Unit - 1

dt- 9/4/19

Biomolecules

Molecule is a stable assembly of atoms which has some functionality

Biomolecules are molecules with biological origin.
→ organic in nature (C, H, O)
→ synthesised by a living system

Major biomolecules
→ Carbohydrates
→ Protein
→ Nucleic Acid
→ Lipids

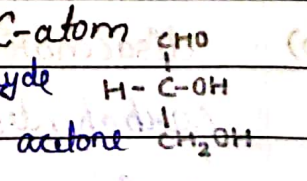
Carbohydrates

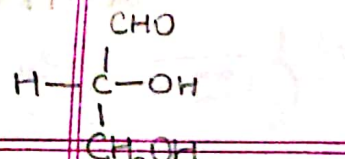
They are organic compounds which are polyhydroxy aldehyde or ketone containing a minimum of 3 carbon atoms.

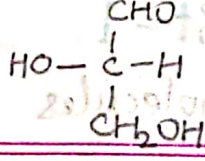
Classification

1. based on Functional group
⇒ Ketone containing — Ketoses — Fructose
⇒ Aldehyde " — Aldoses — Glucose

2. based on Number of C-atom
⇒ Triose — CHO — Glyceraldehyde; CO — dihydroxy acetone
⇒ Tetrose
⇒ Pentose
⇒ Hexose







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* D-form L-form
* naturally occurring form of Carbohydrate

because there is minimisation in steric hinderance, due to bending, cyclic conformation are more stable

cyclic conformation — pyran — aldehydic
furan — Ketonic

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3. based on Number of monomeric/monosaccharide
→ polymers on hydrolysing give monomers
→ monomers can not be further hydrolysed to give # smaller units.

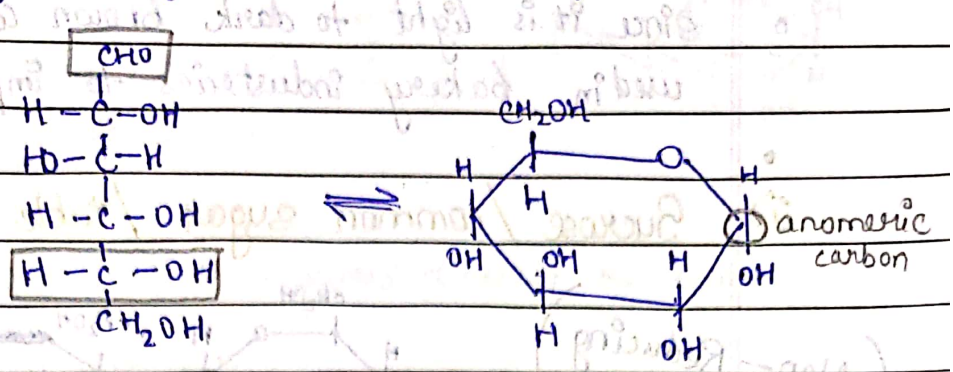
monosaccharides are non-hydrolysable Carbohydrate

a) monosaccharide
aldehydic / ketonic polyhydroxy compound made up of 3 to 6 C-atoms which can not be further hydrolysed to smaller monomeric unit.

b) disaccharide
carbohydrates containing 2 monosaccharide residue of same or different type.

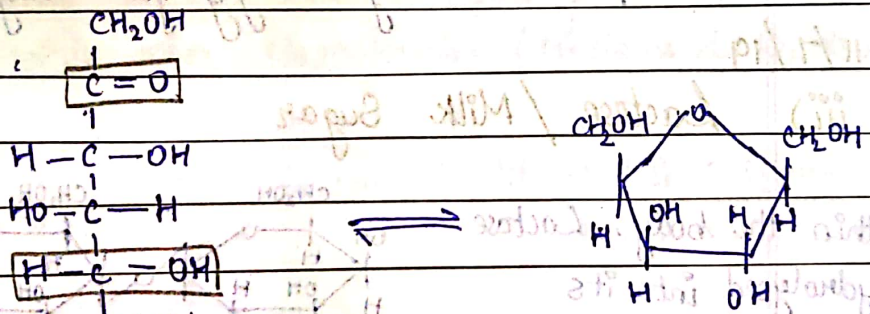
→ Monosaccharide

Glyceraldehyde, Fructose, Glucose



glucose α-D glucose

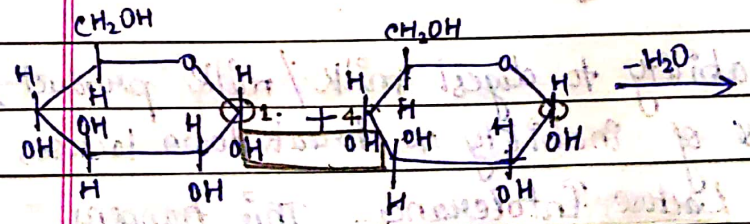
→ If the hydroxyl group at anomeric carbon is above the plane it is called β-D Glucose



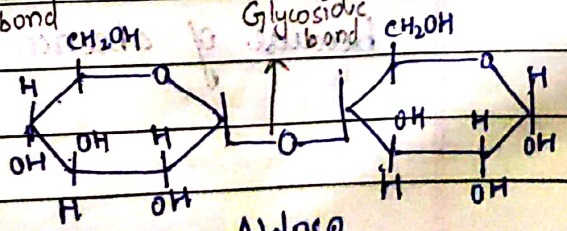
fructose

→ Disaccharide

i) Maltose / Malt sugar



α (1→4) Glycosidic bond

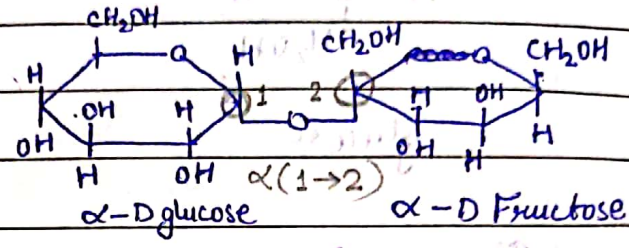


Aldose

- Maltose is added in energy drinks (Horlicks, complan)
- since it is light to dark brown colored, it is used in bakery industries to impart color.

ii) Sucrose / common sugar / table sugar

(Non-Reducing sugars)



α-D glucose α-D Fructose

- Most common agent for sweet food products
- Principle source of energy for living system

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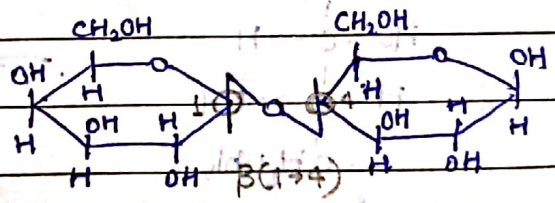
iii) Lactose / Milk Sugar

Within the body, Lactose is hydrolysed into its monomeric unit by Lactase

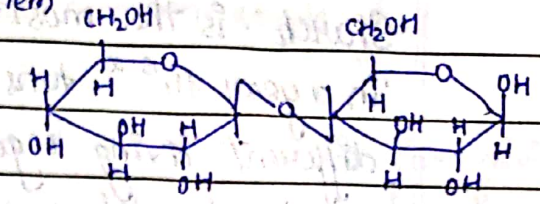


β-D Galactose β-D Glucose

- Primary source of energy for infants
- used for dry milk product

* The inability to digest milk / milk product, because of inability to breakdown lactose, is called Lactose Intolerance. This happens because of absence of Lactase.

iv) Cellobiose



* produced by plant system microbial system
* The higher polymeric form of cellobiose is called Cellulose
* It can not be consumed directly by humans.
  - It is used as a reagent in manufacturing of medicines.

→ Oligosaccharide

* made of 3-10 monosaccharide residue
* they do not exist in free form but complexed with other biomolecules (Proteins & Lipids)

Oligosaccharide complexed with protein : Glycoprotein
" " " lipids : Glycolipid

→ they contain oligomeric units which characterises blood type

* Oligosaccharide act as marker for characteristic biological feature. eg → Blood Group Typing

→ Polysaccharide

* 100 – few thousand monomeric units
* they are proper polymers

⇒ based on functionality - storage, structural
⇒ based on composition - homo, hetero

is Starch / plant sugar

Starch is the most abundant Polygosaccharide. In a year 10^{15-16} tons of starch is produced by different living organisms. The total amount of starch solely accounts for 50% of Carbon on Earth. It is only produced by plant species. It is a polymer of α-D Glucose. Within plant cells it exist in form of granules of 100-200 nm size. Starch granules are made up of amylose and amylopectin. It is of ~~to~~ type : Homo-storage polysaccharide.

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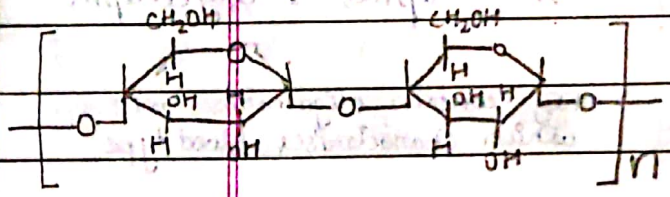
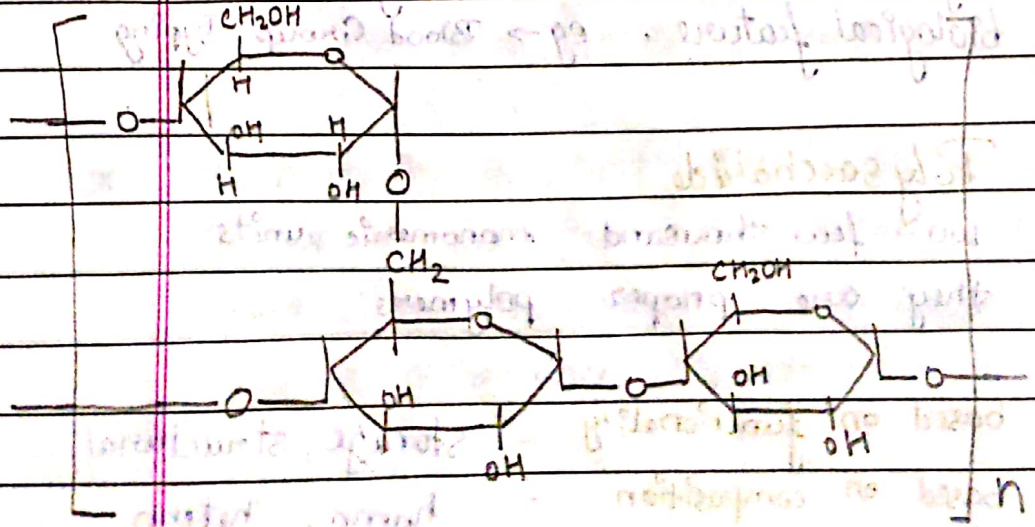
amylose + amylopectin = starch

linear chain of few 1000 α-D glucose residues linked by α(1→4) glycosidic ~~bond~~ bond

branched structure of few 1000 α-D glucose residue linked by α(1→4) and α(1→6) bond. Branching is via α(1→6)

Branch freq: 24-30 residues





* Starch is the most common staple food.
  - used in adhesive industries.
  - used in Pharmaceutical industries for giving shapes to capsules (as a binder)
  - used in firecracker industries.
  - used in ~~form~~ cosmetic industries in powder formation.
  - major component of food industry
  - used in textile industries to give finishing to the clothes, specifically cotton material.
  - starch is the raw material for manufacturing of bioenergy compounds like bioethanol and biodiesel.

ii) Glycogen / Animal Starch

* -produced by animal cell
* present in form of granules 200-400 nm
* homo-storage polysaccharide
* few 1000 residues of α-D glucose
* structurally it resembles amylopectin

branched structure made of α-D glucose linked by α(1→4) and α(1→6) Glycosidic bond.

Branch frequency : 12-14 residues

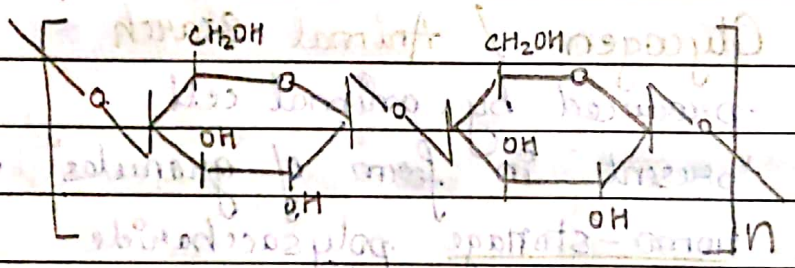
It has major biological / physiological function

- it acts as energy reservoir of animals
- maintains blood glucose level
- maintains cellular osmotic pressure.

iii) Cellulose

plant in origin but also synthesised by some fungi and algae. it is one of the most abundant polysaccharide with an annual turnover of 10^{15} kg. It is homo-structural polysaccharide. approximately 15000 β-D glucose residues. fibrous in structure. present in plant cell wall (cellulose + ligrin). cellulose is the enzyme which can degrade cellulose.

a linear polymer of β-D glucose residues linked by β (1→4) glycosidic bond.



- gives proper structure and rigidity to the plant cell.
- used in furniture industries.
- construction industries
- richest source of cellulose is cotton (90%) which is the backbone of textile industry
- used as packaging material.
- paper and cardboard industry
- act as chemical reagent for research industry
- it was used as a photographic material which was referred as celluloid.

- nitro cellulose is an ingredient used in explosives.
- cellulose is utilized for manufacturing of polymers (bioplastics)
- cellulose is used in transformers.
- source for biology production.

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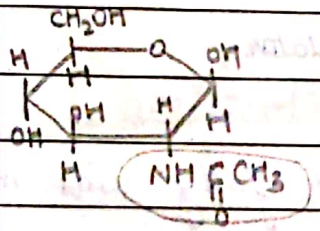
iv) Chitin

→ marine in origin

→ present in exoskeleton of animals, insects and invertebrates

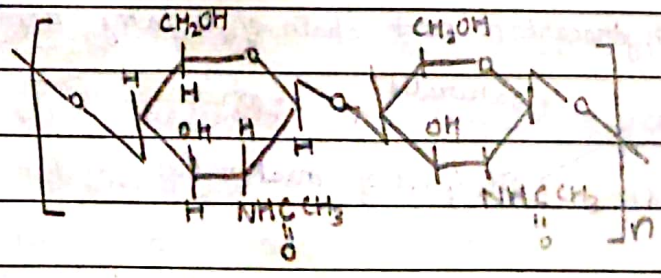
→ made of few 1000 β-D Glucosamine unit



Glucosamine / N-acetyl Glucosamine

→ linear structure

→ hard, brittle and water insoluble



β (1→4) Glycosidic bond

- It protects the soft tissues of marine organisms as well as invertebrates.
- it also act as a water proof coating.
- Chitin is used for making of surgical threads
- used as a reagent for production of enzyme

- also used for making of ~~resins~~ resins (ion exchange)

Lipids

Lipo's = fat (greek)

Lipid
- fat
- oil
- waxes

- secondary energy reservoir
- deposited in tissues (in the body) called as adipose tissue. (just beneath the skin)
- since it is deposited beneath the skin, it also act as thermal insulator.

→ lipid is a polymer of fatty acids monomeric units.

fatty acids: long chain hydrocarbon containing an acidic group

★ $CH_3(CH_2)_nCOOH$ General formula for fatty acid

the hydrocarbon ~~part~~ chain of a fatty acid can be
- saturated → Saturated fatty acid
- site/point of unsaturation → Unsaturated " "

→ Naturally occurring fatty acids have chain length of 12-18 carbon atom

→ Generally fatty acids are linear with few exceptions - where fatty acids can be branched [phytic acid] ★

example of saturated f.a. : stearic acid (C_{18}) & palmitic acid (C_{16})
" " unsaturated " : oleic and linoleic acid
1 = b/w 9-10 2 b/w 9-10 and 12-13

Oleic Acid $CH_3(CH_2)_7CH=CH(CH_2)_7COOH$

C:18:1 1 unsaturation

$CH_3(CH_2)_{16}COOH$ C:18:0 saturated

(trans is preferred)
unsaturated fatty acids are easier to breakdown because due to unsaturation packing of the fatty acids is not very tight, hence less energy required

∴ unsaturated (oil) is healthier than saturated (~~fat~~)(ghee)

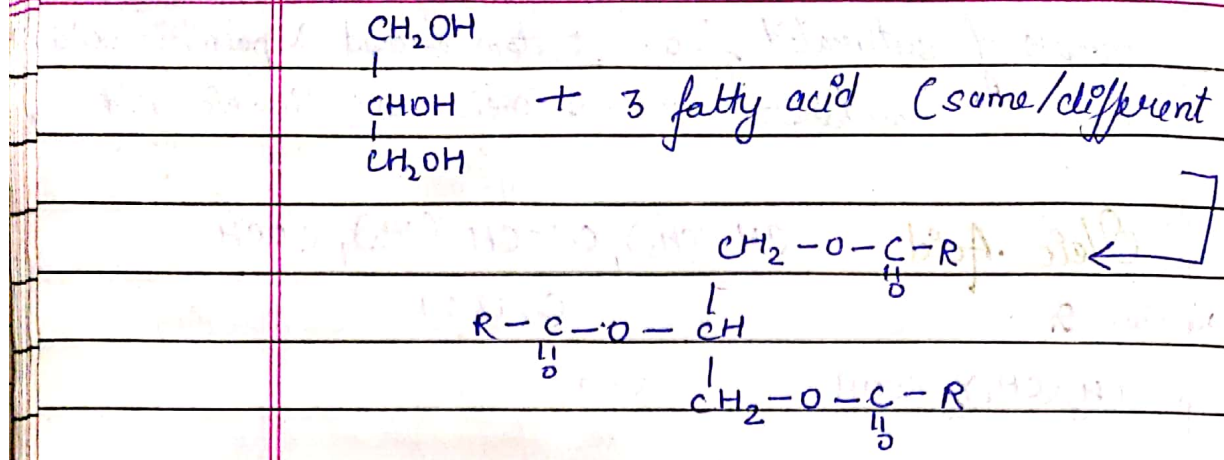
Classification of Lipids

based on structure and function

- simple lipid
- compound lipid
- complex lipid

Simple lipid (water insoluble) (only soluble in org solvents)

→ also referred as Triacyl glycerol / Triglycerids / oil and fat
→ most abundant lipids
→ as energy reservoirs (in storage form)
→ oil droplets / fat droplets
→ they are reduced by almost every living system.
→ structurally they are esters of Glycerol



Function of Tryglycerides

- They are storage lipid & secondary source of energy.
- They also help in Thermal insulation

⇒ Edible Nutritive Compound
⇒ required in food industry
⇒ component of medicines (cod liver oil), ~~used~~
⇒ used in cosmetic formulations
⇒ paint industries as thinner
⇒ as ~~lu~~ lubricant (castor oil)
⇒ used in perfume industries (class of oil is called essential oil)
⇒ soap industry (oil on conversion ~~gets~~ shows cleansing property)

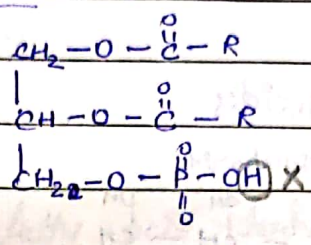
Compound Lipids

basically ester derivatives
on basis of derivatising component / group attached
→ Phospholipids
→ Sphingo lipids

→ ~~Stru~~ they are structural lipids

→ major component of all biological membrane
→ they account for 21% of all body lipid.
→ amphiphilic molec. (can resist both presence and absence of water)

Phospholipid



~~Name~~
~~- H phosphatidic acid~~

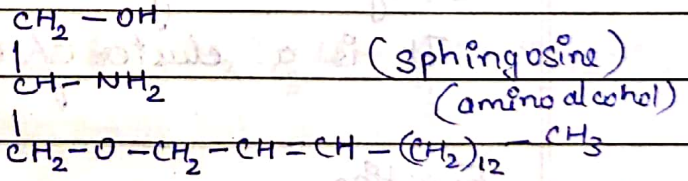
X : Name

- H : phosphatidic acid

- $CH_2-CH_2-\overset{+}{N}(CH_3)_3$: phosphatidyl choline (Lecithine) (egg yolk)
[choline]

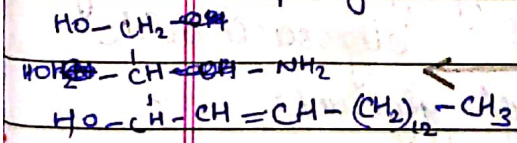
~~CH~~ ~~OH~~ -glycerol-P-phosphatidic acid : Cardiolipin (has greater elasticity)

Sphingo lipid

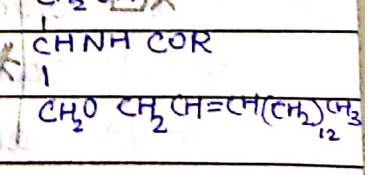


(sphingosine) (amino alcohol)

sphingosine + fatty acid ⟶ ceramide (cementing agent)



correct



- sphingomyelin — X → phosphocholine (discontinuous cable on nerve cells unmyelinated as regulators)
- cerebrosides
- gangliosides

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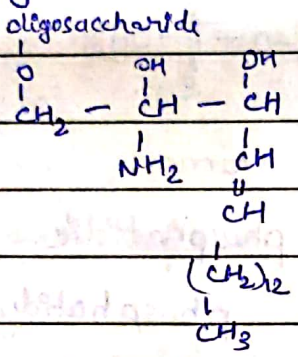
→ Cerebro sides → carbohydrate
associated with brain tissues

membranes of neurons (which is present in brain) are made up of cerebrosides

→ Gangliosides



Sialic acid

if oligosaccharide = Glucose - Galactose - N-acetyl Galactosamine - Galactose

name : GM1

It is an example of Glycolipid

Grey matter of the ~~~~ brain is called Ganglia
It is a cluster of neurons.

Function

- Gangliosides are a type of glycolipid. They consist of a chain of oligosaccharide attached to C-1 of glycerol
- It is the major component of Ganglia Membrane (cluster of neuron present in brain).
- It is responsible for memory and intelligence

Complex Lipid

→ fatty acid derivatives of long chain alcohol or steroid ~~derivatives~~.

→ water insoluble

⇒ Waxes — natural – bee wax, paraffin – synthetic wax

⇒ Cholestrol

Waxes

→ wax is a fatty acid derivative of long chain alcohol. They are natural as well as synthetic in origin.

→ Natural waxes are produced by both plant and animal system

Galactose

Example — Palm wax (obtained from Palm tree)
Lanolin (obtained from whale)
[cetyl palmatate]
Bee wax

cetyl palmatate: $H_3C-(CH_2)_{15}-O-\underset{\underset{O}{\|}}{C}-(CH_2)_{14}-CH_3$

Function

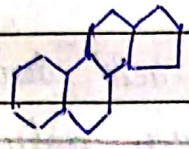
- Wax coat the surface of aquatic plants so that they do not get decayed because of excess of water.
- Apart from giving water proof activity, waxes also help aquatic plants to float on the surface
- Protection to insects habitat
- Lubrication
- cosmetic

- candles
- manufacturing of water proof papers (butter paper)

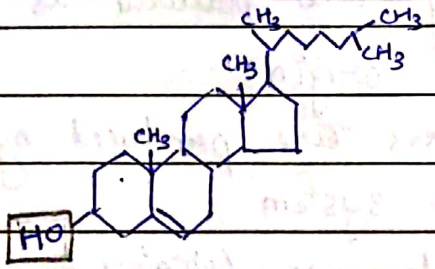
Cholestrol

→ It is a steroid derivative

→ Only lipid which does not have fatty acid or unit moiety



steroid nucleus



Cholestrol

Function

- It is produced by animal cell and is a part of animal cell membrane.
- It provides rigidity to the membrane
- Cholestrol in the body is used as the source of or precursor of Vitamin D
- Cholestrol is also precursor for biosynthesis of steroid hormones.
- Cholestrol is used for production of bile salts

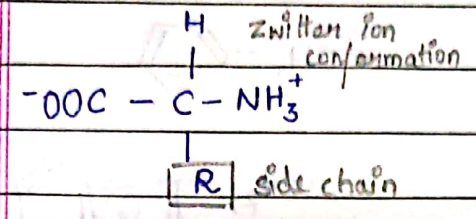
dt - 19/7/19

Proteins

DNA storage
↓
RNA encoded
↓
Protein

polymers of amino acids
(std / proteogenic)

Amino acids : 20/22 std.



(amphoteric)

naturally occurring amino acids are in their L-form

Since, carbon is chiral, hence optically active

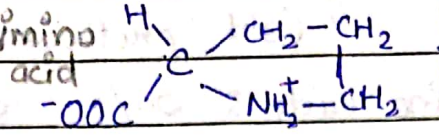
Classification of Amino acid based on nature of side chain

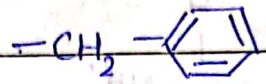
1. non-polar — this class contains 9 amino acids

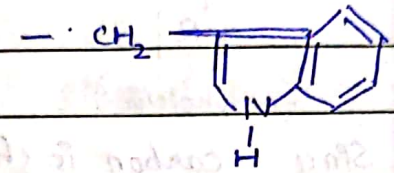
Glycine [Gly, G]

	name	– R	
i)	Glycine / Gly / G	– H	(optically inactive)
ii)	Alanine / Ala / A	$-CH_3$	
iii)	Valine / Val / V	$-CH(CH_3)_2$	
iv)	Leucine / Leu / L	$-CH_2-CH(CH_3)_2$	
v)	Iso leucine / Ile / I	$-CH(CH_3)-CH_2-CH_3$	

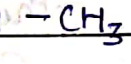
vi) Methonine $-CH_2-S-CH_3$ (sulphur containing)
Met M

vii) Proline (imino acid)
Pro P

(only amino acid which contains secondary amino group)

viii) phenylalanine
phe F


ix) Tryptophane
Trp W


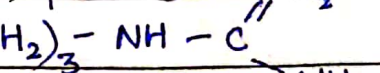
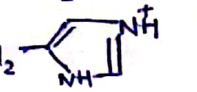
2. uncharged polar 6 amino acids

i) Serine $-CH_2OH$
ii) Threonine

iii) Cysteine $-CH_2-SH$ [sulphur containing]
{-S-S-} they give additional stability to protein structure because of disulphide bond formation

iv) Tyrosine

v) Aspargine $-CH_2CONH_2$
vi) Glutamine $-CH_2CH_2CONH_2$

3. positively charged polar 3 amino acids

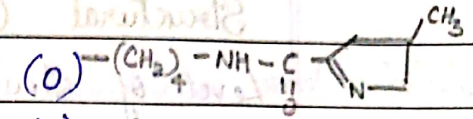
i) Lysine $-(CH_2)_4-NH_3^+$
ii) Arginine

iii) Histidine


selenoprotein

4. negatively charged polar 2 amino acids

i) Aspartate / Aspartic acid — $CH_2 - COO^-$

ii) Glutamate / Glutamic acid — $CH_2 CH_2 COO^-$

★ Pyrrolysine py' (O) 

★ Selenocysteine sec (U) — $CH_2 - SeH$ (selenium)

→ Pyrrolysines are found in the proteins of Methanogenic bacteria

→ Selenocystines are found in the proteins of Archebacteria and Eukaryotes.

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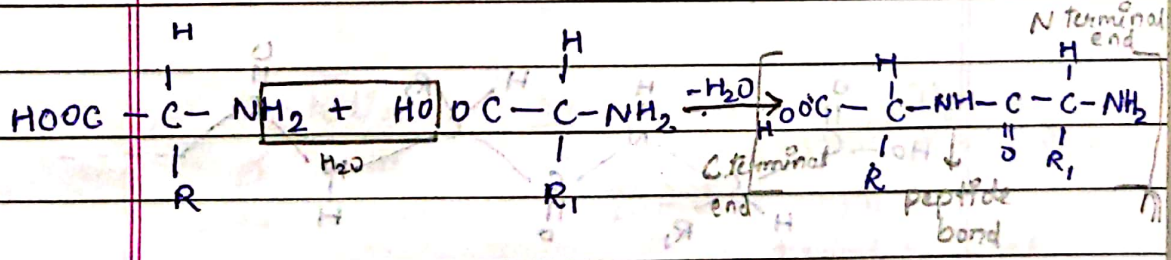


directional molecule

C terminal - carboxyl +vely charged

N terminal - amino +vely charged

Protein - polypeptide

→ Proteins are structural and functional macromolecule of life/cell

→ The functionality of a protein is an outcome of its 3D structure.

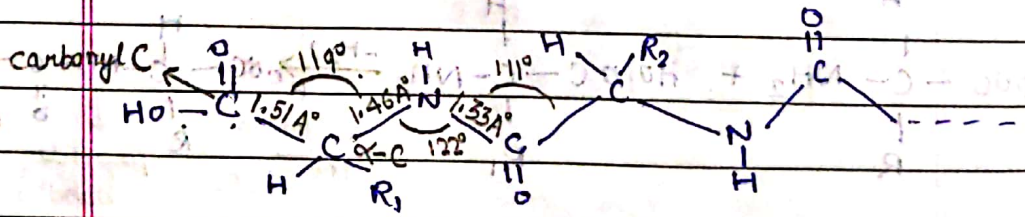
Structural Organisation in Protein

Level of structures

- Primary (1°)
- Secondary (2°)
- Tertiary (3°)
- Quaternary (4°)

Primary

- 1° str. of protein is linear chain configuration of protein exhibiting its amino acid sequence.
- In nature none of the protein exhibit 1° str. Naturally, 1° str do not exist.



angle	b/w bond
ϕ	$C_\alpha - N$
ψ	$C_\alpha - C$ (=O)

★ Ramachandran plot gives an ~~plot~~ idea about the permissible str. that a protein can acquire with stability and it is based on ϕ, ψ and area.

~~Secondary~~

no. of peptide bonds : dipeptide
tripeptide
etc

20 - 100 bonds : Oligopeptide
> 100 bonds : polypeptide

Secondary

in order to acquire stability and minimise the repulsive forces, proteins acquire different structure.

→ spatial arrangement of amino acid (a.a.) of protein
→ based on a.a. sequence, 3 different sec. str. has been found.
- α-helix
- β-pleated sheet
- coil / loop / β-turn (non-repititive structure)

α-helix

ϕ	ψ
-57	-47

to acquire stable α-helix segment permissible angles (←)

pitch (p) 5.4 A° acquired by single polypeptide chain

n : no. of a.a. present per turn
no. of residues per pitch : 3.6 residue

→ right handed α-helical str. is the most common
→ it is majorly stabilised by intramolecular H-bond b/w 1st - 4th a.a.
also Wanderwall's force.

2.2° ribbon

π helix

3_{10} helix

Natural Example - Keratin

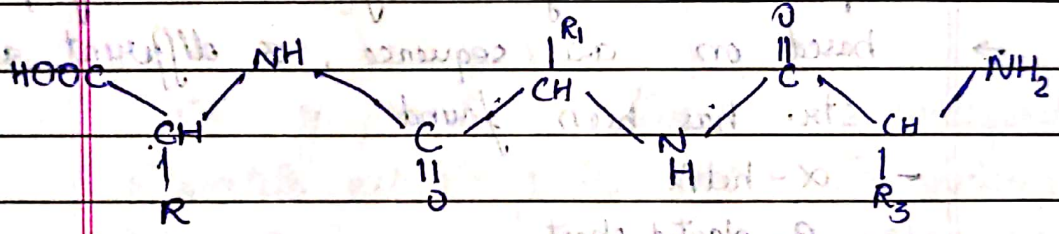
- Collagen

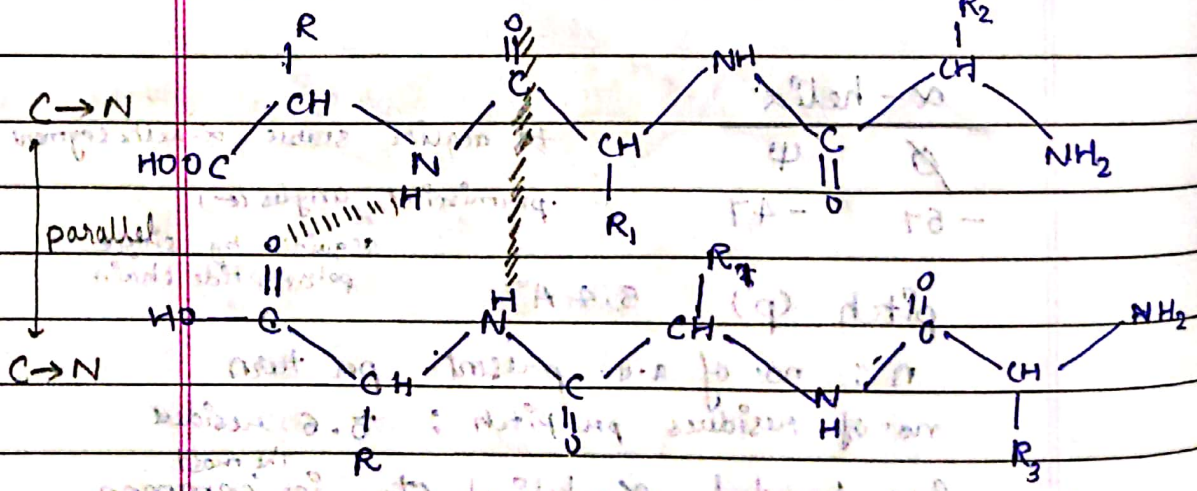
β - pleated

parallel
anti parallel

this str. is acquired due to interaction b/w 2 polypeptide chains.

intermolecular H-bond





N→C
C→N
} anti parallel

	ϕ	ψ
∥	−119	+113
anti	−139	+135

dt 25/7/19

Concavalin – plant protein (β-pleated)

β-turn / coil / loops

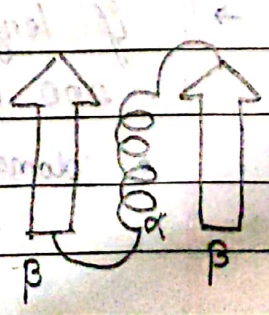
→ non-repitative asymmetric structures
→ 8-15 a.a. residue in a polypeptide
→ usually rich in proline and glycine
→ act as connection b/w 2 other sec. str.

★→ super secondary structure or motif within a polypeptide combination of various secondary str. gives rise to motif.

Structural information about the motifs is called Protein structure database.

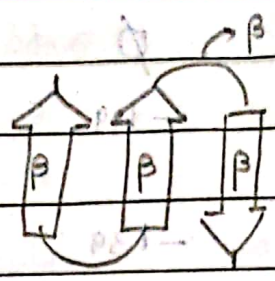
4 common motifs

1. βαβ

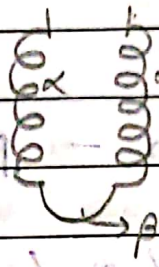


www.rcsb.org

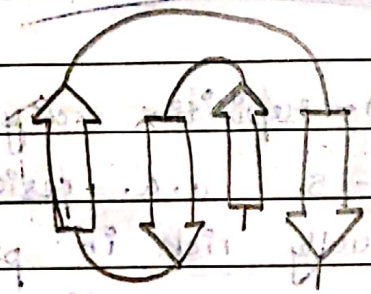
2. β hairpins



3. αα



4. Greek key



Tertiary Structure

→ compact 3-D native (with physiological activity) structure
↓
proper assigned biological function

→ combination of various motifs

→ made up of single polypeptide chain

→ if length of polypeptide chain is more than 200 aa residues,, it exhibits domains

• domain - regions rich in one type of motif

→ at an avg, tertiary struc is made of 31% α helical structure & 28% β pleated sheet

domains of 3° strw are of 2 types
- α domain (3.)
- β domain (2., 4.)
- α/β domain (1.)

Stability factor
→ intra & inter molec. H-bond
→ wanderwaal's forces
→ disulphide bond
→ hydrophobic interaction (interaction b/w non polar aa. hydrophobic pockets)
→ Ionic interaction (int. b/w +ve & -ve charged a.a. or charged surroundings)

Quarternary Structure

→ combination of more than one tert. structure
→ made of more than one polypeptide and each polypeptide of quarternary structure is called subunit.
→ In 4° str. the subunits combine together and act as a single functional unit.
→ subunit interactive forces

haemoglobin - 4 subunit ($\alpha_2\beta_2$ organisation) tetrameric protein

Classification

- fibrous protein (fibre like) Keratin
- globular protein almost spherical, compact

} based on appearance

Function

- carrier protein (Haemoglobin)
  - responsible for transportation of molecules within the cell, tissue or an organism.
- structural component
  - cartilages · give structure to skeleton
- biocatalyst (enzyme) Lactase
  - responsible for catalysing biochemical reactions
- signalling molecules / Receptors
  cells have protein embedded into the PM.
  (insulin receptor)
- hormones (Insulin)
  - hormones are compounds responsible for maintaining metabolic balance in the body
- immunological (antibody) → commercially used and produced as antibody
  - proteins help in the body defense mechanism to fight against diseases.

→ redox centers (cytochrome)
- they are responsible for energy generation

→ vision (Rhodopsin)

→ contraction of muscles (actin and myosin)

Industrial application
- used in body supplement
- cosmetic product like shampoo
- anti wrinkle cream.
- clinical kits for diagnosis (blood group testing kit)
- therapeutic agents / disease curing agents (antibiotics) / (insulin)
- anti foaming agent (in ice creams) (gelatin)
- gellifying agent (gelatin)
- packaging material on food products

dt- 26/7/19

Nucleic Acid

→ The acidic compound/molecule which is present in nucleus.

→ Genetic information carrier, storage molecule

→ Function and info is based on structure of nucleic acid.

→ F. Griffith (assumption)

→ Avery (assumption)

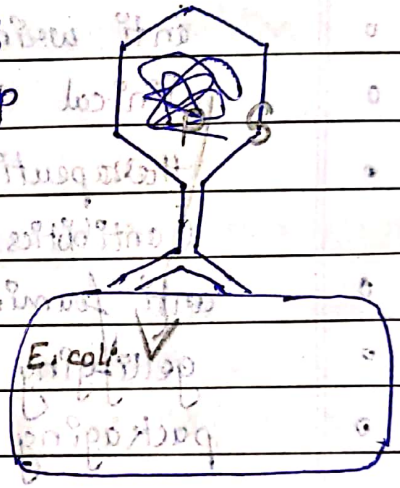
Pneumococci — strain — S colony → pathogenic (rough / smooth)
R colony non-pathogenic

Transformation

→ Hershey and chase

Bacteriophage T2 (virus)
It infects bacteria

radioactive isotope of · Sulphur : ^{35}S
" " Phosphorus : ^{32}P



^{35}S is present in protein coating of the virus

Sulphur radioactivity was not found after the bacteria was infected by virus.

- Ribo Nucleic Acid (RNA)
- DNA

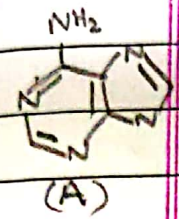
Nucleic acids are polymer of monomeric units called nucleotides.

Nucleotide - planar aromatic heterocyclic compound
- nitrogenous base (purine pyrimidine)
+ ribose sugar

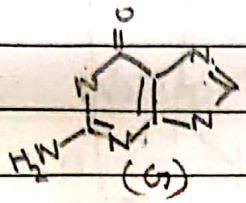
ribose sugar (ribo or deoxyribo) + phosphate (1,2,3)

→ Nitrogenous bases

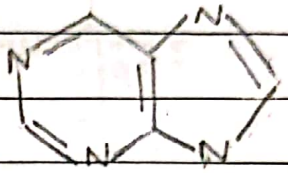
i) Adenine (A) } purine
ii) Guanine (G) }
iii) Uracil (U) }
iv) Thymine (T) } pyrimidine
v) Cytosine (C) }

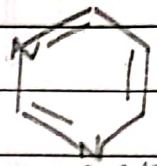


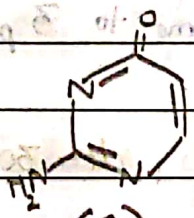
(A)



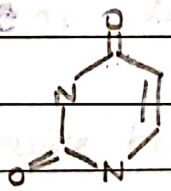
(G)


purine

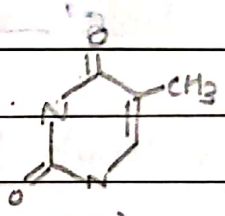

pyrimidine



(C)

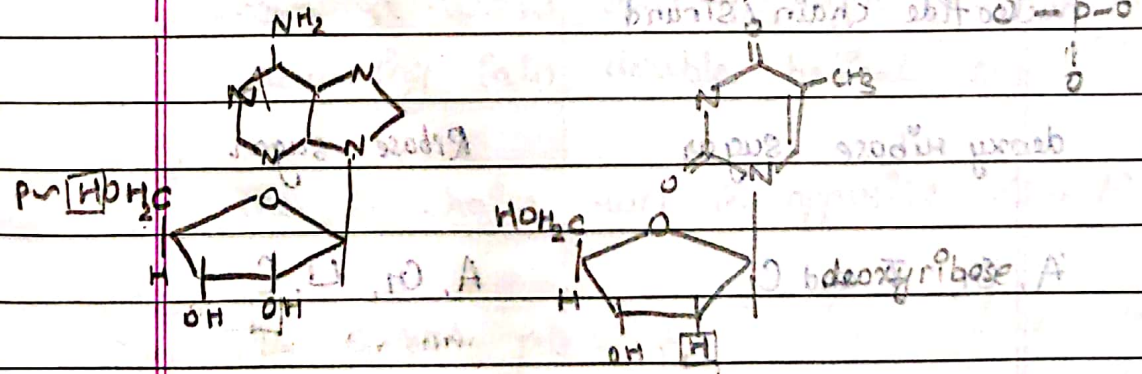


(U)



(T)

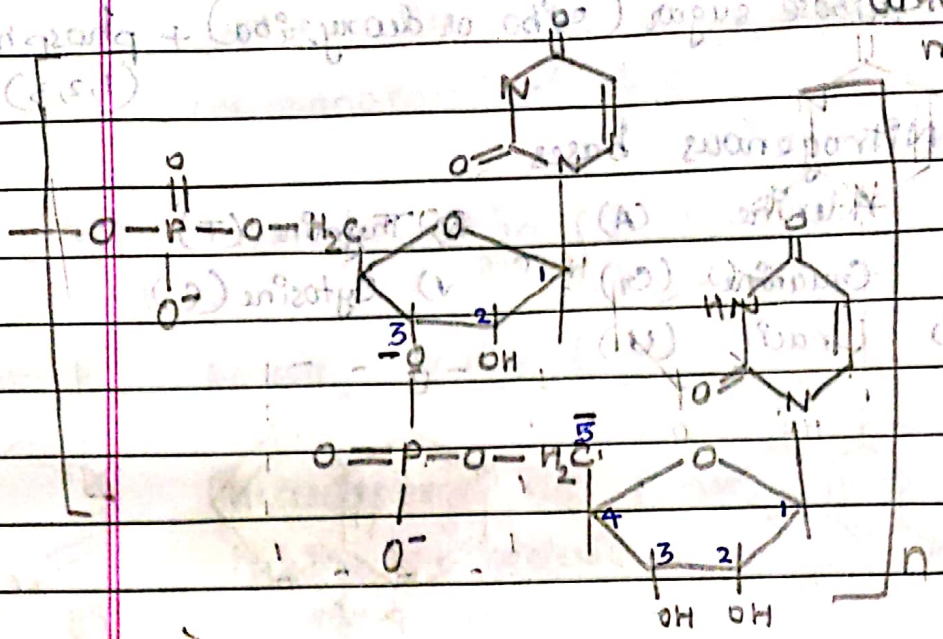
N base + sugar → Nucleoside



Adenosine monophosphate (dAMP)
deoxy mono

nucleotides are bounded by diphosphoester bond to give rise to poly nucleotide

directional molecule



5' — 3' 5 prime to 3 prime

dt- 30/7/19

	DNA	RNA
1.	Made up of double poly-nucleotide chain / strand	single strand exception- virus
2.	deoxy ribose sugar	Ribose sugar
3.	A, G, T and C	A, G, U, C
4.	Genetic material for 'pro' as well as 'eu' karyotes	Genetic material only for viruses
5.		

DNA (deoxy ribo nucleic acid)

Nucleic acids contain equal concentration of purine to pyrimidine

Chargaff's rule : base pairing rule

$A = T$

$G \equiv C$

Watson and Crick 1953

Str. of DNA is called Watson-Crick Model or referred as double-helical structure

Features of double helical structure

A DNA molecule is made up of two polynucleotide chain twisting across ~~and~~ a helical axis in right handed fashion resulting into double helical str.

The 2 chains run in opposite direction

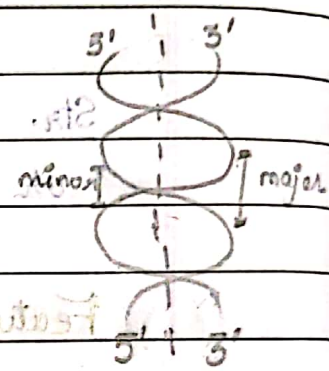
The sugar phosphate residues form the periphery or the backbone of helical str.

The bases are present towards the core or interior of the helix, perpendicular to the helical axis.

DNA structure follows complementary base pair rule: A=T; G≡C

There are 3 possible conformations, that DNA can acquire : A form, B form, Z form
B is the biologically dominating conformation

The helix has a major groove and a minor groove.



DNA form	A form	B form	Z form
helical orientation	right handed	right handed	left handed
helical diameter	26 A°	20 A°	18 A°
helical pitch	34 A°	34 A°	44 A°
base per pitch	11.6	10	12
major groove	Narrow & deep	wide & deep	flat
minor groove	wide & shallow	narrow & deep	narrow & deep

Function of DNA

- Genetic material
- DNA directed DNA synthesis (DNA replication)
- DNA directed RNA synthesis (transcription)

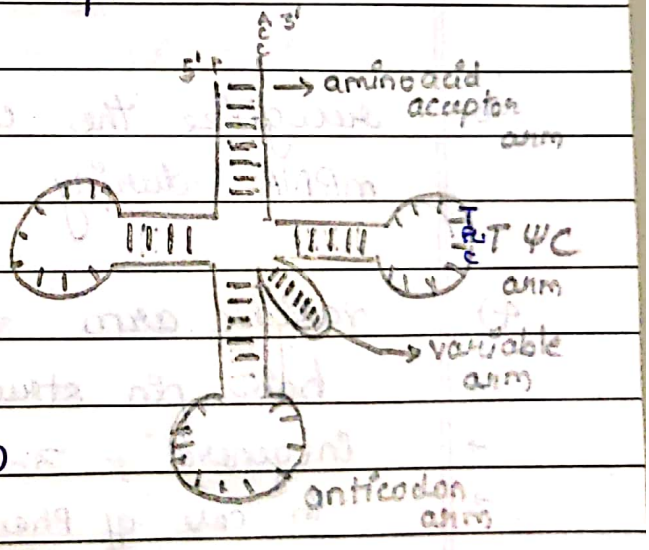
RNA (ribonucleic acid)

3 major types of RNA

1) Ribosomal RNA (rRNA)
2) Transfer RNA (tRNA)
3) Mesenger RNA (mRNA)

The 3 possible sec. str. ~~RNA~~ polynucleotide can acquire
- stem / loop / hairpin

Clover leaf model of tRNA



5 major segments

1) → aa acceptor arm
   → $tRNA^{phe}$
   → stem made up of 7 bp
   (exception) non-watson & crick pairing [G-U]

- aa acceptor arm carry the a.a. through its 3' OH group

2) DHU arm
dihydro uridil arm
→ stem made up of 4 bp
→ & a loop made up of 8 bp
→ 2 modified / derived uracil residue

○ interact with the ribosomal subunits during protein synthesis.

3) Anticodon arm
→ stem of 5 bp and loop of 11 bases
→ anticodon sequence

○ recognize the corresponding codon on mRNA during protein synthesis

4) variable arm
→ hair pin structure
→ in general, 3-21 bp
→ in case of Phenyl aniline, 17 bp

5) T ψ C arm
→ Stem 5 bp
Loop 9 b
→ pseudo uridine (PU) (ψ)
→ it exceptionally has Thymine residue

○ ~~interact with~~ amino acyl tRNA synthetase during protein syn

Function of RNA

- Ribosomal RNA exhibits catalytic activity (Ribozymes : enzymes which are RNA in nature)
- mRNA carries information for ~~pr~~ amino acid sequence of functional protein
- tRNA carry a.a. during course of protein syn.

Functions of Nucleic Acid

- Medicine for Gene therapy
- Nucleotides are used as high energy compounds
- Nucleic acids are used for production of diagonistic tool
- Nucleic acids are designed as probe & primers for biotechnological application

dt - 1/8/19

Unit-2

Date
Page

Enzymes

(Biocatalyst)

★ Enzymes are macromolecules generally proteinous in nature and are responsible for catalysing biochemical reaction without being used during the course of reaction.

→ In 1835 Berzelius reported that malt extract can hydrolyse starch to sugar and called it as diastase (now called amylase)

→ In 1850s Louis Pasteur reported the process of fermentation (conversion of sugar to alcohol).

→ In 1905 (Father of enzymology) Kuhane, coined the term Enzyme. (En : in + zyme : yeast [greek])

→ In 1926, J.B. Sumner for the first time isolated, characterised and crystalised the enzyme 'urease'.

Features of enzyme catalysed reaction

1. High reaction rate with a magnitude of 10^6 to 10^{12} times more than uncatalysed reaction and $10^2 - 10^4$ times more than reaction catalysed by chemical catalyst. (they decrease the amt of Activation energy req.)

2. High specificity towards substrate, type of reaction catalysed and product generated. and

therefore no side reaction or byproduct generated.
[no racemic mixture (impure mixture)]

3. Mild Operational Conditions such as room temperature or atmospheric pressure, pH near to neutrality can also favor ~~ther~~ enzyme catalysed reactions.

Starch hydrolysis to glucose

alkali / acid - NaOH, heat / H_2SO_4

but amylase can hydrolyse starch to glucose at neutral pH and at RT

4. Regulated or Controlled reaction can be achieved by mechanisms like allosteric Regulation, enzyme inactivation, Feedback inhibition, etc.

→ Enzymes can be nucleic acid in nature and are called Ribozymes.

→ Biologically active enzyme is generally combination of a proteinous and a non-proteinous component If the non-proteinous component is inorganic in nature it is called co-factor and if organic in nature it is called coenzyme or cosubstrate

→ a coenzyme / cofactor permanentally bounded to the protein str. by covalent bond, it is known as prosthetic group.

proteinous + non proteinous = Holoenzyme (active)

proteinous (only) = Apoenzyme (inactive)

dt - 2/8/19

Enzyme classification and Nomenclature

→ based on type of reaction catalysed

*1. oxidoreductase oxidⁿ / redⁿ / redox reacⁿ

commonly known as :

oxidases, reductases ; dehydrogenases

eg → Alcohol dehydrogenase

acetaldehyde $\xrightarrow[\text{NADH (coenzyme)}]{}$ ethanol

*2. transferase transfer of ~~set~~ group of atom from one molecule to another molecule

commonly : transferases, Kinases

eg → Glucokinase

Glucose + ATP → Glucose 6 phosphate + ADP

3. hydrolase hydrolytic reactions (removal OR addition of H_2O)

commonly : hydrolase

eg → peptidase

dipeptide $\xrightarrow{-H_2O}$ 2 a.a.

4. Lyases break or reform bonds with involvement of H_2O, usually responsible for '=' formation

commonly : synthase

eg → aldolase

~~Fructose 1,6 bis phosphate~~ → G

Fructose 1,6 bis phosphate → Glyceraldehyde 3 phosphate + dihydroxy-acetone phosphate

5. isomerase isomerisation reaction

↳ common name

eg → Triose isomerase

dihydroxy acetone (Ketone) ⇌ (reversible) Glyceraldehyde (Aldehyde)

6. ligase bond formation or breakage only by involvement of energy compound like ATP

commonly : synthetase

eg → DNA ligase

2 Oligonucleotide → polynucleotide

ATP → ADP + P_i

7. Translocase (2018)

enzymes have 2 names
- common name
- systematic name
  - substrate
  - type of catalysed reaction
  - followed with ase

also Enzyme Commission Number (EC number)

4 digits dot seperated 3.2.1.17 → serial no.

class → sub sub class (type of atom/bond involved)

example → Lysosyme

EC no. : 3.2.1.17

peptidoglycan N acetyl muramohydrolase

hydrolase | glycosylase | O-S group

dt- 6/8/19

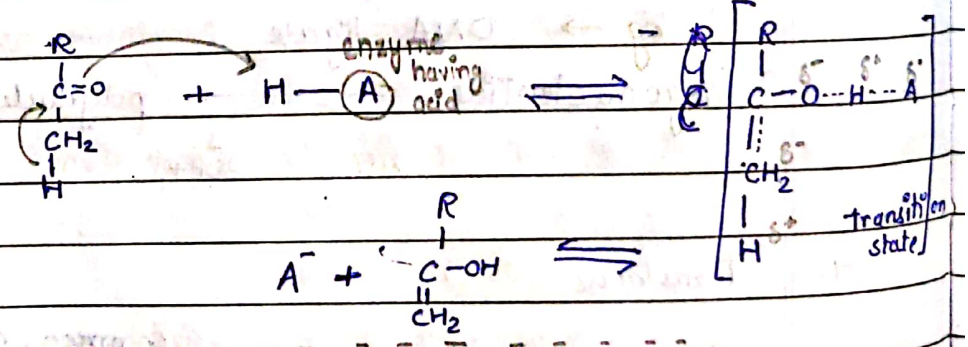
Catalytic Mechanisms

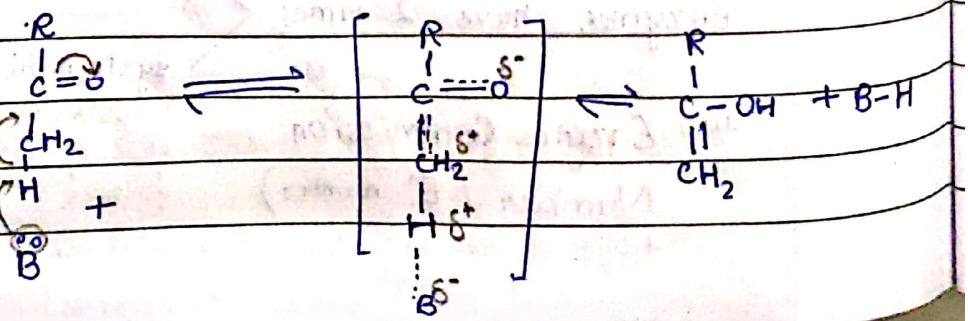
1. Acid- Base catalysis
2. Covalent catalysis
3. Metal ion mediated catalysis

1. Acid - Base

It involves either transfer or abstraction of proton from a Bronsted acid or base which lowers the free energy of the transition state complex. thus increase the rate of reaction

Keto ⇌ enol

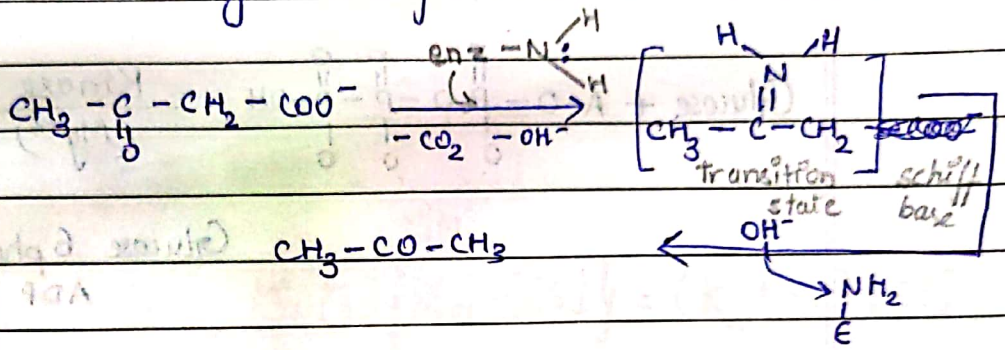




2. Covalent

involves formation of a transient covalent bond b/w the substrate and the enzyme (generally a schiff base formation) that lowers the free energy. (works for those enzymes which have +ve Δ.G.)

decarboxylation of acetoacetate to acetone



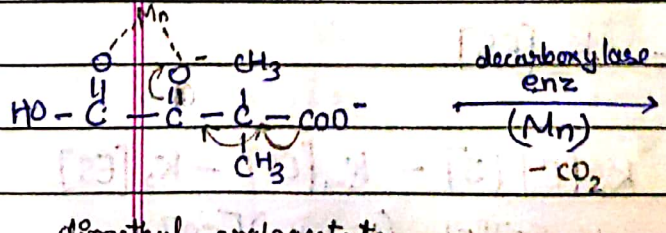
3. Metal ion mediated catalysis

1/3rd of enzymes require a metal ion for its activity

- permanently bound → Metallo enzyme (transition metals) — Fe, Cu, Mo, Mn, Co, Zn.
- associate with enz during reaction → Metal ion activated (alkali and alkaline earth metals) Ca, Mg, Na, K

Mechanism

1. Metal ion gives a proper orientation to the substrate (reacting mol.) during course of reaction thus lowers the energy.



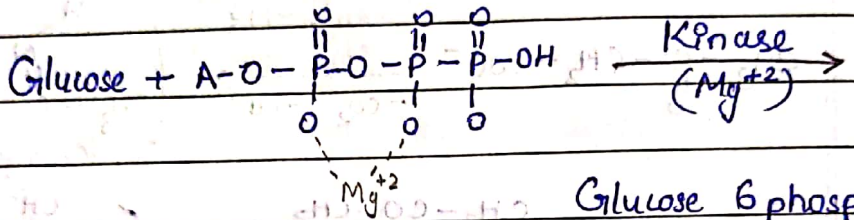
dimethyl oxaloacetate

Mechanism

2. act as redox center and help in oxidation reduction reaction by change in their oxidation state.

$$Cu^{+2} \rightleftharpoons Cu^{+3}$$

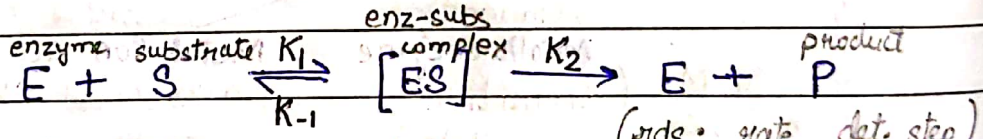
3. Electrostatic stabilisation / -ve charge shielding



Enzyme Kinetics

(basic enzyme kinetic eqn)

Michaelis – Menten Equation



★ conc^n of substrate is higher than that of Enz

★ vel. will be measure of conc^n of Prodt. wrt time

$$v = \frac{d[P]}{dt} = K_2[ES]$$

$$\frac{d[ES]}{dt} = K_1[E][S] - K_{-1}[ES] - K_2[ES]$$

$$= K_1[E][S] - (K_{-1} + K_2)[ES]$$

Assumption

1. Assumption of Equilibrium 1913 (by Menten)
2. Assumption of steady state 1925 (by Brigg)

$$\frac{d[ES]}{dt} = 0$$

∴ based on the assumption

$$K_1[E][S] - K_{-1}[ES] - K_2[ES] = 0$$

$$K_1[E][S] = (K_{-1} + K_2)[ES]$$

$$[E_T] = [E] + [ES]$$

$$[E_T] - [ES] = [E]$$

$$\therefore K_1[S]\{[E_T] - [ES]\} = (K_{-1} + K_2)[ES]$$

$$K_1[S][E_T] = [ES]\{K_{-1} + K_2 + K_1[S]\}$$

dividing by K_1

$$[S][E_T] = \left\{\frac{K_{-1} + K_2}{K_1} + [S]\right\}[ES]$$

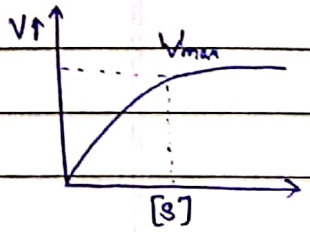
$$[S][E_T] = [ES](K_m + [S]) \quad \{K_m : \text{Michaelis constant}\}$$

$$[ES] = \frac{[S][E_T]}{K_m + [S]}$$

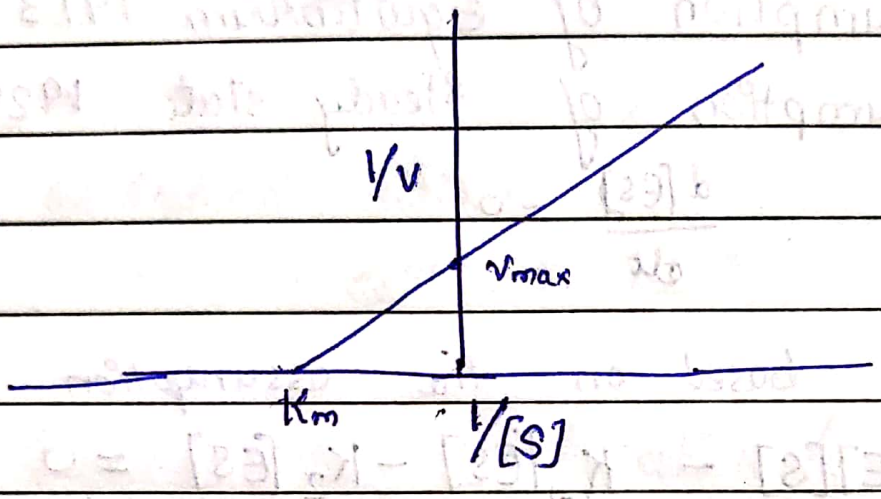
$$V_o = K_2[ES]$$

$$\boxed{V_o = \frac{K_2[E_T][S]}{(K_m + [S])}}$$

$$\boxed{V_{max} = K_2[E_T]}$$



Lineweaver Plot / Double Reciprocal Plot



$K_m \propto \frac{1}{\text{affinity}}$