BIOMOLECULES

They are chemical substance responsible for controlling physiochemical process within a living system that make living system. Relative abundance of C & H are more in living system than in Earth's crust.

METHODS FOR DETECTING DIFFERENT COMPONENTS IN LIVING SYSTEM

FOR ORGANIC COMPOUND EXTRACTION

Take any living tissue(a vegetable or a piece of liver) & grind it in trichloroacetate (Cl_3CCOOH) using mortar & pestle. On straining by cheese cloth or cotton & we would obtain two fractions.

ACID SOLUBLE POOL

Cytoplasmic composition. Rich in organic compounds (phosphate & sulphate) & Biomicromolecules.

ACID INSOLUBLE POOL

Biomacromolecules

FOR DETECTING INORGANIC COMPOUNDS

Weigh a small amount of living tissue (wet weight) & dry it. Remaining material gives dry weight. Burn it all so that all carbon compounds get evaporated & ash is left that contains Ca, Mg etc inorganic ions.

Basically all carbon compounds in living tissue are biomolecules

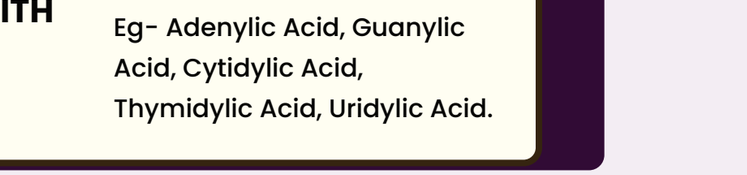
A - AMINO ACIDS

- Organic compounds containing amino group & carboxylic acid group as substituents on the same carbon i.e. alpha-carbon.
- They are substituted methanes.
- They contain four groups - amino, hydrogen, carboxyl group, variable/alkyl group (R).
- Amino acids which occur in proteins are of 20 types

PROPERTIES OF AMINO ACIDS:-

(i) On the basis of no. of amino, COOH group amino acids are of 3 types:- ACIDIC (glutamic acid), BASIC(Lysine), NEUTRA (VALINE).

(ii) Aromatic amino acids:- Tyrosine, Phenylalanine, Tryptophan



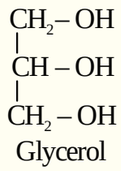
LIPIDS (Water insoluble)

They could be simple fatty acids or glycerol (simple lipid)

FATTY ACID

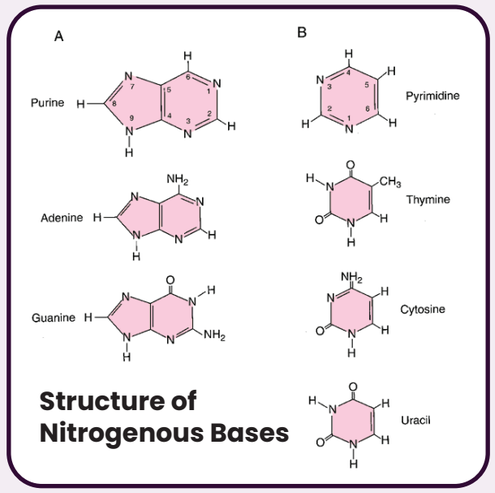
(Carboxyl group attached to R) where R can be (C1 - C19). Eg- palmitic acid (16C including -COOH), Arachidonic acid (20C including COOH). They can be saturated or unsaturated. $CH_3-(CH_2)_{14}-COOH$ Fatty acid (Palmitic acid)

Glycerol (Trihydroxy propane)



- Many lipids have both fatty acids esterified with glycerol. Then they can be mono, di, tri, poly-glycerides.
- They are also called fats & oils based on melting point. Oils have low melting pt. (eg- gingelly oil) hence remain requid in winters.
- Some lipids have phosphorus & a phosphorylated organic compound in them which are called PHOSPHOLIPIDS.

Eg- LECITHIN(found in cell membranes).



NITROGEN BASES

Eg-Adenine(A), Guanine(G), Cytosine(C), Thymine(T), Uracil(U)have heterocyclic ring.

SUGAR

Eg-ribose, deoxyribose.

NUCLEOSIDE

Eg- Adenosine, Guanosine, Cytidine, Thymidine, Uridine

PHOSPHATE ESTERIFIED WITH SUGAR

NUCLEOTIDE

Eg- Adenylic Acid, Guanylic Acid, Cytidylic Acid, Thymidylic Acid, Uridylic Acid.

METABOLITES

Primary Metabolites :

- Includes amino acid,sugars, basic organic compounds, which are found in organisms.
- Their role in metabolism can be easily identified.

Secondary Metabolites :

- Includes alkaloids,flavonoids,rubber,essential oils, antibiotics,coloured pigments, scents, gums, spices.
- Found in plant,fungal & microbial cell.
- Their role in metabolisms is not definite.
- They are useful for human welfare (eg-rubber, drugs,spices, scents, pigments) & also have some ecological importance.

Some Secondary Metabolites

1	Pigments	Carotenoids,Anthocyanins, etc.
2	Alkaloids	Morphine, Codeine, etc.
3	Terpenoides	Monoterpenes, Diterpenes etc.ine, etc.
4	Essential oils	Lemon grass oil, etc.
5	Toxins	Abrin, Ricin
6	Lectins	Concanavalin A
7	Drugs	Vinblastin, curcumin, etc.
8	Polymeric substances	Rubber, gums, cellulose

BIOMOLECULES

Biomicromolecules

- Molecular weight less than 1000 Da
- Found in acid soluble pool.
- Have molecular weight as 18-800 Da.

Biomacromolecules

- Molecular weight more than 1000 Da except lipids.
- Found in acid insoluble pool & except lipids all are polymeric.
- Eg. polysaccharides, proteins, nucleic acids, lipids

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

Why lipids are found in acid insoluble pool?
Lipids are arranged in structure like cell membrane On grinding tissue,they get broken & form vesicles which are water insoluble hence found in macromolecular fraction.
Lipids are not strictly macromolecules. Lipid is less than 800 Da.

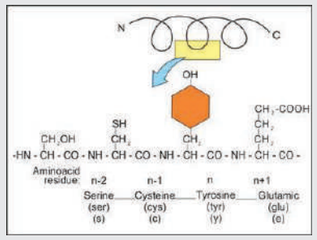
PROTEINS

Introduction

They are polypeptide i.e. linear chain of amino acids linked by peptide bonds.

They are heteropolymers of amino acids(20) eg. alanine,glycine,proline, tryptophan, lysine.

Amino acids can be essential(dietary) or non essential (synthesised by body).



Structure of protein

PRIMARY-sequence of amino acids i.e. positioned information in a protein which is 1st, 2nd amino acids. A protein is imagined as a line. Left end has 1st amino acid (N-terminal a.a) & right end has last amino acid (C-terminal a.a) where N & C stands for amino & carboxyl group.
SECONDARY-originally the structure of protein is not linear, the thread is folded in the form of a helix. In proteins only right handed helices are observed. Those folded portions are called as secondary structure. It can be alpha-helix or beta-pleated.
TERTIARY-The long protein chain is also folded upon itself like a hollow wooden ball, giving rise the tertiary structure. It's 3-D view is important for many biological activities.
QUATERNARY(Architecture of a protein)-proteins made up of more than one polypeptide in which the polypeptide is itself folded & again get folded upon other polypeptide.
Adult human consists of 4 subunits. Two of these are identical to each other. Hence two subunits of a-type & two subunits of type together constitute Hb.

Functions of protein

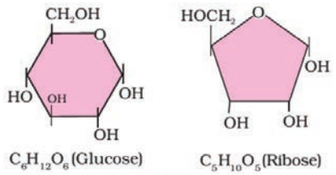
Transport nutrients across membrane, fighting with infectious organisms, hormones, enzymes.
Collagen is most abundant protein in animal world & RubisCO is most abundant protein in biosphere.

Table 9.5 Some Proteins and their Functions

Protein	Functions
Collagen	Intercellular ground substance
Trypsin	Enzyme
Insulin	Hormone
Antibody	Fights infectious agents
Receptor	Sensory reception (smell, taste, hormone, etc.)
GLUT-4	Enables glucose transport into cells

POLYSACCHARIDE

Long chain of sugars, made up of monosaccharides (building blocks). Eg-cellulose {made up of only glucose as monomer (HOMOPOLYMER)}, glycogen, starch, inuline.



Sugars (Carbohydrates)

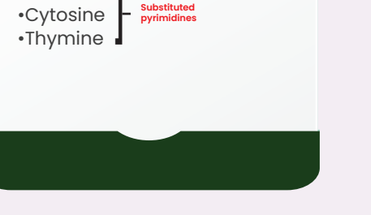
Variant — Polymers or α-D-Glucose

Polymer of Fructose

Right end is reducing & left end is non reducing. Starch forms secondary structure that's why holds Iodine & gives blue colour but cellulose doesn't have that structure.

Complex polysaccharide

Made up of amino-sugars & glucasamime, N-acetyl galactosamine. Eg-



Diagrammatic representation of a portion of glycogen

Paper made from plant pulp and cotton fibre is cellulosic.

NUCLEIC ACIDS

They are polynucleotide, possess secondary structure.
Their bulding block is a nucleotide.

COMPONENTS OF NUCLEOTIDE

1) HETEROCYCLIC COMPOUND

Nitrogenous bases:-
- Adenine Guanine — Substituted purines
- Uracil, Cytosine, Thymine — Substituted pyrimidines

MONOSACCHARIDE (SUGAR)

Can be either of the two :

(i) (Monosaccharide pentose)

(ii) 2'deoxy RIBOSE

PHOSPHORIC ACID (PHOSPHATE)

NATURE OF BOND LINKING MONOMERS IN A POLYMER

In polypeptide amino acids are linked by peptide bond [CO-NH].
In polysaccharide monosaccharide are linked by glycosidic bond. — By dehyderation

Model of DNA was given by Watson & Crick, which says that DNA exist as double helix, 2 strands of polynucleotideare antiparallel, have sugarphosphate backbone. Nitrogenous bases are projected more or less perpendicular to this backbone but face inside.

At each step strand turns 36°. One full helical strand would involve 10 steps(basepair). In a line diagram pitch would be 34A°. And rise per basepair is 3.4 A°.

In nucleic acid phosphate links to 3'C of one sugar of one nucleotide to 5'C of sugar of other nucleotide. Bond b/w phosphate & hydroxyl of sugar is ester bond, & as it is present on either sides hence called phosphodiester bond.

Nucleic acids have secondary structure, Eg- DNA.

A & G of one strand compulsorily base pairs with T&C respectively on other strand. This structure is known as B-DNA.

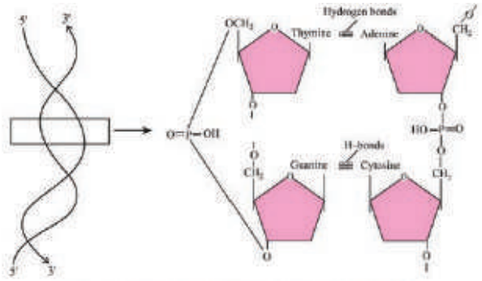


Fig.: Diagram indicating secondary structure of DNA

Dynamic state of body constituents- concept of metabolism :

Turn Over - All the biomolecules undergo turnover means constantly being changes into some other biomolecules via reactions. Together all this chemical reactions are called & METABOLISM (transformation of biomolecules).

- **Eg- conversion of amino acid in amine by release of CO_2, removal of amino group in nucleotide base, hydrolysis of glycosidic bond in disaccharide.**
- **Metabolites are converted into each other in a series of linked reactions called metabolic pathways (can be linear or circular).**
- **Flow of metabolism thr'pathway has definite rate & direction which is known as dynamic state of body constituents. Every chemical reaction is catalysed. Eg- dissolving in the catalysts are proteins (enzymes).**

METABOLIC BASIS FOR LIVING

1

ANABOLIC PATHWAY
(1) Requires energy
(2) simpler to complex
(3) eg- acetic acid + energy - cholesterol

2

CATABOLIC PATHWAY
(1) Releases energy
(2) complex to simpler
(3) eg- glucose by glycolysis into lactic acid & energy in skeletal muscle.

- **Living organisms store the released energy in the form of chemical bonds.**
- **ATP(Adenosine Triphosphate) is energy currency.**
- **BIOENERGETICS- branch of biology which deals with the energy related issues.**

THE LIVING STATE

- Blood concentration of glucose in a normal healthy individual is 4.5-5.0 mM, while hormones are present in nanograms/mL.
- All living organisms exist in steady state/non-equilibrium i.e. to be able to perform work.
- Living process is a constant effort to prevent falling into equilibrium. this is achieved by energy input.
- The living state & metabolism are synonymous.
- Without metabolism there cannot be living state.
- Biomolecules are in a metabolic flux.

ENZYMES

Almost all enzymes are proteins

Ribozymes- RNA that behave like enzymes

The chain of enzymes criss crosses itself & pockets are made which are known as active sites in which substrate fits.

Inorganic catalysts work efficiently at high temp. pressure while enzymes get damaged above 40°C. However enzymes from organisms of hot vents, Sulphur springs can retain upto 80-90°. Thermophilic organisms have thermostable enzyme.

How do enzymes bring about such high rates of chemical conversions!

The chemical which is converted into product(P) is called substrate(S) & this conversion takes place via active site present in 3-D proteins.
The substrate diffuse towards active site & enzyme adjusts its size. After undergoing transient phenomenon Enzyme Substrate (ES) complex is formed. Afterwards the required product is released (by breaking & making bonds) from active site. The pathway must go through the transition state structure. In the above pathway some infinite unstable intermediate are also formed. The transition state is also unstable cause of high energy.

ACTIVATION ENERGY- **Difference in average energy content of S from that of transition state. If energy of P is lower than S then it is exothermic or spontaneous process.**

$$E + S \rightleftharpoons \boxed{ES} \longrightarrow \boxed{EP} \longrightarrow E + P$$

It's formation is very important & also know as victor henri complex

Enzymes product complex

CHEMICAL REACTION

When bonds are broken or new bonds are formed.
E.g.-hydrolysis of starch into glucose.

Rate of Chemical or Physical Process-Amount of product formed per unit time.

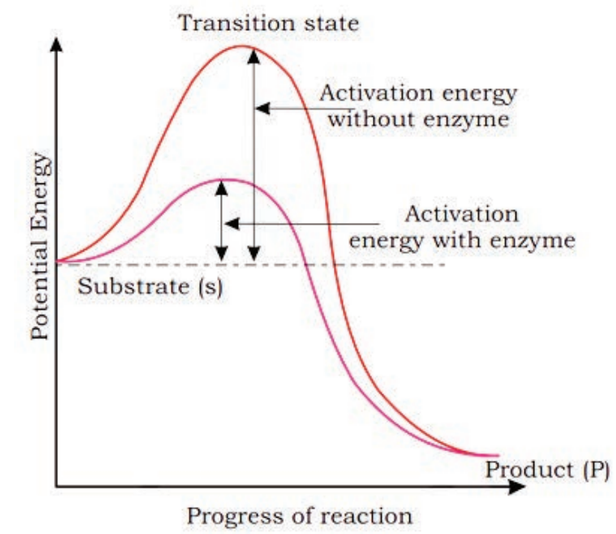
$$\text{Rate} = \frac{\delta P}{\delta t}$$ **Rate is influenced by temp. Change**

Rule of Thumb- Rate doubles or decreases by half for every 10°C change in either direction.

$\{CO_2 + H_2O \longrightarrow H_2CO_3(\text{Carbonic Acid})\}$

In absence of enzyme 200 molecules are formed per hour & when we use enzyme 6,00,000 molecules per second (acceleration by 10 million times).

Metabolic pathway- A multistep chemical reaction when each of the steps is catalyzed by the same enzyme complex or different enzymes is called metabolic pathway. E.g.-Glycolysis. In different condition different products are possible. (E.g.-Yeast, Muscles)

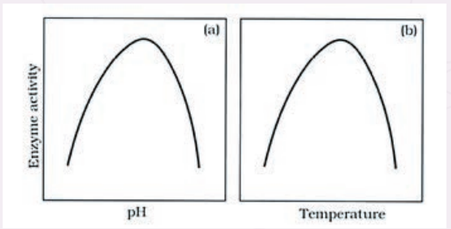


Concept of activation energy

FACTORS AFFECTING ENZYMES ACTIVITY

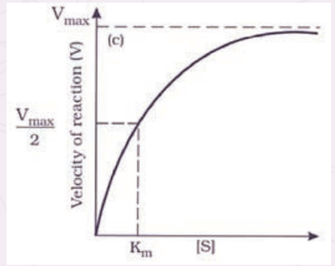
1) Temperature & pH

- Enzyme show its highest activity at an optimum temp. & pH.
- Activity declines both Below (enzyme get inactive) & above (enzyme get destroyed) the optimum value.



2) Concentration of substrate

- On increasing conc. first rate increases & then attain a V_{max} because enzyme molecule are fewer and there are no other free molecules.
- There occurs the saturation of enzyme molecules.



3)

- Some chemicals resemble with substrate & get attached to enzyme which shut off enzyme activity are called inhibitors & process is called inhibition
- More specifically the chemical is called as competitive inhibitor.

- E.g.-inhibition of succinic acid dehydrogenase by malonate which closely resemble the substrate succinate in structure.

CO-FACTOR

There are no. of cases in which non-protein constituents called cofactors are bound to the enzyme to make enzyme Catalytically active. The rest protein part of enzyme is called as apoenzyme.

COFACTOR CAN BE OF THREE TYPES

1) PROSTHETIC GROUP

i) Organic compounds
ii) Tightly bound to apoenzyme

E.g.- in peroxidase, catalase haem is prosthetic group which is part of the active site.It makes water from hydrogen peroxide.

2) CO-ENZYMES

i) Also organic compounds
ii) Essential components - vitamin
iii) Their association with apoenzyme is only transient, usually occurring during the course of catalysis.

E.g.- coenzyme nicotinamide adenine Dinucleotide (NAD) \& NADP contain vitamin niacin.

3) METAL IONS

i) Form coordination bonds with side chains at the active site and at the same time one or more coordination bond with the substrate.

E.g.-Zinc is a cofactor for proteolytic enzyme carboxypeptidase.

CLASSIFICATION & NOMENCLATURE OF ENZYMES :

Enzymes are divided into 6 classes each with 4 - 13 Sub-classes & named accordingly by a 4 digit no.
Enzymes have suffix of 'ase'

1) Oxidoreductases/dehydrogenases-
Catalyse oxidation b/w 2 substrates.
E.g.- **s reduced + s' oxidised → s oxidised + s' reduced**

2) Transferases- catalyse transfer of a group, g (other than h) b/w a pair of substrate.
E.g.- S-Ⓟ + ADP⟶S + ATP

3) Hydrolased- catalyse hydrolysis of ester, ether, peptide, glycosidic, C-C, C-Halide or P-N bonds.

4) Lysases- catalyse removal of groups from Substrate by mechanism other than hydrolysis Leaving a bond.

5) Isomerases- catalyse interconversion of optical, geometrical or positional isomers.

6) Ligases- catalyse linking together of 2 compounds,
E.g.- joining of C – O, C – S, C – N, P – O bonds.

Catalytic activity is lost when the cofactors is removed from the enzyme which testifies that they play crucial role in the catalytic activity of enzyme.