Biomolecules

- These organic compounds which are useful for the growth & maintenance of living organism.
- These includes : Carbohydrates, Enzymes, Proteins, Nucleic Acid, Vitamins, Hormones.

[Carbohydrates] [saccharides]

⇒ These are optically active polyhydroxy aldehydes or ketones or substances which on hydrolysis yield polyhydroxy aldehyde & ketone

⇒ chemical formula : $C_x(H_2O)_y$

* Classification on the basis of taste :

Sugar	Non-sugar
• Sweet in taste	• Tasteless
• Crystalline solid	• Amorphous solid
• Soluble in water	• Insoluble in water
• eg: Sucrose, glucose, fructose	• eg: starch, cellulose

NOTE : All the compounds which fit into the formula i.e, $C_x(H_2O)_y$ may not be classified as carbohydrates eg: Acetic acid $[CH_3COOH]$ fit into this formula but is not a carbohydrates. Similarly rhamnose $C_6H_{12}O_5$ is a carbohydrate but does not fit into this defination.

* Classification based on hydrolysis :

Carbohydrates
- Monosaccharides ← eg: glucose, fructose
- Oligosaccharide — eg: maltose, lactose
  - Disaccharide eg: sucrose
  - Trisaccharide eg: Raffinose
  - Tetrasaccharide eg: stachyose
- Polysaccharide — eg: cellulose, starch

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* Classification of monosaccharides.

⇒ A carbohydrate that can't be hydrolysed further to give simpler unit of polyhydroxy aldehyde or ketone

⇒ About 20 monosaccharides are known to occur in nature.

⇒ eg: glucose, fructose, ribose etc.

• Classification.

⇒ Aldose : Those monosaccharides which contain aldehyde group

⇒ Ketose : Those monosaccharides which contain ketone group.

① Glucose :

⇒ It is an aldohexose & also k/a dextrose → dextrorotatory

⇒ It is the most abundant organic compound on earth

* Methods of preparation of glucose

• From sucrose (cane) :

$$\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{H^+} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Fructose}}{C_6H_{12}O_6}$$

• From starch :

$n = 100-1000$

$$(C_6H_{10}O_5)_n + nH_2O \xrightarrow[\substack{393\,K \\ 2-3\,atm}]{H^+} nC_6H_{12}O_6$$

⇒ Commercially glucose is obtained by hydrolysis of starch by boiling it with dilute H_2SO_4

* Properties of glucose.

① Its molecular formula was found to be $C_6H_{12}O_6$

② Six carbon in straight chain

$$\begin{array}{c} CHO \\ | \\ (CHOH)_4 \\ | \\ CH_2OH \end{array} \xrightarrow[\Delta]{HI} CH_3-CH_2-CH_2-CH_2-CH_2-CH_3$$

HI → Reducing agent

n - Hexane.

⇒ This rxn confirm the presence of straight chain of six

③ Rxn with Bromine water

$$\begin{array}{c} H \\ | \\ C=O \\ | \\ (CHOH)_4 \\ | \\ CH_2OH \end{array} \xrightarrow{Br_2\ water} \begin{array}{c} COOH \\ | \\ (CHOH)_4 \\ | \\ CH_2OH \end{array}$$

gluconic acid.

⇒ This rxn confirm the presence of aldehyde group.

④ Rxn with hydroxyl amine $[NH_2-OH]$

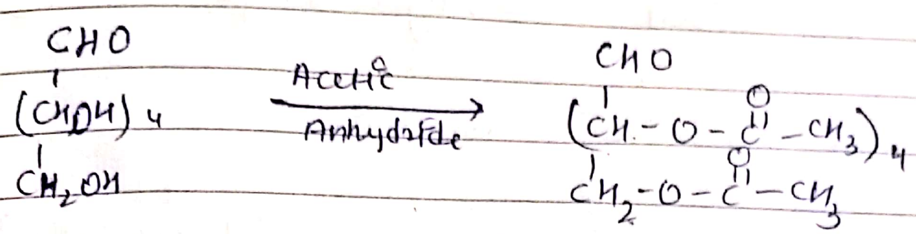
$$\begin{array}{c} H \\ | \\ C=O \\ | \\ (CHOH)_4 \\ | \\ CH_2OH \end{array} \xrightarrow{NH_2OH} \begin{array}{c} CH=N-OH \\ | \\ (CHOH)_4 \\ | \\ CH_2OH \end{array}$$

(oxime)

$$\begin{array}{c} H \\ | \\ C=O \\ | \\ (CHOH)_4 \\ | \\ CH_2OH \end{array} \xrightarrow{HCN} \begin{array}{c} CH\begin{smallmatrix} CN \\ OH \end{smallmatrix} \\ | \\ (CHOH)_4 \\ | \\ CH_2OH \end{array}$$

⇒ These two rxns confirm presence of carbonyl group.

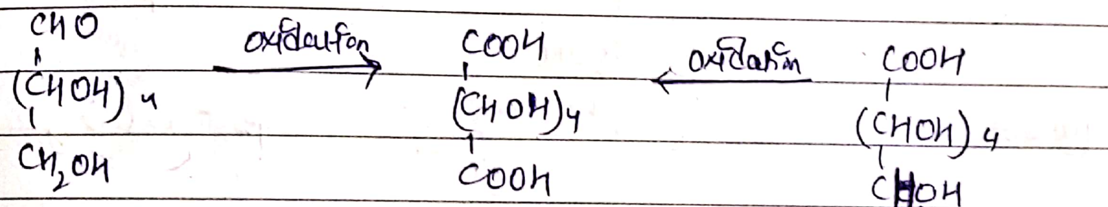
(5) Rxn with Acetic Anhydride.



Glucose pentaacetate

⇒ This rxn confirms the presence of five OH group

(6) Rxn with HNO_3 (nitric acid)



Saccharic acid

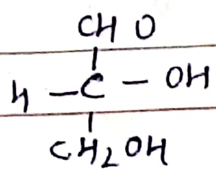
gluconic acid

⇒ This rxn confirm the presence of 1° alcohol.

NOTE : All the naturally occurring sugars belong to D-series
eg: D-glucose, D-ribose, D-fructose

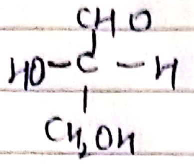
- D and L does not mean dextro rotatory (d) or laevo rotatory (l)
- Although all monosaccharides are optically active molecule
- so for them (+) & (-) are used to represent dextrorotation & laevorotation respectively.

- D-configuration indicates -OH group on R.H.S



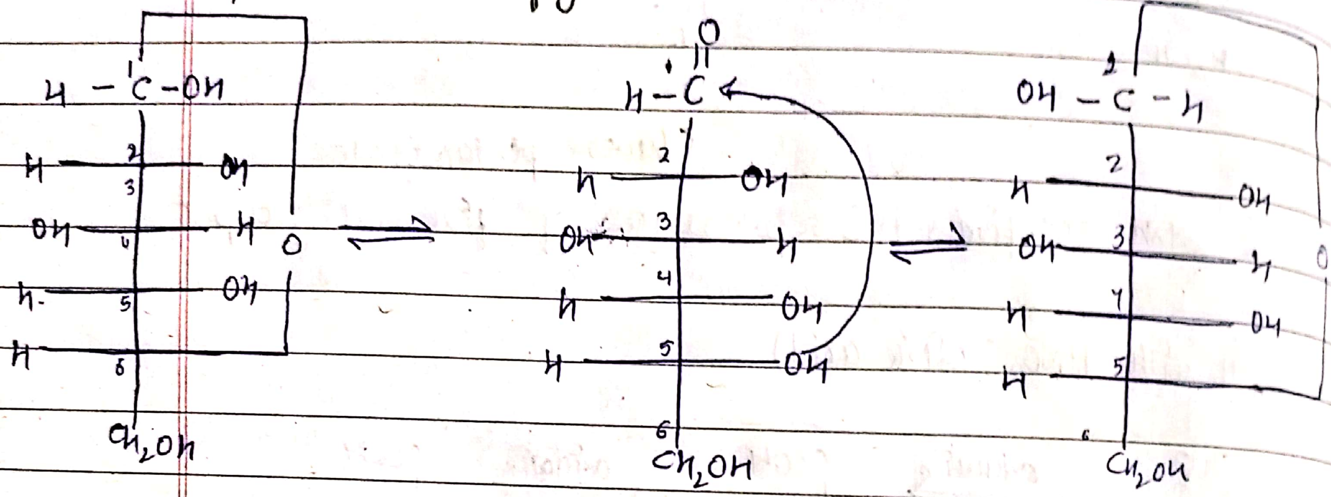
D-glyceraldehyde

• L-configuration indicates -OH group on L.H.S



L-Glyceraldehyde

* Cyclic structure of glucose



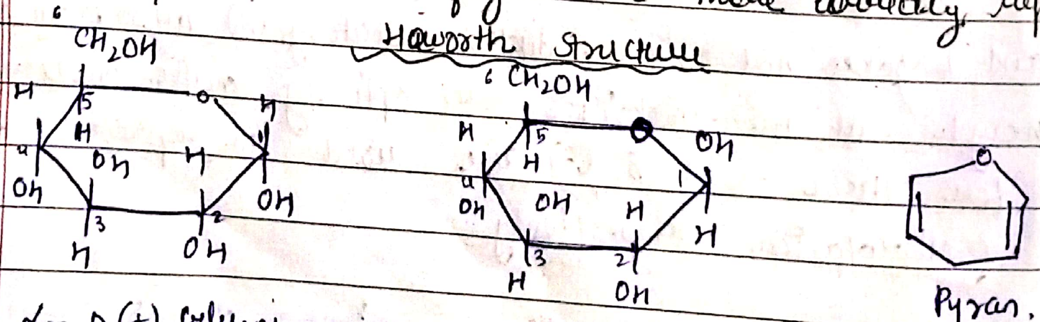
α-D(+) glucose — straight chain — β-D(+) glucose

⇒ Here OH is in RHS side

⇒ Here OH is in L.H.S side.

* Enomers : If the hydroxyl group [OH] is present on first carbon then such isomers are called anomers, α-form & β-form are anomers. & the first carbon $[C_1]$ is k/a anomeric carbon.

* The cyclic structure of glucose is more correctly represented by Haworth Structure



α-D(+) Glucopyranose β-D(+) glucopyranose   Pyran.

Note: i) Haworth projection, the six membered cyclic str. of glucose is called pyranose structure. (in analogy with pyran

* Supporting Evidence : cyclic structure of glucose

1) Despite having aldehyde group, glucose does not give 2,4-DNP test, Schiff test & it does not form adduct with $NaHSO_3$

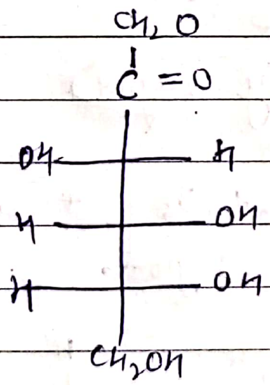
2) Pentaacetate of glucose does not react with NH_2OH indicating the absence of free $-CHO$ group

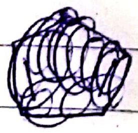
3) Glucose is found to exist in two different crystalline form which are named as α & β. They both have different m.pt & different temp. for crystallisation

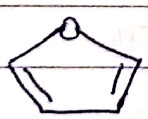
② Fructose. [$C_6H_{12}O_6$]

→ It is an important ketohexose.

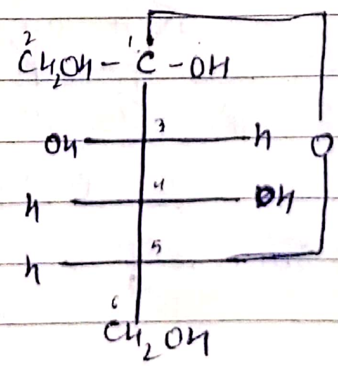
→ It is D-(-) Fructose [laevorotatory].



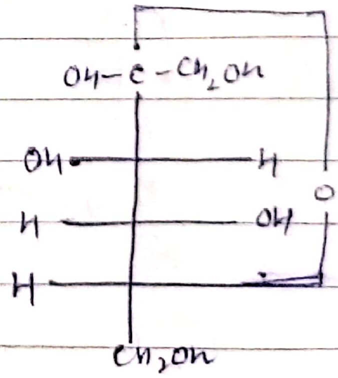




Furan

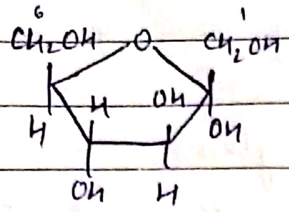


α-D(-) Fructofuranose

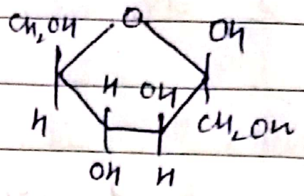


β-D(-) Fructofuranose

★ Haworth structure of fructose anomers :



α-D(-) Fructofuranose



β-D (-) Fructofuranose

✝ Disaccharides.

→ Two monosaccharides are joined together by an oxide linkage formed by the loss of a water molecule. such a linkage is called "Glycosidic linkage"

① Sucrose [dextrorotatory]

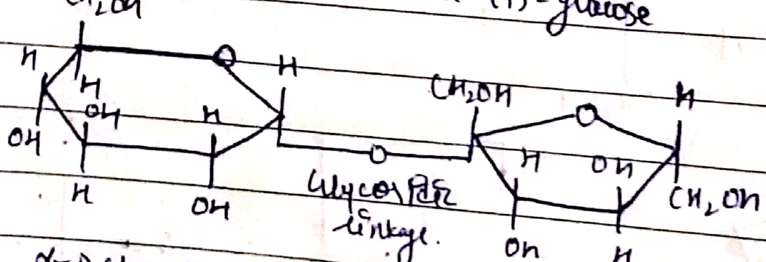
→ Sucrose is most common disaccharides which on hydrolysis gives equimolar mixture of D(+) glucose & D(-) fructose

→ The two monosaccharides are held together by a glycosidic linkage b/w C_1 of α-D glucose & C_2 of β-D fructose are involved in glycosidic bond formation.

→ Sucrose is a non-reducing sugar

$$C_{12}H_{22}O_{11} \longrightarrow C_6H_{12}O_6 + C_6H_{12}O_6$$

α-(+)-glucose β-(-) fructose



α-D glucose

β-D fructose

$\boxed{\text{Sucrose}}$

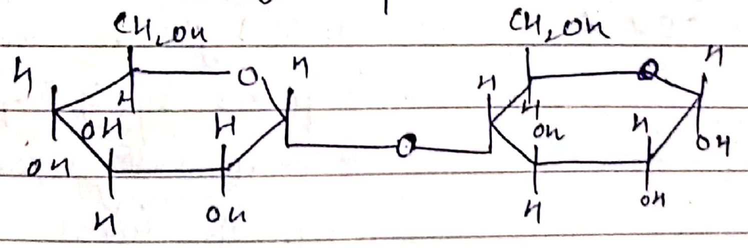
Hydrolysis of sucrose

$$\underset{\substack{D-\text{sucrose} \\ +66.5^\circ}}{C_{12}H_{22}O_{11}} \longrightarrow \underset{\substack{D(+)\text{ glucose} \\ +52.5^\circ}}{C_6H_{12}O_6} + \underset{\substack{D(-)\text{ fructose} \\ -92.4^\circ}}{C_6H_{12}O_6}$$

Imp. Sucrose is dextrorotatory but after hydrolysis it gives dextrorotatory glucose & laevorotatory fructose. Since the laevorotation of fructose [-92.4°] is more than dextrorotation of glucose [+52.5°], the mixture is laevorotatory.
Thus, hydrolysis of sucrose brings about a change in the sign of rotation, from dextro to laevo. This process is k/a inversion of ~~sugar~~ sucrose & the product is k/a invert sugar.

② Maltose:

- composed of two α-D-glucose units.
- C_1 of one glucose is linked to C_4 of another glucose
- The free aldehyde group can be produced at C_1 of second glucose in solution & shows reducing properties
- It is a reducing sugar



$\boxed{\text{Maltose}}$

③ Lactose:

- It is more commonly k/a milk sugar since this disaccharide is found in milk. It is composed of β-D-galactose & β-D-glucose
- The linkage is b/w C_1 of galactose & C_4 of glucose.
- Free aldehyde group may be produced at C-1 of glucose unit
- Hence, it is also k/a reducing sugar

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* Polysaccharides.

→ carbohydrates which yield a large no. of monosaccharides on hydrolysis are k/a Polysaccharides.

→ eg: starch, cellulose, glycogen.

① Starch

→ It is a main storage polysaccharide of plants.
→ It is very important diet for human beings.
→ It is stored in seeds, roots & tubers like potatoes, maize, barley, wheat etc.
→ Polymer of α-glucose

Structure of starch.

Amylose	Amylopectin.
→ It constitutes about 15-20% of starch.	→ It constitutes 80-85% of starch.
→ It is water soluble	→ It is water insoluble
→ It has a long unbranched chain with 200-1000 α-D(+) glucose	→ It has a branched chain of α-D(+) glucose units. The chain is formed by C_1 & C_4 glycosidic whereas, branching occurs by C_1-C_6 glycosidic linkage.
→ Straight chain	→ Highly branched

② Cellulose

→ It is present only in plants
→ It is most abundant organic substance found in plants.
→ It is main component of cell wall of plant cell.
→ The cellulose has β-D glucose units linked with glycosidic linkage at C_1 & C_4 of two glucose units.
→ Its glycosidic linkage is also called β-glycosidic linkage

(3) Glycogen :

- It is also called animal starch
- Present only in animals in their muscles, liver, brain
- when the body of animals need glucose, then glycogen is changed into glucose by enzymes
- Its structure is similar to amylopectin of starch.
- Their is highly branched.
- Glycogen is also found in yeast & fungi

Carbohydrates

Reducing sugar

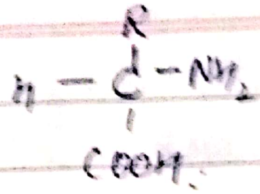
- which can reduce Tollen's Reagent & Fehling solution
- here, free aldehyde/ ketonic group present
- eg: glucose, maltose, lactose, Fructose

Non reducing sugar:

- which can't reduce Tollens & Fehling solution
- Here, free aldehyde / ketonic group absent
- eg: Sucrose, cellulose, Starch

Proteins

- These are nitrogeneous biomolecules which are necessary for growth of living organism.
- Derived from Greek word "Proteios" which means primary or prime importance
- In our body all hormones, all enzymes, haemoglobin etc. all are proteins.
- Proteins are polymer of α-amino acids



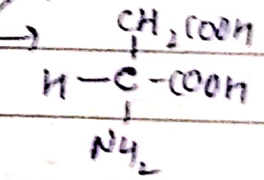
Str. of α- amino acids.

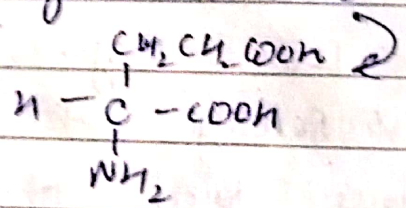
• **NOTE :** Where the exception of glycine all other α-amino acids have chiral carbon atom & are optically active

* Classification of A.A on the basis of nature :

① Acidic amino acid.

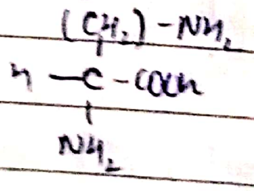
⇒ Total no. of carboxylic acids group are more than amino group. eg : aspartic acid & glutamic acid

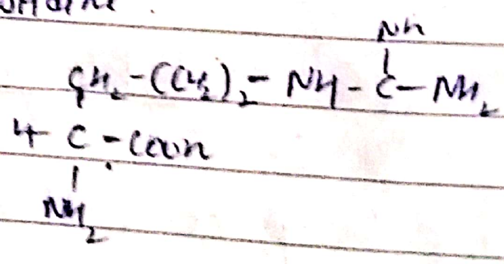




② Basic Amino acid.

⇒ Total no. of amino groups are more than carboxyl group.
eg : lysine & Histidine





③ Neutral amino acids.

⇒ Those amino acids which have equal no. of carboxylic acid & amino group
eg : glycine, Alanine, valine

* Classification on the basis of synthesis.

- Essential amino acids
  - ⇒ Those A.A which are not prepared by our body, so we have to take them from outside through our diet.
  - ⇒ These are total 10 in number.
  - ⇒ Deficiency of essential A.A in diet can cause disease like "Kwashiorker"
  - ⇒ eg: Valine, Isoleucine, Lysine, Leucine etc.

- Non-essential AA
  - ⇒ These are prepared inside our body & need not to be taken from outside
  - ⇒ These are 10 in no.
  - ⇒ eg: Glycine, Alanine, Aspartic acid, glutamic acid.

* Properties of A.A

- A.A are usually colourless, crystalline solids
- They have high m.pt due to their salt like structure.
- Soluble in water

* Zwitter ion.

- ⇒ when, in aqueous solⁿ, the carboxyl group can lose a proton & amino group can accepts a proton giving rise to a dipolar ion k/a "zwitter ion"
- ⇒ Zwitter ion is neutral but contain both charges -ve & +ve

$$\underset{\displaystyle NH_2}{R-\overset{|}{CH}}-\overset{\overset{\displaystyle O}{\|}}{C}-OH \rightleftharpoons \underset{\displaystyle \overset{+}{N}H_3}{R-\overset{|}{CH}}-\overset{\overset{\displaystyle O}{\|}}{C}-O^-$$

[Zwitter ion]

In zwitter ionic form, amino acids show amphoteric behaviour as they have both amine & carboxyl group & react with both acids & bases.

[pH = 5.5 to 6.3]

⇒ Isoelectric Point: The pH value at which zwitter ion show no attraction towards any electrode [+ve & -ve].

⇒ Configuration of α-Amino Acid.

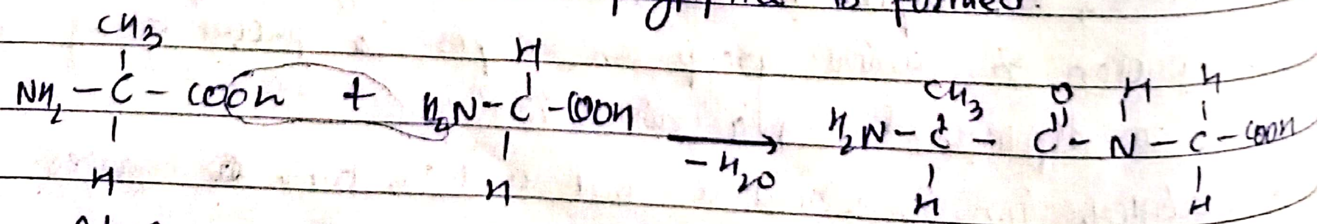
- These exist both in 'D' & 'L' forms.
- Most naturally occuring amino acids have L-configuration.
- L-Aminoacids are represented by writing the $-NH_2$ group on left hand side.

* Peptide Bond:

⇒ When two or more α-amino acids are linked together by peptide linkage, then these are called peptides.

⇒ Chemically, peptide linkage is an amide [CO-NH_2] formed b/w -COOH group & NH_2 group.

- When two amino acids combined a dipeptide is formed.
- When three amino acids combined a tripeptide is formed.
- If more than three the polypeptide is formed.



Alanine

Glycine

Ala-Gly

Note: The polypeptide having molecular mass more than 10000 u are called proteins.
Sometimes, a polypeptide with fewer amino acids is also called a protein, if they have a well defined conformation of a protein, such as $\boxed{\text{Insulin}}$, which contain only $\boxed{51\ A.A}$

Fibrous protein	Globular proteins.
• They have linear thread like structure.	• They have 3-D spheroidal shape
• These are insoluble in water but soluble in strong acid & base	• These are soluble in water or aqueous sol^n of acid, base, salt
• Protein chains are held together by intermolecular hydrogen bonding.	• Protein molecules are folded to give 3-D spheroidal shape
• These are linear condensation product	• These are cross linked condensation products of acidic & basic amino acids
• eg: Keratin [in hair, wool, silk,] Myosin [in muscles]	• eg: Insuline & albumins.

* Classification on the basis of hydrolysis.

• Simple Protein on hydrolysis gives only amino acids eg: albumin, keratin

• Conjugated Protein. on hydrolysis gives α-amino acids as well as some non protein portion also called [prosthetic group]

• Derived Protein. They are the product of partial hydrolysis of simple or conjugated proteins.
eg: Proteoses, peptones & peptides etc.

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* Structure of proteins.

• **Primary structure.**

⇒ Each polypeptide in a protein has amino acids linked with other in a specific sequence & this sequence of amino acid said to be the primary structure of that protein.

• **Secondary structure**

⇒ Secondary st. of proteins refers to the shape in which a polypeptide chain exist.

⇒ They are found to exist in two different type of str namely α – helix & β-pleated sheet structure

• **Tertiary structure**

⇒ The tertiary structure of proteins represents overall foldi the folding of the polypeptide chains i.e further folding of secondary st.

⇒ It gives rise to two major molecular shapes namely fibr & globular.

• **Quaternary structure**

⇒ Some of the proteins are composed of two or more polypepti chains referred to as subunits.

⇒ The spatial arrangement of these sub-units w.r.t to each ot is k/a quaternary structure

NOTE : The main forces which stabilise the 2° & 3° structures of p are hydrogen bonds, disulphide linkages, vander waals & electrostatic forces of attraction

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किसी gt protein को natural form remove करना

when protein in its native form, ~~is subjected to physical change~~ like change in temp. or chemical like change in pH. due to this globules unfold & helix get uncoiled & protein loses its biological activity. Now it

* Denaturation of Proteins

→ During denaturation secondary & tertiary structure was destroyed but 1° structure remains intact. The physical & biological properties also changes but chemical properties remains same.

→ It can be change by, change in pH & temperature. Due to this globules unfold & helix get uncoiled & protein loses its biological activity.

→ eg: • clotting of egg, on boiling it solidified i.e coagulate
• curdling of milk, which is done by change in pH.

ENZYMES

→ These are biological catalyst, which increase rate of biochemical reaction.
→ All enzymes are globular protein.
→ eg: zymase, invertase, maltase, lactase, urease, trypsin etc.

→ They increase the rate of rxn, because they decrease the magnitude of activation energy of biochemical rxns.
e.g Activation energy for acid hydrolysis of sucrose is 6.22 kJ/mol while it is only 2.15 kJ/mol, when hydrolysed with an enzyme

$$\underset{\text{maltose}}{C_{12}H_{22}O_{11}} \xrightarrow{\text{Maltase}} \underset{\text{glucose}}{2C_6H_{12}O_6}$$

→ Properties of Enzymes.
1. High efficiency
2. Extremely small quantities required
3. Optimum temp & pH → about 37°C & around 7 pH
4. specificity

VITAMINS

→ These are the organic compounds which can not be produced by the body & must be taken in small quantity through diet, for normal health, growth & maintenance of b...

→ For simplicity these are designed as A, B, C, D, E & K

★ classification of vitamins.

Water soluble vitamins

- These vitamins are soluble in water
  eg: Vitamin B & C
- These must be taken regularly through diet as these are ~~...~~ excreted in urine & can't be stored

Fat soluble vitamins

- These are the vitamins which are soluble in fats but insoluble in H_2O [eg: vitamin A...
- They are stored in liver & adipose [Fat storing tiss...

~~Imp~~ Note: Deficiency Disease table from book

NUCLEIC ACID

→ These are the biopolymers present inside a nucleus of all living cells in the form of nucleoproteins responsible for heredity. These are also called polynucleotides.

- Polynucleotides are the particles in nucleus of cell [responsible for heredity) are called chromosomes
- Chromosomes are made up of proteins & nucleic acid

Nucleotides → Pentose sugar + Nitrogenous Base + Phosphate group

Nucleosides → Pentose sugar + Nitrogenous Base

N_4 — N_4 — N_4 — N_4

Phosphodiester linkage

Nucleic acid

DNA [Deoxyribo nucleic acid]	RNA [Ribo nucleic acid]
• Sugar present : Deoxy Ribose	• Sugar present : Ribose
• Base → Purines → Adenine, Guanine; Pyrimidine → Cytosine, Thymine	• Base → Purines → Adenine, Guanine; Pyrimidine → Cytosine, Uracil
• DNA has double helix structure	• RNA has single helix structure
• DNA is present in nucleus of cell	• RNA is present in cytoplasm of cell
• DNA has a unique property of Replication	• RNA doesn't have any property of replication.
• DNA are very large in no. that is 6 million to 16 million	• As compared to DNA RNA is small in no.
• DNA is responsible for the transfer of the hereditary effect from one generation to another	• RNA is responsible for protein synthesis.

$T = A$
$G \equiv C$

Note

* Nucleotides are formed together by phosphodiester linkage b/w 5' & 3' carbon atoms of the pentose sugar

* Structure of DNA.
→ It consists of two polynucleotide chains, each chain form a right handed helical spiral with ten bases in one turn of the spiral.

→ The two chains coil to double helix & run in opposite dirn. These are held together by H-bonding.

* Types of RNA

① messanger RNA [m-RNA].
② Transfer RNA [t-RNA]
③ Ribosomal RNA [r-RNA].

* function of nucleic acid
→ Direct the synthesis of protein
→ Transfer the genetic information

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