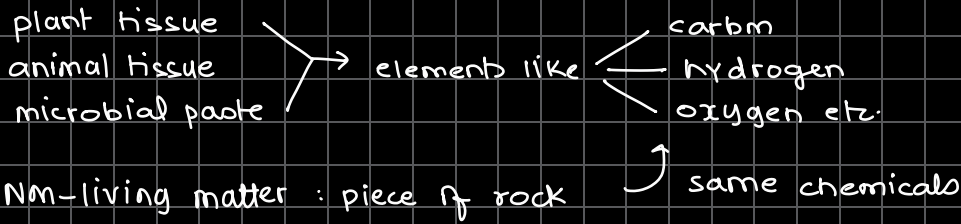


BIOMOLECULES

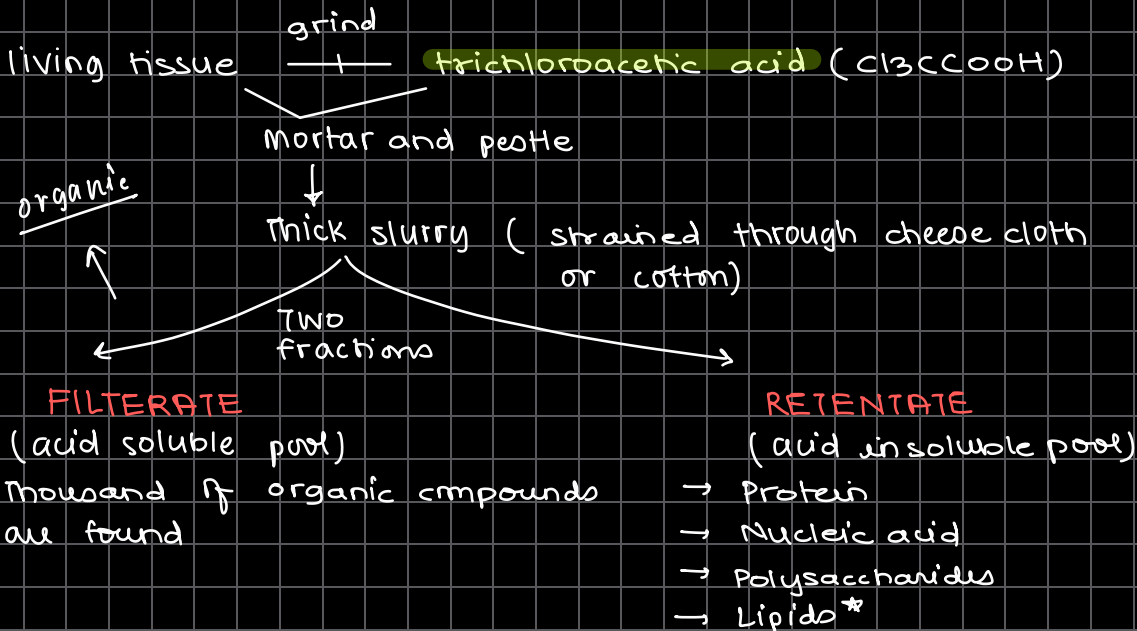
⊗ All living organisms are made of same chemicals i.e. **elements** and **compounds**



In living organisms the relative abundance of carbon and hydrogen with respect to other elements is higher than in earth's crust.

HOW TO ANALYSE CHEMICAL COMPOSITION?

various **bimolecules** that are found in **living tissues** can be studied.



BIOMOLECULES : All carbon compounds that we get from living tissues.

→ Mg^{2+} , (Ca^{2+}) → bones


→ inorganic elements and compounds are also present in living organisms.

↳ which can be known by technique called **ASH ANALYSIS**

Wet weight ← A small amount of living tissue (Leaf, Liver) weighed and dried (All water evaporates) remaining materials gives **dry weight**.

Tissue is fully burnt → carbon compounds are oxidised to gaseous form like CO_2 , H_2O

↓
remnant is called **ASH**
contain many inorganic elements like calcium, magnesium etc.

Fun fact: 
periodic table has all inorganic elements. ∴ that is studied under inorganic section

extra: oxidation + addition of oxygen

organic elements are formed by C + O + H (mainly) other elements can also be present ;)

comparision of elements present in living and non-living matter:

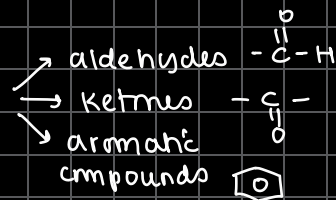
Element	% weight Earth's crust	Human body
Hydrogen (H)	0.14	0.5
Carbon (C)	0.03	18.5
Oxygen (O)	46.6	65.0
Nitrogen (N)	very little	3.3
Sulphur (S)	0.03	0.3
Sodium (Na)	2.8	0.2
Calcium (Ca)	3.6	1.5
Magnesium (Mg)	2.1	0.1
Silicon (Si)	27.7	Negligible

Q: Highest % of element in human body and earth's crust respectively?

Ans:

→ In acid soluble fraction, inorganic compounds like sulphate, phosphate etc. are also present.

From chemistry pov. functional groups like can be identified.

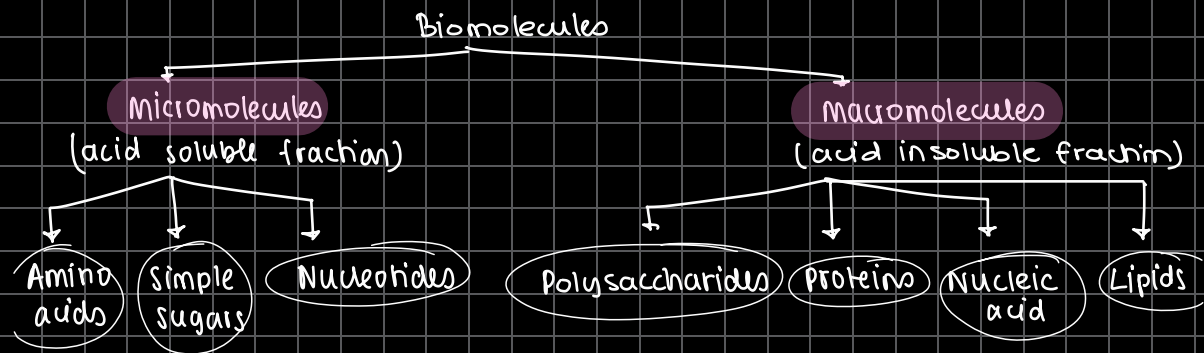


List of inorganic constituents of living tissues:

Component	Formula
Sodium	Na^+
Potassium	K^+
calcium	Ca^{2+}
Water*	H_2O
Magnesium	Mg^{2+}
Compounds	$\text{NaCl}, \text{CaCO}_3, \text{PO}_4^{3-}, \text{SO}_4^{2-}$

→ from biological pov. we can classify the biomolecules

into
micromolecules macromolecules



• contain chemicals with small molecular mass
18-800 Da. Da → daltons

• have molecular wt. in range of 10000 Da or above

except Lipids

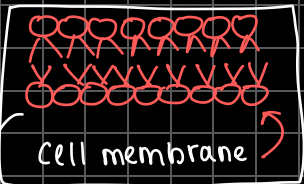
Not strictly a macromolecule

LIPIDS: molecular wt. doesn't exceed 800 Da but they come under acid insoluble fraction

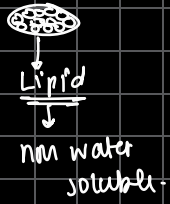


Why?

because when we grind a tissue, cell membranes and other membranes are broken into pieces and form vesicles which are not water soluble [Lipids are also present in structures like cell membrane and other membranes]



hydrophilic: phosphate or glycerol ✓
head ✓
hydrophobic tail: Lipids



cytoplasm

→ acid soluble fraction represents roughly the cytoplasmic composition (without organelles), while acid-insoluble fraction represents the macromolecules of cytoplasm and cell organelles

⊗ The two fractions together represent the entire chemical composition of living tissues and organisms

Average composition of cells:

Q: Most abundant inorganic component and organic component in cell is?

Component	% of the total cellular mass
Water	70-90%
Proteins	10-15%
Nucleic acids	5-7%
Carbohydrates	3%
Lipids	2%
ions	1%

Water is most abundant chemical in living organisms

Ans Water - inorganic
Protein - organic

PRIMARY AND SECONDARY METABOLITES

Living organisms produce lots of organic compounds (Biomolecules) including amino acids, sugars, chlorophylls, haemo etc.

These are required for their primary or basic metabolic processes like photosynthesis, respiration, protein and lipid metabolism etc.

These organic compounds are called **Primary Metabolites**

Many plant, fungi, microbes synthesise a number of organic compounds which aren't involved in primary metabolism and seem to have no direct function in growth and development of organisms

Secondary Metabolites

↳ not produced in humans

PRIMARY METABOLITES: have identifiable functions, play known roles in physiological processes

SECONDARY METABOLITES: role in host organisms are not understood, many of them are useful to human welfare

↓ some have ecological importance

for example: ○ **cyanobacterial** sec. metabolites

exhibit toxic effects on living organisms

ex: Rubber, drugs, spices, sunts, pigments

Algae
↓
Microbe

herbicides and insecticides.

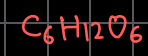
Some secondary metabolites:

Pigments	Carotenoids, Anthocyanins etc.
Alkaloids	Morphine, codeine etc.
Terpenoids	Monoterpenes, diterpenes etc.
Essential oils	Lemongrass oil etc.
Toxins	Abrin, Ricin
Lectins	Concanavalin A
Drugs	Vinblastin, Curcumin
Polymeric substances	Rubber, gum, cellulose.

→ **Cancer**

CARBOHYDRATES: mainly compounds of Hydrogen, carbon and oxygen.

↳ cyclic comp



also known as saccharides because their basic components are sugars.

Two types

small

complex (large)



monosaccharides

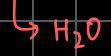
derived monosaccharides

oligosaccharides

Polysaccharides

MONOSACCHARIDES: those sugar or simple carbohydrates which cannot be hydrolysed further into smaller components.

↓
composed of 3-7 carbon atoms.



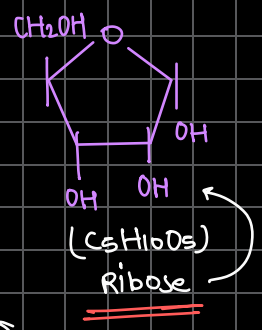
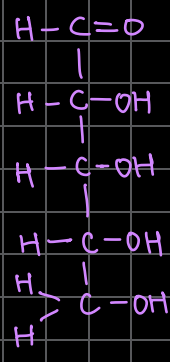
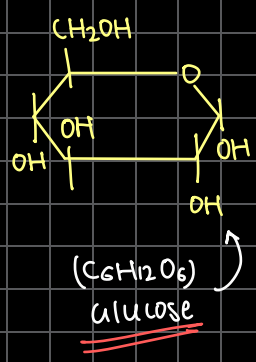
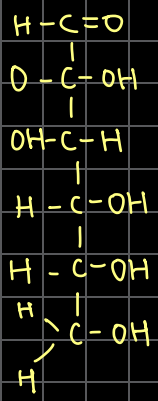
and are micromolecules.

MMO → cannot be broken

EX: Ribose, glucose, fructose etc.

↳ Nucleic

glucose, fructose
↳ $(C_6H_{12}O_6)$ ↵

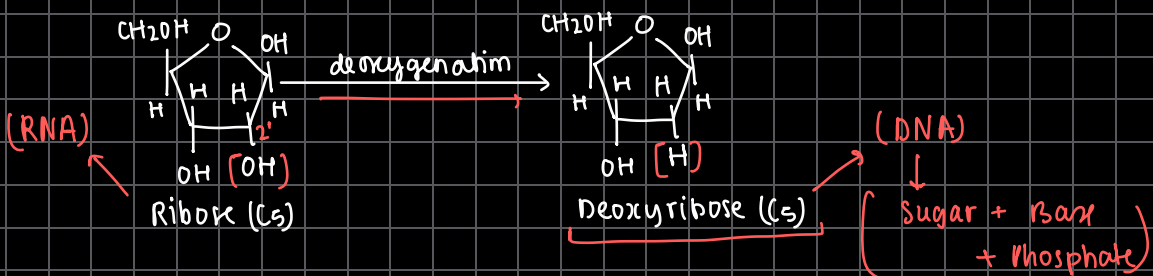


C_3 → unstable
↳ \triangle unstable
(5)

open chain of Ribose

Derived monosaccharides: monosaccharides are modified variously to form number of different substances.

→ Deoxy Sugar: **deoxygenation** of ribose produces deoxy ribose
 ↳ "removal 'O' from 2nd carbon"



→ Amino sugars: eg: glucosamine

→ sugar acid: eg: gluconic acid, ascorbic acid

→ sugar alcohol: eg: mannitol (present in brown algae)
 ↳ (OH)
 ↳ (Storage form of sugar)

OLIGOSACCHARIDES: small carbohydrates which are formed by **condensation** of 2-9 monosaccharides

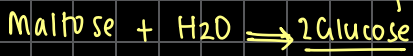
chemical reaction in which two molecules combine to form one molecule with a loss of water

Joined together: **Glycosidic bond**



Dehydration
 ↓
 condensation

Maltose → (Glucose + Glucose)



Glycosidic bond

Depending on the number of monosaccharide molecules condensed to form oligosaccharides, they can be disaccharides, trisaccharides, tetra...

examples of disaccharides →

Sucrose → Glucose + Fructose

Maltose → Glucose + Glucose

(milk)

Lactose → Glucose + Galactose

Trehalose → insects (in haemolymph)

sugar cane



★ Glucose : Cane sugar

Ribose ← (C₅)

(C₆) ↗ fructose
↘ glucose

Q1 : Pentoses and hexoses are common :

- a) oligosaccharides
- b) Disaccharides
- c) Monosaccharides
- d) Polysaccharides

Q2 : Which of the following is present in acid insoluble fraction :

- a) Glucose
- b) Fructose
- c) Amino acids
- d) Lipids

Q3 : Most abundant element present in human body :

- a) Carbon
- b) Nitrogen
- c) Oxygen
- d) Hydrogen

POLYSACCHARIDES : complex sugars

- ⊙ polymer or chains of monosaccharides (macromolecules)
- ⊙ Threads (literal cotton threads) containing different monosaccharides.
- ⊙ Branched or unbranched.

In a polysaccharides \rightarrow individual monosaccharides are linked by glycosidic bonds.

Left end is non reducing

Right end of polysaccharides are reducing

Depending upon the composition polysaccharides

Branched

Homo polysaccharides

only one type of monosaccharides present.

Starch $\left\{ \begin{array}{l} \alpha\text{-glucose} \end{array} \right.$

glycogen $\left\{ \begin{array}{l} \alpha\text{-glucose} \end{array} \right.$

\hookrightarrow intensely branched

Heteropolysaccharides

Storage in plants

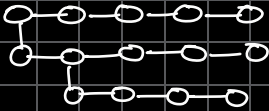
Storage in animals

(i) Glycogen: 30000 glucose residues

Branched structure

1-4 linkage $\left\{ \begin{array}{l} \text{Glycosidic} \\ \text{Linkages} \end{array} \right.$

1-6 linkage



\rightarrow it gives red colour with iodine



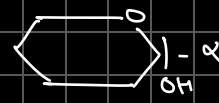
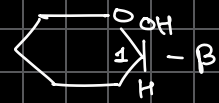
(ii) Starch: helical secondary structure

\hookrightarrow the chain of glucose folds into the form of helix

\rightarrow Blue colour with iodine (I_2) due to ability of iodine to occupy a position in helix.

[$\alpha, \beta \rightarrow$ position of 'OH' on 1st carbon]

(iii) **cellulose**: composed of β -glucose
 → unbranched straight



- present in plant cell wall.
- Paper made from plant pulp called cellulose
- cotton fibre is also cellulose
- 'Rayon': Artificial silk → cellulose
- cannot hold I_2 : -ve test in presence of iodine.

(iv) **Inulin**: polymer of fructose
 → storage polysaccharide of roots and tubers of dahlia etc.
 → not metabolised in human body.
 ↳ readily filtered through kidneys.
 → used in testing of kidney functioning.

(v) **chitin**: second most abundant organic substance.
 → polymer of glucose derivative (derived monosaccharides)

↓
 N-acetylglucosamine

→ exoskeleton of arthropods (insects) have chitin.

HETEROPOLYSACCHARIDES: more than one type of monosaccharide

↓
 more complex than homopolysaccharide.

(i) **peptidoglycan**: two alternative derived monosaccharide (amino-sugar)
 ↳ N-acetylglucosamine
 ↳ N-acetyl muramic acid

(ii) **Hyaluronic acid**

- $H_2O \rightarrow$ branching
 + $H_2O \rightarrow$ break down

Why glycogen and starch used as storage body?

- stored in bulk
- chemically non-reactive
- osmotically inactive

AMINO ACIDS → organic compound

→ have NH_2 group (amino group)

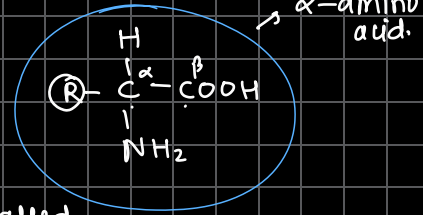
- COOH (carboxylic group)

- H (Hydrogen)

- R (variable group)

} all attached to same carbon
i.e. the α -carbon

→ They are substituted methanes (CH_4)



① since both the functional groups are attached to the α -carbon so they are called α -amino acids.

→ 20 types

→ Based on nature of R group there are many amino acids

* Amino acids which occur in protein are only of 20-types.

↳ R → 20 types

R group can be

- hydrogen (glycine) ✓
- methyl group (alanine) ✓
- hydroxy methyl (serine) ✓

etc

Humans are incapable of synthesizing half of 20 standard amino acids ⇒ ESSENTIAL Amino acids

↓

They must be obtained from diet

ex:

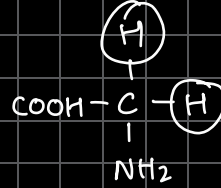
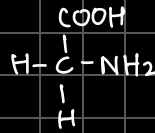
- Lysine ✓
- methionine ✓
- phenylalanine
- tryptophan
- valine ✓
- isoleucine
- leucine
- threonine

Semi-essential amino acids: synthesised very slowly by humans

ex: Arginine and histidine

Neutral amino acids: have one amino group and one carboxylic group

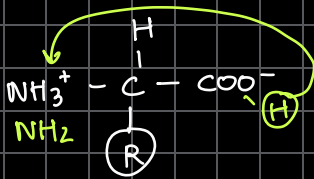
ex: Valine
alanine
glycine
leucine
isoleucine



↗ loose or gain e^-

★ A particular property of amino acids is ionizable nature of NH₂ and COOH groups.

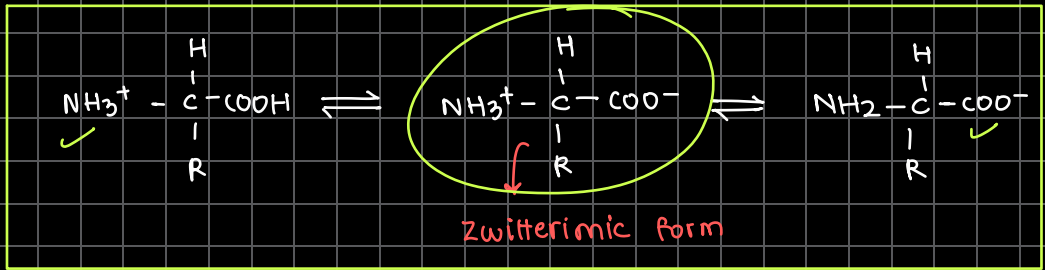
These fully ionized species k/a zwitterions



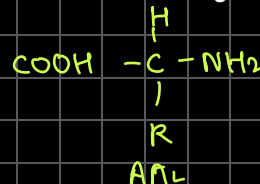
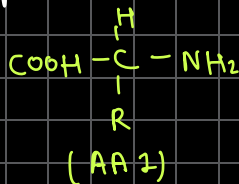
↓
having both positive and negative charge

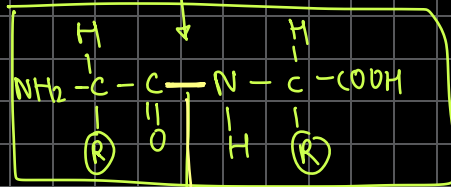
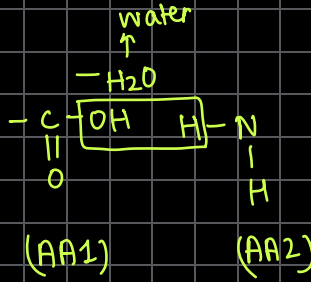
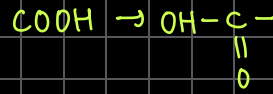
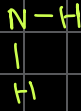
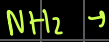
Every amino acid has a carboxylic group and amino group and each group can exist in an acidic form or a basic form depending on the pH of solution. (Neutral = pH = 7)

Notice that amino acid can never exist in as an uncharged compound regardless pH of solution.



Two amino acids can be joined through amino group of one carboxylic group of other forming peptide bond by loss of water molecule.





peptide bond \rightarrow $\begin{array}{l} \text{COOH} \uparrow \\ \text{NH}_2 \uparrow \end{array}$ (AA1)
(AA2)

(2-9)

When few amino acids are joined in this fashion, the structure is called **OLIGOPEPTIDE**

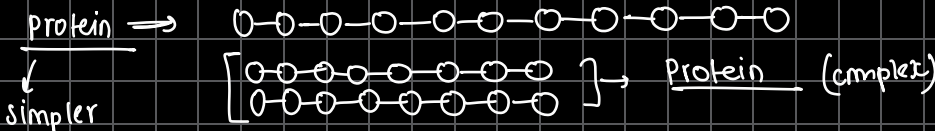
bond

POLYPEPTIDE \rightarrow many amino acids are joined
bond

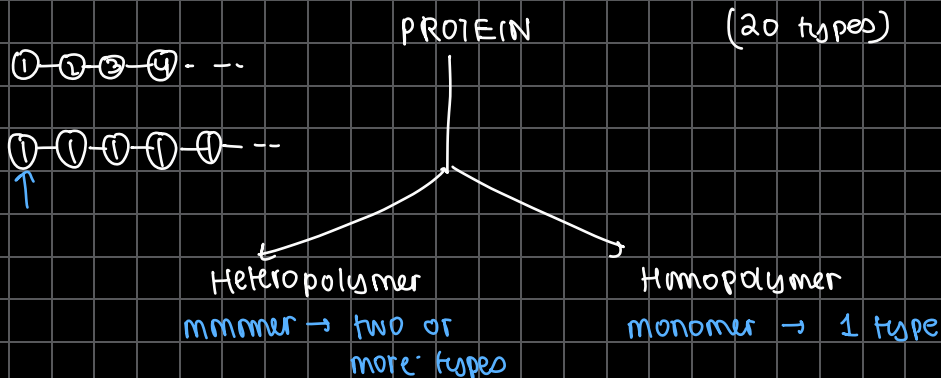
PROTEINS

macromolecules acid insoluble prot \rightarrow Mol. mass $\rightarrow > 10000$ PA

one or more polypeptides (chains of amino acids linked by peptide bond)



single polypeptide chain \rightarrow minimum 50 amino acids.



✓ **COLLAGEN** : most abundant protein in animal world.
: main component of connective tissues of animals

\swarrow cartilage \searrow bones
Acellular collagen

RIBULOSE BIPHOSPHATE CARBOXYLASE - OXYGENASE : (RUBISCO)

most abundant in whole biosphere (earth)

Photosynthesis (carbon fixation) \rightarrow $\text{CO}_2 \rightarrow \text{C}_6\text{H}_{12}\text{O}_6$


STRUCTURE OF PROTEINS

Biologists \rightarrow 4 levels

- \rightarrow primary
- \rightarrow secondary
- \rightarrow Tertiary
- \rightarrow quaternary.

\downarrow complexity

PRIMARY STRUCTURE :

\rightarrow 
sequence of amino acids arranged in polypeptide chain of a protein.

\rightarrow gives us the positional information of amino acids in protein

N-terminal

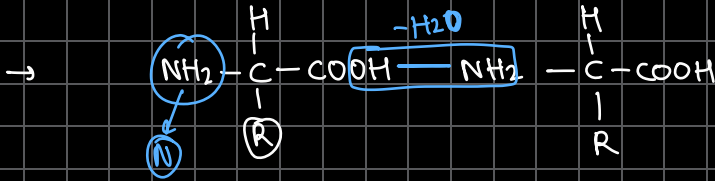
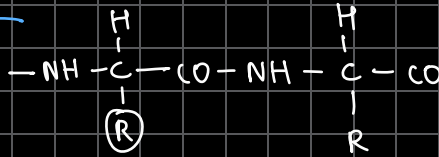
C-terminal

N

C

Left
1st amino acid

Right

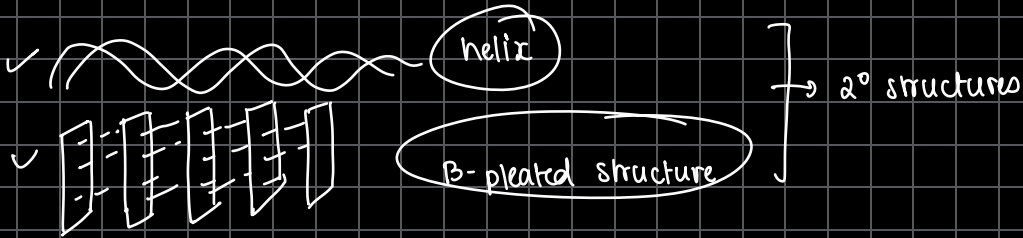


(2 D)

Right

SECONDARY STRUCTURE

(O-O-O-O-O-O) - 1^o structure



α-helix :

every fourth amino acid → interaction

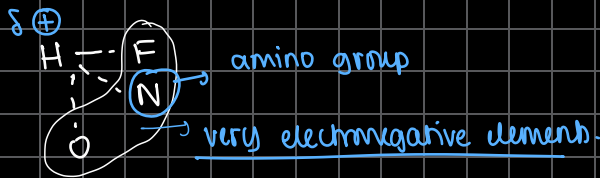
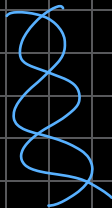
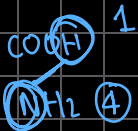
1-4

4-8

8-12

Hydrogen bonds

intramolecular → in the molecule.



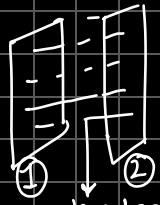
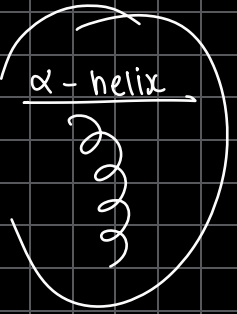
→ Righted handed helical st. :

↪ nails
↪ hair

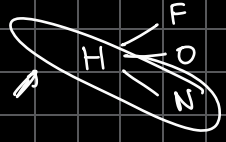
Ex 2° structure protein → helical → Keratin

β-pleated sheets :

two or more polypeptide chains
↳ held together by intermolecular hydrogen bonding



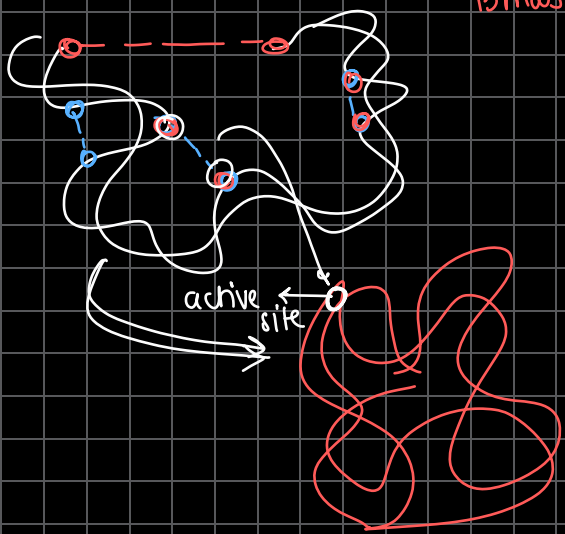
hydrogen bonding



Ex, Fibronin : natural silk

TERTIARY STRUCTURE ⇒ (3° dimensional view)

long protein chain usually folds up on itself forming a woolen ball like structure



- Bonds → sulphate
- ↳ ionic bonds
- ↳ covalent bonds
- ↳ hydrogen bond

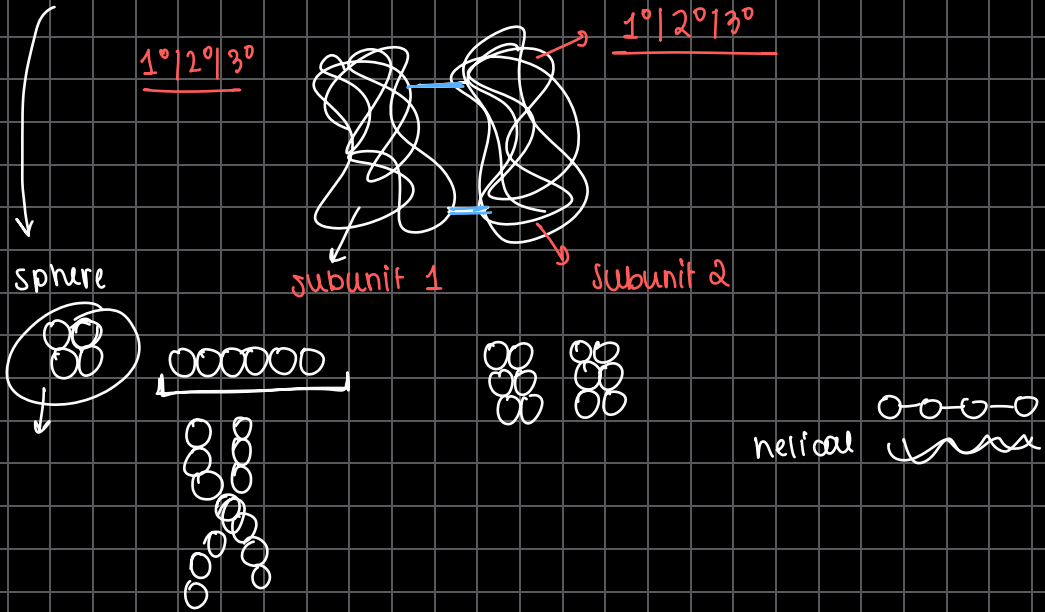
These 3° structures are absolutely necessary for many biological activities of proteins.

→ product
active site (enzyme)

active site ⇒ site at which substrate is attached

ex Myoglobin (muscle cells)
↳ attach O₂

QUATERNARY STRUCTURE



Haemoglobin →

4 helical polypeptide chains
two α-chains
two β-chains

FUNCTIONS OF PROTEIN



RNA
Ribosomes

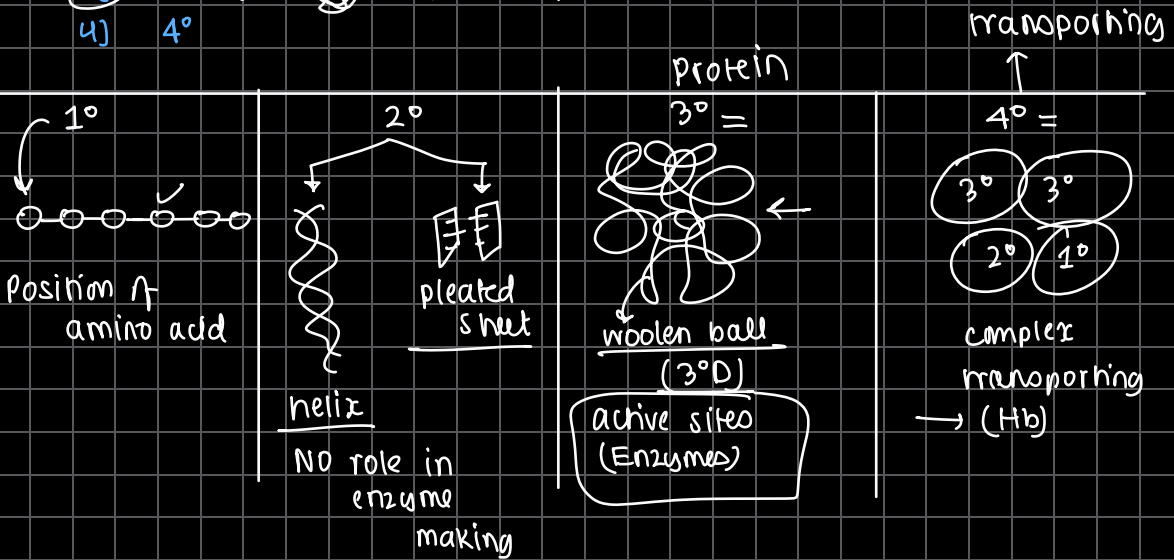
① **ENZYMES**: All enzymes (except a few) are built of proteins or in conjugation with some nm protein material.

P → enzyme

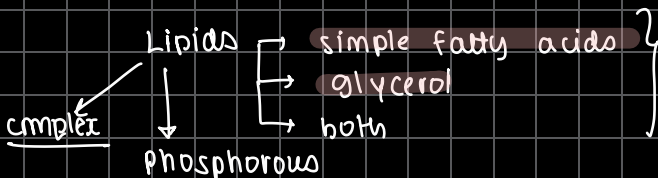
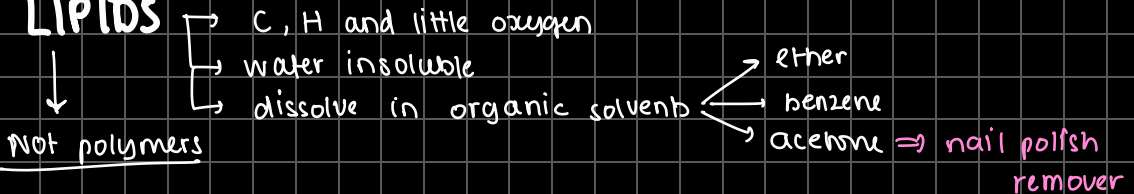
P + NP → enzyme

Which of the following structure of protein is absolutely necessary for many biological activities of proteins? (enzymes)

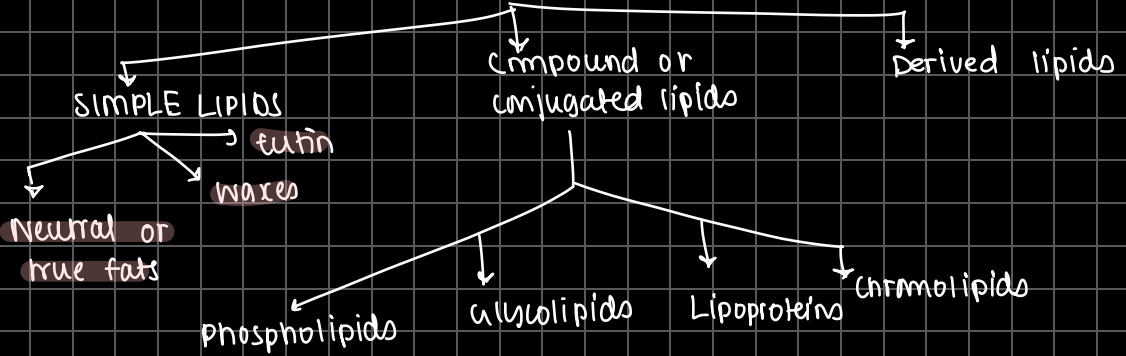
- 1) 1° → ○-○-○-○-○ (Position)
- 2) 2° →  II
- 3) →  → active sites → enzymes
- 4) 4°



LIPIDS



CLASSIFICATION



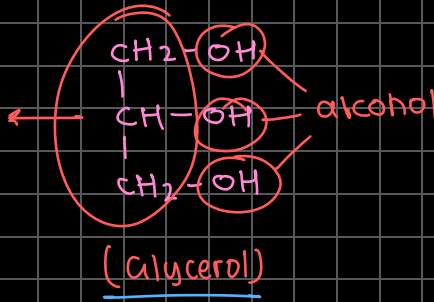
SIMPLE LIPIDS → esters (organic acids and alcohols to ester)
 of fatty acid

$\text{fatty acid} \uparrow$
 $\text{org. acid} + \text{alcohol} = \text{ester}$
 fatty acid

→ various

1) Natural or true fats : esters of fatty acid with glycerol
 (Glycerides)

3C



one molecule of glycerol + 1-3 molecules of fatty acid
 ↓
 esters

↓
 Natural | true fat.

b) SATURATED fatty acid
 (do not have double bonds)

UNSATURATED fatty acid
 (have double bonds)

NUCLEIC ACIDS

macromolecules

Polymers of nucleotides

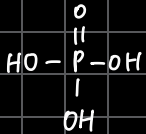
Nucleic acids

Deoxyribonucleic acid (DNA)

Ribonucleic acid (RNA)

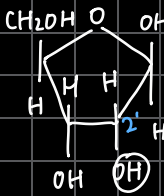
Nucleotide

Phosphate group



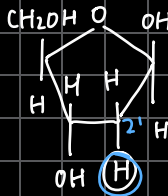
Pentose sugar

Ribose



β -ribose
(RNA)

deoxyribose



β -deoxyribose
(DNA)

Heterocyclic nitrogen containing compound called base

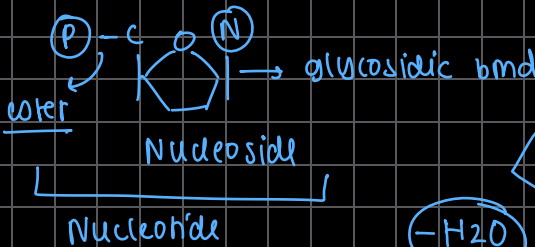
- Adenine (A)
- Guanine (G)
- Thymine (T)
- Cytosine (C)
- Uracil (U)

deoxy → removal of 'O'



By glycosidic bond

By ester bond



Lipids

fatty acid + alcohol



ester

$-\text{H}_2\text{O}$ ← glycosidic

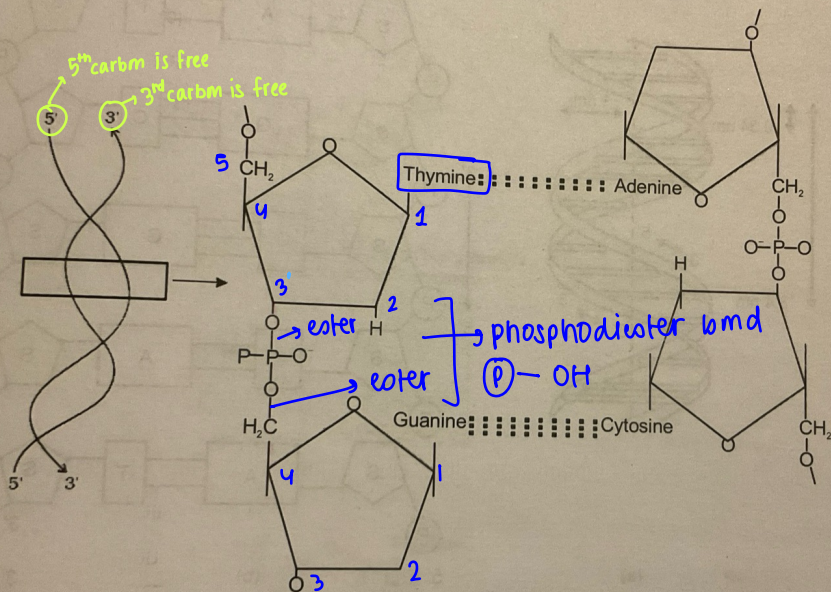


Fig. : Diagram indicating secondary structure of DNA

WATSON-CRICK MODEL OF DNA:

Model says:

⊙ DNA exist as double helix (), DNA molecule has two unbranched polynucleotide strands.

Each polynucleotide chain consist of a sequence of nucleotides linked by phosphodiester bonds.

The polynucleotide chains are antiparallel i.e. runs in opposite directions.

⊙ Now, strand is coiled upon itself around common axis like spiral staircase with base pairs forming steps while the backbone of strands form railings

Backbone is formed of → sugar and phosphate

⊙ Nitrogen bases are projected more or less perpendicular to sugar phosphate backbone but face inside.

① The base pairing is specific.

A = T (Two Hydrogen bonds)
 G ≡ C (Three hydrogen bonds)

Purine — Pyrimidine
 (A) (T)
 (G) (C)

⇒ once the sequence of bases in one strand known, we can find the sequence of the other one.

known as complementary (non-identical)

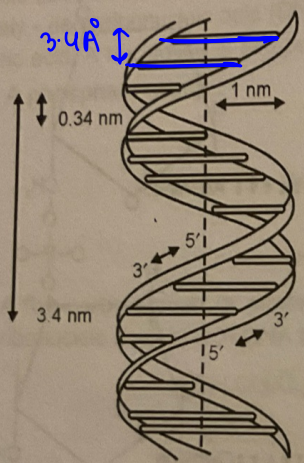
This is known as **COMPLEMENTARY BASE PAIRING**

② At each base pair the strand turns 36°.

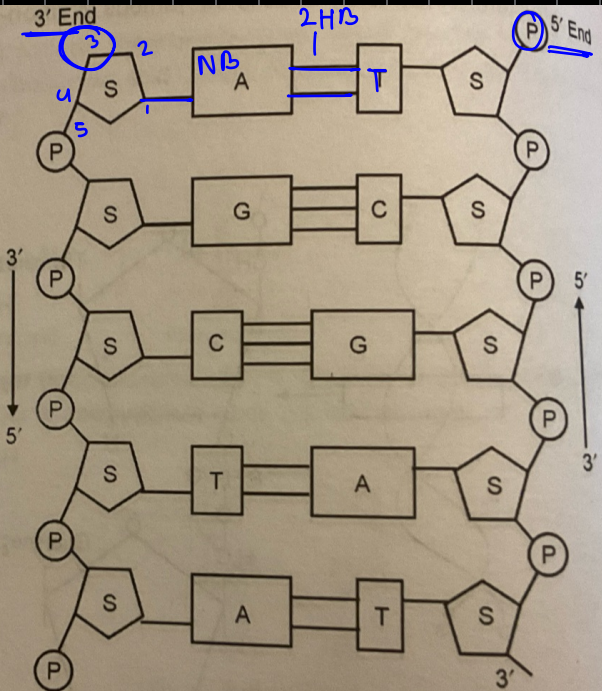
One full turn of helical strand (360°) would involve "10 base pairs"

The base pairs in DNA are stacked at 3.4 Å apart.

Thus pitch of DNA is 34 Å as 10 base pairs occupy a distance of 34 Å.
 ↓
 (10 BP)



(a)



(b)

3' End

Chargaff's rule:

Amount of purines and pyrimidines are equal
 $A + G = T + C$

amount of adenine is always equal to amount of thymine
and guanine is equal to cytosine.

$$\begin{pmatrix} T = A \\ G = C \end{pmatrix}$$

Deoxyribose sugar and phosphate component occurs in equal proportion.



RNA is usually single stranded but sometimes (as in Rinovirus), it is double stranded. ↳ cold

RNA does not follow Chargaff's rule i.e. 1:1 does not exist b/w purines and pyrimidines bases due to single stranded nature and lack of complementarity.

RIBONUCLEIC ACID (RNA):

Three types of RNA:

- 1) Messenger RNA (m-RNA): Produced in nucleus and carries information for synthesis of proteins
- 2) Ribosomal RNA (r-RNA): largest RNA (80% of cellular RNA)
↳ in ribosomes
↳ synthesis proteins
- 3) Transfer RNA (t-RNA): smallest type of RNA (10-15%)
↳ in cytoplasm
amino acids

(LIPIDS)

unsaturated fats are saturated by



- polymerization
- dehydrogenation
- hydrogenation
- hybridization

Basic unit of nucleic acid is

- Pentose sugar
- Nucleotide
- phosphoric acid
- All of these

Incorrect statement:

- 1) ~~Lipids are strictly macromolecules~~
- 2) Adenine forms two hydrogen bonds with Thymidine.
- 3) Fructose is a monosaccharide.
- 4) Peptide bond is formed by dehydration

CONCEPT OF METABOLISM

Metabolites \Rightarrow certain concentration

All these biomolecules have a turn over means they are constantly being changed into some other biomolecules.



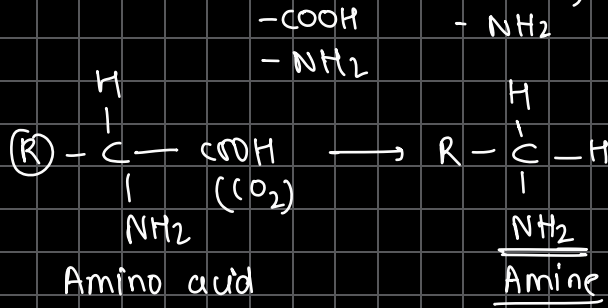
Together all these chemical rxns are called metabolism

breaking and making

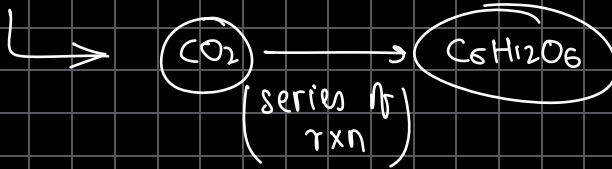
chemical

Biomolecules get transferred due to metabolic rxn that in org.

removal of CO_2 from amino acid \rightarrow amine)



Metabolic pathways

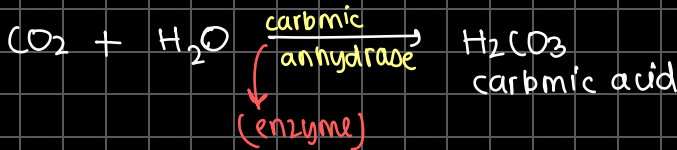


Chemical rxn

real slow

\hookrightarrow fasten them up: Enzymes

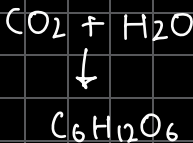
ex



All chemical rxns occurring in living system are mediated through biocatalyst called enzyme.

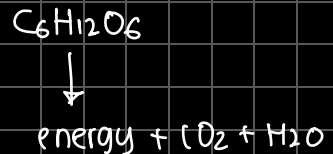
Anabolic pathways

(forming)



Catabolic pathways

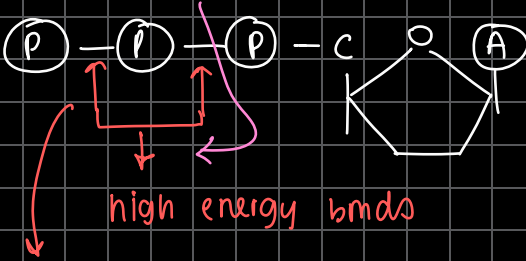
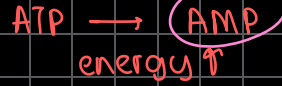
(cutting)



ATP : energy currency of body

Adenosine triphosphate

Adenosine
triphosphate



high energy bonds

release huge amount energy

ENZYMES

Almost all enzymes are proteins.

exceptions :
Ribozyme (Ribosome)
Ribonuclease - P (Nucleic acid)

enzyme →
2° structure protein X
3° structure protein ✓
4° structure protein X

active sites : pockets (enzymes)

↓
substrate attacks

↓
product → used by cells/body

(body) organic enzymes

(X) inorganic catalysis

- almost proteins
- in living cells
- perform specific reactions
- damaged (Temp > 40°C)

- elements (Ni, Cr)
- don't occur living org
- no. of rxn
- work well at high Temper.

