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

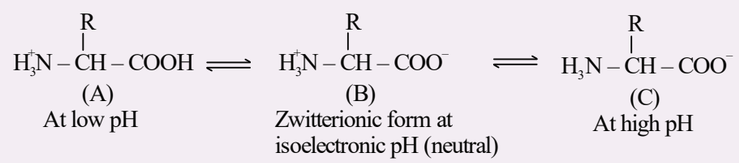
A - AMINO ACIDS

- 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



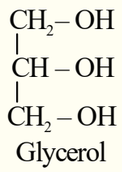
LIPIDS (Water insoluble)

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

FATTY ACID

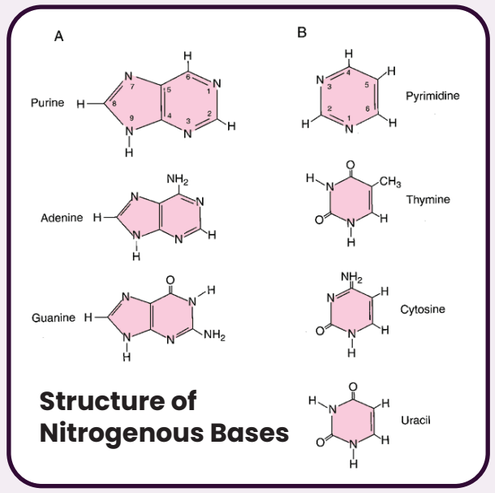
(Carboxyl group attached to R) where R can be (C1 - C19). Eg- palmitic acid (16C including -COOH), Arachidonic acid (20C including COOH). They can be saturated or unsaturated. $CH_3–(CH_2)_{14}$ – COOH Fatty acid (Palmitic acid)

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).



Structure of Nitrogenous Bases

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.

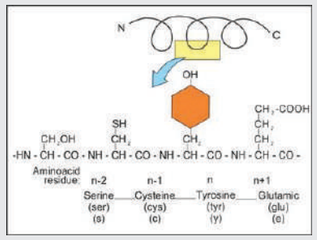
PROTEINS

Introduction

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

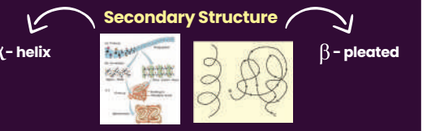
They are heteropolymers of amino acids(20) eg. alanine,glycine,proline, tryptophan, lysine.

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

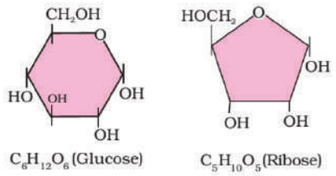
Transport nutrients across membrane, fighting with infectious organisms, hormones, enzymes.
Collagen is most abundant protein in animal world & RubisCO is most abundant protein in biosphere.

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)

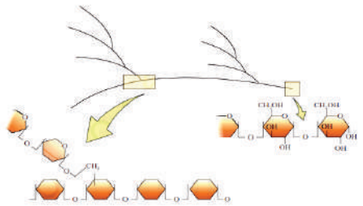
Variant — Polymers or α-D-Glucose

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.

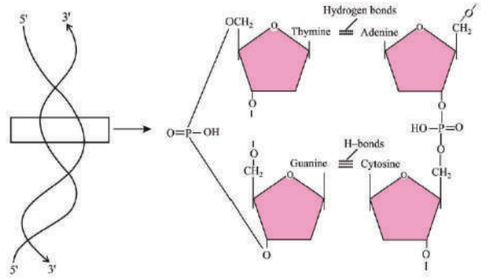


Fig.: Diagram indicating secondary structure of DNA

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.**

Breathing and Exchange of Gases

Process of exchange of O_2 from the atmosphere with CO_2 produced by the cells is called breathing/respiration (physical, chemical & biological process).

Respiratory Organs

- Lower invertebrates like sponges, coelenterates, flatworms exchange gases via their entire body surface.
- Earthworms use their moist cuticle & insects have a network of tubes (tracheal tubes) to transport atmospheric air within the body.
- Aquatic arthropods (prawns/crustaceans) and molluscs use vascularized structures called gills (branchial respiration).
- Vascularised bags called lungs (pulmonary respiration) are use by terrestial forms.
- Among vertebrates fishes use gills, amphibia, reptilia, birds, mammals use lungs. Frogs can respire through their skin (cutaneous respiration).

Human Respiratory System

External nostrils→nasal passage→nasal chamber→pharynx (nasopharynx) →lysngopharynx→ larynx region in trachea→trachea divides at 5th vertebra (thoracic) into right & left primary bronchi →secondary & tertiary bronchi & bronchioles →terminal bronchioles (thin)→ irregular walled vascularised bag like structure called alveoli (the branching network of bronchi, bronchioles & alveoli comprise the lungs)

- Larynx is a cartilaginous box helps in sound production\& hence called the sound box.
- Trachea, primary, secondary, tertiary bronchi and initial bronchioles are supported by incomplete cartilaginous rings.
- We have 2 lungs, surounded by double layered wall called as pleural membrane with pleural fluid filled between them. It reduces friction on the lung surface the outer pleural membrane is in contact with the thoracic lining whereas the inner layer is in contact with the lung surface.

Respiratory System

CONDUCTING PART

(External nostrils to terminal bronchioles)

- Conducts atmospheric air to alveoli
- clears foreign particles
- humidifies air
- brings air to body temperature

RESPIRATORY/EXCHANGE PART

(Alveoli & their ducts)

- site of actual diffusion of O_2 & CO_2 b/w blood & atmospheric air.

- Lungs are situated in the thoracic chamber which is an anatomically air tight chamber.
- Any change in the volume of the thoracic cavity will be reflected in lung (pulmonary) cavity. It is very important as we cannot directly alter the pulmonary volume.

Steps of Respiration

- Breathing (intake of O_2 & exhalation of CO_2)
- Diffusion of gases across alveolar membrane
- Transport of gases by the blood
- Diffusion of gases b/w blood & tissues.
- Utilisation of O_2 by cells in deriving energy and of CO_2 (cellular respiration)

Mechanism of Breathing

Pressure gradient b/w lungs & atmosphere

Inspiration

- Atmospheric air is moved in
- There is a negative pressure in the lungs with respect to atmospheric pressure.
- Diaphragm contracts (increases volume of anterio posterior axis)
- External intercostal muscles contract & ribs/ sternum moves upwards which increases volume of the thoracic chamber in the dorso-ventral axis.
- Intrapulmonary pressure is decreased.

We have ability to increase the strength of breathing with the help of additional muscles in abdomen. Healthy man breaths 12-16 times per minute. The volume of air involved in breathing movements can be estimated by using spirometer helps in clinical assessment of pulmonary functions.

Expiration

- Alveolar air is released out.
- Intrapulmonary pressure is higher than the atmospheric pressure.
- Relaxation of diaphragm and the intercostal muscle return to their original position & reduce the thoracic volume.
- Intrapulmonary pressure is increased
- Causes expulsion of air from the lungs.

Respiratory Volumes & Capacities

Tidal Volume(TV)

Volume of air inspired or expired during a normal respiration. It is approx 500 ml. i.e. healthy man can inspire or expire approximately 6000 to 8000 ml per minute.

Inspiratory Reserve Volume (IRV)

Additional volume of air, a person can inspire by a forcible inspiration. This averages 2500 ml to 3000 ml.

Expiratory Reserve Volume (ERV)

Additional volume of air a person can expire forcefully. This averages 1000 ml to 1100 ml.

Residual Volume (RV)

Volume of air remaining in lungs even after forceful expiration. This averages 1100 to 1200 ml.

Inspiratory Capacity (IC)

Total volume of air a person can inspire after a normal expiration. Sum of tidal volume and inspiratory reserve volume (TV+IRV).

Expiratory Capacity (EC)

Total volume of air a person can inspire after a normal expiration. Sum of tidal volume and inspiratory reserve volume (TV+IRV).

Functional Residual Capacity (FRC)	Vital Capacity (VC)	Total Lung Capacity
Volume of air that will remain in lungs after a normal expiration. This includes ERV+RV. FRC = ERV+RV	Maximum volume of air a person can breath in or out after a forced expiration/inhalation. Includes ERV+TV+IRV. VC = ERV+TV+IRV	Total volume of air accomodated in the lungs at the end of a forced inspiration. Includes RV, ERV TV, IRV or VC+RV TLC = RV+TV+ERV+TV+IRV OR TLC = VC+RV

Exchange of Gases

It is based on pressure and concentration gradient.

Factors Responsible

Solubility of gases, thickness of membrane.

Pressure contributed by an individual gas in a mixture of gases is known as partial pressure and is denoted as pO_2 & pCO_2 for O_2 & CO_2 respectively.

As the solubility of CO_2 is 20-25 times higher than that of O_2, the amount of CO_2 that can diffuse through the diffusion membrane per unit difference in partial pressure is much higher compared to that of O_2.

Diffusion membrane is made of 3 Layers

- Thin squamous epithelium of alveoli
- Endothelium of alveolar capillaries
- Basement substance b/w them
- Its total thickness is less than 1 mm. Hence every condition is favourable for respiration in our body.