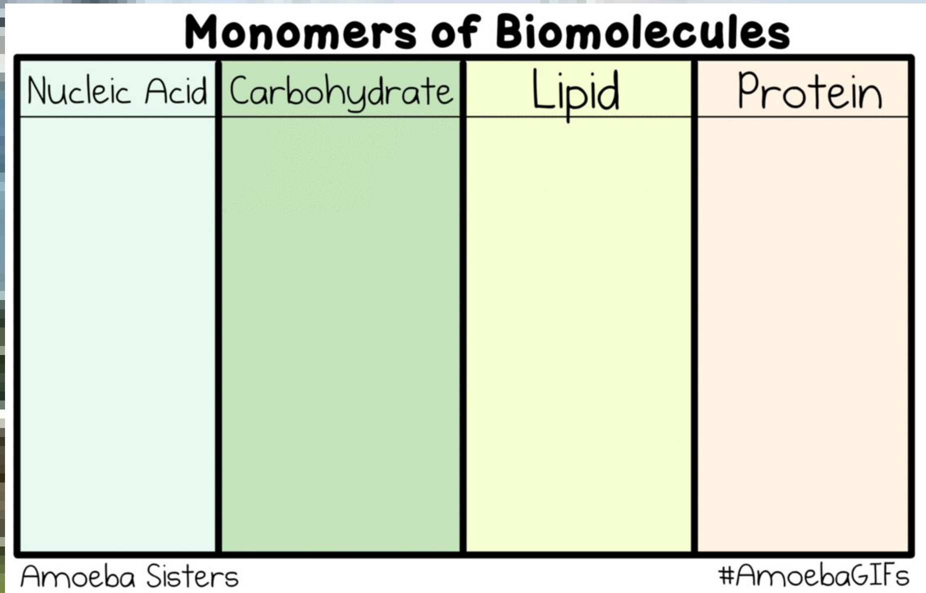
Biomolecules are the most essential organic molecules, which are involved in the maintenance and metabolic processes of living organisms.

- All Biomolecule contain CARBON
- Carbon is the most versatile and prominent element of life
- Other elements –
  - HYDROGEN(H)
  - OXYGEN(O)
  - NITROGEN (N)
  - SULPHUR (S)
  - SODIUM (Na)
  - CALCIUM (Ca)
  - MAGNESIUM (Mg)

BIOMOLECULES

INORGANIC

ORGANIC



These are very large molecules of many ATOMS covalently bonded

ENERGY is stored in the COVALENT BONDS. When we eat, we get ENERGY to lives because chemical reactions within our bodies break these bonds

CARBOHTDRATES

LIPIDS

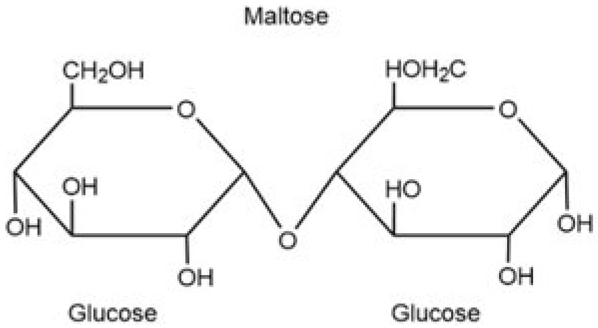
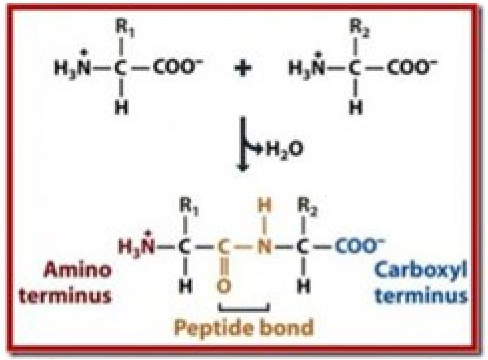
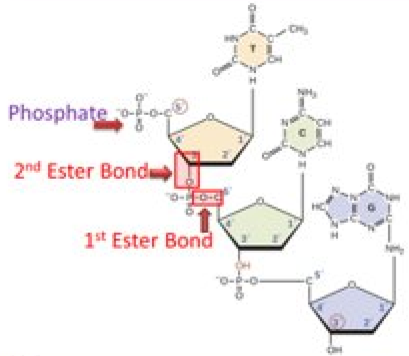
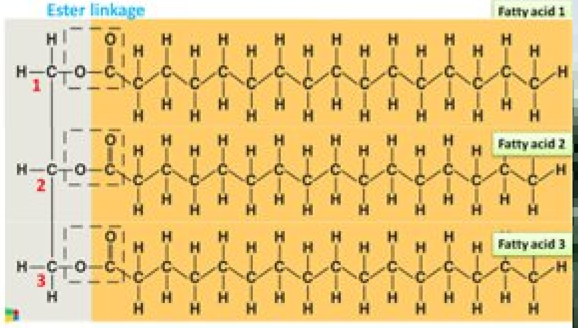
PROTEINS

NUCLEIC ACIDS

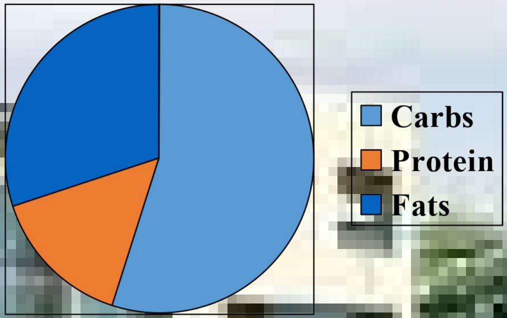
ENZYMES

VITAMINS

Biomolecules

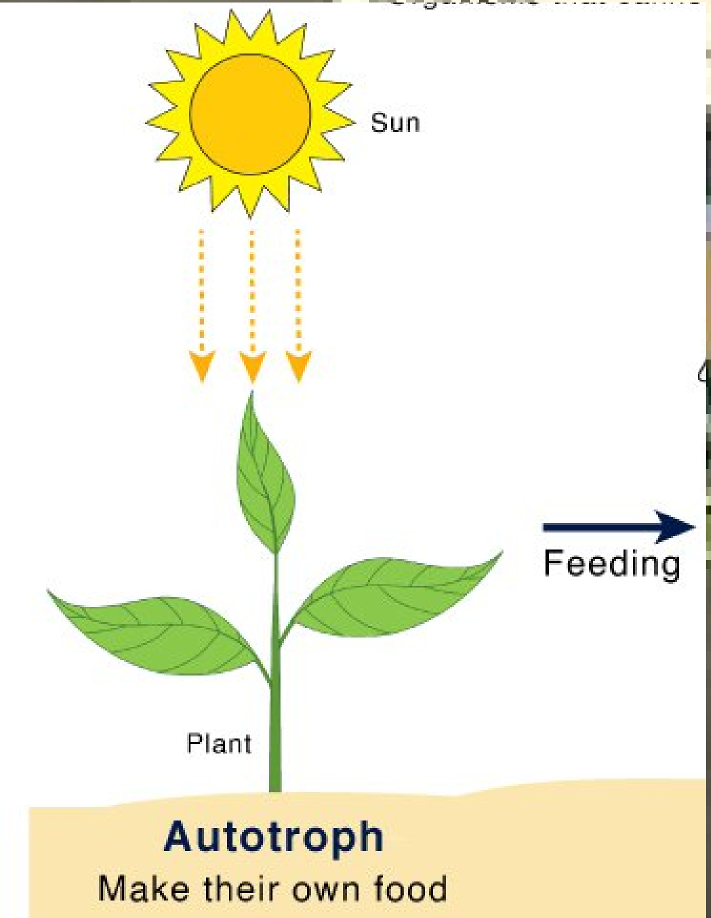
	Carbohydrates	Proteins	Nucleic acids	Lipids
				
Monomers	Monosaccharides joined by glyocosidic bond	Amino acids joined by peptide bond	Nucleotides joined by phosphodiester bond	Fatty acids and glycerol joined by ester bond
Examples	Starch, Cellulose	Insulin, Collagen	DNA, RNA	Fats, Oils, waxes
Elements	C,H,O	C,H,O,N, S	C,H,O,N,P	C,H,O
Functions	Energy source Structural component Reserve food	Enzyme, structure movement, defence hormones	Stores genetic information	energy source, insulation, membrane components, hormone

What are Carbohydrates?

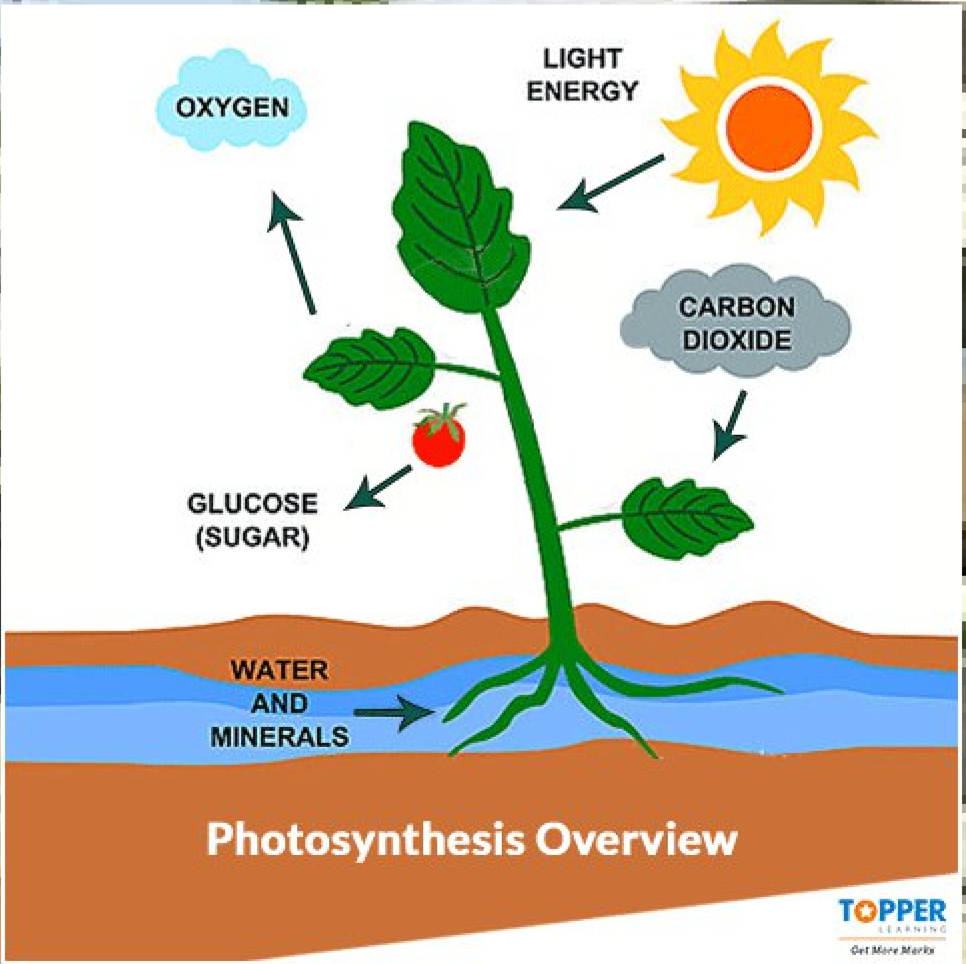


- Carbohydrates are organic **biomolecules abundantly present in nature.**
- Found in the **cells of plants and animals.**
- They are the **best source of fuel for the body**. Carbohydrates also help **to digest protein and fat.**

Animals and **Human beings cannot biosynthesize Carbohydrates** predominantly.



Photosynthesis.



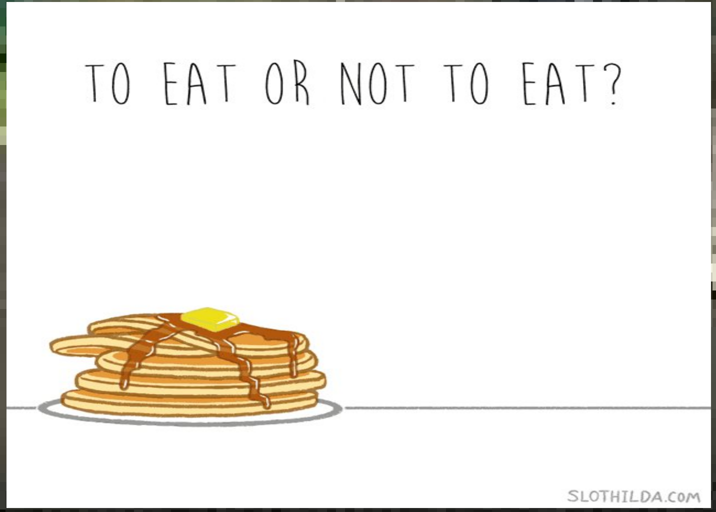
$$6CO_2 + 6H_2O \xrightarrow[\text{Sunlight}]{\text{Chlorophyll}} C_6H_{12}O_6 + 6O_2$$

Sugars (Simple carbohydrate)

Sugars $\rightleftharpoons$ **Starch or Cellulose**

Complex carbohydrates of plants

Plants predominantly biosynthesize carbohydrates through **photosynthesis**.

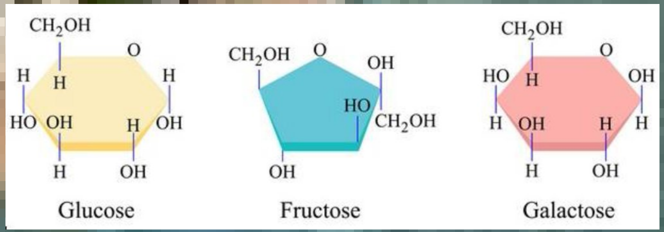


Carbohydrates

Simple sugars

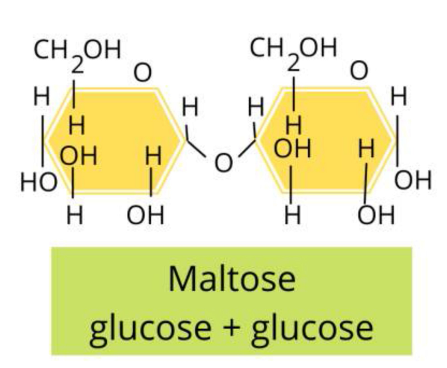
Monosaccharides

The simplest carbohydrates are termed simple sugars. The monosaccharides most commonly contain three to six carbon atoms in an unbranched single-bonded chain.



Disaccharides

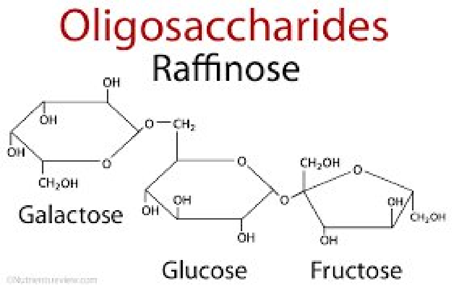
Two monosaccharides are joined by glycosidic linkage



Complex sugars

Oligosaccharides

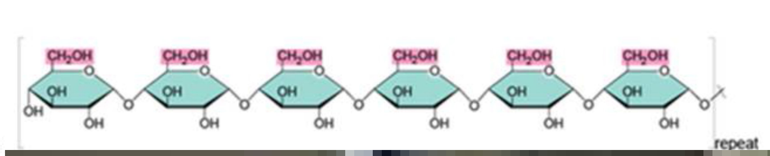
Carbohydrates that contain between 3 and 10 single sugar residues



raffinose, stachyose

Polysaccharides

long chains of carbohydrate molecules, composed of several smaller monosaccharides.



Starch

Cellulose

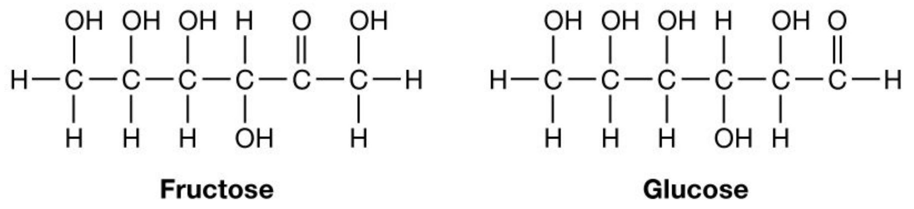
CARBOHYDRATES

- Plants are the primary producers of carbohydrates, which comprise a **large group of naturally occurring organic compounds**. Cane sugar, glucose, starch, etc are examples The majority of them have the general formula $C_xH_{2y}O_y$
- They were thought to be **carbon hydrates**, hence the name carbohydrate.
- The molecular formula of glucose $C_6H_{12}O_6$ hence fits into this general formula.

$$C_x(H_2O)_y$$

CARBOHYDRATES

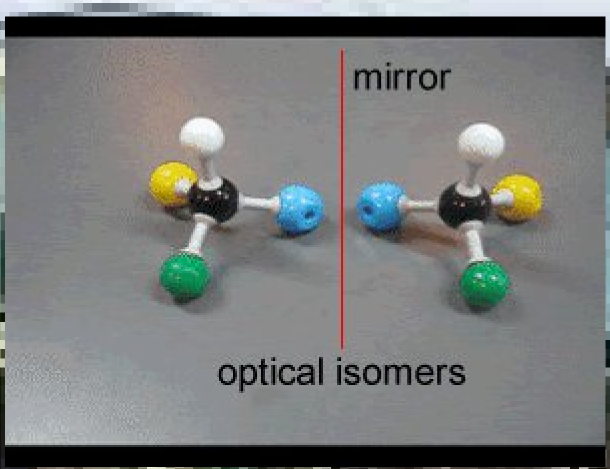
- Carbohydrates can be defined chemically as optically active polyhydroxy aldehydes or ketones, or compounds that produce such units upon hydrolysis.
- Some carbohydrates with a sweet taste are also known as sugars.
- Sucrose is the most common sugar found in our homes, whereas lactose is the sugar found in milk.



CARBOHYDRATES

Properties

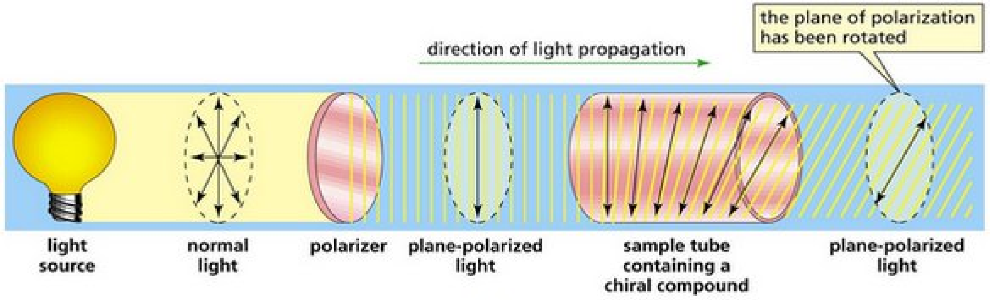
- **Isomerism:** Carbohydrates exhibit isomerism. They have the same molecular formula but different structural formulas. For example, glucose and fructose both have the formula C6H12O6, but their structures are different.
- **Solubility:** Most carbohydrates are soluble in water. The solubility is due to the presence of multiple hydroxyl (-OH) groups that can form hydrogen bonds with water.
- **Crystalline Structure:** Many carbohydrates, especially simple sugars, are crystalline solids at room temperature.
- **Chemical Reactions:** Carbohydrates undergo a variety of chemical reactions, including oxidation, reduction, and esterification.



CARBOHYDRATES

Properties

- **Energy Source:** Carbohydrates are a primary source of energy. They provide 4 kcal of energy per gram.
- **Optical Activity:** Due to the presence of asymmetric carbon atoms, carbohydrates exhibit optical activity. They can rotate the plane of polarized light either to the right (dextrorotatory) or to the left (levorotatory).
- **Presence of Functional Groups:** Carbohydrates contain multiple hydroxyl groups and at least one carbonyl group (either aldehyde or ketone).



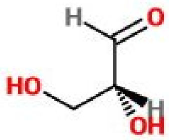


Fig 1

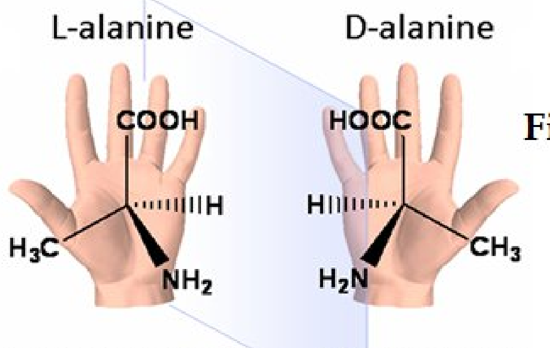
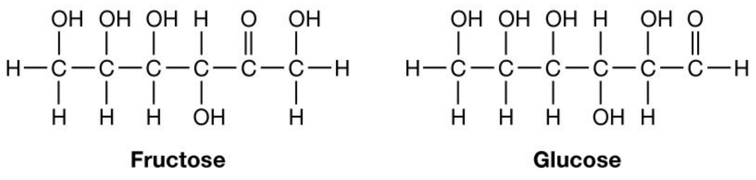


Fig 2



CARBOHYDRATES

Applications

- **Energy Supply:** Carbohydrates are the body's main source of energy. They are broken down into glucose, which can be used immediately or stored in the liver and muscles for later use.
- **Protein Sparing:** Carbohydrates help to protect the body's proteins. When there are enough carbohydrates, the body can use proteins for growth and repair rather than as an energy source.
- **Digestive Health:** Certain types of carbohydrates, known as dietary fiber, aid in digestion by adding bulk to the diet and helping to prevent constipation.
- **Disease Prevention:** Some types of carbohydrates, such as whole grains and dietary fiber, may help to reduce the risk of certain diseases, including heart disease and type 2 diabetes.
- **Energy Storage:** Excess glucose is converted and stored as glycogen in animals, primarily in the liver and muscles. Plants store excess glucose as starch in specialized storage organs.

CARBOHYDRATES

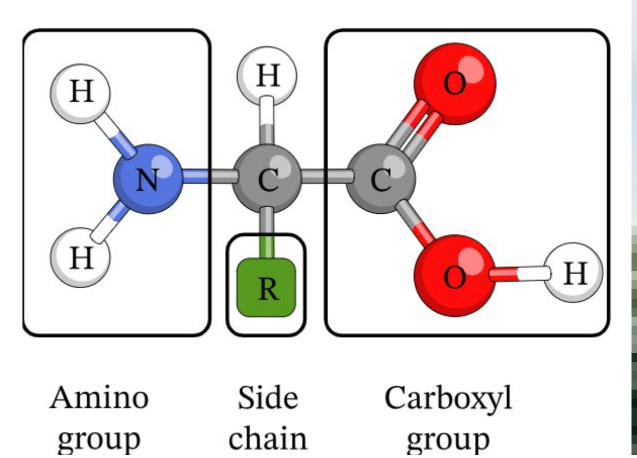
Applications

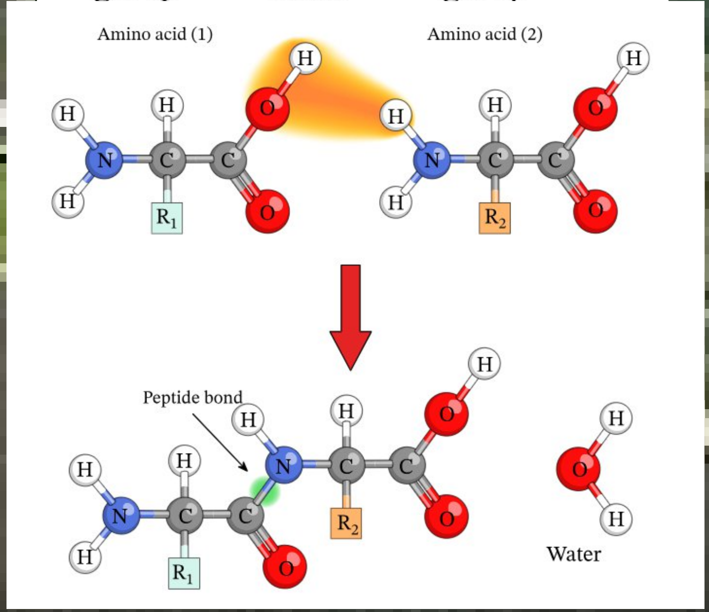
- **Structural Support:** Carbohydrates play a structural role in living organisms. In plants, cellulose provides structural support to cell walls, while chitin, a type of carbohydrate, is a major component of the exoskeleton of arthropods.
- **Cellular Recognition:** Carbohydrates on the surface of cells play a crucial role in cell-cell recognition and communication. They are involved in various cellular processes, including immune responses and cell signaling.
- **Dietary Fiber:** Certain carbohydrates, such as cellulose and pectin, are considered dietary fiber. Fiber is important for maintaining digestive health and can help prevent constipation.
- **Plant Structure:** Carbohydrates are essential for the structural integrity of plants. They provide rigidity to plant cells and help maintain the overall structure of the plant.

Proteins

- Proteins are polymers of amino acids that are linked covalently through peptide bonds.
- **Amino acid:** an organic compound containing both amino and carboxyl functional groups; they are the simplest units of proteins
- There are **20 different kinds of amino acids**, combined in different proportions and arrangements to build all protein molecules
- When **only two amino acids** combine by a peptide bond ,it is **called dipeptide**, when amino acids involved in the bond formation become 3, 4, 5 they are named as **tri-, tetra-, and penta- peptides respectively.**
- All proteins contain **carbon, hydrogen, oxygen, and nitrogen;** some proteins may also contain **sulfur phosphorous, copper, iron, zinc, iodine, and other elements**.

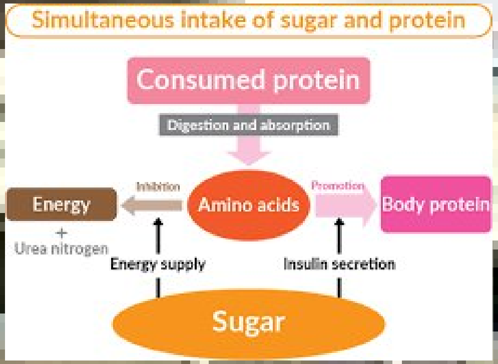
The presence of nitrogen in all proteins sets them apart from carbohydrates and lipids.

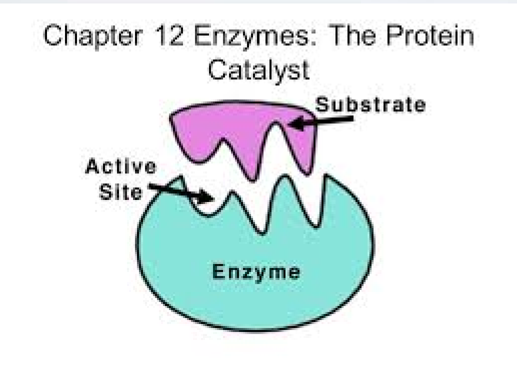


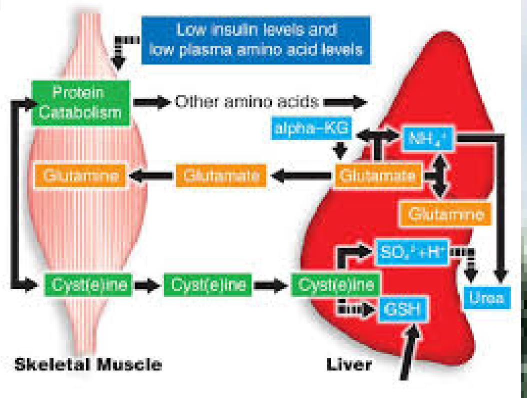


ATME College of Engineering

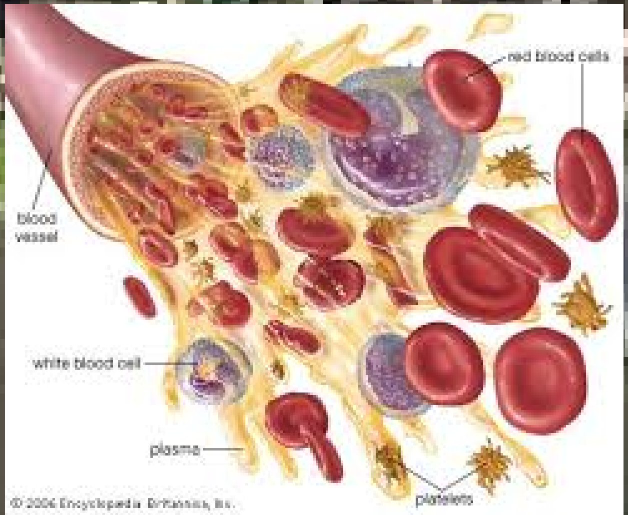
Function of Proteins







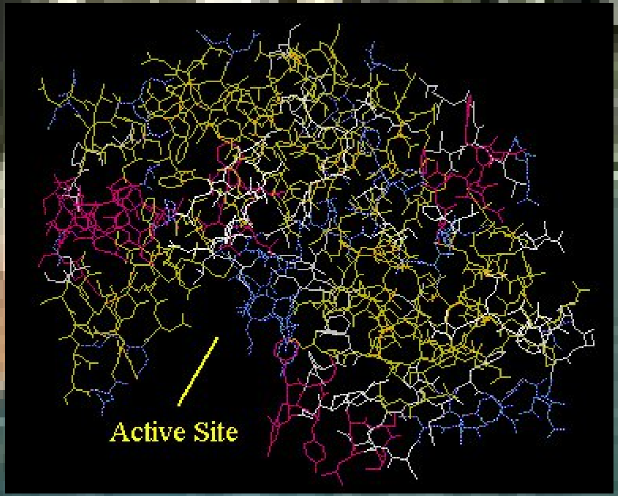
- Used to construct or **build our body**
- Catalyze biochemical reactions as an enzyme
- Regulate body metabolism as hormones
- Protect our body from foreign body attack as an antibody
- Maintain osmotic pressure in plasma
- Transport different lipids, minerals, hormones, vitamins etc as hemoglobin, apolipoprotein, albumin etc
- Assist to arrest bleeding and maintain homeostasis as coagulation factor

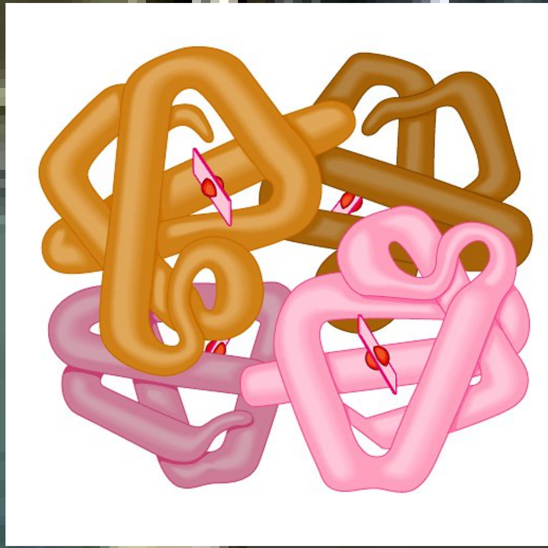


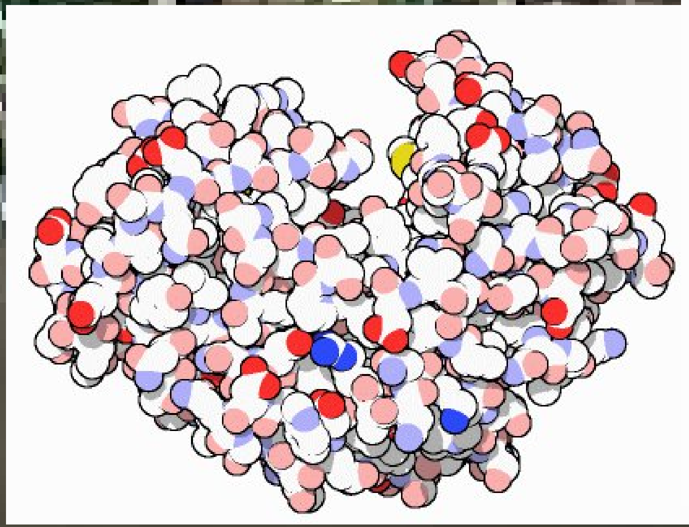
Structure of Proteins

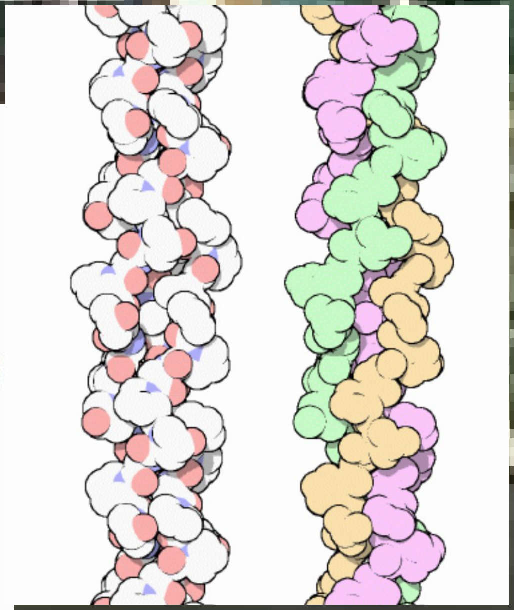
Function depends on structure

- 3-D structure
- twisted, folded, coiled into unique shape



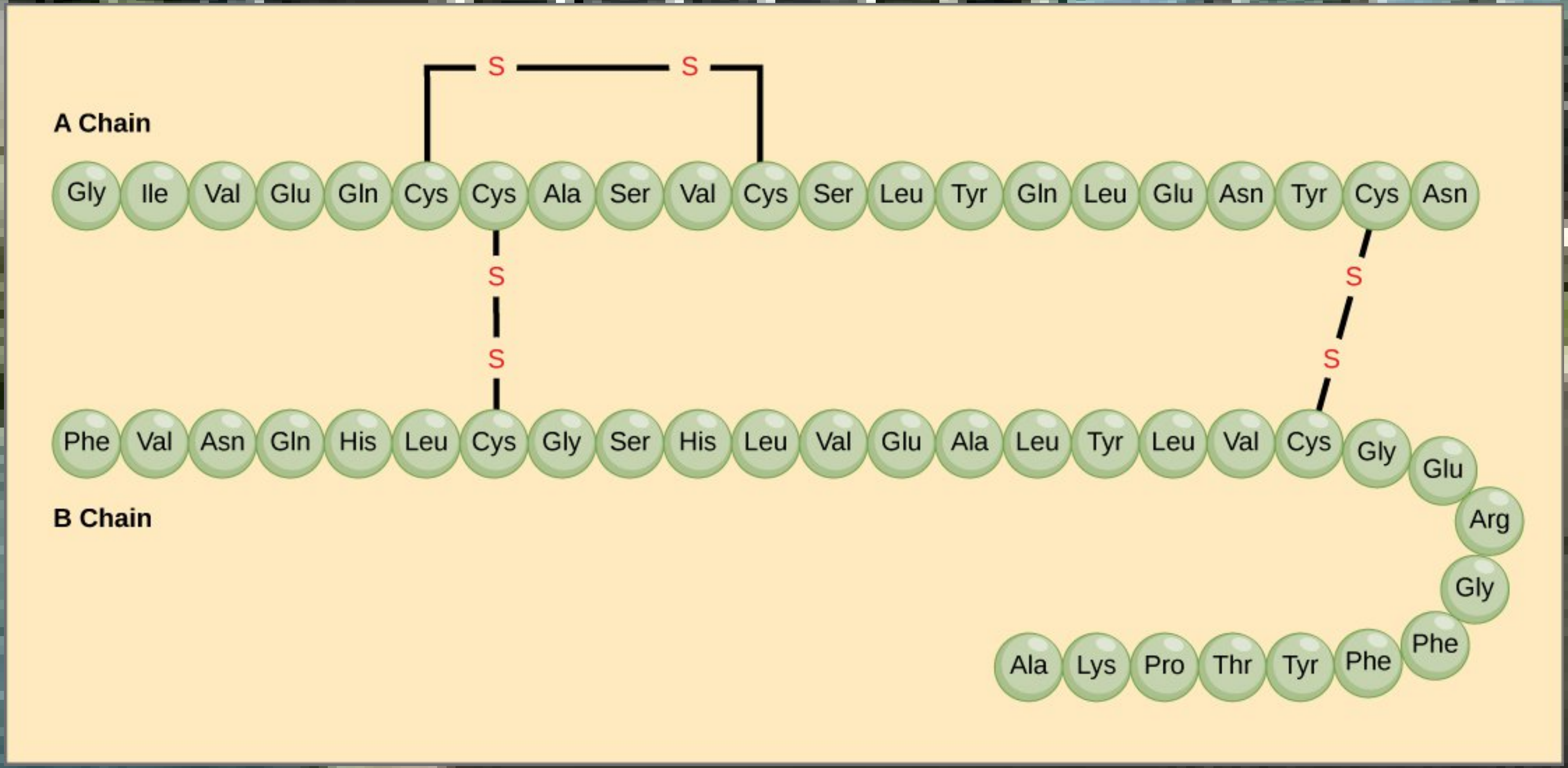






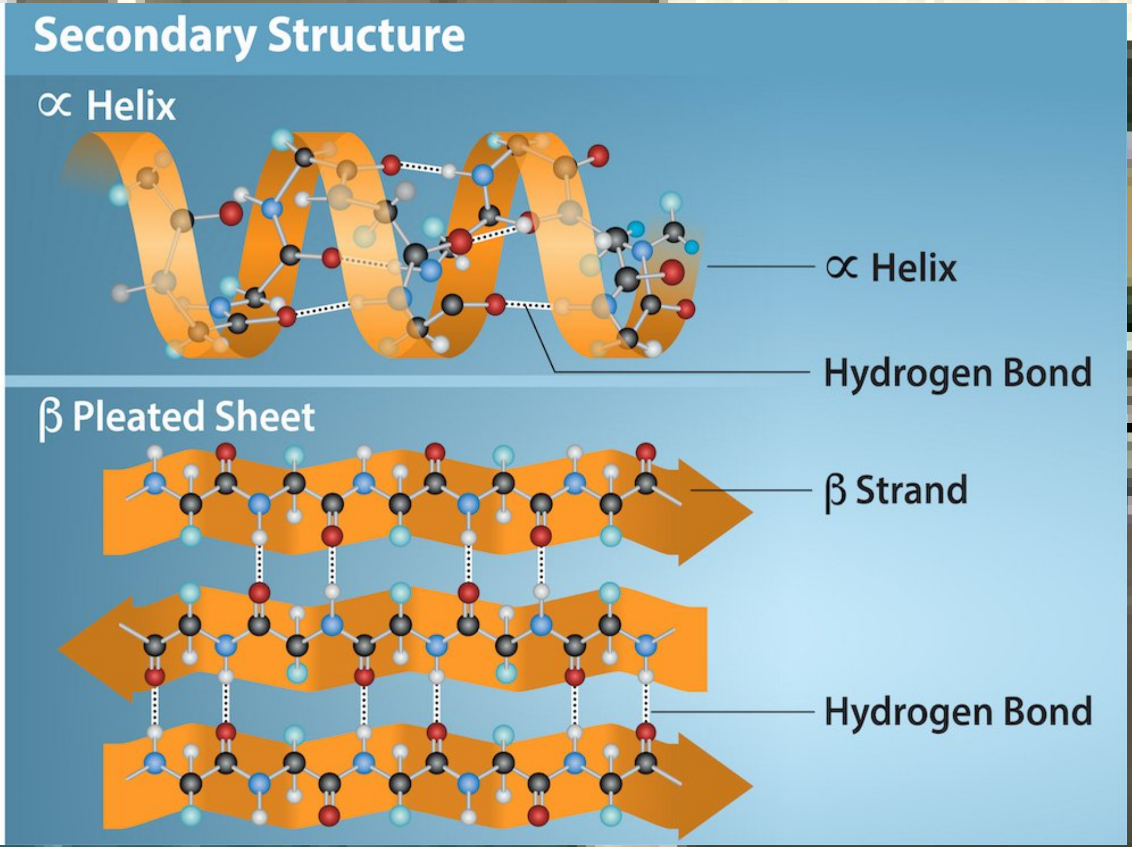
Primary (1°) structure

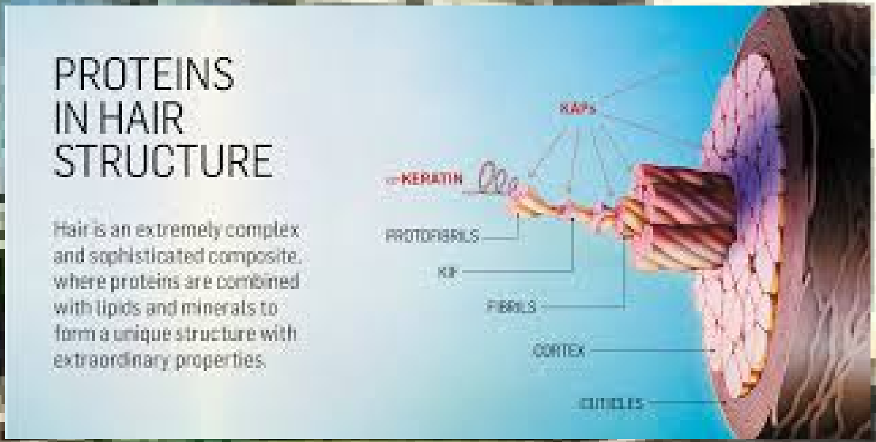
- Amino acids' unique sequence in a polypeptide chain is its primary structure.
- For example, the pancreatic hormone insulin has two polypeptide chains, A and B, and they are linked together by disulfide bonds.



Secondary (2°) structure

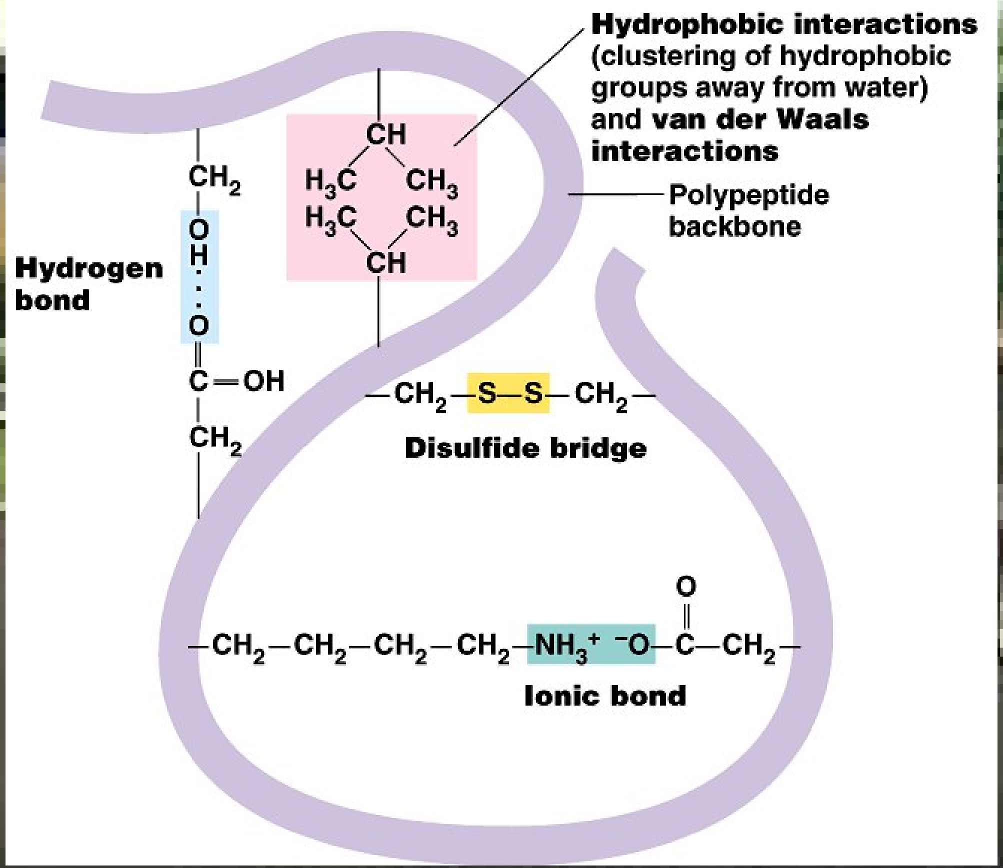
- The local folding of the polypeptide in some regions gives rise to the secondary structure of the protein. The most common are the α-helix and β-pleated sheet structures





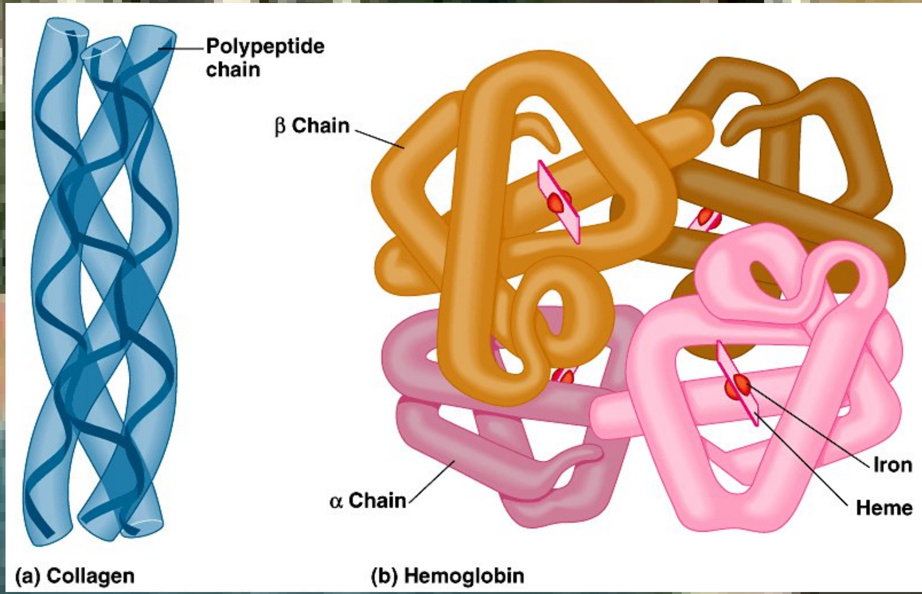
Tertiary (3°) structure

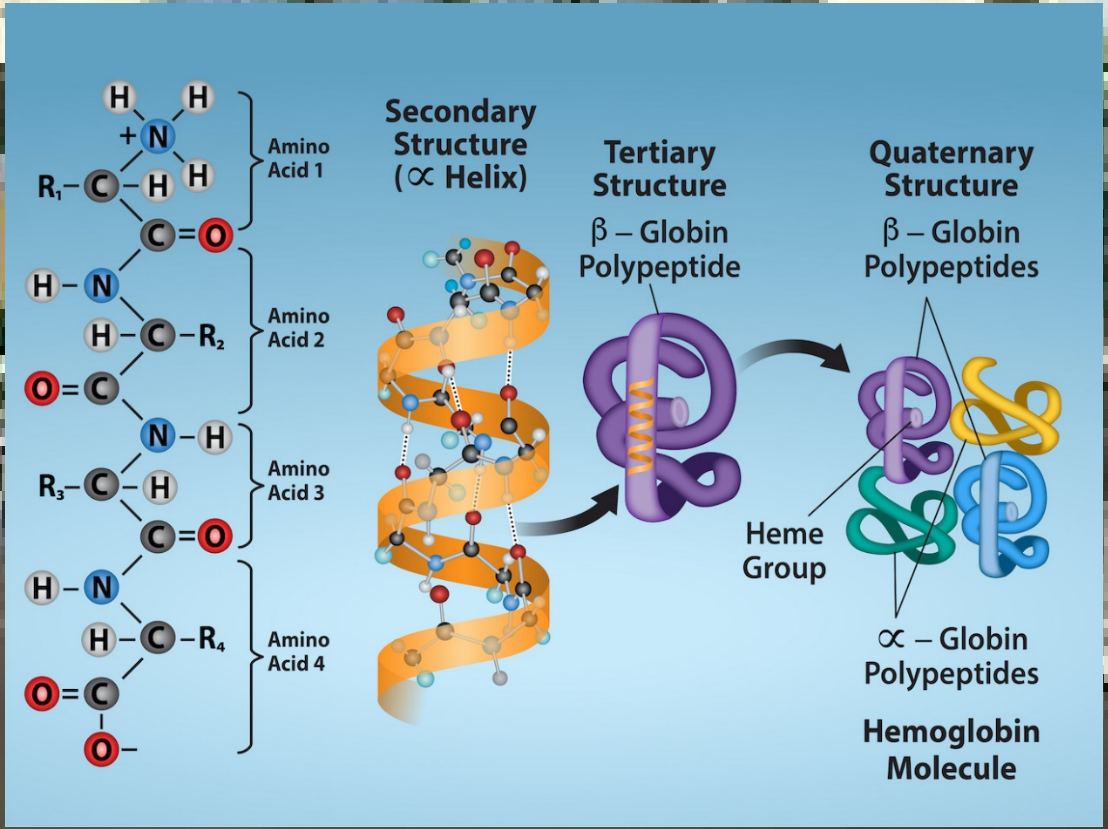
- “**Whole molecule folding**”
  - **created when the secondary structure fold and form bonds to stabilize the structure into a unique shape**
  - determined by interactions between R groups
    - Hydrophobic interactions
    - anchored by disulfide bridges
    - Ionic Bonds between R groups
    - Hydrogen bonds between backbones
    - Van der Waals Force



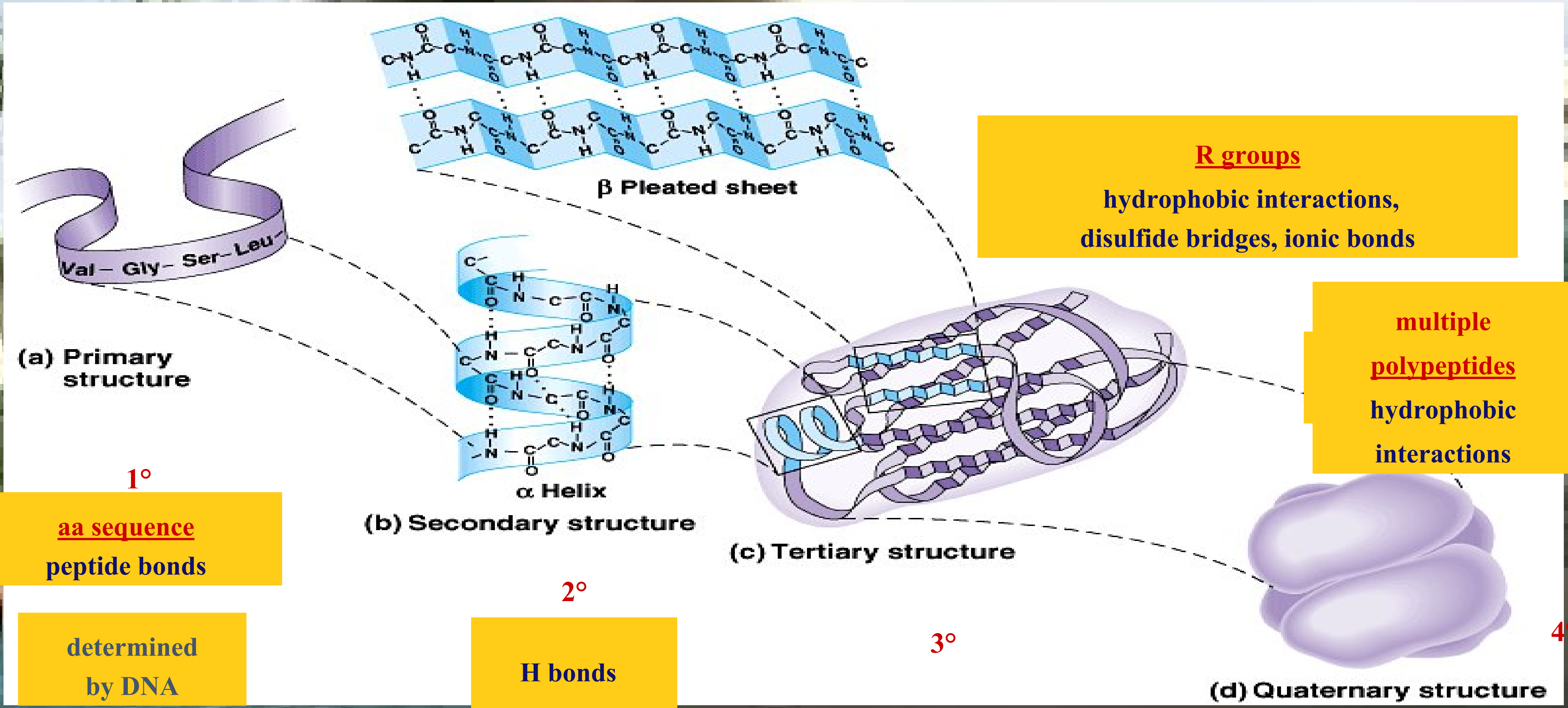
Quaternary (4°) structure

- Two or more tertiary folded peptide subunits bonded together to make a functional protein
  - Hemoglobin – 4 polypeptides
  - Collagen – 3 polypeptides





Protein structure (review)



1°

aa sequence
peptide bonds

determined by DNA

2°

H bonds

3°

R groups
hydrophobic interactions,
disulfide bridges, ionic bonds

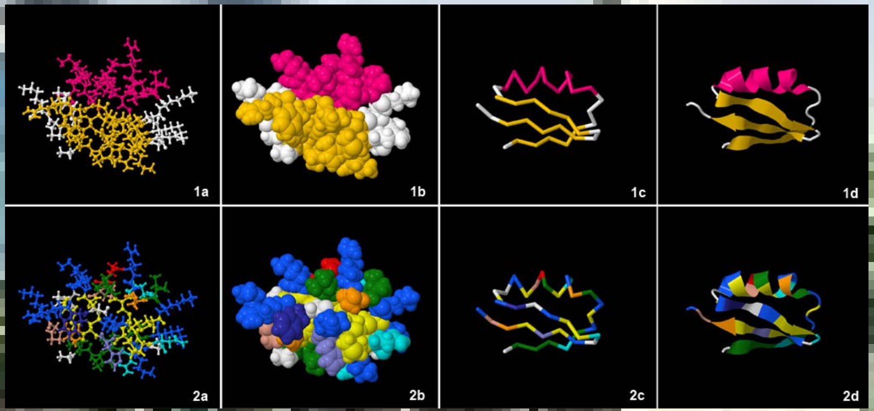
4°

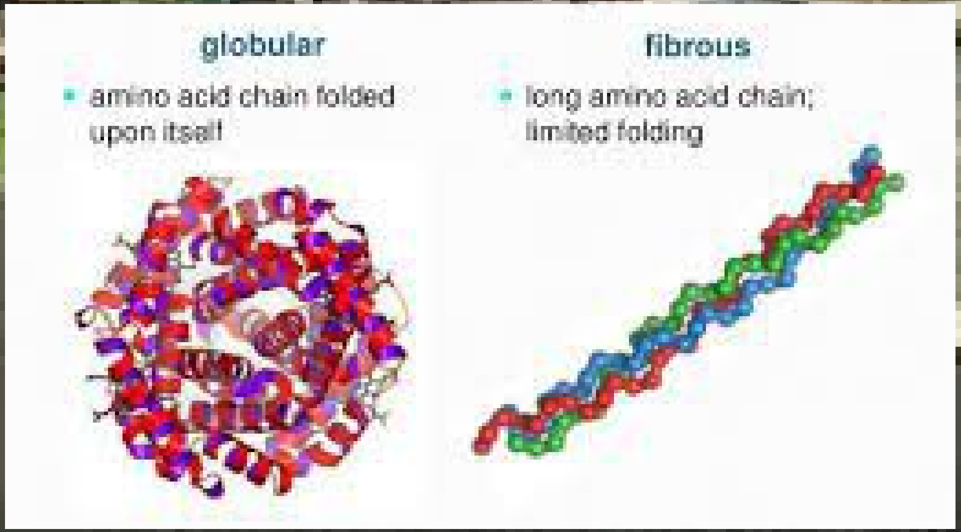
multiple polypeptides
hydrophobic interactions

PROTEINS

Properties

- **Colour and Taste:** Proteins are usually colorless and tasteless, homogeneous and crystalline.
- **Solubility:** Two general kinds of proteins are found in cells, water soluble and water insoluble proteins.
  - Water soluble proteins, which include enzymes and transport proteins, are found free in cellular compartments such as the cytoplasm, nucleus.
  - Water-insoluble proteins are proteins that are unable to form a solution with water, a polar solvent. These proteins are also known as scleroproteins, Fibrous proteins are insoluble in water.
  - **Shape and Size** : They range in shape from simple **crystalloid spherical** structures **to long fibrillar** structures. Two distinct shapes have been characterized.
  - **Globular proteins:** They are spherical in shape; examples of globular proteins include pepsin, insulin, and ribonuclease etc.
  - **Fibrillar proteins:** These are thread-like or ellipsoidal in shape. Examples of such proteins include fibrinogen, myosin etc





PROTEINS

Properties

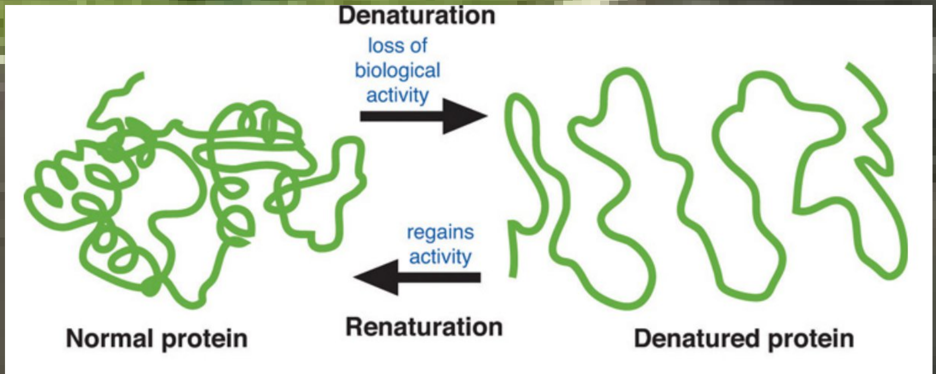
- **MW:** Proteins generally have very high molecular weights ranging between 5×10^3 and 1×10^6 daltons (Table).
- **Denaturation:** This is a process that involves the disruption of the secondary and tertiary structures of the protein, leading to the loss of biological activity. Denaturation is due to coagulation and forms precipitate.

Denaturation may be caused by a variety of agents, both physical and chemical.

- Physical agents include mechanical action, heat treatment, cooling and freezing operations, high hydrostatic pressures, rubbing, UV rays and ionizing radiations such as X-rays, radioactive and ultrasonic radiations, etc.
- Chemical agents include organic solvents (acetone, alcohol), aromatic anions (salicylates), some anionic detergents (such as sodium dodecyl sulfate), etc

Table 6–1 Molecular data on some proteins

	Molecular weight	Number of residues	Number of polypeptide chains
Insulin (bovine)	5,733	51	2
Cytochrome c (human)	13,000	104	1
Ribonuclease A (bovine pancreas)	13,700	124	1
Lysozyme (egg white)	13,930	129	1
Myoglobin (equine heart)	16,890	153	1
Chymotrypsin (bovine pancreas)	21,600	241	3
Chymotrypsinogen (bovine)	22,000	245	1
Hemoglobin (human)	64,500	574	4
Serum albumin (human)	68,500	~550	1
Hexokinase (yeast)	102,000	~800	2
Immunoglobulin G (human)	145,000	~1,320	4
RNA polymerase (*E. coli*)	450,000	~4,100	5
Apolipoprotein B (human)	513,000	4,536	1
Glutamate dehydrogenase (bovine liver)	1,000,000	~8,300	~40



PROTEINS

Functions

❑Enzymatic Activity:

- **Function:** Enzymes are proteins that catalyze biochemical reactions, increasing the rate of reactions without being consumed in the process.
- **Example:** **Amylase** – An enzyme found in saliva that helps break down ***starches into sugars*** during digestion.

❑Structural Support:

- **Function:** Structural proteins provide support and shape to cells and tissues
- **Example:** **Collagen** – A structural protein in connective tissues like ***skin, bones***, and tendons, providing strength and elasticity.

❑Transport and Storage:

- **Function:** Transport proteins carry substances throughout the body, while storage proteins store essential nutrients.
- **Example:** **Hemoglobin –** A transport protein in red blood cells that carries oxygen from the lungs to the rest of the body.
- Example: Ferritin – A storage protein that stores iron in the liver.

PROTEINS

Functions

Signaling:

- **Function:** Some proteins act as signaling molecules, helping cells communicate with each other.
- **Example:** **Insulin** – A hormone (protein) that regulates **blood glucose levels** by signaling cells to take up glucose.

Movement:

- **Function:** Motor proteins facilitate movement within cells.
- **Example:** **Myosin** – A motor protein involved in muscle contraction.

Immune Response:

- **Function:** Proteins play a crucial role in the immune system by identifying and neutralizing foreign invaders like bacteria and viruses.
- **Example:** **Antibodies (Immunoglobulins)** – Proteins that recognize and bind to specific antigens to neutralize or destroy them.

PROTEINS

Functions

Regulation:

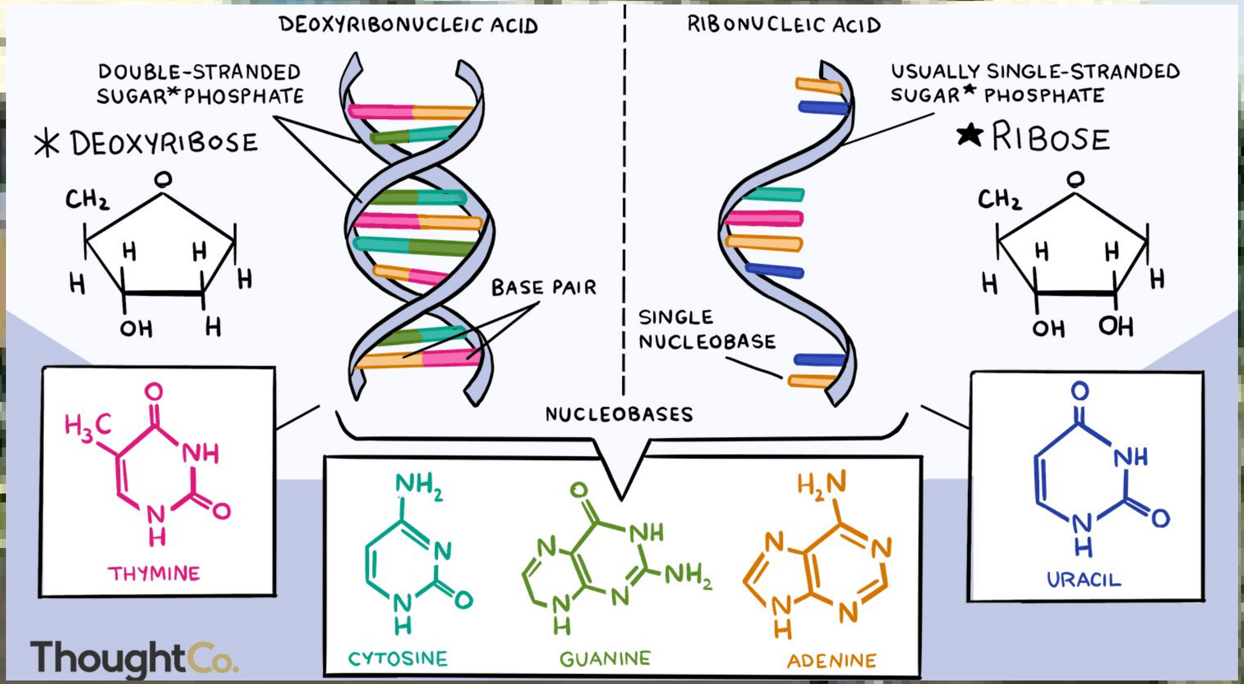
- **Function:** Regulatory proteins control various physiological processes, including gene expression and cell cycle regulation.
- **Example:** **Transcription Factors** – Proteins that regulate the transcription of genes by binding to specific DNA sequences.

Buffering:

- **Function:** Proteins help maintain pH balance within cells and body fluids.
- **Example:** **Albumin** – A protein in blood plasma that helps maintain pH and osmotic pressure.

NUCLEIC ACIDS

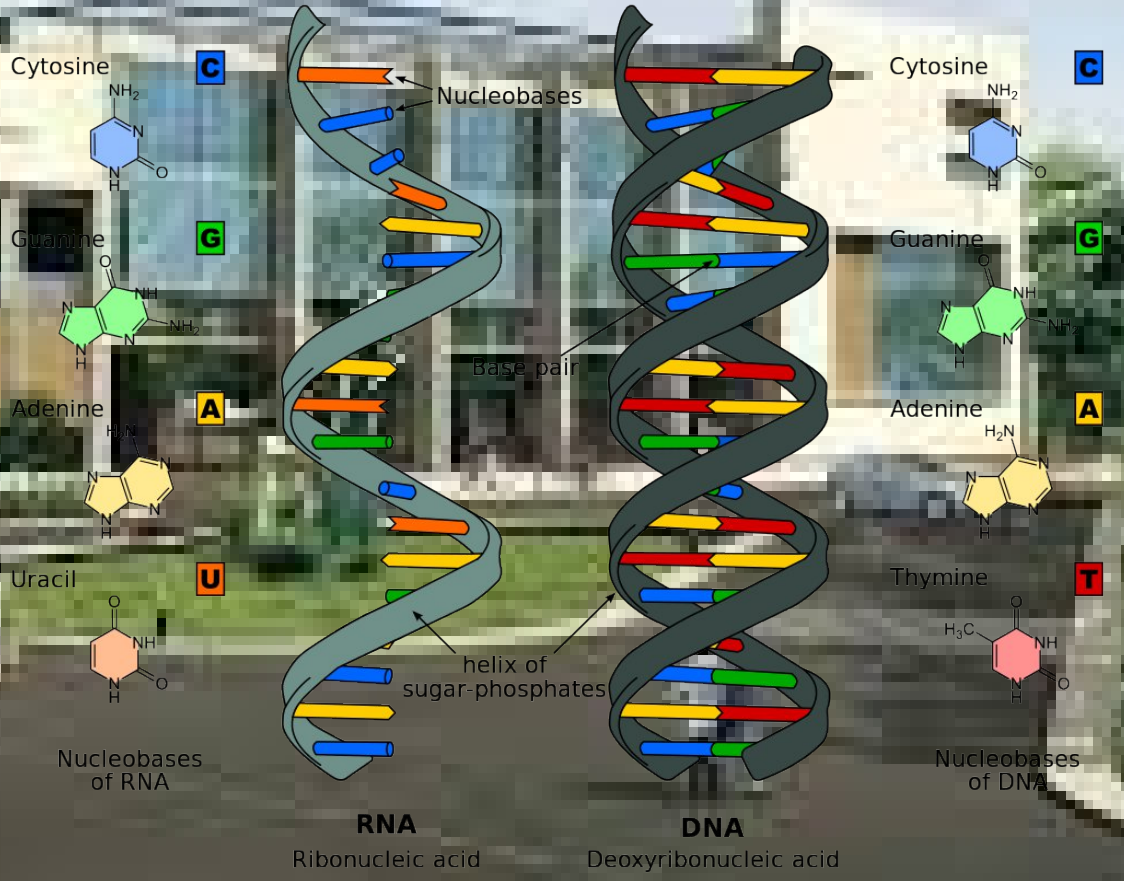
- Nucleic acids are large biomolecules that are found in all cells and viruses.
- They are composed of nucleotides, which are the monomer components: a **5-carbon sugar**, a **phosphate group**, and a **nitrogenous base**.
- A major function of nucleic acids involves the storage and expression of genomic information.
- The two main classes of nucleic acids are deoxyribonucleic acid (DNA) and ribonucleic acid (RNA).
- If the sugar is **ribose**, the polymer is RNA; if the sugar is **deoxyribose**, a variant of ribose, the polymer is DNA.



NUCLEIC ACIDS

Structure

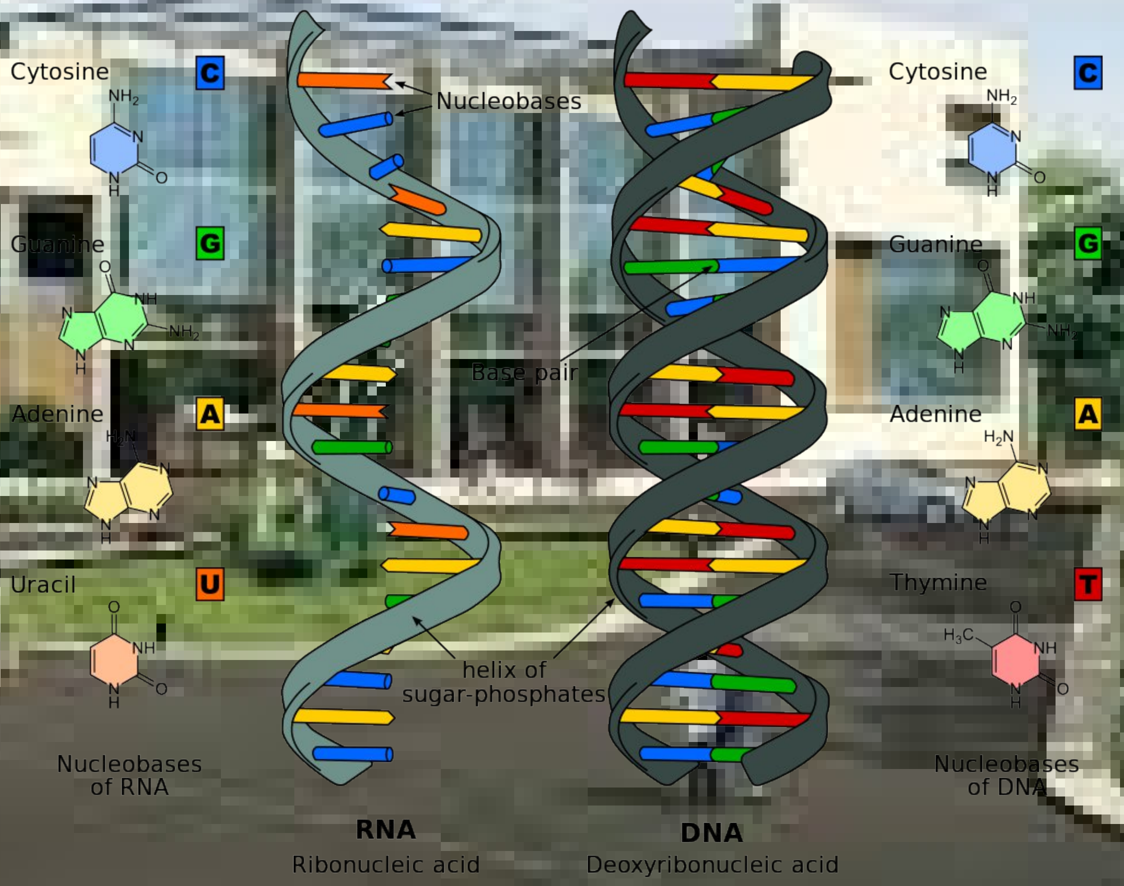
- Nucleic acids are **polynucleotides**—that is, long chainlike molecules composed of a series of nearly identical building blocks called **nucleotides.**
- Each nucleotide consists of a **nitrogen-containing aromatic base** attached to **a pentose (five-carbon) sugar,** which is in turn attached to **a phosphate group.**
- Each **nucleic acid** contains four of 5 nitrogen-containing bases: *adenine (A), guanine (G), cytosine (C), thymine (T), & uracil (U).*
- A and G are categorized as *purines*, and C, T, and U are collectively called *pyrimidines*. All nucleic acids contain the bases C, G, and A, T, however, is found only in DNA, while U is found in RNA.



NUCLEIC ACIDS

Structure

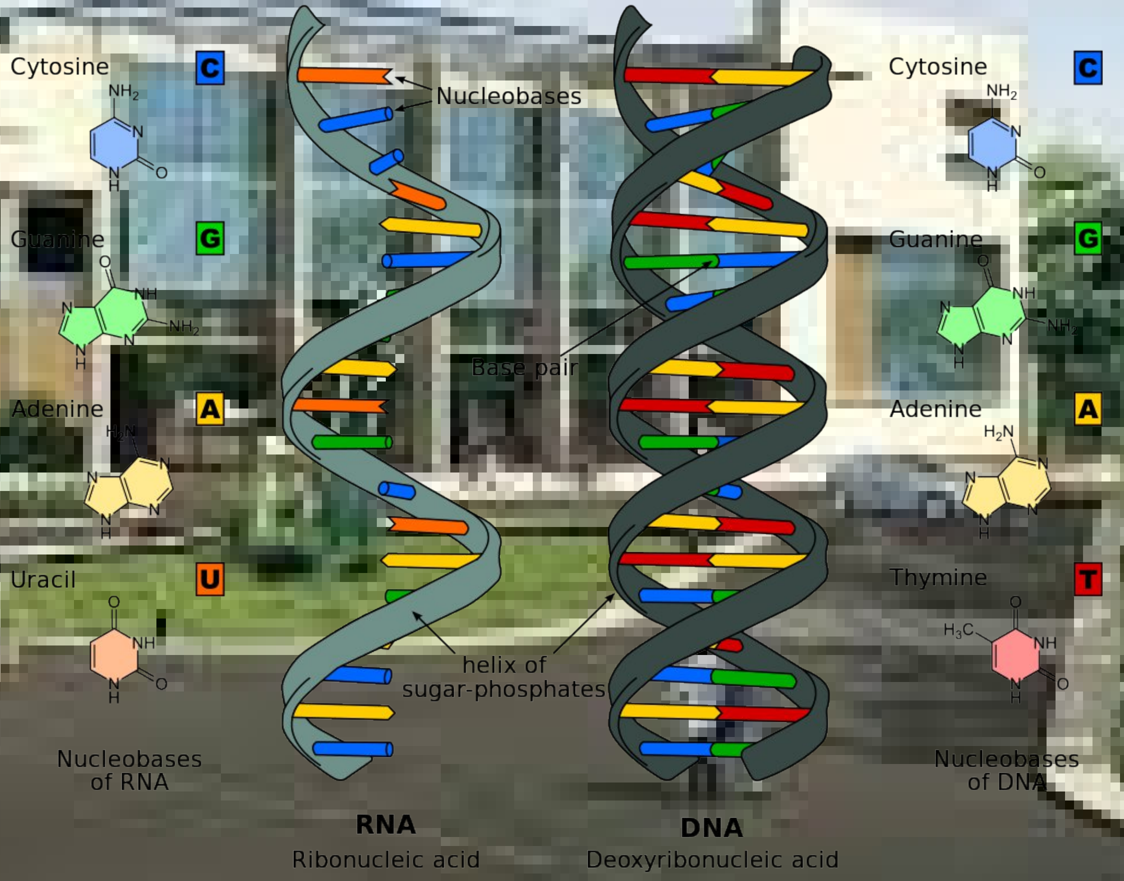
- One DNA or RNA molecule differs from another primarily in the sequence of nucleotides.
- Nucleotide sequences are of great importance in biology since they carry the ultimate instructions that encode all biological molecules, molecular assemblies, subcellular and cellular structures, organs, and organisms, and directly enable cognition, memory, and behavior.



NUCLEIC ACIDS

Structure

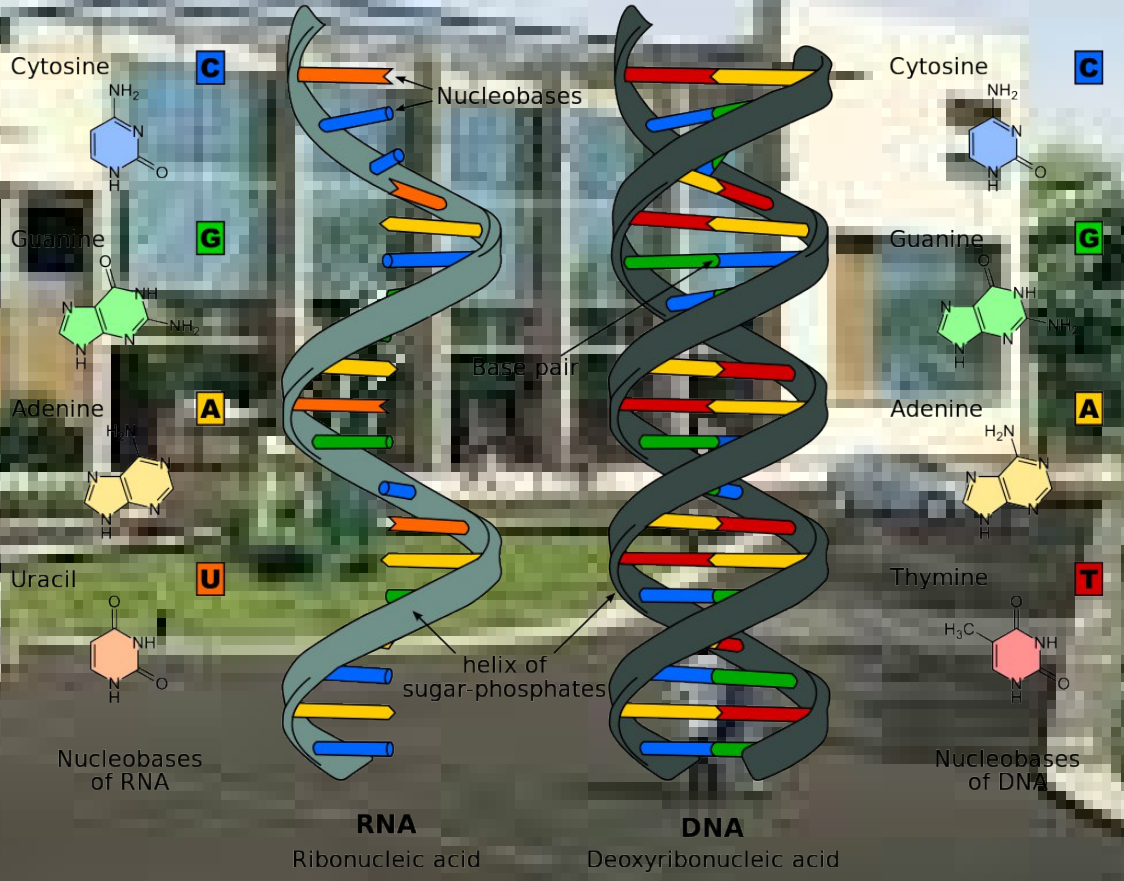
- **Deoxyribonucleic Acid (DNA)**
- Chemically, DNA is composed of a **pentose sugar, phosphoric acid** and some cyclic bases **containing nitrogen**.
- . The cyclic bases that have nitrogen in them are adenine **(A), guanine (G), cytosine(C) and thymine (T).**
- These bases and their arrangement in the molecules of DNA play an important role in the storage of information from one generation to the next one.
- DNA has a double-strand helical structure in which the strands are complementary to each other.



NUCLEIC ACIDS

Structure

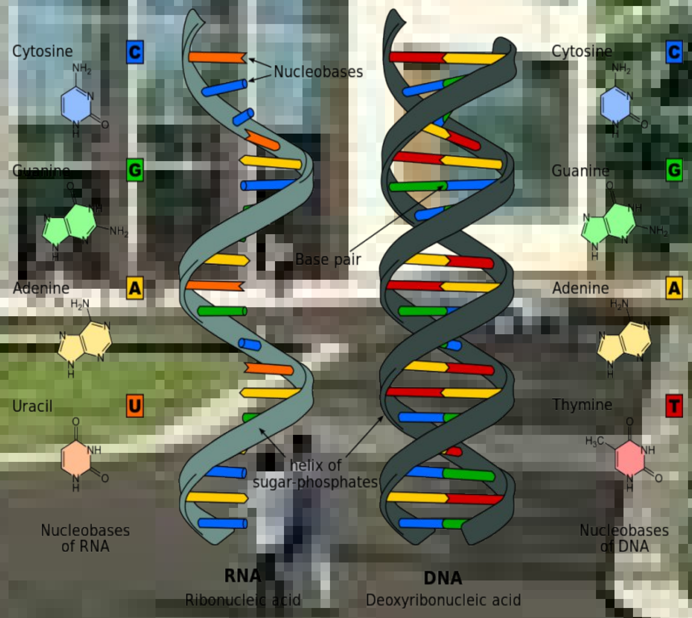
- ***Ribonucleic Acid (RNA):***
- *Chemically, RNA is composed of a* ***pentose sugar, phosphoric acid*** *and some cyclic bases* ***containing nitrogen****.*
- The heterocyclic bases present in RNA are adenine (A), guanine (G), cytosine(C) and uracil (U).
- In RNA the fourth base is different from that of DNA. The RNA generally consists of a single strand structure.



NUCLEIC ACIDS

Properties

- **Chemical Composition:**
- Each nucleic acid contains four of 5 nitrogen-containing bases: adenine (A), guanine (G), cytosine (C), thymine (T), & uracil (U).
- All nucleic acids contain the bases A, C, and G; T, however, is found only in DNA, while U is found in RNA.
- **Structure:**
- DNA: Typically a double-stranded helix with complementary base pairing (A-T and G-C) stabilized by hydrogen bonds. It has an antiparallel orientation, with the strands running in opposite directions.
- RNA: Usually single-stranded but can form complex secondary structures like hairpins and loops due to intramolecular base pairing.
- **Genetic Information Storage:**
- DNA: Stores genetic information in the sequence of its bases. It is the hereditary material in most organisms.
- RNA: Transfers genetic information from DNA to the ribosome for protein synthesis (mRNA), and also plays roles in regulation (miRNA, siRNA) and catalysis (rRNA, tRNA).



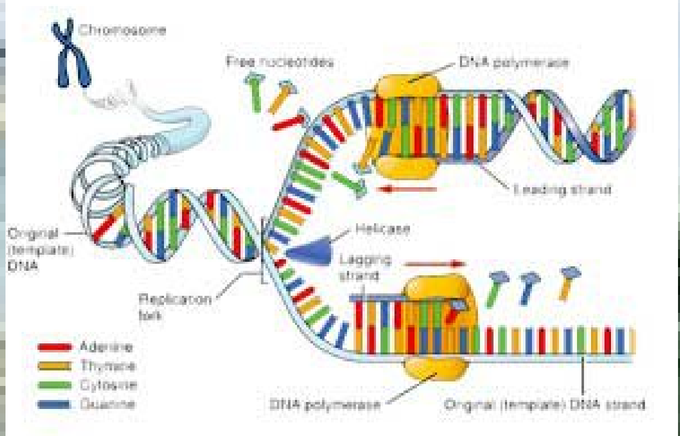
NUCLEIC ACIDS

Properties

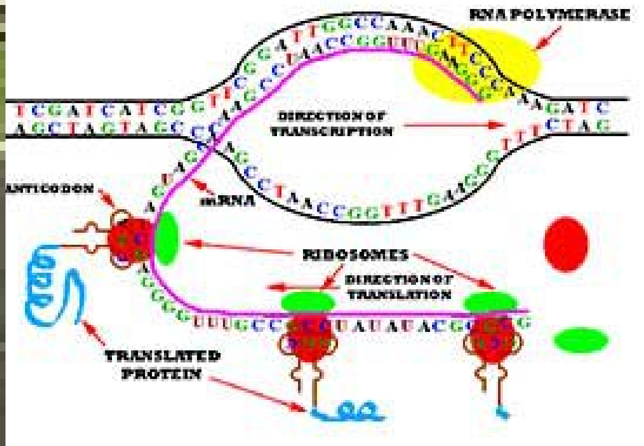
- **Replication and Transcription:**
- **Replication:** DNA can replicate itself through a **semi-conservative process**, ensuring each new cell receives an identical copy of genetic information.
- **Transcription:** DNA is transcribed into **RNA**, a process that involves the synthesis of RNA from a DNA template.
- **Stability:**
- DNA: More chemically stable due to the **lack of a hydroxyl group** at the 2' position of the deoxyribose sugar, making it less reactive.
- RNA: Less stable than DNA due to the presence of the **2'-hydroxyl group** in ribose, making it more susceptible to hydrolysis.

Physical Properties:

- **Viscosity:** DNA solutions are highly viscous due to the large size and polymeric nature of the DNA molecules.
- **Absorbance:** Both DNA and RNA absorb ultraviolet light with a peak at around 260 nm.



Replication



Transcription

NUCLEIC ACIDS

Functions

Storage of Genetic Information:

- **DNA:** The primary function of DNA is to store genetic information that determines the characteristics of an organism. This information is encoded in the sequence of nucleotide bases (adenine, thymine, cytosine, and guanine).

Transmission of Genetic Information:

- DNA Replication: DNA can replicate itself, ensuring that genetic information is passed from one cell generation to the next during cell division.
- Transcription: DNA is transcribed into messenger RNA (mRNA), which carries the genetic code from the DNA in the nucleus to the ribosomes in the cytoplasm.

Signaling:

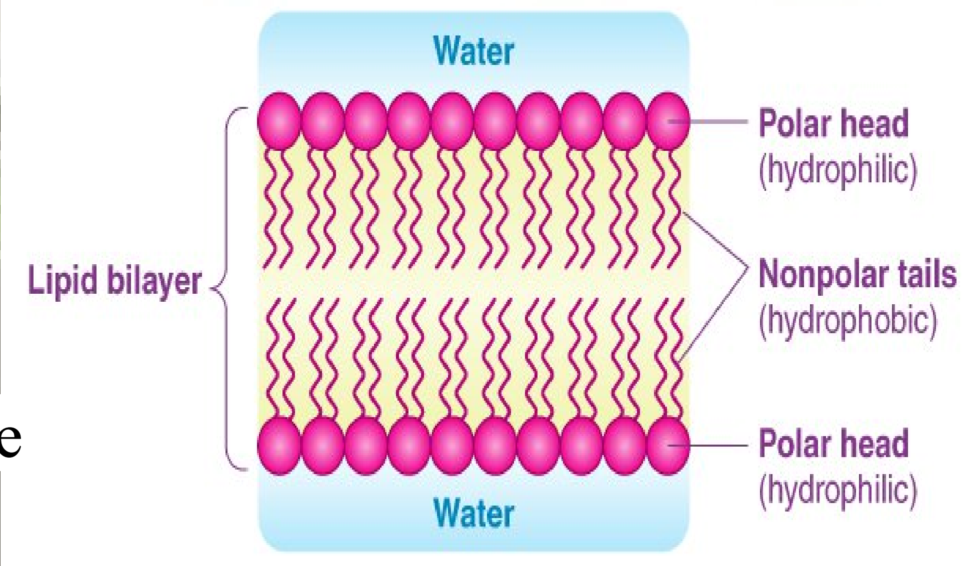
- **Second Messengers:** Some nucleotides, such as cyclic adenosine monophosphate (cAMP), act as second messengers in cellular signaling pathways, transmitting signals from cell surface receptors to target molecules inside the cell.

Maintenance of Genomic Integrity:

- **DNA Repair:** DNA repair mechanisms correct damage to the DNA, ensuring the integrity of the genetic information.
- Protect the ends of chromosomes from deterioration and prevent them from fusing with neighboring chromosomes.

LIPIDS

- “Lipids are organic compounds that contain hydrogen, carbon, and oxygen atoms, which form the framework for the structure and function of living cells.”
- These organic compounds are nonpolar molecules, which are soluble only in nonpolar solvents and insoluble in water because water is a polar molecule.
- Lipids are a family of organic compounds, composed of fats and oils.
- These molecules yield high energy and are responsible for different functions within the human body.



Saturated fat

Saturated fats occur naturally in many foods. Most come from animal sources, including meat and dairy products, as well as tropical fats like coconut, palm, and palm kernel.

Examples of saturated fats

- beef
- lamb
- pork
- poultry, especially with skin
- beef fat (tallow)
- cream
- butter

Unsaturated fat

An **unsaturated fat** is a fat or fatty acid in which there is at least one double bond within the fatty acid chain. A fatty acid chain is monounsaturated if it contains one double bond, and polyunsaturated if it contains more than one double bond.

Examples of unsaturated fats

- Olive, peanut, and canola oils.
- Avocados.
- Nuts such as almonds, hazelnuts
- Seeds such as pumpkin and sesame seeds.

Unsaturated Fats

Saturated fat vs Unsaturated fats

What are they?

Unhealthy fats

Why?

Too much saturated fat can increase LDL- cholesterol levels: the bad cholesterol that causes coronary heart disease.

How do I find them?

Saturated fats are solids at room temperature. They have no double bonds between the molecules.

What are they found in ?

- Meat
- Dairy products – butter, cream, cheese
- Baked goods
- Coconut oil
- Milk
- Cream

Healthier fats

Why?

Swapping saturated fats for unsaturated fats helps lower cholesterol levels.

How do I find them?

They are liquid at room temperature – olive oil. They have double bonds, which breaks up the hydrogen chains and create gaps. Hence they are liquids.

What are they found in ?

- Oily fish – salmon, mackerel
- Nuts and seeds – walnuts, cashews, almonds
- Vegetable oil – sunflower oil, olive oil, spreads
- Avocados

Properties of Lipids

- Lipids may be either liquids or non-crystalline solids at room temperature.
- Pure fats and oils are colourless, odourless, and tasteless.
- They are energy-rich organic molecules
- Insoluble in water
- Soluble in organic solvents like alcohol, chloroform, acetone, benzene, etc.
- No ionic charges

1. Hydrolysis of triglycerol's

Tri glycerol like any other esters react with water to form their carboxylic acid and alcohol– a process known as hydrolysis.

2. Saponification:

Triacylglycerols may be hydrolyzed by several procedures, the most common of which utilizes alkali or enzymes called lipases. Alkaline hydrolysis is termed saponification because one of the products of the hydrolysis is a soap, generally sodium or potassium salts of fatty acids.

3. Hydrogenation

The carbon-carbon double bonds in unsaturated fatty acids can be hydrogenated by reacting with hydrogen to produce saturated fatty acids.

4. Halogenation

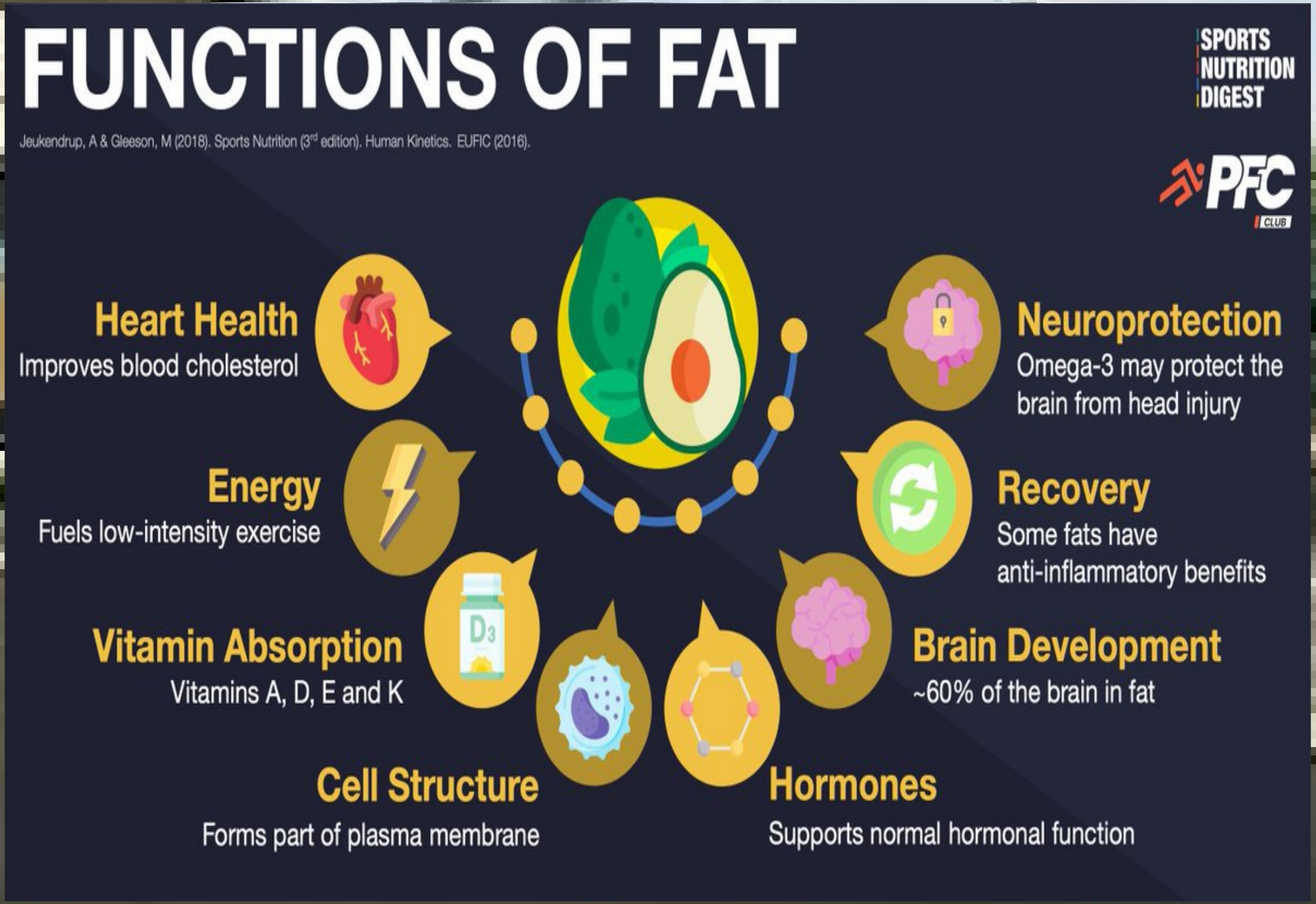
Unsaturated fatty acids, whether they are free or combined as esters in fats and oils, react with halogens by addition at the double bond(s). The reaction results in the decolorization of the halogen solution.

5. Rancidity:

The term rancid is applied to any fat or oil that develops a disagreeable odor. Hydrolysis and oxidation reactions are responsible for causing rancidity.

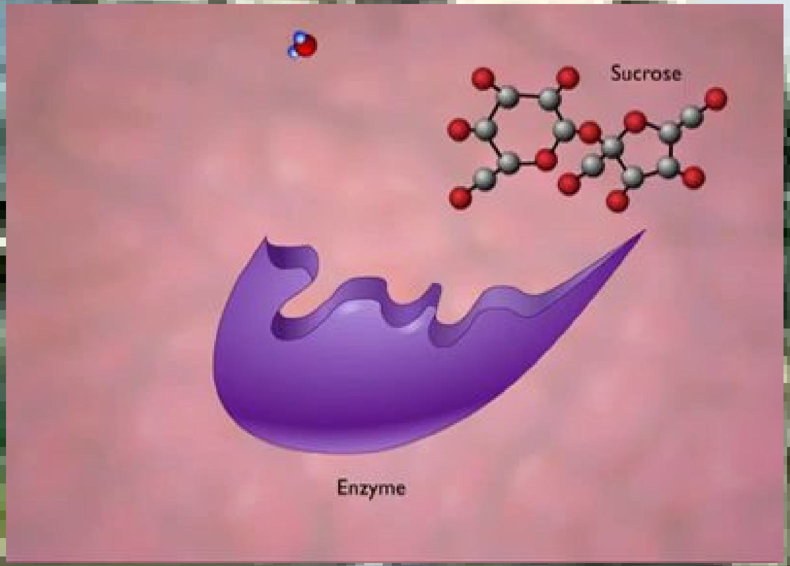
Functions of Fat

- Storing Energy
- Insulating and Protecting
- Regulating and Signaling
- Aiding Absorption and Increasing Bioavailability
- Contributing to the Smell, Taste, and Satiety of Foods
- Providing Essential Fatty Acids



Enzymes

- Enzymes are proteins that help speed up chemical reactions in our bodies.
- Enzymes are essential for digestion, liver function, and much more. Too much or too little of a certain enzyme can cause health problems
- Enzymes in our blood can also help healthcare providers check for injuries and diseases.
- They build some substances and break others down. All living things have enzymes.
- Our bodies naturally produce enzymes. But enzymes are also in manufactured products and food.



ENZYMES

- Enzymes are biological catalysts that accelerate biochemical reactions by lowering the activation energy required for the conversion of substrates into products.
- They are classified into six main classes:

1) **Oxidoreductases**: which catalyzes the oxidation-reduction reactions by transferring electrons between substrates.

2) **Transferases**: This facilitates the transfer of functional groups between substrates

3) **Hydrolases**: which catalyzes the hydrolysis reactions, breaking chemical bonds by adding water molecules.

4) **Lysaes**: which catalyzes the addition or removal of groups to double bonds or the cleavage of bonds without hydrolysis or oxidation-reduction.

5) **Isomerases**: catalyze the rearrangement of atoms within a molecule.

6) **Ligases**: which is also known as synthetases, catalyze the formation of bonds between molecules, often using energy from ATP hydrolysis.

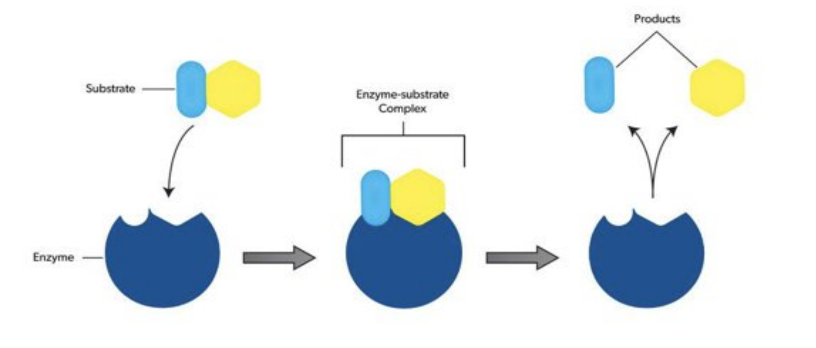


Fig 1. How an Enzyme Generally Works. Substrate binds to the enzyme's substrate binding site. This form an enzyme-substrate complex, allowing the chemical reaction to take place. The products of the reaction are then released.

Enzyme Class	Reaction Catalyzed	Example
Hydrolase	Hydrolysis (catabolic)	Lipase, protease
Isomerase	Rearrangement of atoms within a molecule	Phosphohexoisomerase
Lyase	Splitting chemicals into smaller parts without using water (catabolic)	Decarboxylases, aldolases
Oxidoreductase	Transfers electrons or hydrogen atoms from one molecule to another	Dehydrogenases, oxidases
Synthetases	Joining of two molecules by the formation of new bonds (anabolic)	DNA ligase, DNA polymerase
Transferase	Moving a functional group from one molecule to another	Kinases, transaminase

Properties of enzymes:

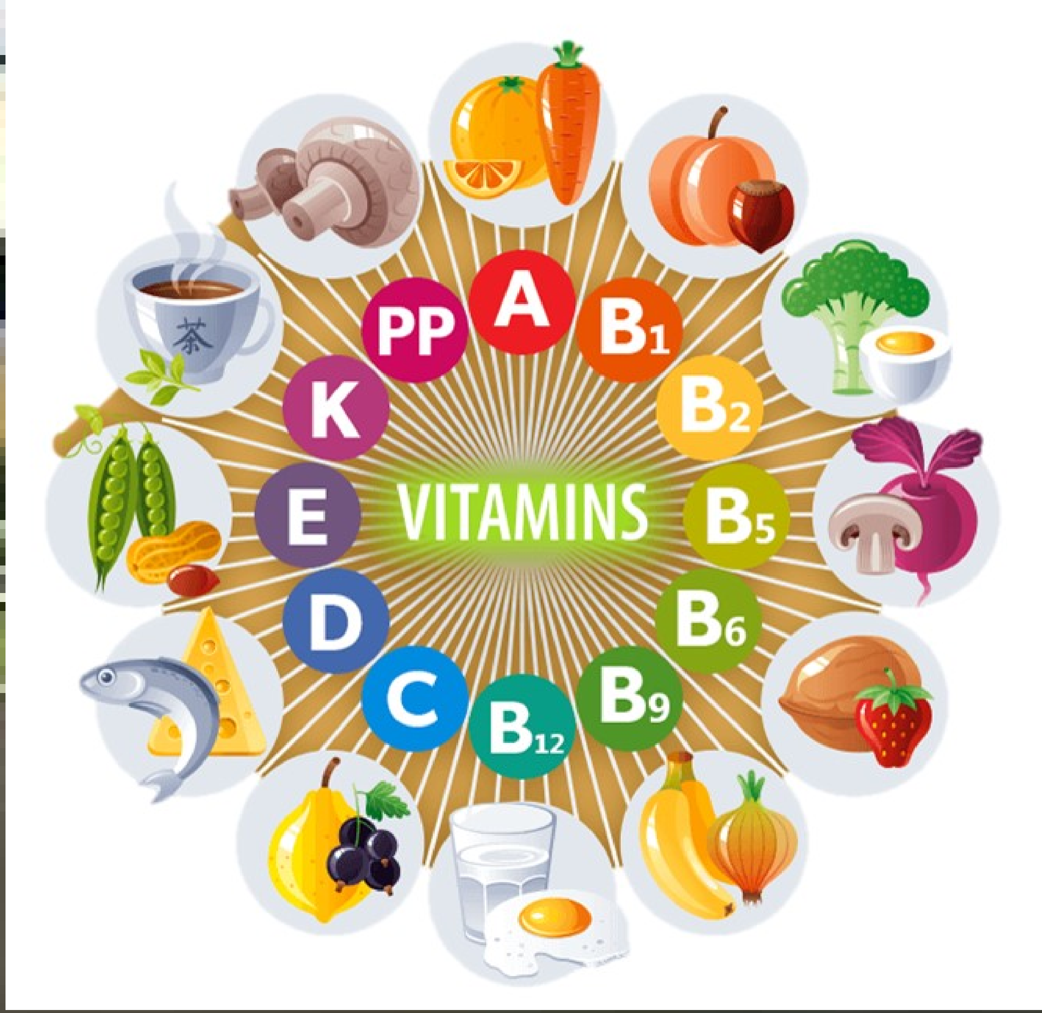
- **Specificity**: Enzymes are incredibly specific. Each enzyme has a unique shape that fits only with a particular molecule called its substrate, like a lock and key. This ensures only the intended reaction occurs.
- **Catalysis:** Enzymes speed up chemical reactions in cells by lowering the activation energy, the energy required to get the reaction going. This allows reactions to happen much faster than they would without enzymes, making life processes efficient.
- **Regulation:** Enzyme activity is often regulated to meet the needs of the cell. This can involve factors like substrate concentration, product concentration, and the presence of regulatory molecules.

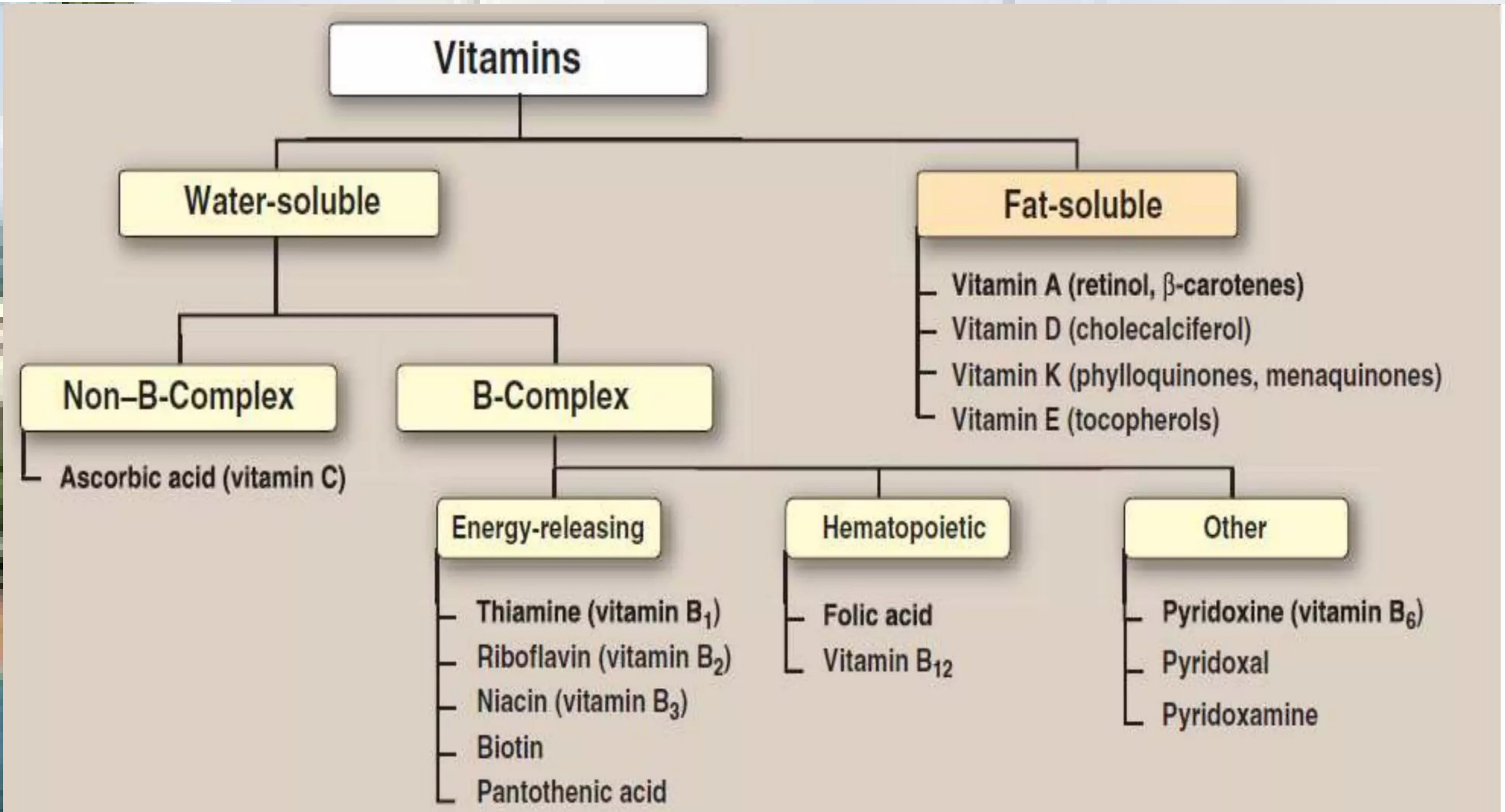
Functions of Enzymes

- **Metabolic Reactions**: Enzymes are essential for all metabolic pathways in cells. They break down large molecules into smaller ones for energy production.
- **Cellular Processes**: They play a role in various cellular processes like signal transduction, replication, and transport by facilitating specific chemical reactions.
- **Digestion**: Enzymes break down food molecules in the digestive system into components the body can absorb.
- **Blood Clotting and Immunity**: Enzymes are involved in blood clotting to prevent excessive bleeding and in immune responses to fight pathogens.
- **Temperature**: Enzymes have an optimal temperature range for function. Very high or low temperatures can denature (inactivate) them.
- **pH**: Enzymes also have a preferred pH level for activity. Large deviations from this can alter their shape and hinder function.

VITAMINS

- Vitamins and minerals are micronutrients required by the body to carry out a range of normal functions.
- However, these micronutrients are not produced in our bodies and must be derived from the food we eat.
- Vitamins are organic substances that are generally classified as either fat soluble or water soluble. Fat-soluble vitamins (vitamin A, vitamin D, vitamin E, and vitamin K) dissolve in fat and tend to accumulate in the body.
- Water-soluble vitamins (vitamin C and the B-complex vitamins, such as vitamin B6, vitamin B12, and folate) must dissolve in water before they can be absorbed by the body, and therefore cannot be stored. Any water-soluble vitamins unused by the body is primarily lost through urine.

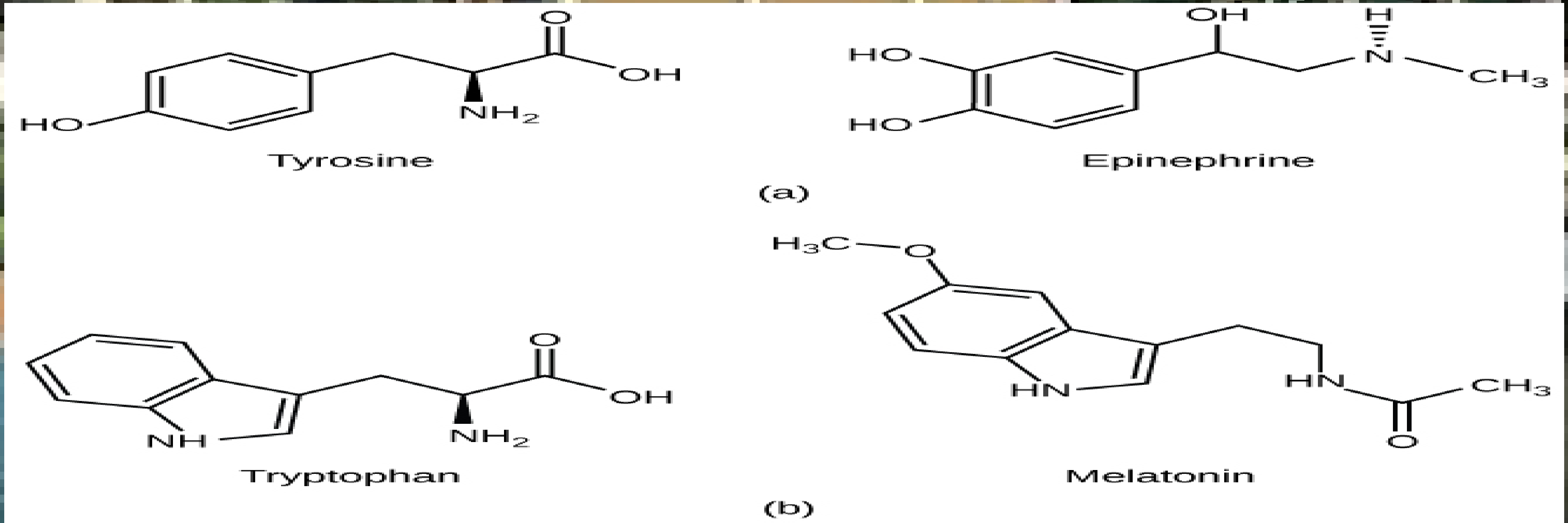



Vitamins
Water-soluble
Fat-soluble
Vitamin A (retinol, β-carotenes)
Vitamin D (cholecalciferol)
Vitamin K (phylloquinones, menaquinones)
Vitamin E (tocopherols)
Non–B-Complex
B-Complex
Ascorbic acid (vitamin C)
Energy-releasing
Hematopoietic
Other
Thiamine (vitamin B_1)
Riboflavin (vitamin B_2)
Niacin (vitamin B_3)
Biotin
Pantothenic acid
Folic acid
Vitamin B_{12}
Pyridoxine (vitamin B_6)
Pyridoxal
Pyridoxamine

Vitamin	Source	Function
A	Milk, butter, egg yolk, carrot, tomato, green vegetables	- night vision, -healthy skin
B	Yeast, eggs, liver	- Releases energy from carbohydrates - Healthy nervous system - Healthy skin - Formation of red blood cells
C	Fresh fruits and vegetables	- healing of wounds - resistance to disease
D	Butter, fish oils, eggs	- strong bones and teeth
E	Cereals, green vegetables	- May be needed for reproduction - Helps to fight against diseases
K	Milk, butter, egg yolk, carrot, tomato, green vegetables	- clotting of blood

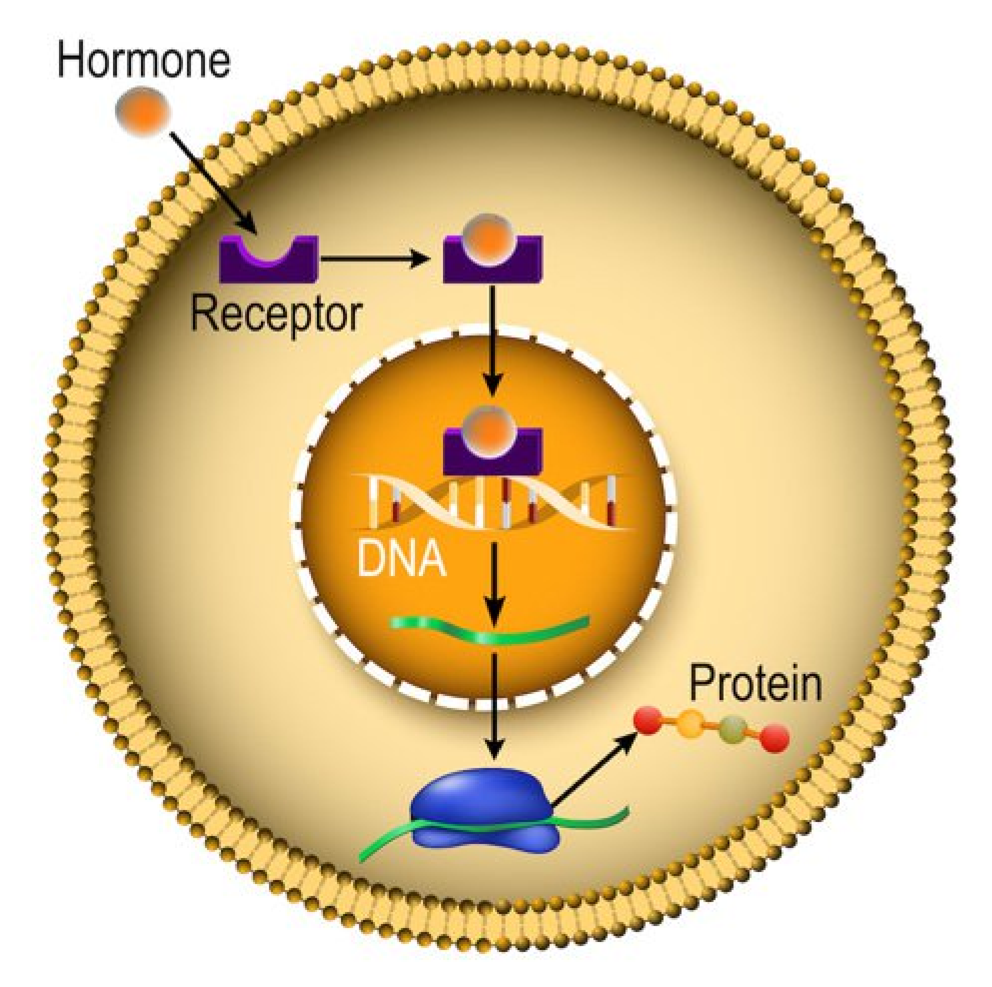
HORMONES

- Hormones are powerful chemical messengers produced by endocrine glands (e.g., thyroid, pancreas, adrenals) that travel through the bloodstream to regulate vital processes like metabolism, growth, reproduction, and mood.
- These molecules act as keys that unlock specific cellular receptors, triggering actions that maintain homeostasis and overall bodily function.



Properties of Hormones

- **Secretion:** Released directly into the bloodstream by ductless endocrine glands.
- **Concentration:** Active in very low concentrations (traces).
- **Specificity:** Act only on specific target tissues or organs that possess corresponding receptors.
- **Action:** Modify cellular metabolism and can be either stimulatory (excitatory) or inhibitory.
- **Chemical Nature:** Organic in nature, classified as peptides, proteins, amines, or steroids.
- **Transport:** Carried by blood, sometimes bound to carrier proteins.
- **Longevity:** Generally short-lived and non-antigenic (do not cause immune reactions).
- **Regulation:** Production is controlled by feedback mechanisms (often negative feedback).
- **Effect:** Not energy-providing; they are regulatory, not building materials.
- **Versatility:** Some are secreted in inactive forms (prohormones).
- **Interaction:** Can act synergistically (together) or antagonistically (opposing).



FUNCTIONS OF HORMONES

- **Metabolism and Energy Balance:** Regulating how the body breaks down food, produces energy, and maintains blood sugar levels (e.g., insulin, thyroxine.)
- **Growth and Development:** Controlling tissue growth, bone development, and physical maturity.
- **Reproduction and Sexual Function:** Managing puberty, fertility, menstrual cycles, and libido (e.g., estrogen, testosterone).
- **Homeostasis (Internal Balance):** Maintaining stable internal conditions, such as fluid balance and blood pressure.
- **Response to Stress and Environment:** Triggering immediate reactions to danger (e.g., adrenaline) or long-term stress management (e.g., cortisol).
- **Mood and Behavioral Changes:** Influencing emotions, sleep-wake cycles (e.g., melatonin), and cognitive function

Classification of Hormones

Hormones	Source	Example
Steroid hormones	Derived from cholesterol which belong to a chemical compounds known as steroids	sex hormones, adrenal cortex hormones
Amine hormones	Hormones derived from the modification of amino acids are referred to as amine hormones. Typically, the original structure of the amino acid is modified such that a —COOH, or carboxyl, group is removed, whereas the —NH^{3+}, or amine group remains. Amine hormones are synthesized from the amino acids tryptophan or tyrosine.	An example of a hormone derived from tryptophan is melatonin, while tyrosine derivatives include thyroid hormones and catecholamines
Peptide hormones	These hormones are made up of only few amino acid residues and they are usually present themselves in form of a linear chains	Oxytocin and vasopressin
Protein hormones	These hormones are build up from large number of amino acid residues	Insulin, glucagon, somatotropins
Glycoprotein hormones	These are conjugated protein bound to carbohydrate which include galactose, mannose, fructose	luteinizing hormones follicle stimulating hormones, thyroid stimulating hormones
Eicosanoid hormones	Made up of small fatty acid derivatives with a variety of arachidonic acid	Prostaglandins

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PITUITARY GLAND

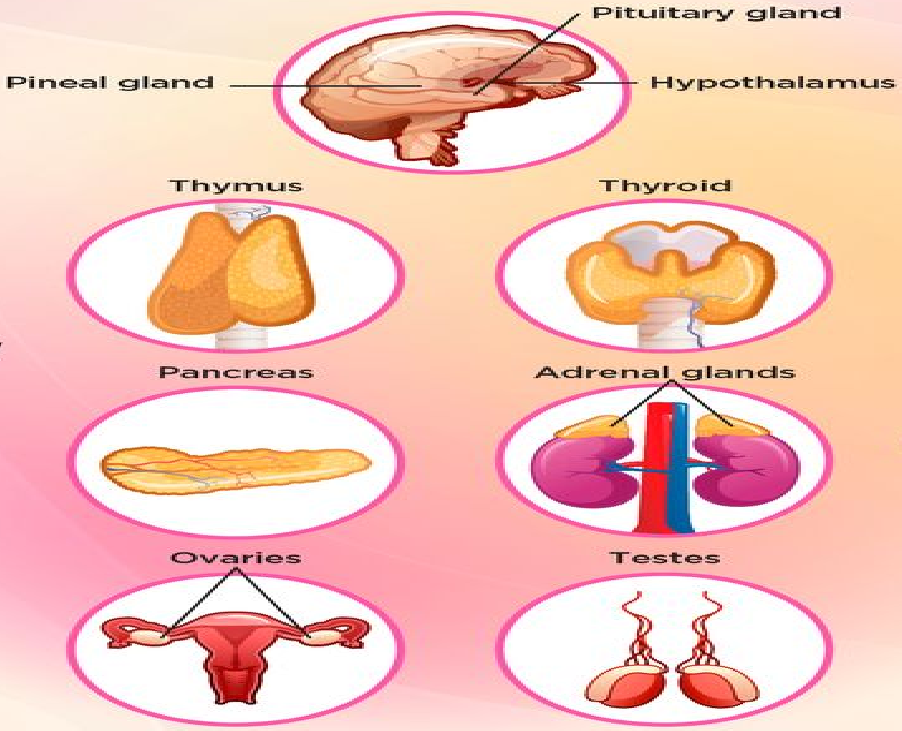
Produces FSH, LH, TSH, oxytocin, and many other hormones, playing a central role in regulating when other endocrine organs produce and release hormones.

PINEAL GLAND

Produces melatonin and regulates circadian rhythms

HYPOTHALAMUS

Produces GnRH, TRH, and dopamine to regulate pituitary gland activity



THYMUS

Produces hormones that regulate T-cell development and immunity

THYROID

Produces T3 and T4 and controls metabolic processes

PANCREAS

Produces insulin and glucagon, regulating glucose metabolism

ADRENAL GLANDS

Produce cortisol, regulating metabolism and stress responses

GONADS

Produce androgens, estrogens, and progestogens involved in reproductive organ development, muscle and bone health, and secondary sex characteristics related to puberty.

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Thank You

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