CLASS – 11
BIOLOGY

Chapter – 9

BIOMOLECULES

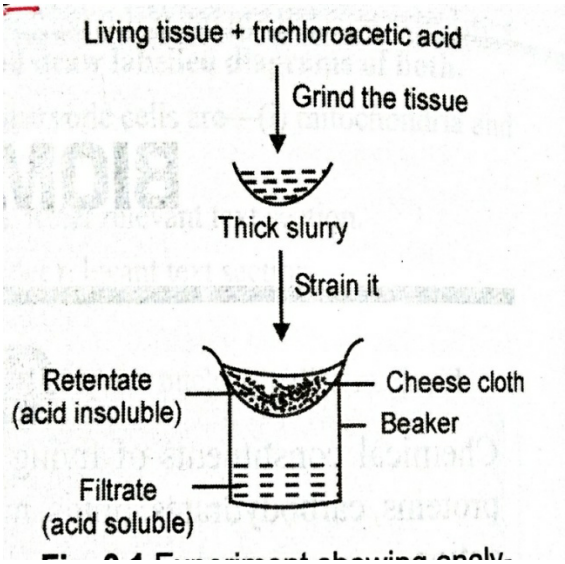
By –Shahanshah Shahid

PGT- Biology

Chandra Public School, Mau (U.P)

Biomolecules

- ***All cells, tissue and organs*** are composed of chemical that occurs in different proportion in cell.
- Chemical composition of living tissue can be analysis' by ***physical process*** by given in procedure.
- The analysis of acid soluble compound show thousand of ***organic compound*** which show presence of inorganic compound like ***sulphate , phosphate etc***.



- The biomolecules present in a cell form a cellular pool that consist of consist **of organic** (*i.e. carbohydrate, protein, fat and nucleic acid*) and **inorganic compound** (*i.e. salts, minerals, ions and water*).

- On the basis of molecular weight of organic molecules differentiate into :

1. **Micro-molecules** (*i.e. low molecular weight and formed by basic elements like C, O, N*).

Example: ***carbohydrate saturated of unsaturated fatty acids, nucleotides and amino acid***.

2. **Macromolecules** (*i.e. have high molecular weight formed by polymerization of large molecules of micro-molecules*).

Example: ***Polysaccharides, lipids, proteins, DNA , RNA***

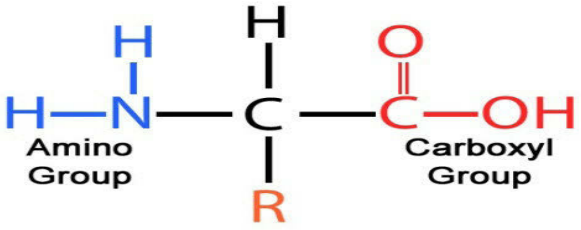
Amino Acid

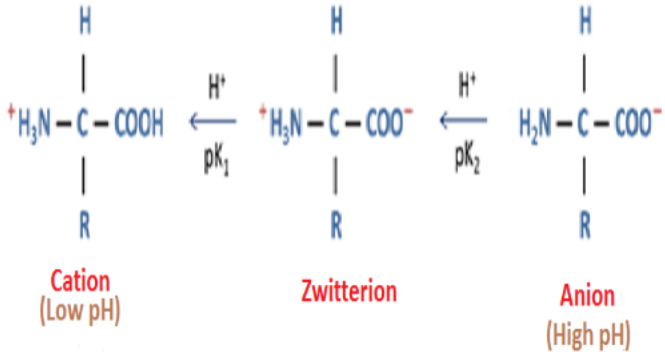
- It is the basic unit of protein that have one acidic carboxylic group (-COOH) and one basic amino acid ($-NH_2$).

- It show the **physical property** (*i.e. colourless, crystalline solids*) and **chemical properties** (*i.e. soluble in water and insoluble in inorganic solvents*).

- Amino acid can ***be aromatic in nature***. Example: *Tyrosine, Phenylalanine and Tryphtophan.*

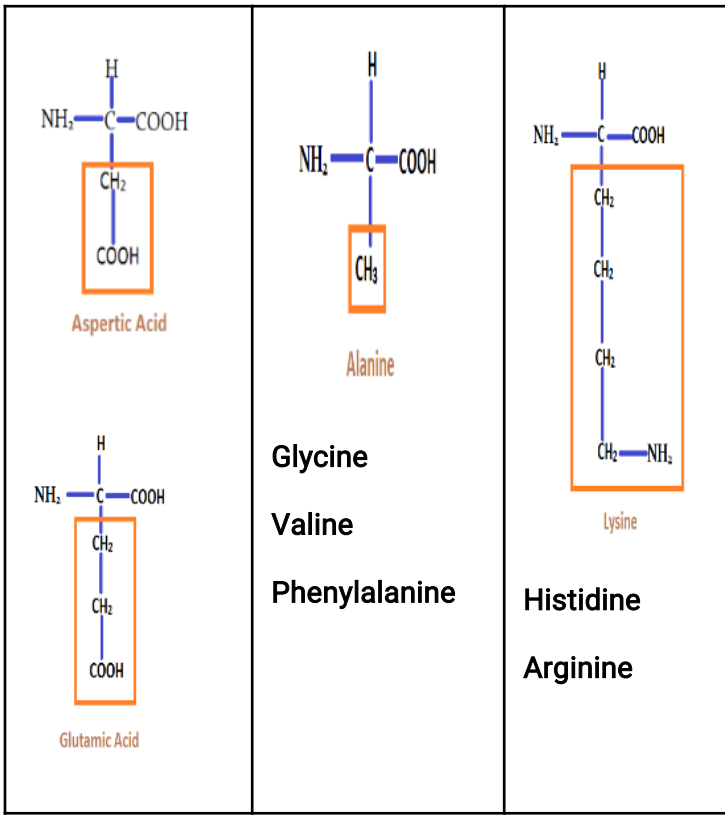
- Amino acids have an ***ionisable nature of amino ($-NH_2$) and carboxyl group (-COOH)*** hence *structure of amino acid change in solution of different pH*. In which B show the **zwitterionic form**





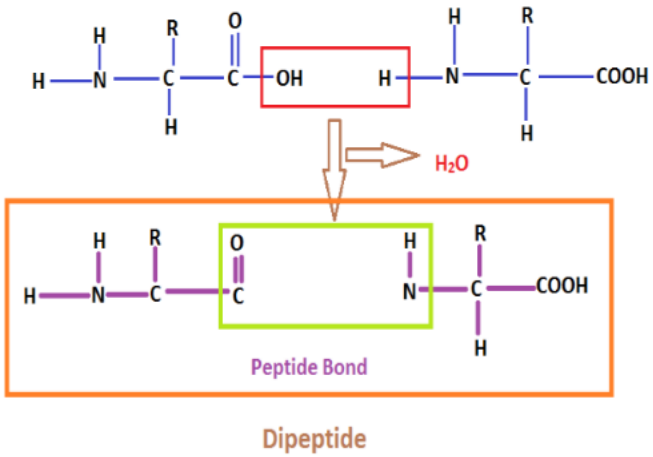
- Depending on the kind of ***R group or alkyl group*** present or ***based on the number of amino and carboxyl group present pr R group*** (*i.e. alkyl chain*) , amino acid could be acidic, basic or neutral.

Acidic amino acid	**Neutral acids**	**Basic amino acid**
Have more than one carboxylic group	Have only one acidic and one basic group	Have more than one basic group



Formation of Peptide Bond

- When a carboxyl group (-COOH) of one amino acid reacts with an amino group (-NH_2) of other amino acid then a peptide bond (-CO-NH) is formed with the removal of a water molecules.



Types of Amino Acid

- Depending on availability of amino acid and their sources amino acid are two type:

1. **Non-essential Amino Acid**
2. **Essential amino Acid**

Non –essential amino acid	Essential amino acid
They are not require in diet	They must be obtained from the diet
It can be synthesis by body	It cannot be synthesis by the body
Example: *Glutamic Acid* *Glycine* *Aspartic Acid* *Alanine*	**Example:** *Isoleucine* *Leucine* *Threonine* *Valine*

Function of Amino Acid

- Make building block of proteins.
- Specific amino acid are convert into biologically active compound like:

1. Tyroxine ---------- Hormone – thyroxin and adernaline ---- pigment melanin
2. Glycine ---------- Heam part of hemoglobin
3. Tryptophan -------- vitamin nicotinamide, plant hormone indole – 3 - acetic acid.

- Convert into glucose after the removal of amino group and carbon chain.
- Form biologically active amines like histamine on removing the carboxyl group.

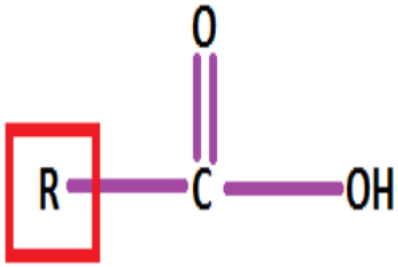
Lipid

- It form heterogeneous group but made of

Carbon, Hydrogen and Oxygen.

- The ***number of oxygen atom*** is *very small* as compare to ***carbon atom*** so *they need large amount of oxygen for their oxidation to release energy.*
- It is insoluble ***in water*** but ***soluble in organic solvent*** like - *acetone, ether and alcohol* etc.
- It could be –

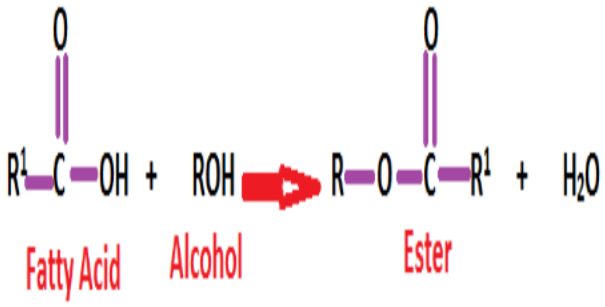
1. **Simple fatty acid:** in this carboxylic group is attached to alkyl group(R).



Example: *Palmitic acid (16C) Arachidonic acid (20C)*

2. **Glycerol :** it is also called ***trihydroxypropane***

3. ***Ester of fatty acids and glycerol:*** In this ***fatty acid are joined with glycerol*** and also called *fat or oil depending upon their boiling point.*



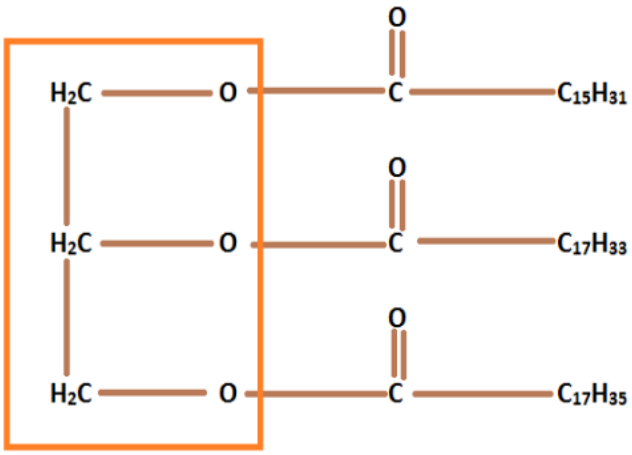
Types of Fatty acid

Unsaturated Fatty Acid	Saturated Fatty Acid
- It *contain one or more double bonds* between the carbon atoms	- *Do not have any double bond* between the carbon atoms.
• Melt at a much *lower temperature* Example: 1. Oleic Acid $CH_3(CH_2)_7\ CH{=}CH(CH_2)_7\ COOH$ 2. Linoleic acid $CH_3(CH_2)_4\ CH{=}CH(CH_2)CH{=}CH(CH_2)_7\ COOH$ 3. Linolenic acid $CH_3CH_2CH{=}CHCH_2CH{=}CHCH_2CH{=}CH(CH_2)_7COOH$	- Melt at *higher temperature* Example: 1. Palmitic acid $CH_3(CH_2)_{14}COOH$ 2. Steric acid $CH_3(CH_2)_{16}COOH$

Major categories of lipids

A. **Simple Lipids:**

- They are esters of fatty acid and glycerol.
- It could be fats, oils or waxes.



1. Fat:

1. These are ***ester of fatty acid and glycerol***.
2. In this each molecules of ***glycerol react with three molecules of fatty acids***.
3. Depending upon the number of fatty acids attached they could be

I. **Monoglyceride** (*i.e. one molecules of glycerol+ one molecules of fatty acid*),

II. **Diglyceride** (*i.e. one molecules of fatty acid + Two molecules of fatty acid*),

III. **Triglycerides** (*i.e. one molecules of glycerol + three molecules of fatty acid*).

2. Oils:

- These are fats which are rich in ***unsaturated fatty acids due*** to presence of unsaturated fatty acid it is *recommended by physicians to whom suffering from high blood cholesterol*.

3. waxes:

- It has eaters of long chain fatty acid and long chain of alcohols other than glycerol and *form protective in functions and form water insoluble coatings on hair and skin of animals, on stem, leaves and fruits of plants*.

B. Compound Lipids:

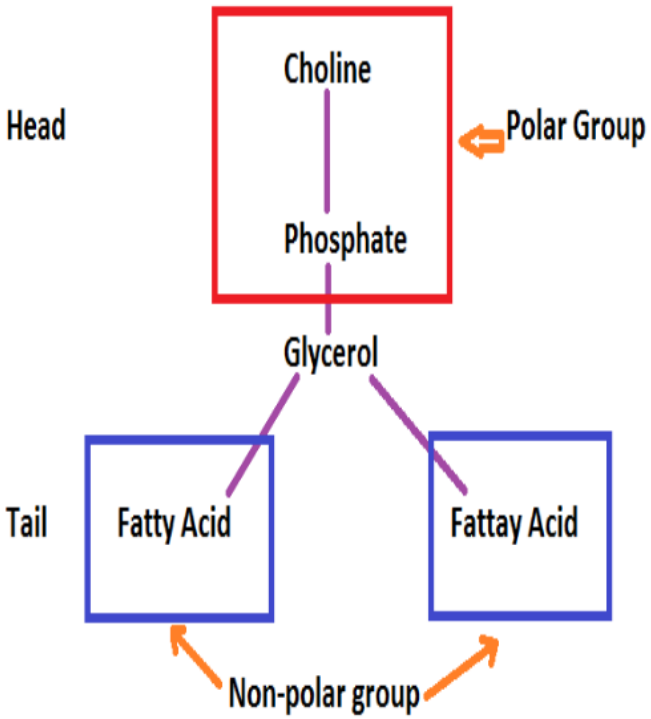
1. Glycolipids:

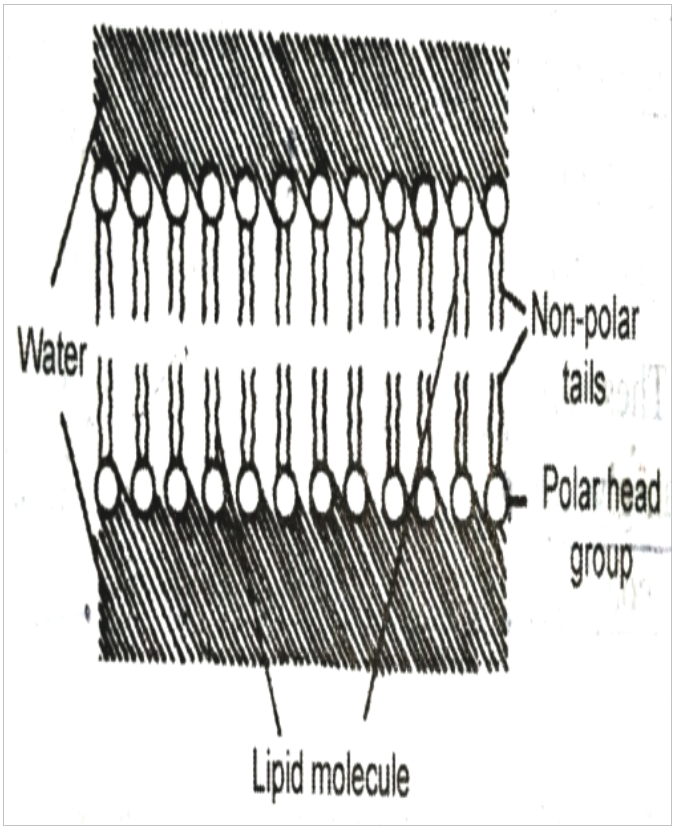
- It formed by the association of lipids with carbohydrates molecules and these are founds in membranes.

Carbohydrate + Lipid

2. Phospholipids:

- These are lipid containing phosphate group and found in cell membrane with having attachment of choline group.





Phosphoric acid + Lipid

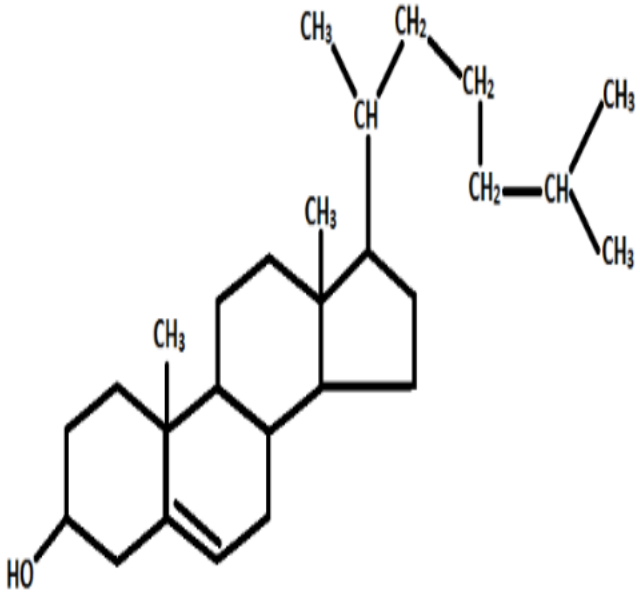
3. **Lipoprotein:**

Protein + Lipid

C. **Derived lipids:**

1. **Steroids:**

- It composed of fused hydrocarbon rings and long hydrocarbon chain



Example: *Cholesterol, Diosgenin*

Disadvantage of Cholesterol:

- It create abnormal thickenings of walls of arteries which raise the blood pressure

Advantage of Cholesterol:

- It can ward off bacterial diseases (du to high density lipoprotein).
- Bile salts (i.e. modified for of cholesterol).On the exposure of UV light change to vitamin D (i.e. necessary for bone growth)

Function of Lipids

1. **Fats:**

- Act as storage products in animals and plants.
- Provide nourishment for embryo during germination.
- Minimize heat loss in animals as it forms a layer beneath the skin.
- Act as cushion to absorb mechanical

impacts.

2. **Oil:**

- Stored in adipocytes in animals.

3. **Waxes:**

- Use as waterproofing material in animals and plants.

4. **Phospholipids:**

- Constitute of membranes.

Example: Lecithin

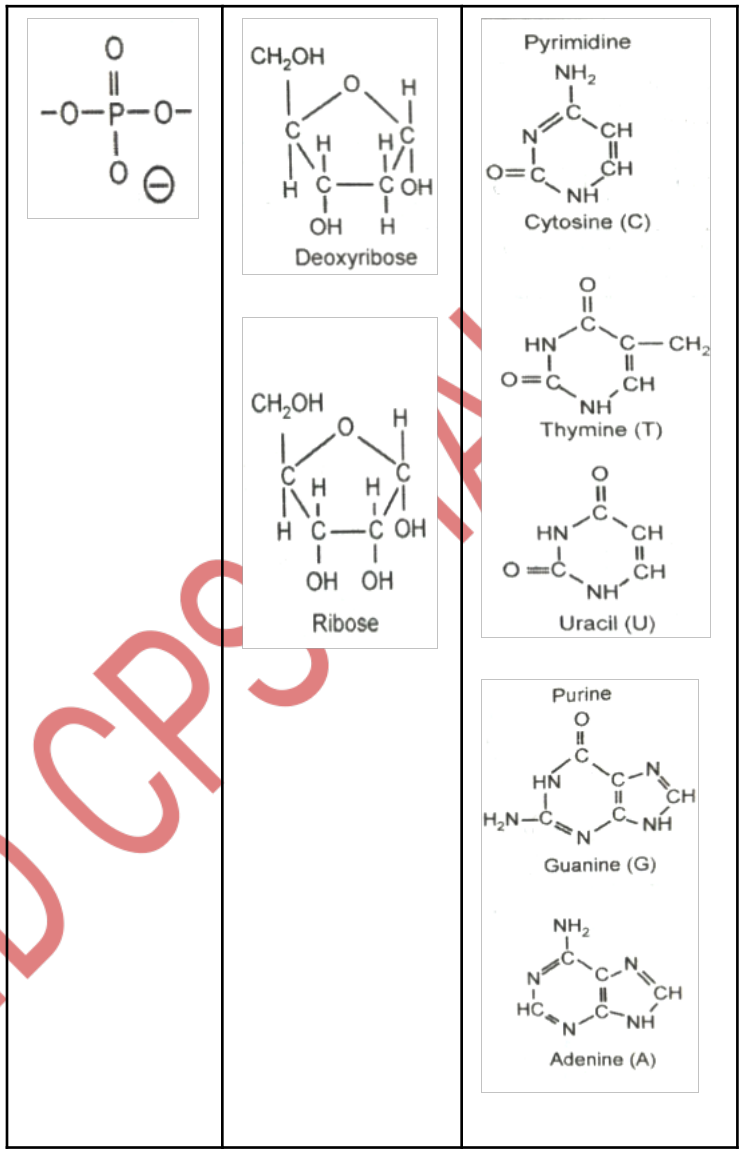
5. **Glycolipids:**

- It also forms components of cell membrane and myelin of nerve cells.

Nucleic Acid

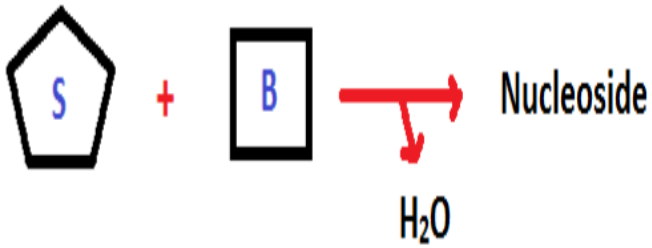
- It is macromolecule that found in the acid insoluble fraction of the cell.
- Nucleoside is the building block of nucleotide.
- It is made up of

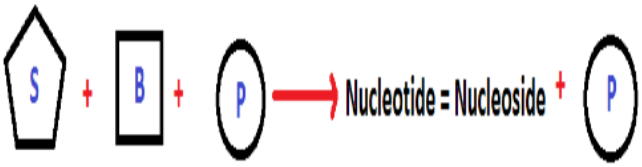
Phosphoric Acid	Pentose sugar	Nitrogenous Base



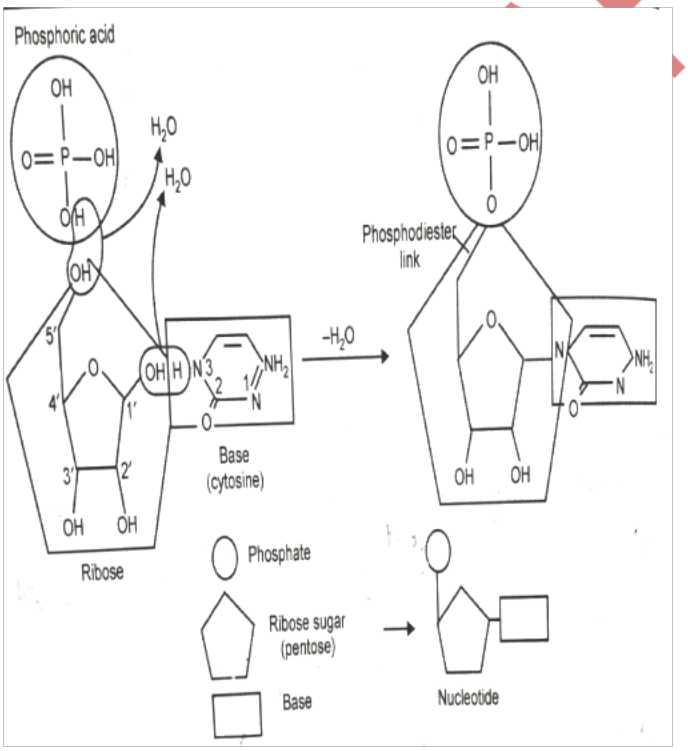
Formation of Nucleotides

- As nucleoside is building block of nucleotide which is formed y combination of sugar and a base.
- Depending upon the ***pentose sugar*** (ribose or deoxyribose) present nucleoside could be ***ribonucleosides or deoxyribonucleosides***.





- Nucleotide is formed by a combination of a sugar, a base, and phosphoric acid.
- Depending upon the type off ribose sugar present nuleotide nucleotide could be ribose **nucleotides or deoxyribosnucleotides**.
- Depending upon the number of phosphate group present nucleotide could be **mono, di or triphosphate of nucleoside.**



Kind of Deoxyribonucleotides

Nitrogenous Base	Deoxyribo-nucleoside	Deoxyribo-nucleotide	Abbreviation
Adenine (A)	Deoxyadenosine	Deoxyadenylic Acid	dAMP
Guanine (G)	Deoxyguanosine mono-phosphate	Deoxyguanylic acid	dGMP
Cytosine (C)	Deoxycytidine mono-phosphate	Deoxycytidylic acid	dCMP
Thymine (T)	Thymidine mono-phosphate	Thymidylic acid	dTMP

Kind of Ribonucleotides in RNA

Nitrogenous Base	Rionucleoside	Ribonucleotide	Abbreviation
Adenine (A)	Adenosine monophosphate	Adenylic acid	AMP
Guanine (G)	Guanosine monophosphate	Guanylic acid	GMP
Cytosine (C)	Cytidine monophosphate	Cytidylic acid	CMP
Uracil (U)	Uridin monophosphate	Uridylic acid	UMP

Types of Nucleic Acid

- Two type of nucleic acid is present (i.e. DNA and RNA)

DNA (deoxyribonucleic acid)	RNA (ribonucleic acid)

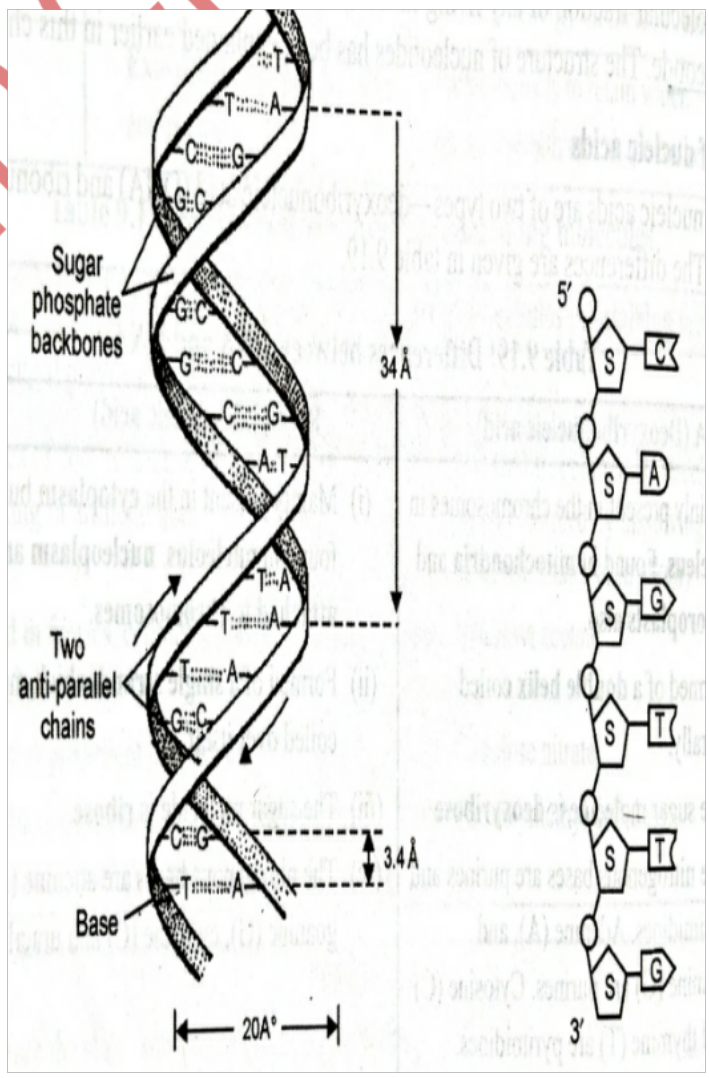
Present in chromosome of nucleus, mitochondria and chloroplast.	Mainly present in cytoplasm but also present in nucleolus, nucleoplasm and attached to chromosome.
Formed double helix coiled spirally	Formed of a single strand which may be coiled itself.
Deoxyribose sugar is present	Ribose sugar is present
Nitrogenous base are – A, G, C, T	Nitrogenous base are –A, G, C, U
Carry genetic information that passed one generation to next and also control cellular activities.	Participate in protein synthesis
Large molecules of many nucleotides	Comparatively smaller

Types of RNA

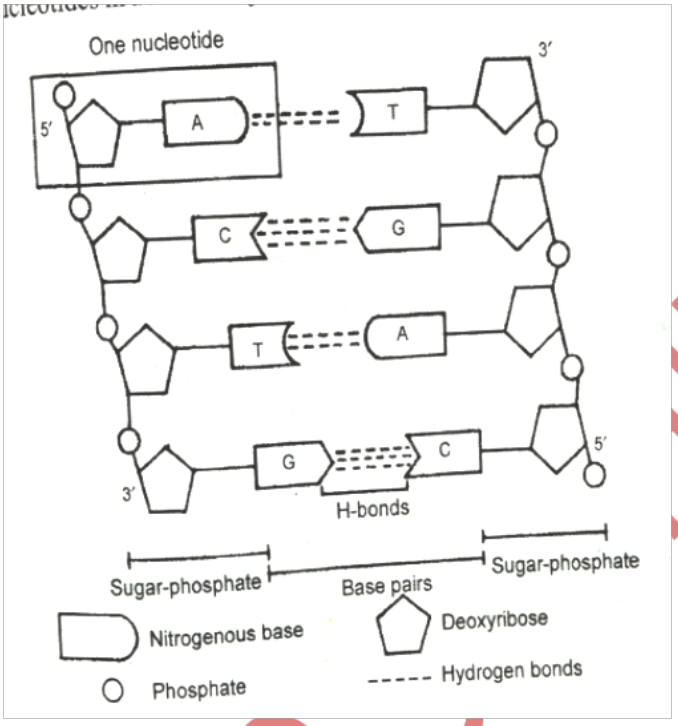
Kind of RNA	Structure	Location	Function
m-RNA	Long chain of RNA made up of a number of codons	Produce by nucleus and found in cytoplasm	*Carries information for synthesis of protein.*
r-RNA	Coiled molecule closely bound to protein fraction	Found only in ribosome	*Forms structure of ribosome's*
t-RNA	Single strand clover leaf shaped molecules with anticodon end	Found in cytoplasm	*Transfer amino acid from cytoplasm to the site of protein synthesis.*

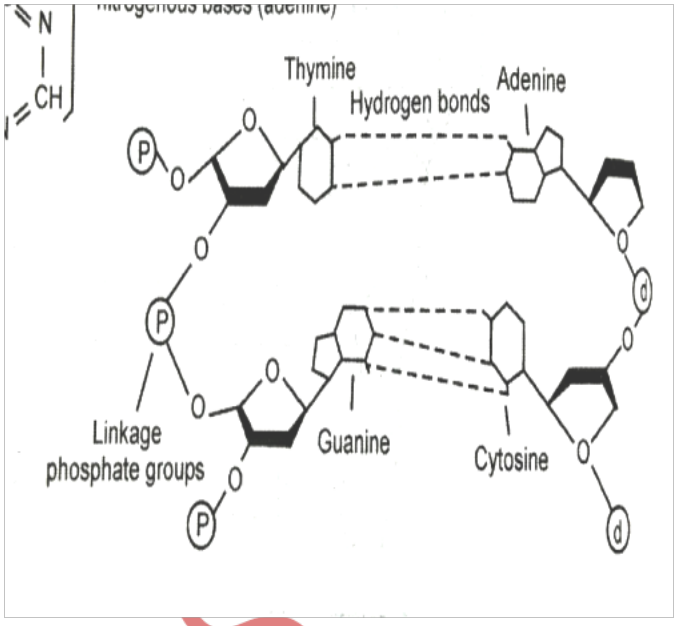
Watson crick model of DNA

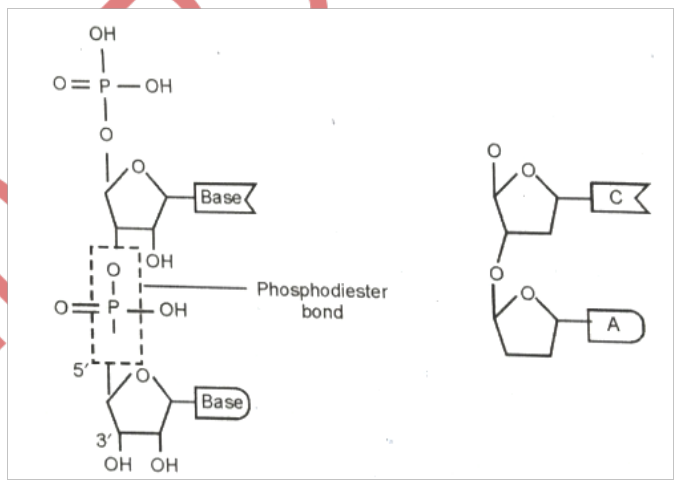
- DNA molecules consist of ***two polynucleotide's chain*** which forms a double helix like a spiral staircase.
- The ***sugar phosphate unit form backbone*** and ***base form the center.***
- Both strand joint together by weak hydrogen ***bonds***.



- The two strand are **anti-parallel** (*i.e. 3' to 5' direction or 5' to 3' direction*)
- The wide of DNA molecules is **$20A^0$** and the helix takes a complete turn after $34A^0$.
- Distance between nucleotide is **$3.4A^0$** (*i.e. ten nucleotide present in one complete turn*).
- Base pairing is following ***complementary base pairing.***
- The nucleotide in a helix is joined together by ***phosphodiester bonds***.







Carbohydrate

- These are mainly **hydrates of carbon** (CH_2O) (*i.e. compound of Carbon, hydrogen and oxygen*).
- The ***composition of hydrogen and oxygen is same*** as present in H_2O (*i.e. one oxygen and two hydrogen for each carbon atom*).
- General formula is **$C_nH_{2n}O_n$**.
- They posses more than one **alcoholic(i.e. OH) group**.
- It is the principal source of energy for the body and ***produce by green plant through photosynthesis***.

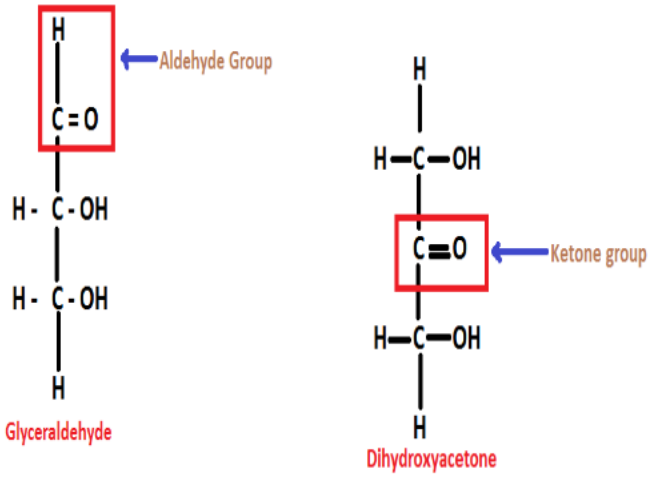
- It make up about ***80% of the dry weight of plants***.

Classification

Carbohydrate			
Physical properties	**Sugar**		**Polysaccharides**
	Low molecular weight, sweet in test, readily soluble in water crystalline in nature		High molecular weight, not sweet in taste, insoluble or slightly soluble in water, non crystalline in nature
No. of molecules	**Monosaccharide**	**Disaccharides**	Made by joining of many monosaccharide
	Made of one molecules	Made by joining two molecules of monosaccharide	
Chemical property	Reducing sugar	Reducing sugar	Non-reducing sugar
General formula	$C_nH_{2n}O_n$	$C_{12}H_{22}O_{11}$	$C_x(H_2O)_y$
Example	Glucose, Fructose and galactose	Maltose, sucrose and lactose	Cellulose and Glycogen

Monosaccharide

- It composed of ***3-7 carbon atom*** and an ***not hydrolyzed into smaller*** carbohydrates.
- All carbon atom have **hydroxyl group** (OH) except **C_1 or terminal carbon** which has ***aldehyde or ketone group***.

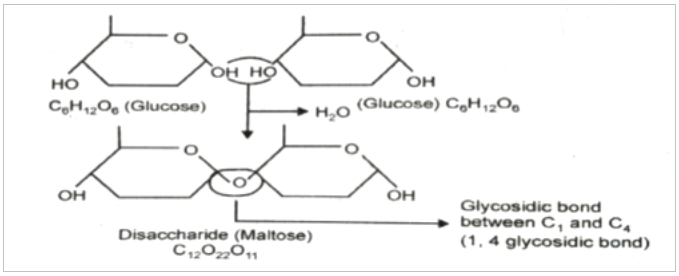


- The free **aldehyde** (-CHO) or **ketone**(-C=O) group can ***reduce Cu^{++} to Cu^{+} form*** which is called **reducing sugar** (*i.e. give Benedict's and Fehling's test*).
- The terminal carbon binds with alcoholic group of organic compound by forming a ***glycosidic bond***.

Monosaccharide	Chemical formula	Example
Trioses	$C_3H_6O_3$	*Glyceraldehyde, dihydroxyacetone*
Tetrose	$C_4H_8O_4$	*Erthyrose*
Pentose	$C_5H_{10}O_5$	*Ribose, Deoxyribose*
Hexoses	$C_6H_{12}O_6$	*Glucose, Fructose, Galactose*
Heptulose	$C_7H_{14}O_7$	*Heptulose*

Disaccharide

- It is made up of ***two molecules of monosaccharides***.
- The two monosaccharide joined together by **glycosidic bond** (*i.e. forming by lose of water molecules in which 1'Ccarbon of one monosaccharide lose its hydrogen and another monosaccharide lose its 4'C lose its hydroxyl group*).



- General formula $C_{12}H_{22}O_{11}$

Monosaccharide unit	Disaccharide	Source
Glucose + Glucose	Maltose	Formed by breakdown of starch during digestion and in germinating seed.
Galactose + Glucose	Lactose	Milk sugar
Glucose + Fructose	Sucrose	Cane sugar

Polysaccharide

- It presents in the **acid insoluble pool** and contain *long chain of sugars*.
- They are *polymer of monosaccharide's* which linked through ***glycosidic bonds***.
- In this monosaccharide is present in linear chain that could be ***branched or unbranched***.
- Molecular formula is $(C_6H_{10}O_5)_n$ where n is the number of units.
- They are ***storage molecules*** and *insoluble in water.*
- It can be ***easily converted into sugars by hydrolysis***.

Type of polysaccharide

- On the basis of type of monosaccharide is present into polysaccharide it categories into **homosaccharides** (*i.e. contain single type of monosaccharide*) and **heteropolysaccharide** (*i.e. contain two or more types of monosaccharide*).
- Both type of polysaccharide act as *storage molecules* or *structural molecules*.
- ***Right end*** of polysaccharide chain is reducing end and **left** is called *non-reducing end.*

Name	Basic structure	Molecular of polymer
Cellulose	Linear long chain 6000 or more units	*1-4 linkage of β – glucose*
Starch	Has two component like Amylose (strait chain) and amylopectin (branched chain)	*(1-4) α – glucose* *(1-4) α – glucose and (1-6) α – glucose*
Glycogen	Highly branched chain	*(1-4) α – glucose and (1-6) α – glucose*

Chitin	Linear long chain	*1-4 β – linkage of N-acetyl glucosamine*

Comparison amongst various polysaccharides

Name of polysaccharide	Location	Functions
Cellulose	Found in *cell wall of plants.*	Give *mechanical support , permeable to water, source of food* for some animals, bacteria and fungi
Starch	Present in *plants in the form of stored food material* in storage organs and chloroplast of leaves	*Source of food* for animals act as fuel of plants
Glycogen	Stored in liver and muscle of animals and found in many fungi	Useful *source of glucose in respiration*
Chitin	Form exoskeleton of insects, crabs and prawns.	It help animal to *retain water and gives strength and shape to the animals*

Mucopolysaccharide

Name	Location	Function
Murine	*Cell wall of bacteria*	- It is structural component
Hyaluronic acid	*Outer coat of animal cell*	- Binds the protein together, give the ability to the cells to recognize each other and provide intracellular lubrication.
Hyaluronic acid **Chondrotin sulphate** **Keratin sulphate**	*Connective tissue*	- Part of ground tissue i.e. matrix - Important lubricant in synovial fluid in joints. - Major component of cartilage, bone and cornea which give strength and flexibility.

Metabolites

- It is intermediate and product of metabolism.
- Based on the involvement it categorized into:

1. Primary metabolites:

- These are directly involve in normal growth, development and reproduction and have identifiable functions and play roles in normal physiological processes.
- Found in plant and animal cells.

Example: *amino acid, sugar etc.*

2. Secondary metabolites:

- They not directly involve in metabolic

process but have important ecological functions.

- Found in plants, fungal and microbial cells.

Secondary Metabolites	Example
Pigments	Carotenoids, anthocyanins
Alkaloids	morphhine., codeine
Terpenoids	Monoterpenes, diterpenes
Essential oils	Lemon grass oil
Toxins	Abrin, ricin
Lactins	Concanavalin A
Drugs	Vinblastin, curcumin
Polymeric substance	Rubber, gums, cellulose

Protein

- It built from **amino acid** (*i.e. polymers of amino acid*).
- It contains carbon, hydrogen, oxygen and nitrogen and some time contain sulphur also.
- It is **heteropolymers** (*i.e. contain different units like amino acid in a protein*).
- **Collagen** is most aboundant peotein in the *animal* and **Ribulose biphosphate-carboxylase-oxygenase (RUBISCO)** is most abundant in biosphere.
- Protein is highly organized molecules which has linear chain of amino acid that linked by the peptide bonds and chain are folded branched or cross-linked by different kind of bond.

Protein	Functions
Collagen	Intracellular ground substance
Trypsin	Enzyme
Insulin	Hormone
Antibody	Fights infectious agents
Receptor	Sensory reception
GLUT-4	Enable glucose transport into cells

Structure of protein

	Primary	Secondary	Tertiary	Quaternary
Basis of Characterization	Number, nature and sequence of amino acid	Shape of polypeptide chain and kind of bonds present	Shape of polypeptide chain and kind of bonds present	Number of polypeptide chain joined
Nature of	A simple	- Spiral or	- A highly end and	Aggregation

molecules	linear polypeptide	coiled chain forming α-helix - A plated structure(two or more polypeptide chain)	folded polypeptide chain over itself exposing hydrophilic chains.	of polypeptide chain, Complex protein, Giant molecules.
Kind of bond	Peptide bond between successive amino acid	Peptide bond, weak hydrogen bond between every fourth amino acid of the coil.	Ionic bond, hydrogen bond, hydrophobic interaction, disulphide linkage	Ionic bond, hydrogen bond, hydrophobic interaction, disulphide linkage
Example	Not a functional molecules	A-helix – keratin of hair B- plated structure – silk fibre	Enzyme, egg albumin, protein myoglobin	Hemoglobin has four chain of polypeptide (two α chain, and two β chain)

Classification of protein

Protein are classified into two group according to composition

1. **Simple protein** (*i.e. have only amino acid in their structure*).

Name	Properties	Location
Albumins	Neutral Soluble in water Soluble in dilute salt solution Large molecules Coagulate by heat	– Egg albumin – Serum albumin of blood
Globulins	Neutral Insoluble in water Soluble in dilute salt solution Large molecules Coagulated by heat	– Antibodies in blood Blood fibrinogen – Serum globulins
Histones	Basic in nature Soluble in water Small molecules Not coagulated by heat	– Associated with nucleic acids, in nucleoproteins of cell
Scleroproteins (only in animal)	Insoluble in water and most other solvents Very long molecules	– Keratin of hair, skin and feathers, collagen of bone matrix and tendon, elastin of ligament

2. Conjugate protein (*i.e. consist of globular protein and non-proteinaceous material or prosthetic group*).

(ii) **Conjugated proteins**

Name	Prosthetic group	Location
(i) **Nucleoprotein**	Nucleic acid	Chromosomes, ribosome structure, component of viruses.
(ii) **Metal proteins**	Metal (Fe)	Ferritin
(iii) **Chromoprotein**	Pigment	Haemoglobin (iron-containing pigment), phytochrome (plant pigment), cytochrome (respiratory pigment).
(iv) **Phosphoprotein**	Phosphoric acid	Casein of milk, vitellin of egg yolk
(v) **Lipoprotein**	Lipid	Membrane structure, lipid is transported in blood as lipoprotein.
(vi) **Flavoprotein**	FAD	Important in electron transport chain in respiration.
(vii) **Glycoprotein**	Carbohydrate	Blood plasma, mucin (component of saliva).

Function of Protein

Kind of Protein	Example	Functions

1. Structural	Keratin	Found in skin, hair, nails, horns, feathers and wool.
	Collagen	Component of connective tissue, bone, cartilage, tendons.
	Elastin	Elastic connective tissue.
	Sclerotic	Exoskeleton of insects.
	Lipoprotein	Structural component of cell membranes, organelles.
2. Enzymes	Pepsin, amylase, hexokinase	Catalyse various biochemical pathways
3. Hormones	ACTH, insulin	Help to regulate the glucose metabolism and growth of the body.
4. Carriers	P-proteins	Transport of organic molecules in plants
	Haemoglobin	Transport of O_2 in blood
	Myoglobin	Transport of O_2 in muscles
	Serum albumin	Transport of fatty acids and lipids in blood
5. Protective	Antibodies	Form complexes with antigens
	Fibrinogen	Form fibrin during blood clotting
	Thrombin	Required in blood clotting
6. Contractile	Actin, myosin	Protein filaments in muscles for contraction and locomotion
7. Storage	Casein	Form milk protein
	Albumin	Egg white
	Glutelin	Seeds of wheat