BIOMOLECULES

Biochemistry → A study of what goes on within the living system.

These molecules are important for biological processes.

Biochemistry
- Bioorganic
  - Molecules
    - Carbohydrates
    - Proteins
    - Nucleic Acids.
    - Lipids
    - Vitamins
    - Hormones.
- Bio-Inorganic

* CARBOHYDRATES

Sugar → $C_{12}H_{22}O_{11} = C_{12}(H_2O)_{11}$

glucose → $C_6H_{12}O_6 \Rightarrow C_6(H_2O)_6$

Initially, carbohydrates were defined as $C_x(H_2O)_y$.

But this was not correct fully.

as other molecules also follow $C_x(H_2O)_y$.

Ex. Acetic acid $CH_3COOH \Rightarrow C_2(H_2O)_2$ but this isn't a carbohydrate.

∴ This definition was wrong.

→ At the same time, some carbohydrates don't have molecular formula $C_x(H_2O)_y$.

Classic definition: These are hydrates of carbon.

General formula is $C_x(H_2O)_y$.

The structures that are known to satisfy this formula are Glucose ($C_6H_{12}O_6$) or Sucrose ($C_{12}H_{22}O_{11}$).

Ex of carbohydrates that don't have $C_x(H_2O)_y$ →

Rhamnose: $C_6H_{12}O_5$ but it is still a carbohydrate.

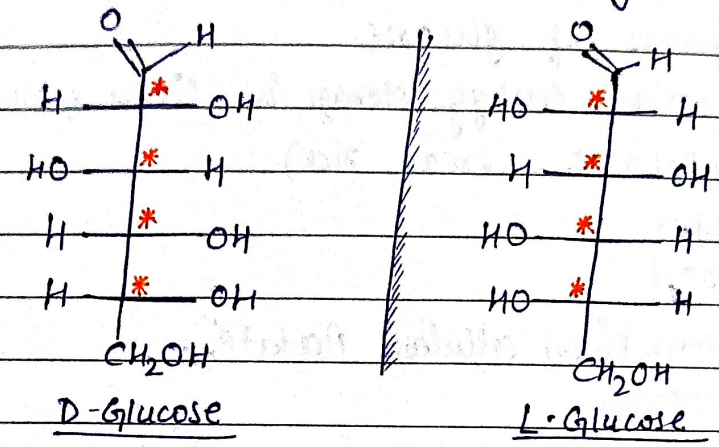
Modern Definition →

Carbohydrates are optically active polyhydroxy aldehydes or ketones or any such compounds which produce these on hydrolysis.

* Classification and Naming

(+) D Glucose (+) represents dextrorotatory.

D, L ⇒ naming → no relation with optical activity



4 chiral carbons

★ If the 2nd carbon from bottom has −OH gp. on right side, it is called D- compound.

If 2nd carbon from bottom has −OH gp. on left side, it is called L- compound.

→ (+) D Glucose is most abundant substance in biomolecules.

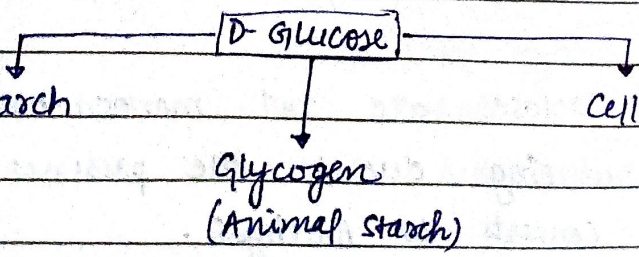
→ "ose" represents sugar or saccharide.

Sources: (1) Photosynthesis in plant leaf ($CO_2 + H_2O$).

External Conditions - Sunlight and chlorophyll

Chlorophyll is a metal ion complex of Magnesium.

Storage :



D Glucose is interconvertible in Starch, Glycogen, Cellulose.

Starch → In plant seeds as food
Glycogen → Animal starch
Transported via blood stream
Stored in liver
Cellulose → Framework of structure of plants

Uses of biopolymers of glucose
Glycogen: long term energy storage in livers & muscles.
starch: food (Potatoes, bread, rice).
Cellulose: → Paper
→ wood
→ Cotton Fiber cellulose Acetate.

Classification of Carbohydrates.

I. on the basis of Functional Group
1) Polyhydroxy Aldehyde ex. Glucose
2) Polyhydroxy Ketone ex. Fructose

II. on the basis of Reducing Nature
(1) Non Reducing Sugars — which don't reduce Tollen's and Fehling solution.
ex. sucrose
. The Aldehyde group isn't available for reducing
(2) Reducing Sugars - which reduce Tollen's & Fehling solution
→ All Monosaccharides are reducing sugars
ex. Glucose, Fructose, Maltose, lactose, etc.

→ Maltose and Lactose are not monosaccharides.
→ Fructose is reducing due to the presence of 1° Alcohol which converts to Aldehyde.

ulose.

III. on basis of sweetness.

(1) Sugar (2) Non-Sugar.

Saccharide came from Latin word saccharum which mean sugar.

IV. on the basis of NO. of carbon atoms

3	4	5	6
Triose	Tetrose	Pentose	Hexose

$-CHO$ Aldose $-C=O$ Ketose

So, if a carbohydrates has 4 carbon and 1 CHO

It is "ALDO-PENTOSE".

Carbohydrate 5 carbon & 1 C=O ⇒ Ketohexose.

V. on the basis of NO. of Products of Hydrolysis.

(1) Monosaccharides → Don't undergo hydrolysis.

ex. Glucose, Fructose, Ribose.

(2) Oligosaccharides → give 2-10 units on hydrolysis; Crystal solids, water sweet

ex. Sucrose, maltose.

$$C_{12}H_{22}O_{11} \xrightarrow{H_3O^+} C_6H_{12}O_6 + C_6H_{12}O_6$$

Sucrose (glucose) (fructose)

(3) Polysaccharides → give more than 10 units on hydroly

ex. starch, cellulose, Glycogen. | amorphous, inso in water, tast

* Preparation of Glucose.

(1) Hydrolysis of Canesugar:

$$C_{12}H_{22}O_{11} + H_2O \xrightarrow{H^+} C_6H_{12}O_6 + C_6H_{12}O_6$$

acid catalyst (glucose) (fructose)

Boil in the presence of alcohol or the enzyme "Invertase" can cause this reaction.

For a typical hydrolysis of polysaccharides.

$(M-M-M-M)_n \xrightarrow[(n-1)\,H_2O]{\text{hydrolysis}} n \times M$.

for a polysaccharide containing n monomeric units (4)
(n-1) H_2O molecules are required for hydrolysis.

(2) Commercial method:

$(C_6H_{10}O_5)_n \xrightarrow[H^\oplus]{n\,H_2O} n\,(C_6H_{12}O_6)$

Starch or cellulose

acid → dil. HCl or H_2SO_4 at 393K, 2-3 atmp.

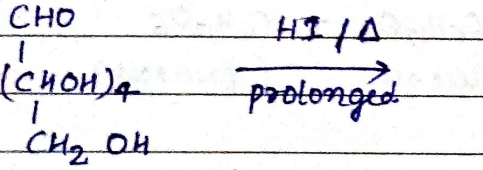
or if we write $(C_6H_{12}O_6)_n \xrightarrow[H^+]{(n-1)\,H_2O} n\,C_6H_{12}O_6$

(n-1) mole water required. (5)

* Evidence of Glucose Structure.

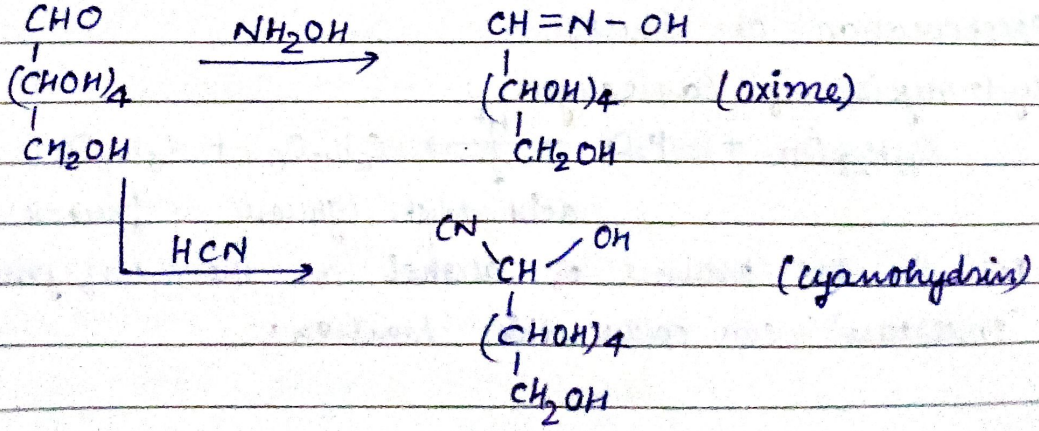
(1) Molecular formula of Glucose is:
using mole concepts like mass percent or combustion products percent we find empirical formula -
So. m.f was determined to be $C_6H_{12}O_6$.

(2)



It proves that all carbon are connected in straight chain.

(3)



It proves that carbonyl group is present in glucose.

(4) $CHO-(CHOH)_4-CH_2OH \xrightarrow{Br_2/H_2O} COOH-(CHOH)_4-CH_2OH$ (Gluconic acid)

Bromine water is a mild oxidising agent. So, it oxidises only Carbonyl group; not -OH group.

Aldose ⟶ Aldonic acid

As Br_2/H_2O oxidises it; presence of aldehydic group is confirmed.

(5) $CHO-(CHOH)_4-CH_2OH \xrightarrow[\text{Strong oxidising agent}]{\text{Conc. } HNO_3} COOH-(CHOH)_4-COOH$ Glucaric Acid

∴ Thus it was confirmed that first carbon is -CHO & last Carbon is 1° Primary alcohol.

Aldose ⟶ Aldaric Acid

(6) $CHO-(CHOH)_4-CH_2OH \xrightarrow[\text{Pyridine}]{Ac_2O} CHO-(CHOAc)_4-CH_2OAc + 5AcOH$

(Penta-Ester)

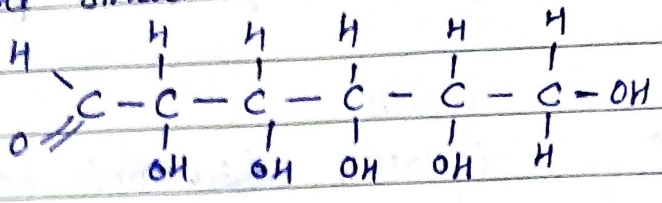
Anhydride + ROH ⟶ Ester + Acid

ex $CH_3-OH + CH_3-\overset{\overset{O}{\|}}{C}-O-\overset{\overset{O}{\|}}{C}-CH_3 \longrightarrow CH_3COOH + CH_3-\overset{\overset{O}{\|}}{C}-OCH_3$

it was confirmed that 5 alcohol gp. are present in it. As two -OH on same carbon are unstable, so these 5-OH groups must be on different carbons as glucose is stable.

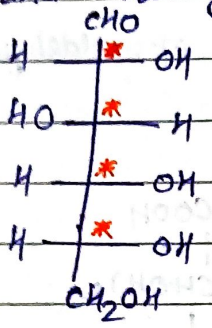
1 Aldehydic group is present on 6th carbon.

∴ The structure is →



* Stereochemistry of Structure.

The examination of stereochemistry was done by Fischer and he gave following structure.



⇒ carbon backbone

4 chiral carbons

⇒ $2^4 = 16$ possible configurations exist

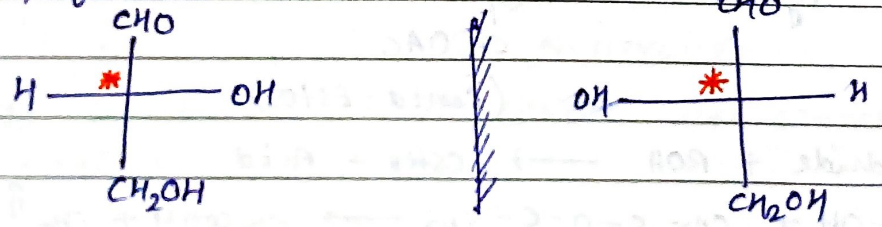
only 1 out of 16 is (+) D-glucose

* D-L Nomenclature.

→ "D" represents the configuration & not related to optical activity or optical nature.

→ They indicate the relative configuration of a particular stereoisomer.

→ The simplest carbohydrate "GLYCERALDEHYDE" is chosen as reference.



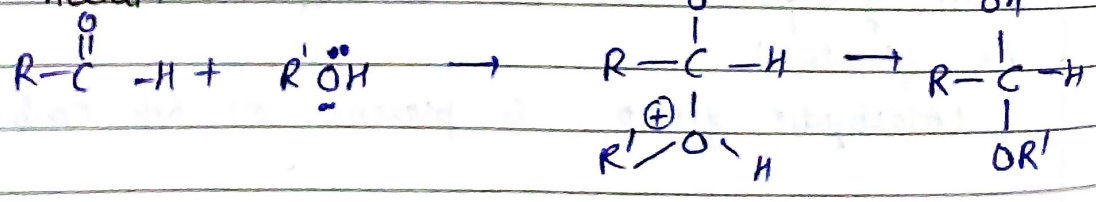
OH group in right ⇒ "D"

D- glyceraldehyde

OH group in left ⇒ "L"

L- glyceraldehyde.

* Hemi-Acetal:



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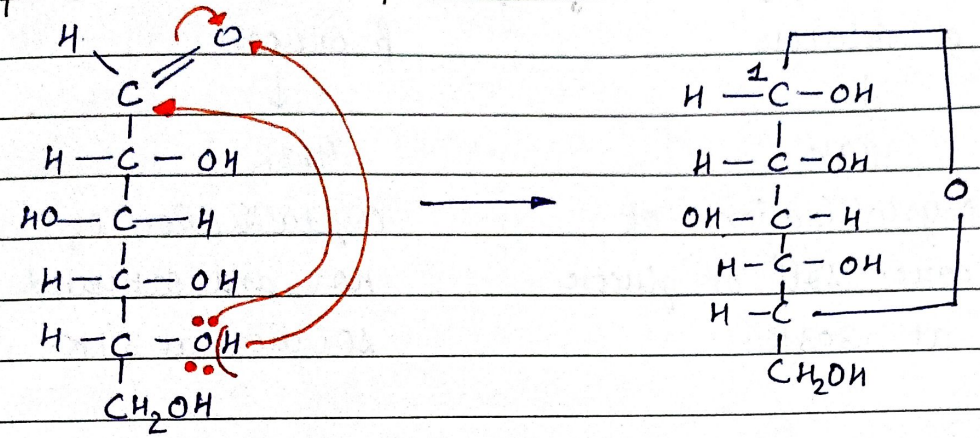
CYCLIC STRUCTURE OF GLUCOSE

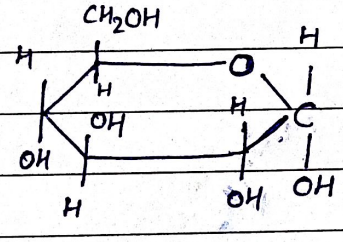


6 membered ring formation

Intramolecular Hemi-Acetal formation.

★ Why this particular -OH was chosen?

Because 6-membered ring is the most stable ring.



"HAWORTH STRUCTURE"

* Why did need of cyclic structure arise?

or Failures of Straight Chain Structure.

The straight chain structure fails to explain the following properties or reactions shown by glucose-

(1) Glucose doesn't show 2-4 DNP test, Schiff's Base test, $NaHSO_3$ Adduct product.

⇒ It was concluded that oxygen of the aldehydic group is not free and busy in ring formation.

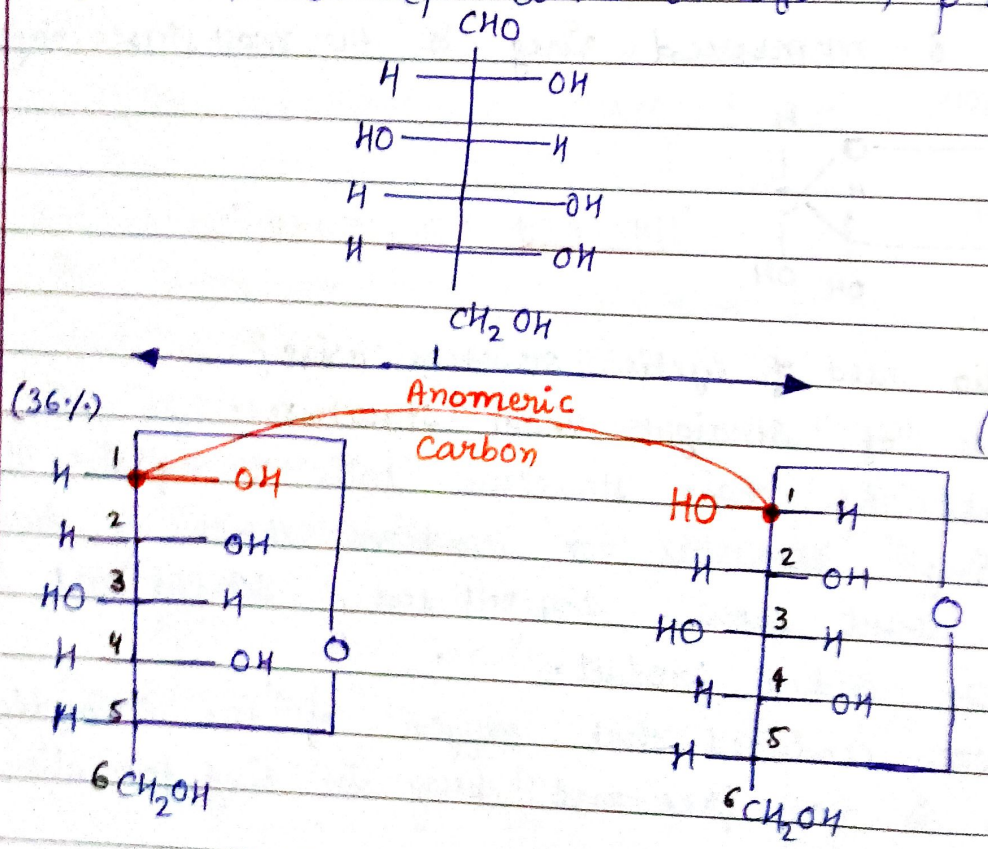
(2) The pentacetate of Glucose doesn't react with NH_2OH to form oximes.

But straight chain reaction form oximes and cyclic structure doesn't, so, cyclic structure preferred.

crystalline forms of Glucose

	α - Glucose	β - Glucose
Melting pt.	419K	423K
Preparation	Crystallization of conc. sol^n of glucose at 303K	Crystallisation of hot and saturated solution at 371K.

On the cyclisation of straight chain structure, if -OH on C_1 comes on right ⇒ α-D glucose.
If -OH on C_1 comes on left ⇒ β-D Glucose.



There exists equilibrium. α & β can interconvert via straight chain.

α-D glucose ⇌ Straight chain ⇌ β-D glucose

C_1 is sp^2 hybridised and planar. so, the -OH group can attack from both above and below.

above → α below → β.

★ There are 4 chiral carbon in straight chain structure but 5 chiral carbon in cyclic structure.

The α- and β forms are called EPIMERS OR ANOMERS of EACH other.

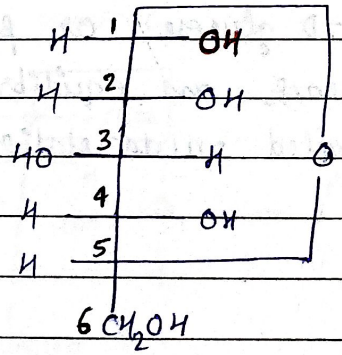
Anomers: Anomer is a special type of epimer that differs in configuration specifically at the hemi acetal / acetal carbon atom.

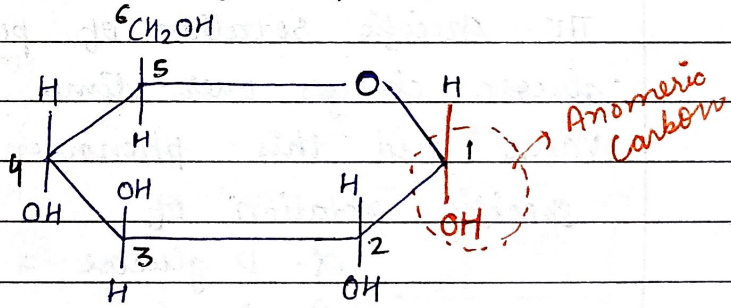
Epimers: Epimers are those compounds in which the configuration differs only at 1 chiral atom out of all those present in it.

The C_1 is called "Anomeric carbon"

★ Epimers and Anomers are diastereomers.

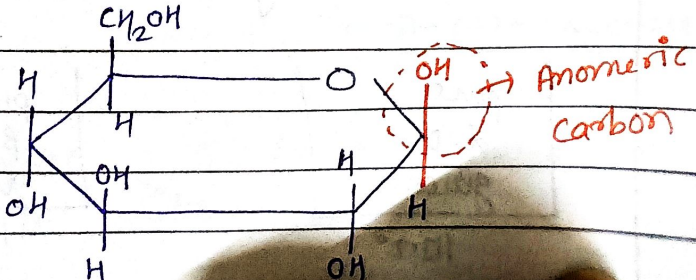
* Drawing Haworth Structures of α & β forms →





α-D-(+) glucose.

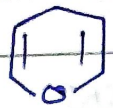
for β- just rotate config. at C_1 by 180°.



β-D-(+) glucose

Q. Which anomer is more stable; α or β?

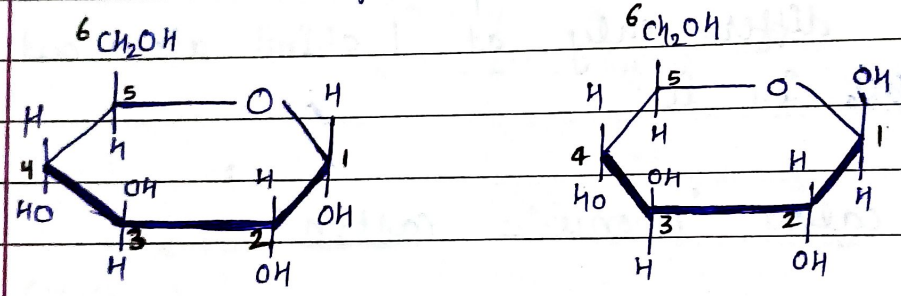
Due to less steric repulsion of bulky groups, β- form is more stable. Hence it is formed 64%. (-OH is equatorial in β forms).

 → pyran.

As glucose also has 1 O atom in 6 membered ring, thus structures are pyranose. For glucose derivatives, also Gluco pyranose.

→ The front bonds of Haworth structure are darkened to highlight 3-D nature.

Hence the final structures are →



α-D-(+)-Gluco-Pyranose β-D-(+)-GlucoPyranose.

* MUTAROTATION

The specific rotation of pure α-D glucose or β-D glucose changes over time to reach an equilibrium value and this phenomenon is called mutarotation.

Specific rotation of:

α- D glucose = +112.2°

β- D glucose = +18.7°

optical activity at equilibrium = +52.6°

pure α-D glucose
112.2°

pure β-D glucose
18.7°

as $\alpha \rightleftharpoons \beta$. optical rotation decreases till equilibrium reached

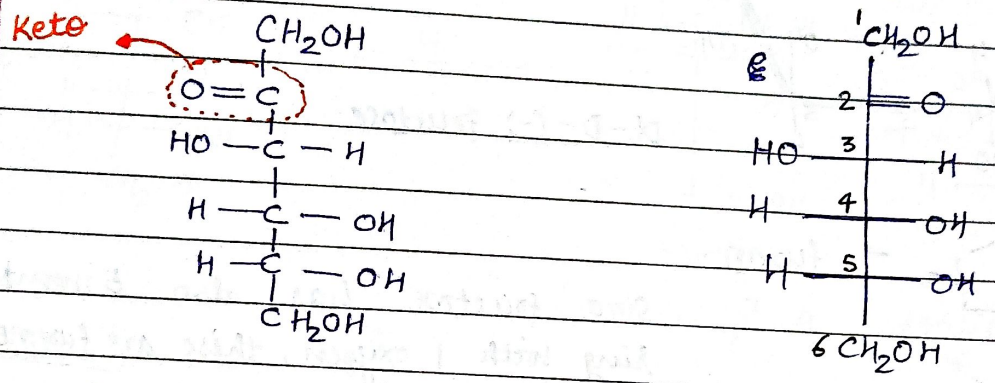
At eqm $\beta = 64\%$ $\alpha = 36\%$

So, rotation at eqm $\theta_{eqm} = 0.36 \times 112.2° + 0.64 \times 18.7°$

$= \boxed{52.6°}$ ✓

"FRUCTOSE"

$C_6H_{12}O_6$ Keto Hexose, Laevose (leavo rotatry).

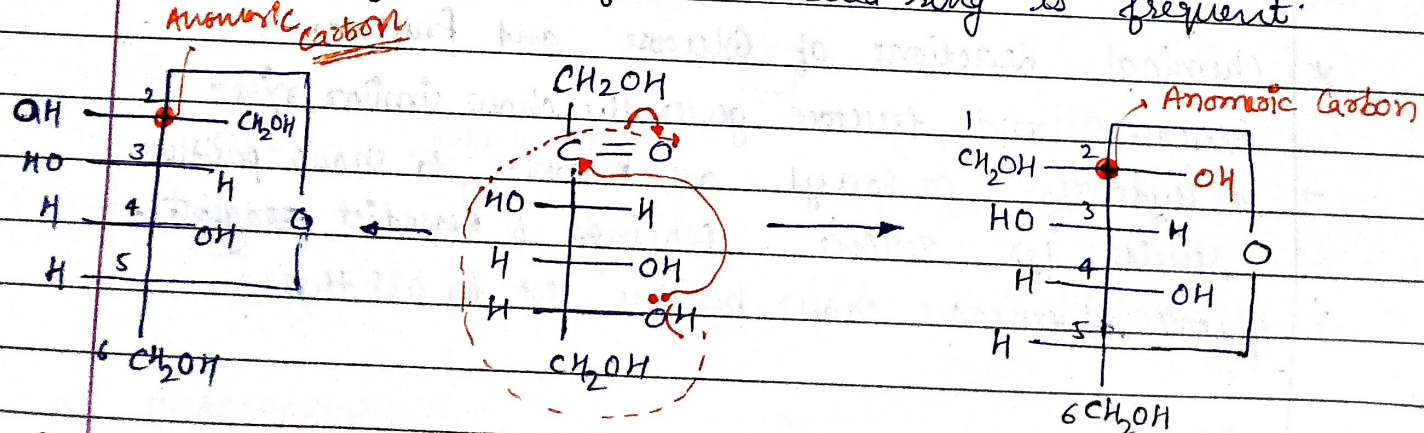


As OH on C_5 is on right, D-fructose

Since it is leavo rotatry, D-(-)-fructose.

→ C_2 is Anomeric carbon.

→ unlike glucose, in fructose practically it is seen that 6 membered ring is formed in very small quantity & relative formation of 5 membered ring is frequent.

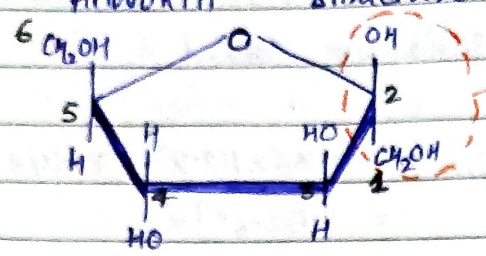


β-D-(-)-Fructose

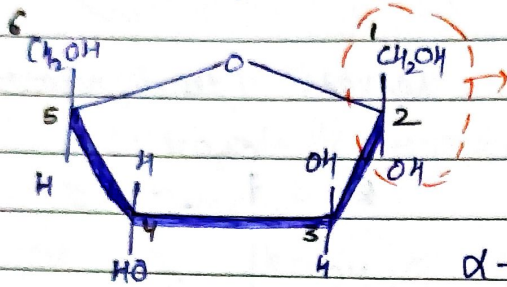
α-D-(-)-Fructose

This is due to the sp^2 nature of C_2 due to which attack can occur from both sides.

HAWORTH Structures are:



β-D-(-)-fructose



α-D-(-)-fructose

 → furan.

Since fructose has also 5 membered ring with 1 oxygen, these are furanose

Hence, name of these structures are:
· α-D-(-)-fructofuranose and β-D-(-)-fructofuranose

→ In α-form, both $-CH_2OH$ are on same side while in β-form, both $-CH_2OH$ are on opposite side.

* Chemical Reactions of Glucose and Fructose.

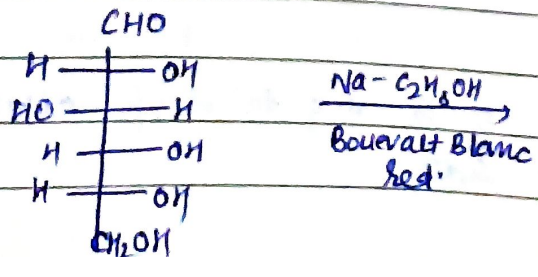
Glucose and fructose generally show similar rxns.

→ α-Hydroxy carbonyl are known to show positive results for Tollen's, Fehling's & Benedict reagent.

→ Glucose & fructose show positive test for all three.

Glucose

(I) Reduction.

(A) 

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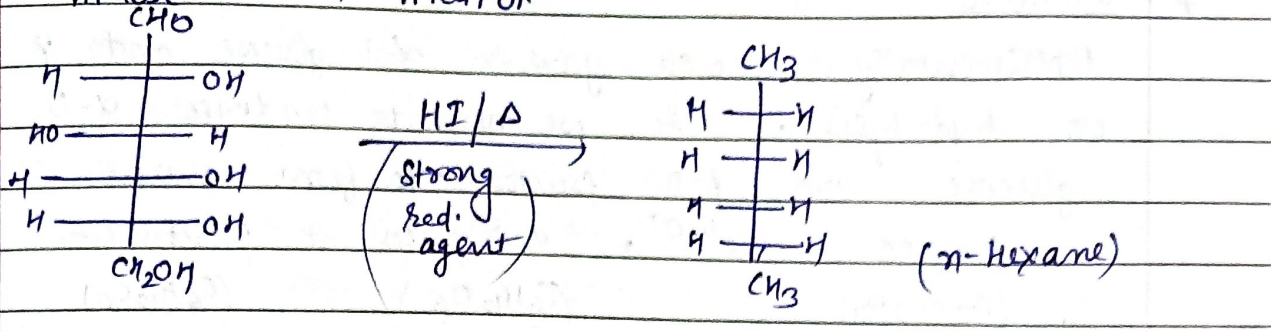
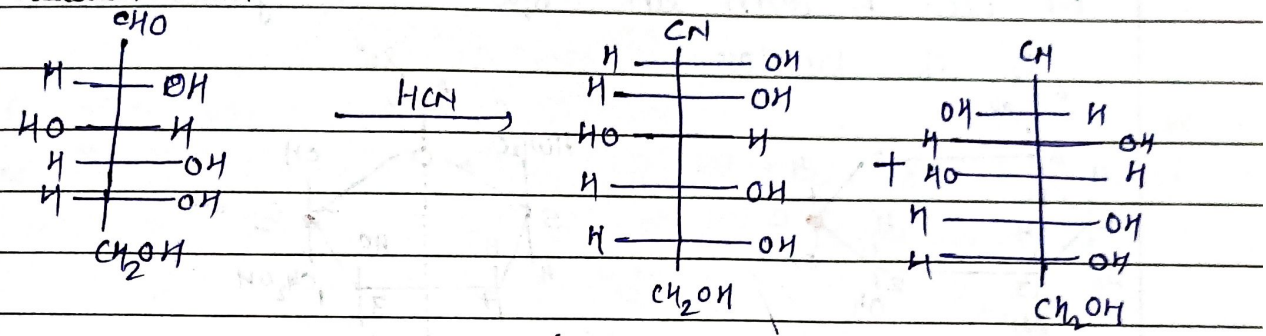
Aldose ⟶ Alditol.

(B)



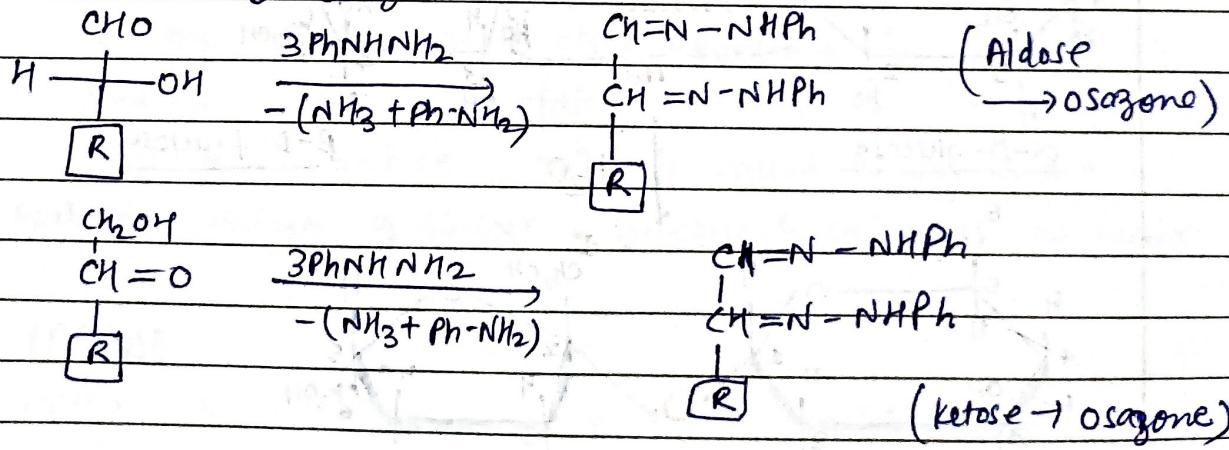
(2) Reaction with HCN



(CHO is sp^2 ⇒ double attack)

OSAZONE FORMATION

Aldose and ketones react with 3 mole phenyl hydrazine ($PhNHNH_2$) to form osazone. Epimers will give same osazone.



DISACCHARIDES

To form a disaccharide, we need to join two mono saccharides.

Mono saccharide + Mono saccharide ⟶ Disaccharide

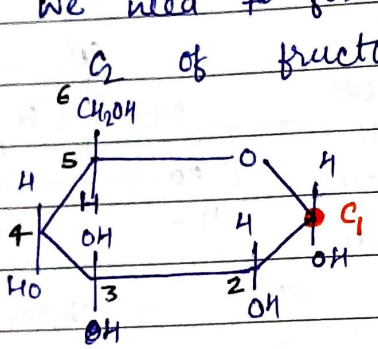
Ex. Lactose, Maltose, Sucrose.

SUCROSE

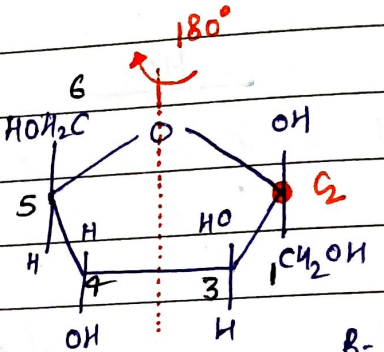
Experimentally, sucrose gave α-D-glucose and β-D fru on hydrolysis. So, we need to condense α-D glucose and β-D fructose to form sucrose.

Sucrose ($C_{12}H_{22}O_{11}$) $\xrightarrow{H_3O^+}$ α-D glucose ($C_6H_{12}O_6$) + β-D fructose ($C_6H_{12}O_6$)

We need to form link b/w C_1 of glucose and C_2 of fructose.



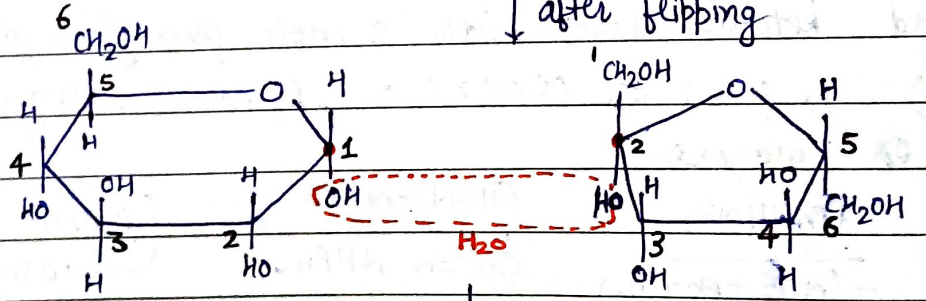
α-D glucose.



β-D-fructose

To form required link, we need to rotate β-D fructose by 180°.

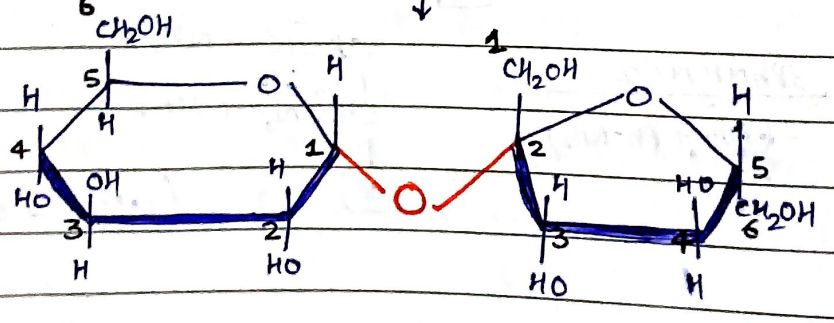
↓ after flipping



α-D-glucose

β-D-fructose

$-H_2O$



SUCROSE "α-β-Glycosidic linkage"

C_1—O—C_2 linkage is called "GLYCOSIDIC LINKAGE"

Page No :

* REDUCING AND NON-REDUCING SUGARS.

Hemi acetal or Hemi ketal is present ⇒ it is reducing sugar.

To identify hemi acetal or hemi ketal:

Hemi Acetal → -OH, ether, H on same carbon.

Hemi Ketal → -OH, ether, R on same carbon.

Ex. In glucose, C_1 has H, OH, and ether ⇒ reducing sugar.

Ex. In fructose, C_2 has OH, Ether, and R. ⇒ reducing sugar.

Ex. In sucrose, there is no carbon which has hemi ketal or hemi acetal. Hence, sucrose is non reducing.

* INVERT SUGAR.

$C_{12}H_{22}O_{11} + H_2O \xrightarrow{H^\oplus} C_6H_{12}O_6 + C_6H_{12}O_6$

Sucrose.	Glucose	Fructose
(dextro rotatory)	(dextro rotatory)	(leavo rotatory)
$+66.5°$	$+52.5°$	$-92°$
	$-39.5°$ (leavo)	

So, the overall mixture after hydrolysis is leavo rotatory and the optical rotation is inversed wrt. pure sucrose. This is called invert sugar.

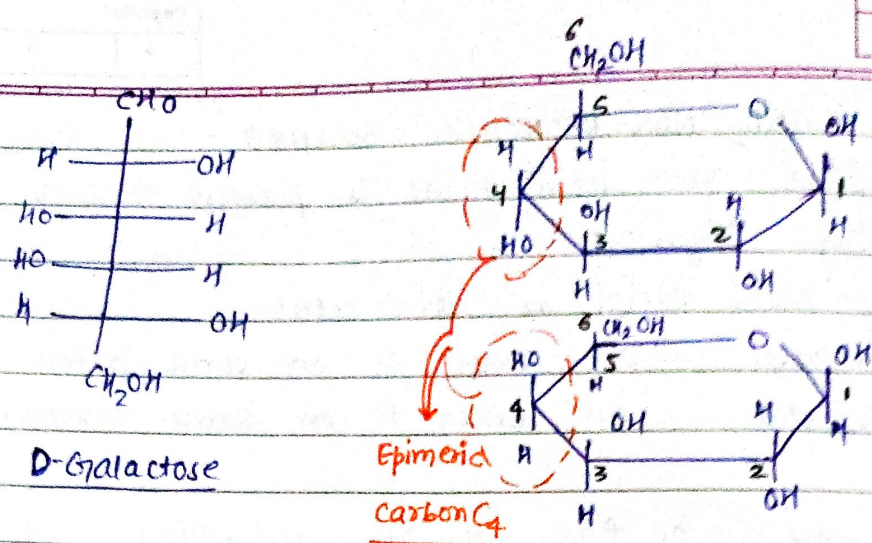
★ Equimolar mixture of glucose & fructose is called invert sugar.

\# LACTOSE

Lactose on hydrolysis gives β-D-glucose and β-D-galactose.

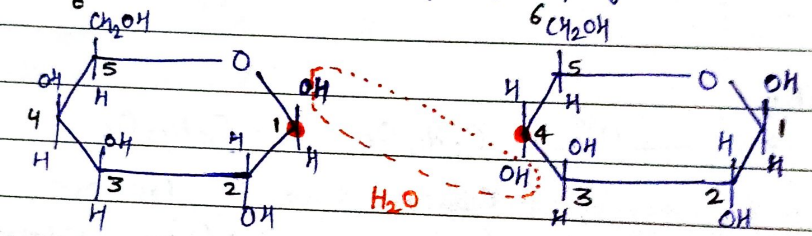
Lactose $\xrightarrow{H_2O}$ β-D-galactose + β-D-glucose.

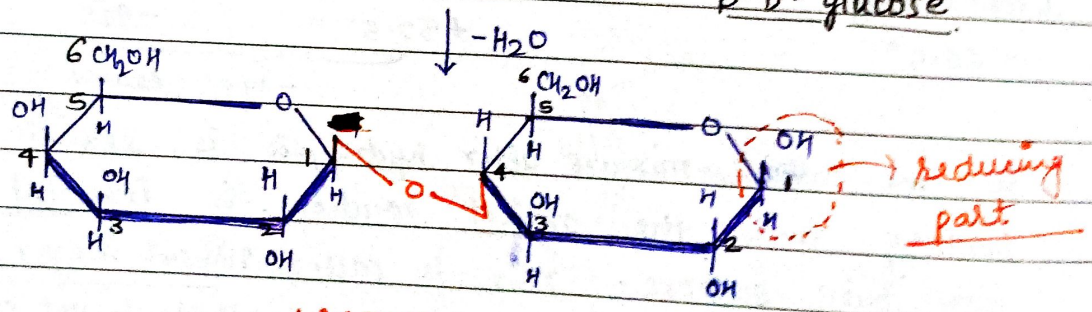
★ Galactose: Glucose and galactose are C_4 Epimers. formed by C_4 flipping of glucose.



Formation of lactose:

It is formed by glcosidic linkage b/w C_4 of β glucose and C_1 of β galactose, expelling H_2O.





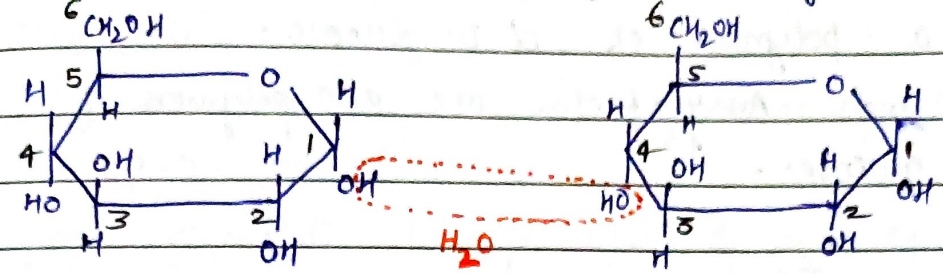
Lactose is a reducing sugar as C_1 of β-D-glucose has hemi-acetal.

MALTOSE

Maltose on hydrolysis gives 2 units of α-D glucose.

Maltose $\xrightarrow{H_3O^+}$ α-D glucose + α-D glucose.

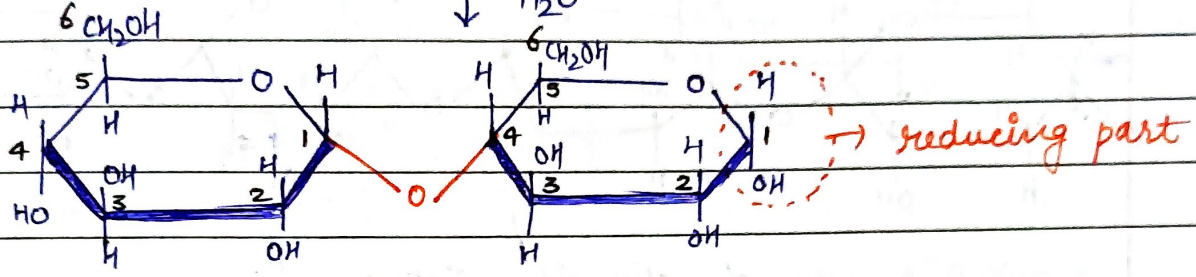
we need to form glycosidic link b/w C_1 of 1 molecule & C_4 of other molecule of α-D glucose.



α-D glucose

α-D glucose

$-H_2O$



MALTOSE "α-GLYCOSIDIC LINKAGE."

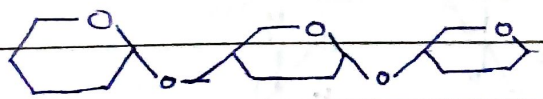
→ Maltose is a reducing sugar due to C_1 of α-D glucose.

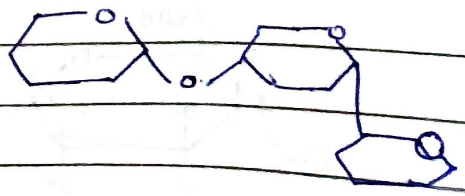
* POLYSACCHARIDES.

give many units of monomers on hydrolysis.

1) Starch → Amylose
   → Amylopectin
2) Glycogen
3) Cellulose.

→	Amylose	Amylopectin
1)	Straight chain structure.	Branched chain structure.
2)	only C_1-C_4 link present.	C_1, C_4 and C_1-C_6 link present.
3)	soluble in water.	Insoluble in water.
4)	15-20% of starch.	80-85% of starch.

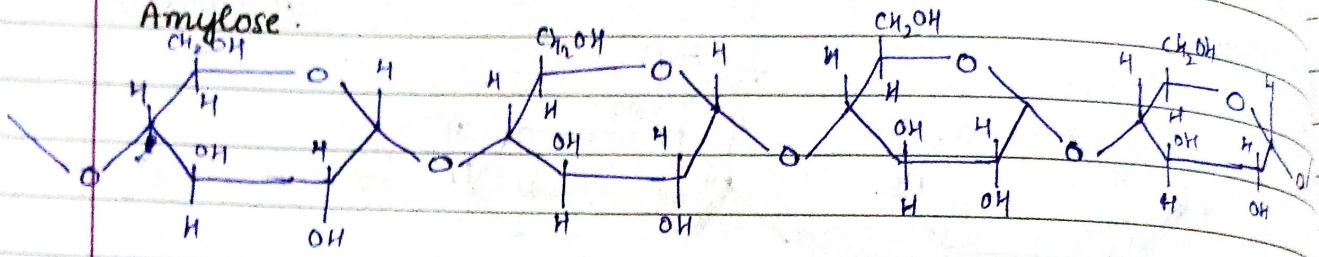




STARCH

→ starch is constituted of Amylose & Amylopectine.
→ It is a polymer of α-D-glucose.
→ Amylose and Amylopectin are also polymers of α-D glucose..

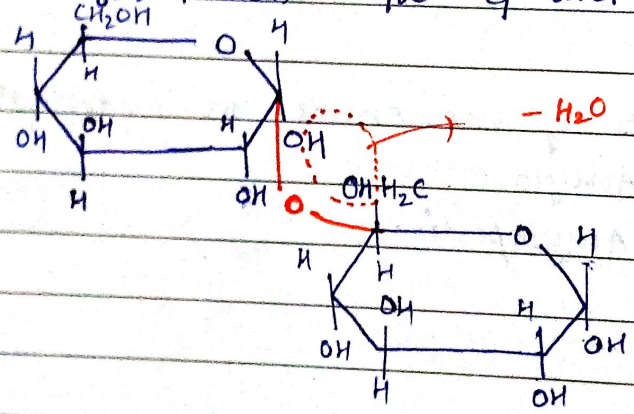
Amylose.



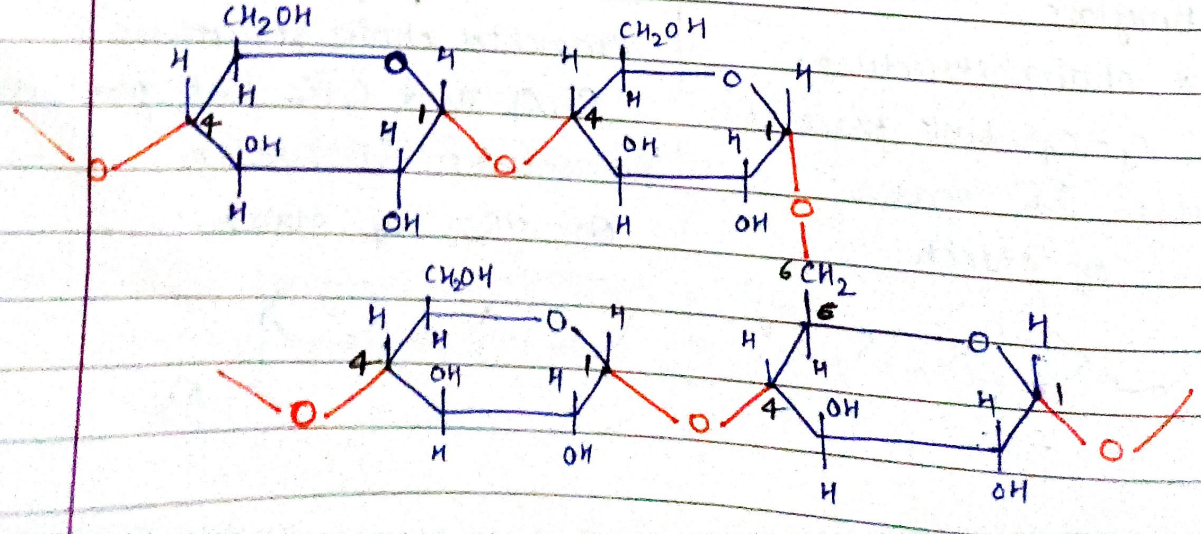
α- glycosidic linkage.

Amylopectin

Bond formation b/w C_1 and C_6 :



Structure looks like :

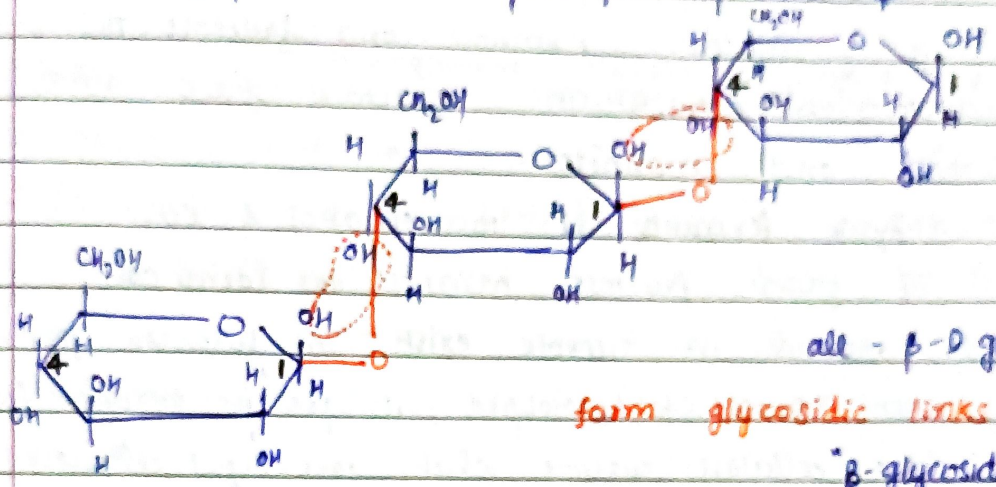


→ Starch is a non reducing sugar.

CELLULOSE

It is a straight chain polysaccharide composed only of β-D- glucose.

→ form glycosidic linkage b/w C_1 and C_4.



all - β-D glucose.

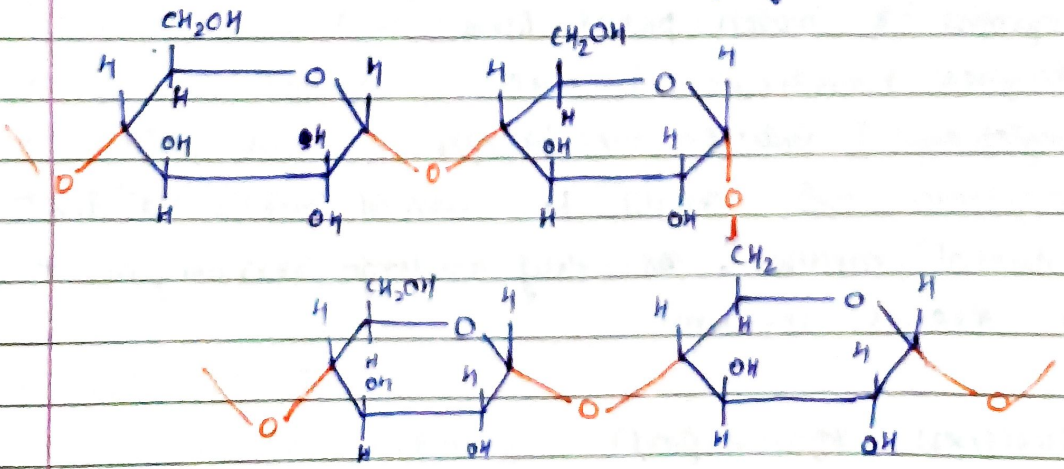
form glycosidic links

"β-glycosidic links"

→ cellulose is non reducing sugar.

GLYCOGEN

It is called animal starch. Its structure is similar to Amylopectin and rather highly branched.



→ glycogen is non reducing sugar.

Important Points about Carbohydrates:

- Fructose also shows muterotation.
- Fructose isn't oxidised by Br_2/H_2O.
- on oxidation with HNO_3, fructose gives glycolic and tartaric acid.
- under alkaline conditions, fructose rearranges to give a mixture of glucose, mannose and fructose. This is called Lobry de Bruijn Van Ekenstein rearrangement.
- on reduction with Na/C_2H_5OH, fructose gives sorbitol and mannitol.
- Zymase enzyme ferments it to ethanol & CO_2.
- Osazone of glucose, fructose, mannose are identical.
- Fructose molecule in sucrose exists in furanose form but when sucrose is hydrolysed, it goes in pyranose form.
- Cattles have cellulase enzyme which can digest cellulose but human beings cannot.

  Cellulase hydrolyses cellulose to glucose.
- Gun cotton is cellulose trinitrate. It is explosive.
- Blasting gelatin is mixture of nitroglycerine and 7%. gun cotton.
- cellulose acetate is used in making non inflammable photographic & motion picture films.
- Amylose + iodine → blue

  Amylopectin + iodine → brown
- Carbohydrates rxn should be carried out in acidic or neutral medium as they undergo rearrangement in alkaline medium.

* Sweetness of sugars.

Sugar	Degree of Sweetness
• Cane Sugar (sucrose)	100
• Lactose	16
• Maltose	33

- Glucose 74
- Fructose 175
- Invert sugar 130
- Galactose 32

→ Fructose present in invert sugar makes it sweeter than normal sugar (Sucrose)

Some compounds which are not sugar but much sweeter than sucrose →

(1) Saccharin → O-sulphobenzoic imide → 500 times sweeter than sucrose

(2) Monellin → A protein . (2000 times sweeter)

(3) Aspartame : peptide (160 times sweeter)

Tests for Carbohydrates

(1) MOLISCH'S TEST

Carbohydrate + phenol (usually α-naphthol or resocinol) = Test sol^n.

Test sol^n + sulfuric acid (or HCl) ⟶ Violet red ring

mechanism : carbohydrate + H_2SO_4 ⟶ aldehyde

Aldehyde + 2(phenol) ⟶ Violet coloured product.

→ All carbohydrates (mono, di, poly) show positive result.

→ Nucleic Acids & glycoproteins also show positive result.

→ Trioses and tetroses show negative result.

→ Glucose, Fructose, Maltose, Lactose, Sucrose ⟹ (+ve result.

(2) BENEDICT TEST

A test for reducing and non reducing sugars.

→ red ppt of Cu_2O confirms reducing sugar.

Glucose ✓ Fructose ✓ Maltose ✓ Lactose ✓

Sucrose ✗

All reducing sugars show positive result.

(3) BARFOED'S TEST

Reagent → 0.33M copper(II) Acetate + 1% acetic acid

→ Monosaccharides reduce Cu(II) to Cu(I) forming brick red ppt of Cu_2O.

→ The brick red ppt confirms presence of monosaccharides

→ Disaccharides react much slowly.

All monosacc. show positive results.

Glucose ✓ Fructose ✓ Sucrose ✗ Lactose ✗ Maltose ✗

(4) SELIWANOFF'S TEST

Reagent → Resocinol + conc. HCl (6M).

→ Based on dehydration: ketose gets dehydrated rapidly on heating than aldoses.

So, Ketose + reagent → deep cherry red colour

Aldose + reagent → faint pink colour.

→ Aldoses react so slowly that they show (−)ve results.

→ The disaccharides which produce ketoses on hydrolysis also give (+) test.

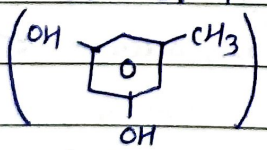
Glucose ✗ Fructose ✓ Lactose ✗ Maltose ✗

Sucrose ✓ (as it hydrolyse into fructose).

(5) BIAL'S TEST

used to differentiate b/w Pentose and Hexose.

Reagent: orcinol + $FeCl_3$ + HCl



Ketose/ Aldose + Bial's reagent → Blue green product ⇒ Pentose

→ Muddy brown grey product ⇒ Hexose.

(6) I_2/KI Test

Carbohydrate + I_2/KI → No reaction ⇒ Simpler Carbohydrate

→ Blue black complex ⇒ Starch

(7) OSAZONE FORMATION TEST

→ depends on specific crystal structure of osazones.

Carbohydrate	Shape of osazone formed	
1) Glucose	Needle shaped crystals	} Identical
2) Fructose	Needle shaped crystals	
3) Maltose	Sunflower shaped crystals	
4) Lactose	Powder puff shaped crystals	
5) Sucrose	— NO osazone	

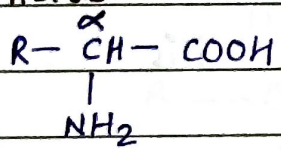
"PROTEINS"

derived from greek word 'Proteios' → which means something of vital importance.

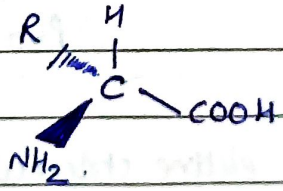
→ Proteins are polymers of α-Amino Acids.

→ Polymers of β, γ amino acids also exist but proteins contain α- amino acids only.

Amino Acids.



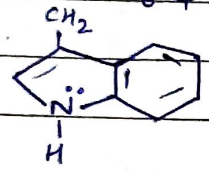
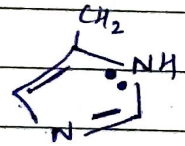
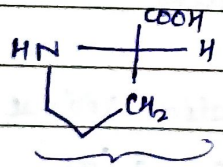
→ Natural Amino Acids are L-Amino Acids.



'R' is called residue of amino acids.

	R	Name	Symbol	Code
1)	-H	Glycine	Gly	G
2)	$-CH_3$	Alanine	Ala	A
* 3)	$(CH_3)_2CH-$	Valine	Val	V
* 4)	$(CH_3)_2CHCH_2-$	Leucine	Leu	L
* 20)	$CH_3-CH_2-\underset{\displaystyle CH_3}{\underset{\vert}{CH}}-$	Isoleucine	Ile	I

Neutral and amino acids have PI < 7

* 5)	$H_2N-(CH_2)_4-$	Lysine	Lys	K
6)	$HOOC-(CH_2)_2-$	Glutamic Acid	Glu	E
7)	$HS-CH_2-$	Cysteine	Cys	C
* 8)	$Ph-CH_2-$	Phenyl Alanine	Phe	F
* 9)	$HN=C(NH_2)-NH-(CH_2)_3-$	Arginine	Arg	R
10)	Aspartic Acid	$COOH-CH_2-$	Asp	D
11)	$H_2N-C(=O)-CH_2-CH_2-$	Glutamine	Gln	Q
12)	$H_2N-C(=O)-CH_2-$	Asparagine	Asn	N
* 13)	$CH_3-CHOH-$	Threonine	Thr	T
14)	$HO-CH_2-$	Serine	Ser	S
* 15)	$CH_3-S-CH_2-CH_2-$	Methionine	Met	M
16)	(P) $HO-C_6H_4-CH_2$	Tyrosine	Tyr	Y
* 17)		Tryptophan	Trp	W
* (18)		Histidine	His	H
(19)		Proline	Pro	P

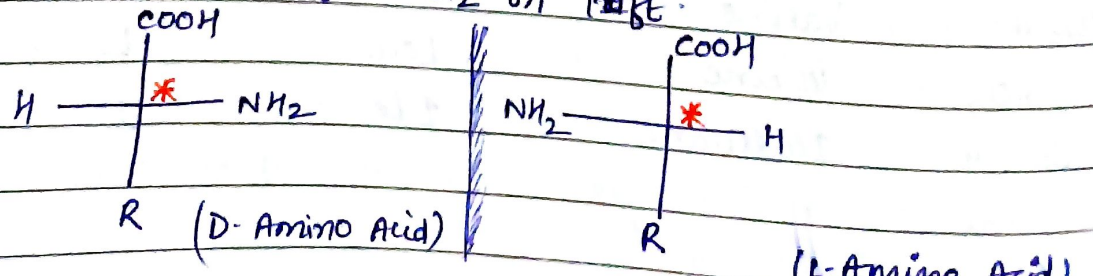
This is amino acid entire structure.

* essential Amino Acids.

* Naming of Amino Acids

D ⇒ if $-NH_2$ on right

L ⇒ if $-NH_2$ on left.



Page No :

* Classification of Amino Acids.

(1) on the basis of character.

(A) Essential → can't be synthesized in our body, so have to be provided externally.

(B) Non Essential → can be synthesized in our body.

(2) on basis of Acidic/Basic Nature

(A) depends on the no. of $-NH_2$ group and $-COOH$ group.

(A) Acidic → no. of $-COOH$ gp > no. of $-NH_2$ gp.

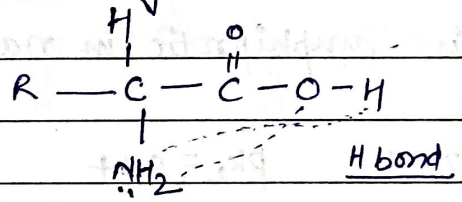
(B) Basic → no. of $-NH_2$ gp > no of $-COOH$ gp.

(C) Neutral → no. of $-NH_2$ gp = no. of $-COOH$ gp.

★ Glycine is the only optically inactive Amino Acids.

* Properties of Amino Acids.

(1) Amino Acids are water soluble due to extensive Hydrogen bonding.

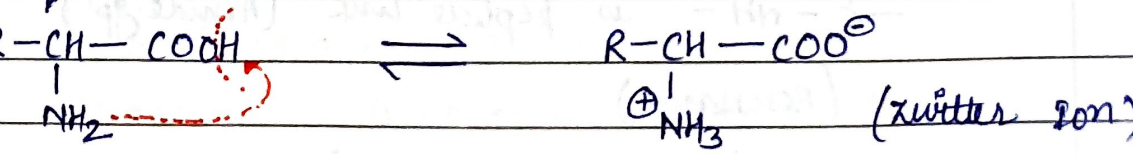


(2) Colorless.

(3) Crystalline solids. with high melting points. as acidic $-COOH$ and basic $-NH_2$ react to form salt.

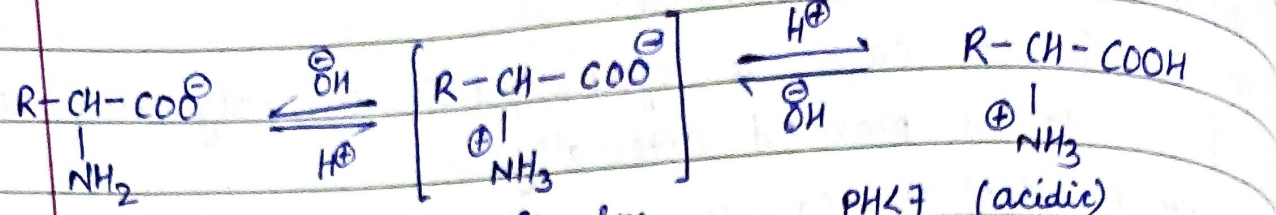
ZWITTER ION.

In aq. sol^n.



It is a dipolar ion but overall it is neutral.

Zwitter ion exist in 3 forms in aq. sol^n.

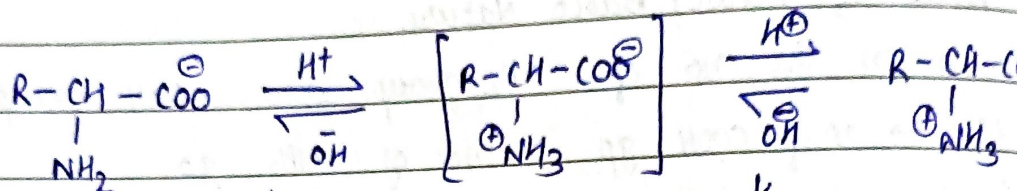


pH > 7 (basic) — (−) charged

Zwitter ion

pH < 7 (acidic) — (+) charged

Now



(K_1) K_2

The (+) species move to cathode during electrolysis.
The (−) species move to anode in electrolysis.

* Isoelectric point: The pH at which zwitter ion is uncharged and migrates no where.

$$pI = \frac{pk_1 + pk_2}{2}$$

* The zwitter ion is amphiprotic in nature.

Ex Alanine $pk_1 = 2.34$ $pk_2 = 9.64$

$$pI = \frac{2.34 + 9.64}{2} = \frac{11.98}{2} = \boxed{5.99}$$

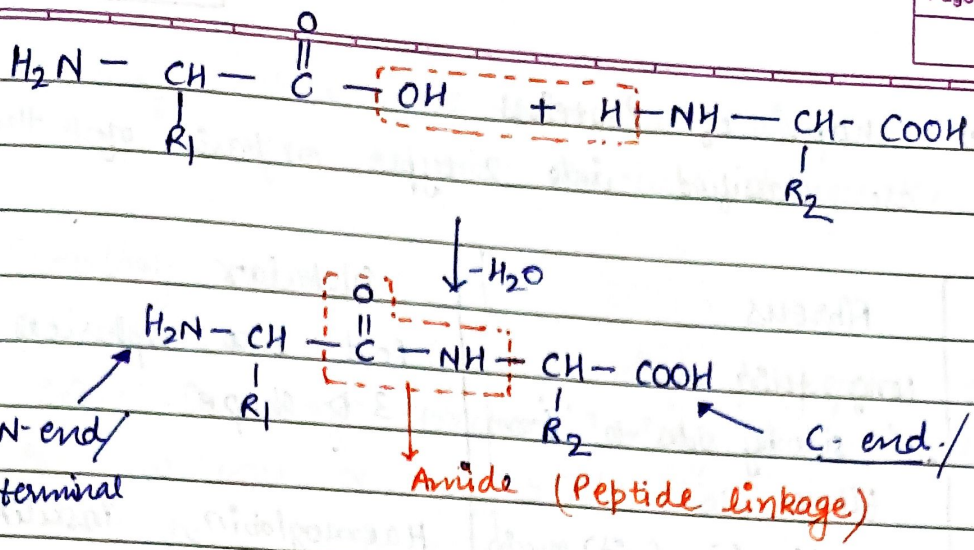
PEPTIDES

Small polymers of α-amino acids are called peptides. These links are called peptide link or peptide bond.

$-\overset{\overset{O:}{\|}}{C}-\ddot{N}H-$ is peptide link (Amide gp.)

→ (Resonance)

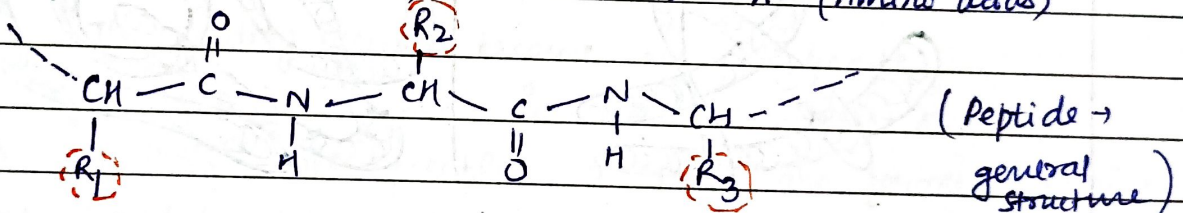
→ all bonds about N lie in one plane.



2 amino acid → di peptide
3 amino acid → tri peptide
4 amino acid → tetrapeptide
>10 " " → poly peptides
>100 " " → proteins. (have mmass > 10000 u)

→ Hydrolysis of peptides gives Amino Acids :-

Peptide (n-amino acid) $\xrightarrow{(n-1)H_2O}$ n (Amino acids)



The R's are away to reduce steric hindrance.

→ As resonance takes place along Amide bond, we get trans configuration.

→ Insulin is only protein with 51 amino acids.

* **Proteins**

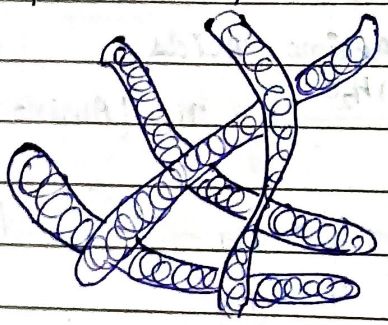
A polypeptide with More than 100 amino acids and molar mass (>1000 u) are called proteins.

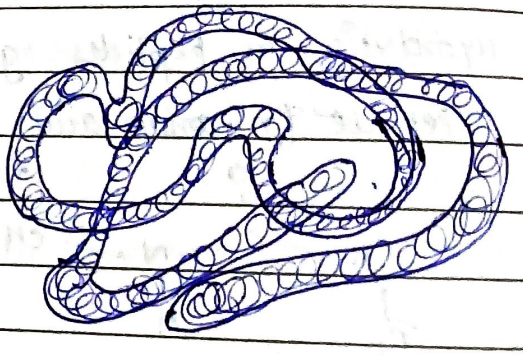
M. mass > 10000 amu (Dalton).

Molecular shape of Proteins

Proteins are classified into 2 types on basis of this.

		Fibrous	Globular
1)	Molecules	long, thin. Lie side by side to form fibres	Fold into spherical 3-D shape
2)	Examples	Keratin (in hair), myosin Collagen (skin & bone)	Haemoglobin, Insulin, Enzymes; Albumin
3)	Solubility	Insoluble in H_2O	Soluble in water
4)	Roles	Structural: - Collagen in bone & cartilage - Keratin in finger nails & hairs	Metabolic: - Enzymes in all organisms - Plasma proteins, antibodies in mammals.



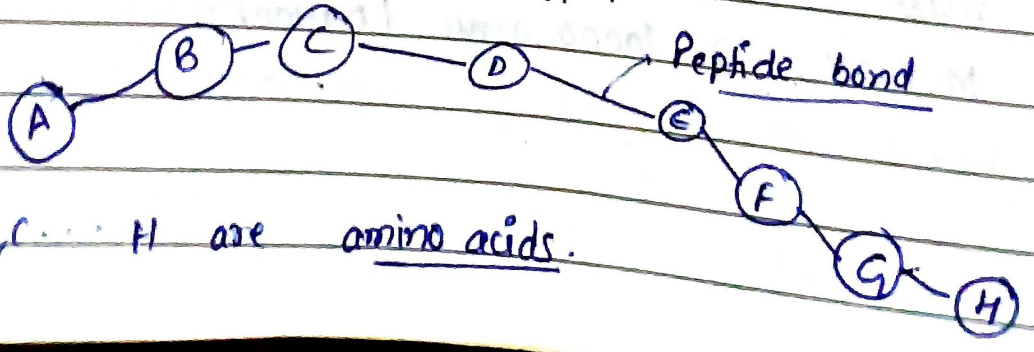


The structure and shape of protein can be studied at 4 diff. levels: Primary, Secondary, Tertiary, Quarternary.

Each subsequent level is more complex than previous one.

Primary structure of Proteins →

It describes the sequence of amino acids connected together to form polypeptide.



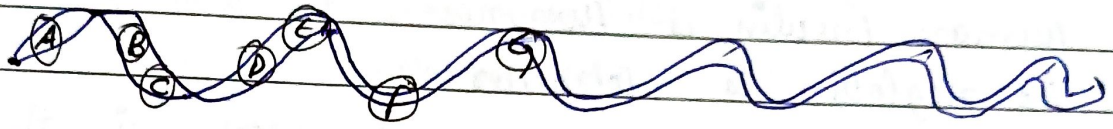
A, B, C ... H are amino acids.

It may contain more than one chain
Any change in prim. structure changes the protein.

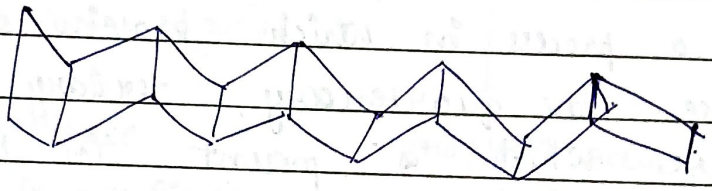
* Secondary structures

It describes the shape in which polypeptide chain can exist. Secondary structure arises due to folding of the backbone of polypeptide chain.

→ Two types can exist -
α-Helix , β-pleated sheets



3 Dimensional α-Helix



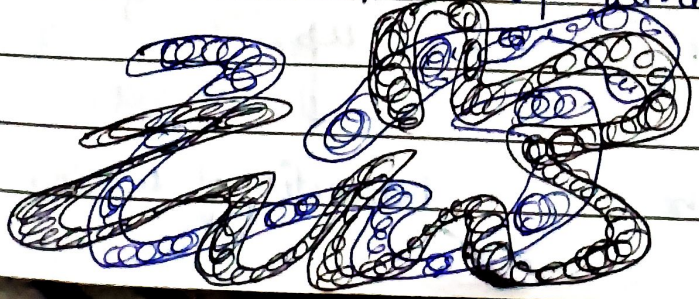
β pleated sheet (2-D)

The folding occurs because of H bonding.

→ A single polypeptide can have both secondary structures.
→ In α-Helix, all possible H-bonds are formed to give right handed screw structures.
→ In β pleated structure, the peptide chains are stretched out to max. extension and then joined by intramolecular H bonds.

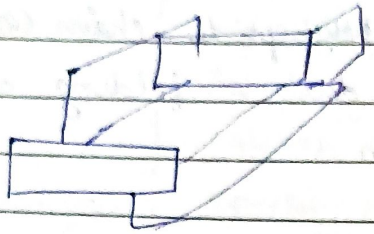
* Tertiary structures

→ describe overall folding of polypeptide chain, further folding of secondary structure.
This is due to disulphide linkages, van der waals and electrostatic force of attraction.



Two secondary structures are folded & 

* Quaternary Structures:
on joining multiple tertiary structure, we get Quaternary ~~tertio~~ structure.
→ It is like conformation of tertiary structure.



Quaternary structure describes different tertiary structure in particular spatial arrangement.

Human insulin is Hexamer.
Haemoglobin is tetramer.

* Denaturation of Proteins
Denaturation is a process in which protein or nucleic acids lose the quartenary, tertiary & secondary structure which is present in their native state.
It is due to external stress or compound such as a strong acid or base, a concentrated inorganic salt, an organic solvent (eg. C_2H_5OH, $CHCl_3$), radiation or heat. If proteins in a living cell are denatured, this results in disruption of cell activity and possibly cell death.

Native protein → Protein found in a biological system with unique 3-D structure & Biological activity.

Denaturation

Globules unfold
fibre strands separate
↓
Destruction of tertiary Structure

Helices uncoil/sheets open up.
↓
Destruction of secondary structure

→ Primary structure remain intact in denaturation.

* Reasons of denaturation
→ Physical change (change in temperature)
→ Chemical change (change in pH)

"NUCLEIC ACIDS"

Cell → Nucleus → Chromosome → Nucleic acids.

They are responsible for Heredity

→ Nucleic acids are poly-nucleotides

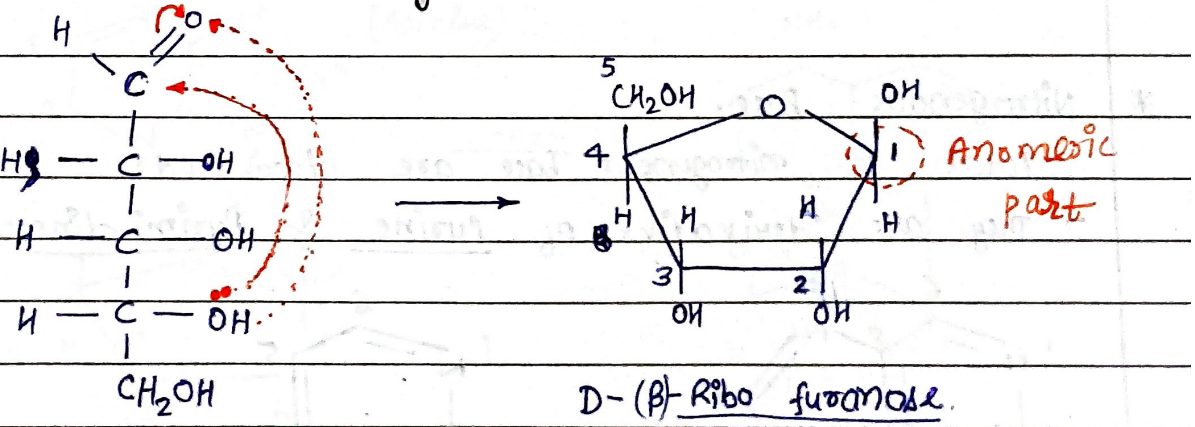
Nucleic Acid

it is formed by three particular substances.

Nucleic Acid

- Pentose Sugar ← Carbohydrate
  - β-Ribose
  - β-De-oxy Ribose
- Phosphoric Acid derivative
  - Phosphate Ester.
- Nitrogenous base.
  - usually heterocyclic.

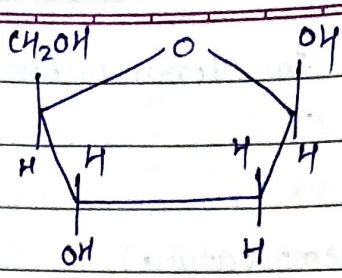
* Ribose and De-oxy Ribose.



D-(β)-Ribo furanose.

In nucleic acids, only β-form is present.

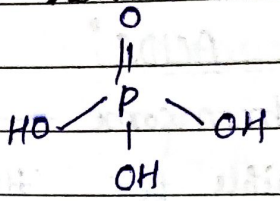
→ For de-oxy ribose, just replace -OH at C_2 by H.



β-D- Deoxy ribose.

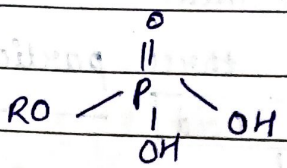
* Phosphoric Acid Derivatives

H_3PO_4 →

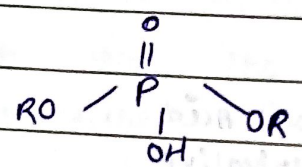


Replace H by R (carbon chain) to form phospho esters.

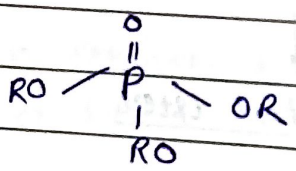
→ mono ester



→ Di ester



→ Tri ester

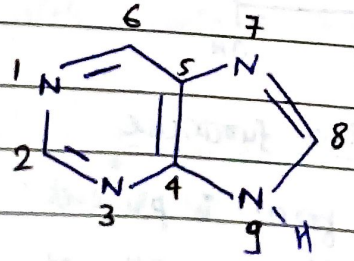


Nucleic Acids contain only mono-esters.

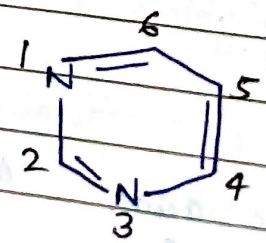
* Nitrogenous Base.

Total 5 nitrogenous base are discovered.

→ They are derivative of Purine & Pyrimidine.



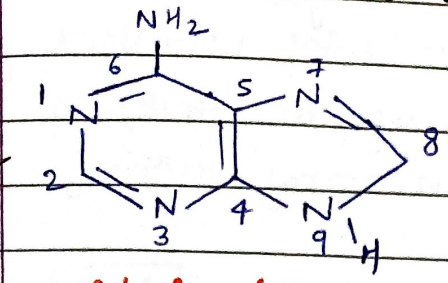
Purine



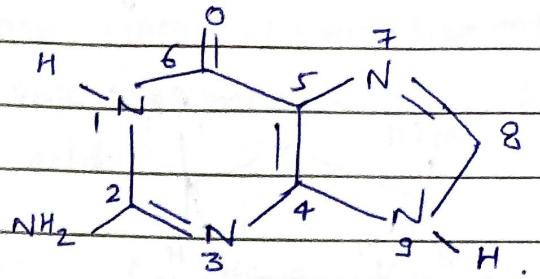
Pyrimidine

The 5 derivatives of Purine and Pyrimidine are →

Purine

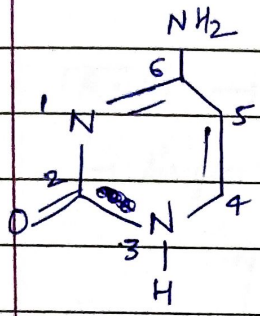


Adenine (A)

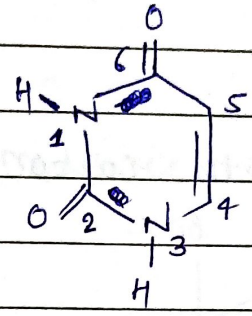


Guanine (G)

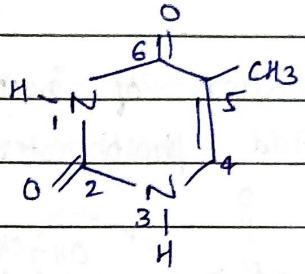
Pyrimidine



Cytosine (C).



Uracil (U)



Thymine (T)

* Nucleosides and Nucleotides.

→ Combination of a nitrogenous Base and a sugar.

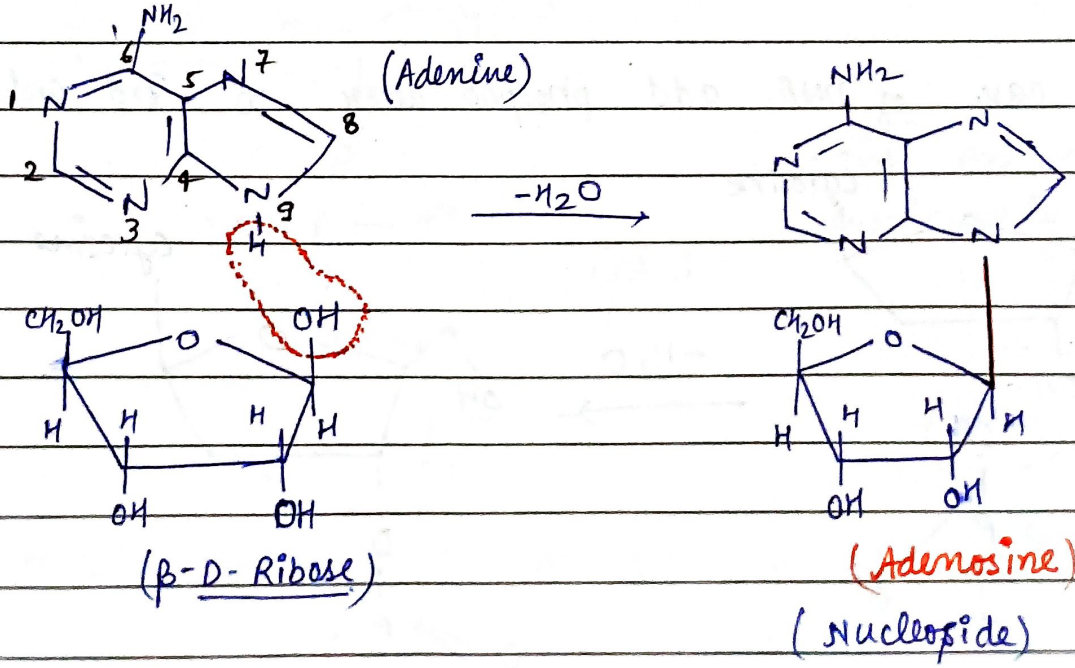
Base + Sugar.

Sugar may be ribose or de-oxy ribose

→ Combination of a nitrogenous base + sugar + phospho di-ester

Base + Sugar + Phosphate

ex.



(Adenine)

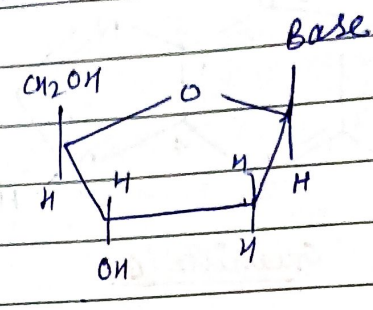
$-H_2O$

(β-D-Ribose)

(Adenosine)

(Nucleoside)

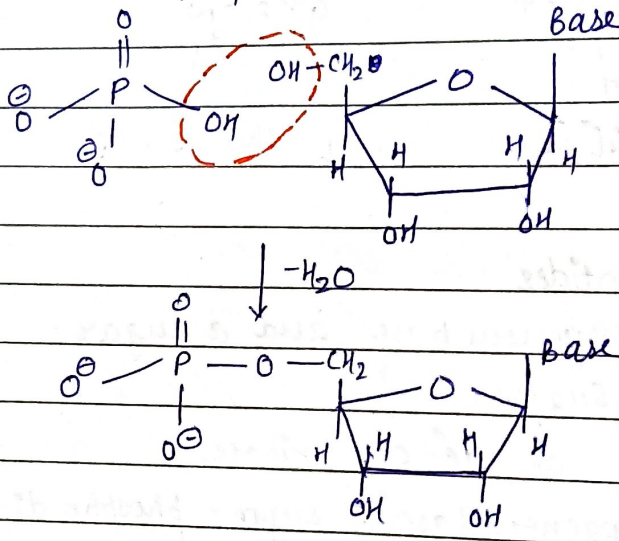
If we use de oxy ribose ⇒ 2-Deoxy-Adenosine is formed.



(2 deoxy Adenosine)

* formation of nucleotide

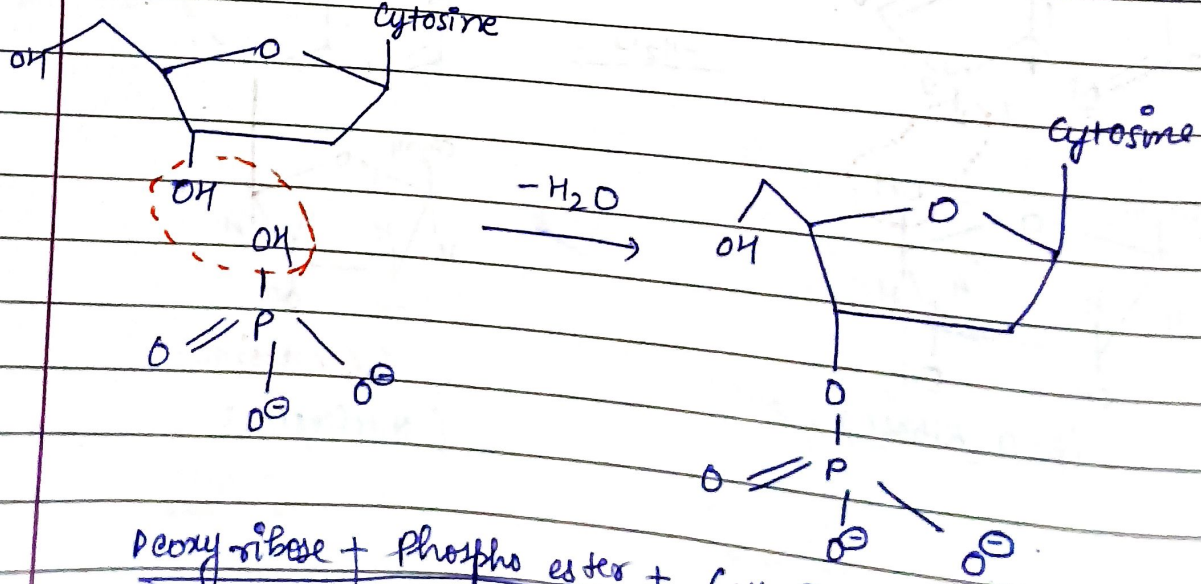
Add phosphoester to 5th carbon.



(Nucleotide)

Adenosine 5'-monophosphate : a ribonucleotide.

→ In case of DNA add phospho-ester to 3rd carbon.



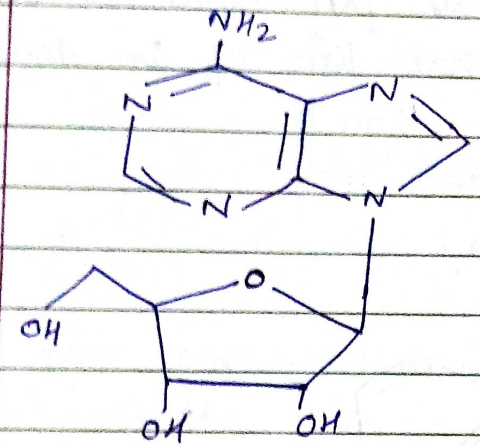
Deoxyribose + Phospho ester + Cytosine

★ DNA and RNA

Nucleotides joins with each other through 3' and 5' phosphate linkages to give polynucleotides which further forms Nucleic acids.

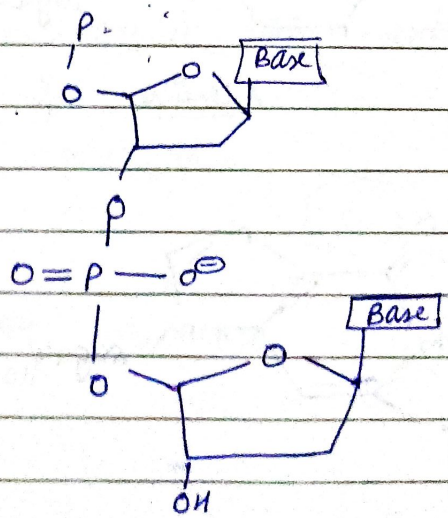
double helix structure ← **DNA** → A, T, G, C. (uracil is never present)
A, T : H bond; G, C : H bond

RNA → A, U, G, C (Thymine is never present)
↳ Single helix structure.



The link b/w sugar and base is forming a kind of an acetal, which has one N atom and one - O atom instead of 2 - O - atoms.

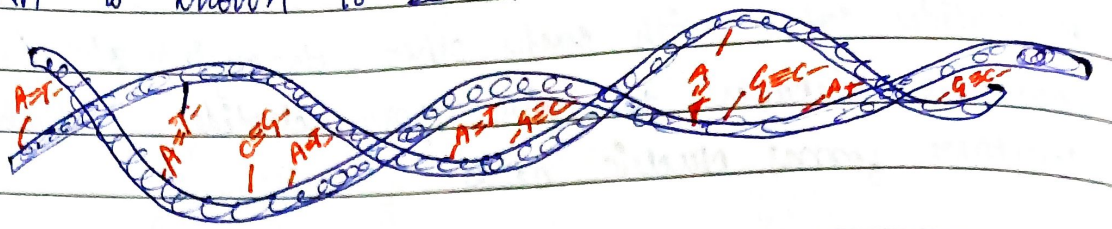
Structure of DNA



chain extends continuously.

Phospho group starts at 3 and ends at 5.
This is an alternating structure of an di - ester.

DNA is known to be double helical structure.



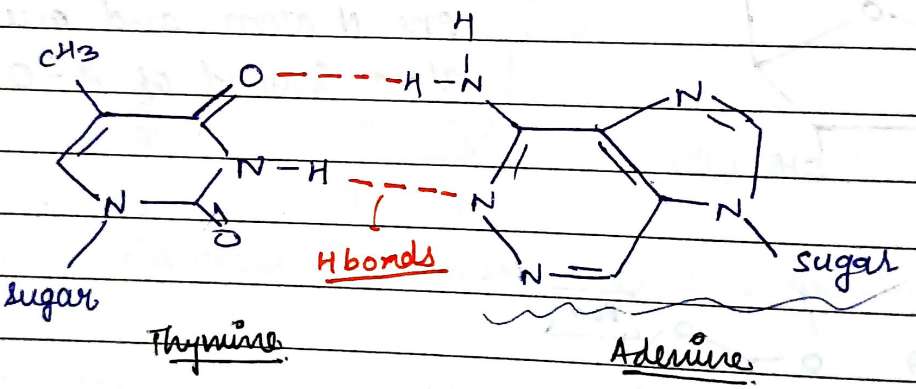
Two helices are bonded by H bond between bases. Sugar and phospho groups appear to form rails & bases form connections.

* Complementary bases.

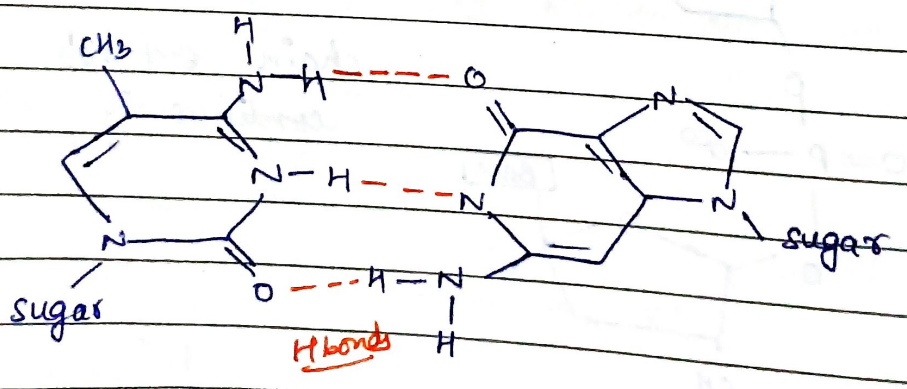
In DNA, bases don't randomly pair with each other but there are fixed pairs that pair up in double strands.

Adenine ↔ Thymine

Guanine ↔ Cytosin.



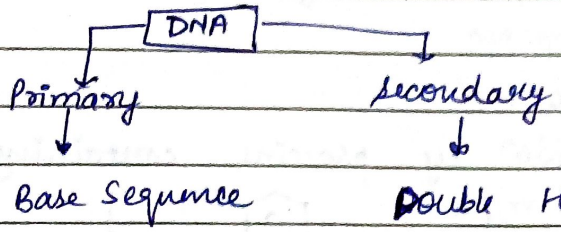
Thymine Adenine

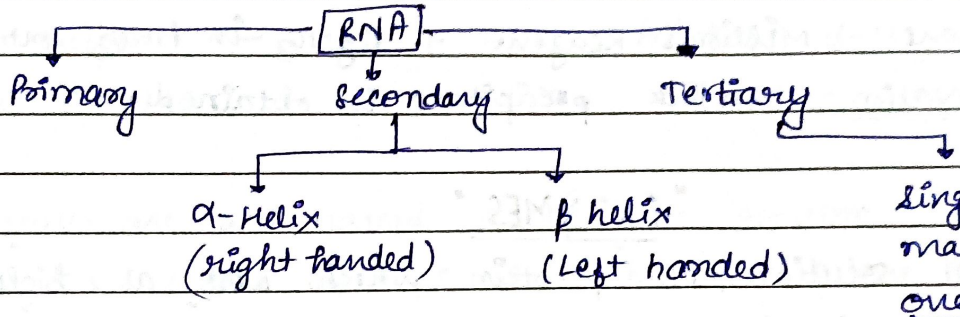


Cytosine Guanine

* Hydrolysis of Nucleic acids

Hydrolysis of nucleic acid gives sugar, Base, Phosphoric Acid.



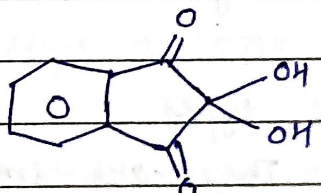


TESTS FOR PROTEINS.

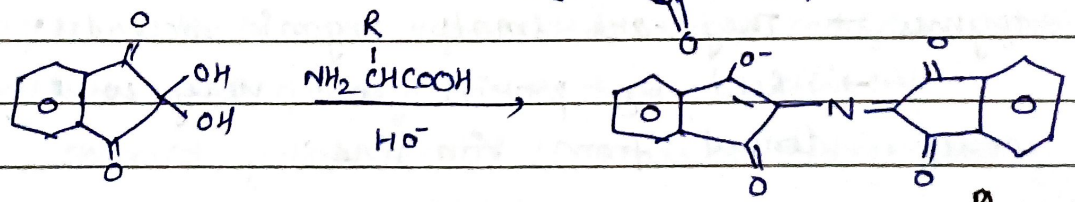
1. NINHYDRIN TEST

Protein treated with a pyridine solution of ninhydrin give colour ranging from deep blue to violet pink or even red in some cases.

Reagent Ninhydrin



Rxn



Rhumann's Purp

+ $RCHO + CO_2 + 4H_2O$

→ α-Amino acids → purple-blue

Proline (secondary amine) → yellow

2. BIURET TEST (PIOTROWSKI'S TEST)

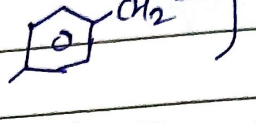
Reagent: Aq. $CuSO_4$ + alkaline medium

Observation: deep blue colour (violet bluish)

It confirms presence of peptide bond.

3. MILLION'S REACTION

This test is shown by proteins containing phenol group.

eg Tyrosine (R = )

Reagent: Million's Reagent → $HgNO_3$ in HNO_3 containing HNO_2

Observation: white precipitate is obtained.

"ENZYMES"

→ Colloidal solution of protein which work as biological catalyst is known as enzyme.

→ Enzymes are globular proteins.

→ The non protein component present in enzymes is called the cofactor of their activity.

Co-factors are of two types -.

(A) Inorganic: Zn^{+2}, Mg^{+2}, K^{+}, Mo^{++}, Cu^{++}, Fe^{++}, etc.

(B) Organic: Two types

(i) Co enzymes → They are small organic molecules.
→ held by protein with very weak bond.
→ mostly derived from vitamins.

(ii) Prosthetic groups → They are bonded to protein by covalent bond.

★ All enzymes are conjugated proteins.

→ Naming of Enzyme & function are inter related.

	Nam of Enzyme	function.
1.	Zymase	glucose & fructose → C_2H_5OH
2.	Invertase	Sucrose → Invert sugar
3.	Maltase	Maltose → Glucose
4.	lactase ✓	✓Lactose → Glucose + Galactose
5.	Emulsin	Cellulose → Glucose
6.	Urease	Urea → $CO_2 + NH_2$
7.	Pepsin	Proteins → α-amino acids
8.	Trypsin	Proteins → α-(L) amino acids
9.	α- Amylase	Starch → glucose.

★ Enzymes are also named according to function as the enzymes which catalyse the oxidation of one substrate and simultaneous reduction of other substrate is called oxido reductase enzyme.

* Mechanism of Enzyme Action & Temperature Dependence.

They are biological catalysts and reduce activation energy.

→ They work best at optimum temperature of 298 to 313K. Their activity decreases with increase or decrease in temperature and stops at 273K.

→ Enzyme molecules are regenerated during catalytic activity. so, small amount of enzymes are highly efficient.

→ The chemical substance which tends to reduce activity of enzyme are enzyme inhibitors.

→ streptokinase used to dissolve blood clot.

→ Deficiency of tyrosinax causes albinism.

→ Deficiency of phenylalanine hydroxylase causes diseases phenylketonuria.