ST. LAWRENCE HIGH SCHOOL

A JESUIT CHRISTIAN MINORITY INSTITUTION

STUDY MATERIAL -1

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Topic - BIOMOLECULES

BIOMOLECULES

INTRODUCTION

All living organisms are made of different organic compounds that are again formed of various inorganic elements like carbon, hydrogen, oxygen, nitrogen etc. All the carbon compounds that are obtained from living tissues are called 'biomolecules'. There are two types-

(i) Micromolecules
(ii) Macromolecules

SMALLER MOLECULES (MICROMOLECULES)

A small molecule of low molecular weight (less than 900 Dalton), organic compound, soluble in acid. (Dalton is the unit of molecular weight of biomolecules, which signifies weight of 1 atom of hydrogen.

A) SIMPLE SUGARS

Simple sugars are the simplest form of carbohydrates that act as primary source of energy in the human body e.g. monosaccharides). Monosaccharide contain only one unit of simple sugar e.g. Glucose, fructose, galactose etc. *Fructose is the sweetest natural sugar*.

Major role in life process

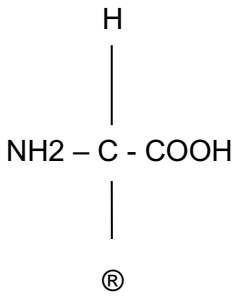
- **Glycolysis** - Glucose undergoes glycolysis to produce pyruvic acid in cell cytoplasm.
- **Storage** – Excess of glucose may be converted into starch in plants and glycogen in animals.
- **Maintenance of blood sugar** - Normally 100 ml human blood contains 80-120 mg glucose. Increase of this glucose level results into hyperglycemia (Diabetes mellitus) whereas decrease of glucose level is called hypoglycemia.
- **Synthesis of fats, proteins** - By various metabolic reactions in liver excess glucose may be converted to fatty acid, glycerol, amino acids etc.

B) AMINO ACIDS

Amino acid is the structural and functional unit (building block) of protein.

Basic Structural features

Amino acid contains at least one central carbon (alpha) which is bound to a free amino group (- NH_2), a carboxyl group (-COOH), one hydrogen (- H) and a side chain (R) which is different in each amino acid. Besides ®, all other three positions are fixed.



In nature there are 20 types of amino acids. However, the basic classification is as follows :-

- Essential amino acid – Ten amino acids that are not synthesized in human body and are taken along with diet e.g. Valine, Histidine, methionine, Phenylalanine, leucine, Isoleucine, Tryptophan, Lysine, Alanine and threonine
- Non essential amino acid – remaining 12 amino acids are synthesized in liver of human body e.g. Glycine, Alanine, Serine, Cystine etc. **Glycine is the simplest amino acid**.

C) FATTY ACIDS

Fatty acid is the essential component of fat and structural unit of fats.

Basic structural features :

- Fatty acid has a carboxyl group (-COOH) attached to it.
- It is insoluble in water but soluble in fat solvents like chloroform, ether, alcohol etc.

Types of fatty acids

- Saturated fatty acid –Fatty acids that consists of single bonds among the adjacent carbon atoms..e.g. stearic acid, palmitic acid etc.
- Unsaturated fatty acid-Consists of two or more double or triple bonds among adjacent carbon atoms. e.g. Oleic acid, Crotonic acid.

- Essential fatty acid – Those fatty acids which are needed for normal growth but are not synthesized in the body- so they are taken along with diet. e.g. Linoleic acid, Linolenic acid and Arachidonic acid.
- Non essential fatty acids- Those acids which are synthesized in our bodies and we do not need to take them in our diet. E.g. lauric acid, stearic acid etc.

D) NUCLEOTIDES

Nucleotide is the structural unit of nucleic acid (DNA and RNA). Deoxyribonucleotide is the structural unit of DNA and ribonucleotide is the structural unit of RNA.

Basic structural features

- One nucleotide consists of pentose sugar (5-C-sugar), Nitrogenous base (N-Base) and phosphoric acid (H_3PO_4).Each nucleotide is linked to another nucleotide by a **phosphodiester bond**
- N-Base can be of – Purine [Adenine (A) and Guanine (G)] and Pyrimidine [Thymine (T), Cytosine (C) and Uracil (U)].
- A, T, G and C are present in DNA whereas A, U, G and C are present in RNA.
- **Nucleoside** consists of pentose sugar and nitrogenous base without H_3PO_4..A nucleoside binds up with phosphoric acid to form **nucleotide.**

Role in life processes :
DNA and RNA function as genetic material and they consist of nucleotides only.

HOW CAN YOU EXPLAIN THE TERM 'GENETIC MATERIAL' ?
ATP (Adenosine Tri Phosphate) - **It is a nucleoside triphosphate used in cells**. It is often called the "molecular unit of currency" or "energy currency" of intracellular energy transfer. ATP provides chemical energy within cells for various metabolic reactions. It is one of the end products of photophosphorylation, cellular respiration, fermentation.

MACROMOLECULES –(Larger organic molecules)

Those organic compounds that are acid insoluble, having molecular weight more than 900 Dalton (except lipid) are called macromolecules. They are complex carbohydrates (oligo-and polysaccharide), protein, lipids and nucleic acids.

A) Complex Carbohydrates

Complex carbohydrates are oligosaccharides (disaccharides, trisaccharides etc) and polysaccharides. Polysaccharides are formed of two or more monosaccharide units.Each unit is called a monomer.The polysaccharasides may be consisting of only one type monomers or two different types of monomers.The monomers are linked to each other by **Glycosidic bond**

Simpler Complex carbohydrates (Oligosaccharide) : It consists of :

Disaccharides : They are formed by the combination of two monosaccharide units with the elimination of one molecule water. E.g. Sucrose, Maltose
Trisaccharides : These consists of three sugar units. Eg.- Raffinose
Tetrasaccharides: These consists of four sugar units.e.g. Stachyose

More Complex Carbohydrates (Polysaccharide) : Polysaccharides are polymer of large number of monosaccharide units (monomer).

Some common polysaccharides :

- **Starch** – Polymer of glucose, produced by plants; insoluble in cold ; gives blue colour with iodine; tasteless.
- **Glycogen** – Found in animals and in fungus, known as 'animal starch' soluble in water, gives reddish colour with iodine.
- **Cellulose** – Found in plants; Insoluble in water; taken in body along with vegetable; can not be digested in human body;

Roll in process :

- Starch is the main constituent of food grains.
- Glycogen (animal starch) is generally stored in liver and muscle as food reserve.
- Cellulose forms 'roughage', stimulates peristalsis and helps in defaecation.

B) PROTEIN

Protein is the polymer of amino acids that are interlinked by **peptide bonds (-CO-NH-)**.

Role in life process :

- **Body building food** – Protein is the chief organic constituent of protoplasm of a living cell. So it is called as body building food.
- **Maintenance of body** – Protein helps to maintain body structure, body growth, repair of damaged tissues due to wear and tear, storage of proteins etc.
- **Synthetic function** – It helps in synthesis of plasma proteins (albumin, globulin, prothrombin, fibrinogen etc.), haemoglobin, enzymes, most animal hormones, milk protein (lactalbumin, lactoglobulin) antibodies (Immunoglobulin), melanin pigments etc.
- **Enzyme** : Enzymes are biological catalyst, protein in nature, produced by the living cells, aculerate various biochemical reaction, but itself remains undestroyed after reaction.

C) LIPID AND FAT

Fat is the ester of fatty acid and glycerol. The salt of alcohol (glycerol) with organic acid (fatty acid) is known as ester. Lipid is a broad term which includes fat, wax, cholesterol, hydrocarbon since all of them are insoluble in water but soluble in organic solvents. **Hence all fats are lipids but all lipids are not fats**.

Basic structural / compositional features :

- They are insoluble in water but soluble in ether, chloroform etc.
- At ordinary temperature, some fats remain solid (e.g. lard) whereas others in liquid form.
- **Unsaturated fats**: Those fats which remain liquid at ordinary temperature are called oils. Some common plant oils are mustard oil, groundnut oil, coconut oil, soyabean oil, sunflower oil etc. Some oils from animals like cod-liver oil, shark-liver oil, etc. are rich sources of vitamin A and D.
- **Saturated fats –** Those fats which remain solid at room temperature.E.g. Butter ,Ghee etc

Source

- **Plant Source** – Mustard oil, coconut oil, groundnut oil etc.
- **Animal source**- Meat, milk and milk products like ghee, butter, cheese etc.

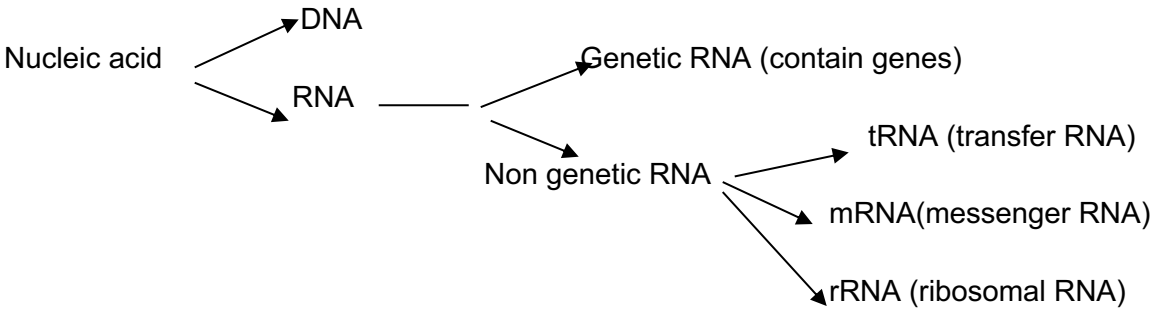
Role in life process

- **Caloric value** : Lipid provides a food with high calorific value. One gram lipid produces about 9.3 Kcal energy.
- **Storage** : Lipid acts as reserve food material because it can be easily stored in the body for future use.
- **Heat Insulations** : Lipid acts as Insulator. Thus subcutaneous fat helps to regulate body temperature (thermoregulation).

D) NUCLEIC ACIDS

Nucleic acid is the polymer of nucleotides (polynucleotide). They are distributed in nucleus and cytoplasm of a cell.

Basic Structural features :



DNA (DEOXYRIBO NUCLEIC ACID)

- It is usually double stranded or double helical.
- There are two complementary chains.
- Two chains of polynucleotides are antiparallel.
- Structural unit of DNA is called deoxyribonucleotide which consists of pentose (deoxyribose) sugar, H_3PO_4 and N-Base.
- N-Base can be of two types – purine and pyrimidine.
- Purine of DNA is again of two types – Adenine (A) and Guanine (G) whereas pyrimidine is agin of two types – Thymine (T) and Cytosine (C)

RNA (RIBO NUCLEIC ACID)

- It is generally single stranded or single helical.
- Structural unit of RNA is ribonucleotide which consists of pentose sugar (ribose), H_3PO_4 and N-Base.
- N-Base can be of two types – Purine and Pyrimidine.
- Purine in RNA is of two types – Adenine (A) and Guanine (G) whereas pyrimidine is again of two types – Uracil (U) and Cytosine (C)

Role in life process

DNA

- It contains genes and is responsible for inheritance of characteristics from parents to offsprings.
- It is responsible for all characteristics of an organism.

RNA

- RNA contains genes – so RNA is the genetic material in certain viruses
- mRNA (Messenger RNA) carries information from DNA and helps in protein synthesis.
- tRNA (Transfer RNA) collects amino acids from cell cytoplasm for protein synthesis.
- rRNA (Ribosomal RNA) is the structural component of ribosome and helps in protein synthesis.

Difference between DNA and RNA

DNA	**RNA**
(i) It is deoxyribonucleic acid	(i) It is ribonucleic acid.
(ii) Pentose sugar is deoxyribose sugar.	(ii) Pentose sugar is ribose sugar.
(iii) Nitrogen base is thymine (T).	(iii) Nitrogen base is uracil (U).
(iv) Double stranded or double helical structure.	(iv) Single stranded or single helical structure.
(v) Carries genetic information and responsible for inheritance from parents to offsprings.	(v) Takes part in protein synthesis.

ROLE OF ATP AS ENERGY CURRENCY OF A CELL

ATP (Adenosine Tri Phosphate) is the primary molecule for storing and transferring energy in cells. It is often referred to as “energy currency of the cell” and may be compared to storing money (ATP) in a bank (Cell). In any energy related biochemical reaction of the cell, ATP is either produced or consumed. For example, during photosynthesis, ATP is synthesized (photophosphorylation) by using solar energy whereas during respiration, ATP is synthesized through glycolysis, krebs cycle and ETC. The production of ATP in ETC (Electron transport chain) is known as oxidative phosphorylation.

ATP is a nucleotide consisting of a N-Base [Adenine (A)], attached to a ribose pentose sugar (5-C-sugar), which is attached to three phosphate groups, that are linked to one another by two high-energy bonds.

VITAMINS AND THEIR ROLES IN HUMAN BODY

The word vitamin was suggested in 1912 by Casimir Funk. He isolated a concentrate from rice polishing which was found to contain nitrogenous bases (amines). As these substances were vital for sustaining life, they were called vitamins.

- Vitamins are organic compounds present in variable minute quantities in natural food stuff which are required for the normal growth as well as maintenance of health and life.
- Importance (Functions) of vitamins : Vitamins are needed to resist diseases, as they act protective principles of food.
- General characteristics of Vitamins :
  - (i) Vitamins are obtained from plant products and animal products.
  - (ii) Daily requirement of vitamin is very low.
  - (iii) Little amount of fat soluble vitamins may be stored in liver and that of vitamin C in adrenal cortex.
  - (iv) Vitamins are destroyed after reaction hence it must be supplied to the body regularly.
  - (v) Some of the vitamins are heat stable (eg. Vitamin A, D, E, K, B_2 etc) but some of the vitamins are heat labile (e.g. vitamin B_1, B_3, vitamin C etc).
  - (vi) Some vitamins are fat soluble (Vit A,D,E,and K) while others are water soluble (Vit B-Complex and C)

Name of the vitamin. A. Water soluble vitamins	Source		Roles (Functions) in human body	Deficiency disease and symptoms
	Plant source	Animal source		
(i) **Vitamin B-complex** : The vitamin B – complex comprises about a dozen of chemical substances e.g., **Thiamine** (Vit B_1), **Riboflavin** (Vit B_2), **Niacin** or **Nicotinic acid** (B_3) **Pantothenic acid** (Vit B_5), **Pyridoxine** (Vit B_6), **Cyanocobalamin** (Vit B_{12}), **Nicotinic acid**, **Folic acid**, **Biotin**, **Choline**, **Inositol**, etc.	Unpolished husk containing rice, whole flour, germinating seed, green vegetables, beets, beans, carrots, lettuce, etc.	Milk, egg, fish, meat, etc. .	(i) Different types of vitamin B-complex act as the co-enzymes of several enzymes. (ii) Help in carbohydrate, fat and protein metabolism. (iii) Essential for growth. (iv) Stimulate central nervous system. (v) Essential for the formation and maturation of red blood cells.	Absence or deficiency of vitamin B-complex causes various diseases, such as – Dermatitis (skin disease), Cheilosis, Beriberi (disease of nervous system), anaemia, etc.

Name of the vitamin. A. Water soluble vitamins	Source		Roles (Functions) in human body	Deficiency disease and symptoms
	Plant source	Animal source		
(ii) Common name – **Vitamin C** Chemical name – **Ascorbic acid** Clinical name – **Antiscorbutic factor** Vitamin that contains cobalt is Vit B_{12}	Citrus fruit like orange, lemon, tomato,Papaya, pineapple, green chilli, bean, cauliflower, cabbage, lettuce, spinach, etc.	Generally, meat and fish contain little vitamin	(i) Vitamin C regulates oxidation and reduction processes inside the cell. (ii) It is related to carbohydrate metabolism. (iii) It is essential for the healthy maintenance for connective tissue. (iv) It plays an important role in wound repair. (v) It takes part in maturation of red blood cells. (vi) Essential for nourishment of nerve cells.	(i) **Scurvy** – This symptom is characterized by spongy and bleeding gums, bleeding under skin and extreme weakness. (ii) **Susceptibility** to various diseases. (iii) **Anaemia** – The number of red cells and platelets in blood are reduced. (iv) **Healing** of wounds impaired (v) Increased brittleness of bone leading to fracture. (vi) Reproductive failure. (vii) Lack of resistance to infection, etc. **Vitamin C has molecular formula $C_6H_8O_6$. Vitamin C is synthesized from glucose through different enzymatic steps. Most animals can synthesize Vitamin C in liver or kidney except man, primates, guineapigs, birds etc.**.

Name of the vitamin. B. Fat soluble vitamins	**Source**		**Roles (Functions) in human body**	**Deficiency disease and symptoms**
	Plant source	**Animal source**		
(i) Vitamin A (Retinol) or Antixerophthalmic factor : Common name - **Vitamin A** Chemical name – **Retinol** Clinical name – **Antixerophthalmic** factor :	Carrots, spinach, mango, tomato, ripe papaya, etc.	Cod liver oil, halibut liver oil, milk, butter, egg, fish, etc.	(i) Vitamin A is essential for growth. (ii) Essential for night vision. (iii) Prevents infection. (iv) Maintains the integrity and activity of epithelial tissue and glands. (v) Helps in keeping normal fertility.	(i) **Growth** – Growth is retarded (ii) **Night blindness (Nyctalopia)** – The ability to see an object in dim light (night vision) is lost. (iii) **Xerophthalmia** - Redness, abnormally dry and lustereless condition of the eye-ball. (iv) **Keratinisation** – Dryness and roughness of the epithelial tissue of the skin. (v) Defective growth of bone and teeth.
(ii) Common name- **Vitamin D** Chemical name – **Calciferol** Clinical name- **Antirachitic factor** :	Negligible	Cod liver oil, halibut liver oil, milk, butter, egg. etc.	(i) Vitamin D helps in the absorption of calcium and phosphorus from the intestine and controls their metabolism. (ii) Helps in the formation of bone and thus helps in the body growth. (iii) Helps in the development of teeth.	(i) **Ricket** - Takes place in children (6 to 18 months of age). It is characterized by the deformities of the skeleton especially the limbs, spine bone and skull. (ii) **Osteomalacia** - Ricket like disease in adults. (iii) **Tetany**- A painful tonic muscular spasm in children suffering from rickets.
(iii) Common name - **Vitamin E** Chemical name- **Tocopherols** Clinical name- **Antisterilitic factor** :	Vegetable seed oils (Soyabean, wheat corn) and leafy vegetables.	Egg, milk, fish and meat.	(i) Prevents unwanted oxidation (anti-oxidant) in the body.	(i) **Sterility**- Deficiency of vitamin E causes loss of reproductive ability

Name of the vitamin. B. Fat soluble vitamins	Source		Roles (Functions) in human body	Deficiency disease and symptoms
	Plant source	Animal source		
			(ii) Involved in the maintenance of integrity of genital organs and thus prevents sterility. (iii) Essential for foetal development. (iv) Maintains normal muscular functions.	(ii) Muscular dystrophy.
(iv) Common name - **Vitamin K** Chemical name - **Phyllo-quinone** Clinical name- **Antihaemorrhagic factor** :	Alfa-alfa, cabbage, spinach, tomato, soyabean, etc.	Liver, milk, butter, etc.	(i) **Blood clotting** - It takes part in the manufacture of prothrombin (clotting protein factor of blood in plasma) in liver and helps in normal blood coagulation. (ii) Helps in oxidative phosphorylation in the mitochondria.	**Defective blood coagulation** with bleeding tendency, specially in the new born baby. What is **provitamin**? They are organic compounds from where vitamins are synthesized in animal body e.g. carotene is the provitamin of Vit A. It is interesting to know that some chemicals may destroy or inhibit the function of vitamin called as **antivitamin**. e.g.Avidin present in raw egg white prevents the action of Biotin vitamin.

MINERALS AND THEIR GENERAL ROLE IN HUMAN BODY

Various minerals are needed to maintain vital functions of our body like enzyme activity, hormonal functions etc. They are essential component for cellular biomolecules structure and function of cell and so on.

MACRO MINERALS: These minerals are required in large quantities in the body.

Role of macromineral in human body :

Name of mineral	Functions in human body
(i) Potassium (K)	Maintains membrane potential of cell. Maintains rhythmicity of heart and proper functioning of nervous system
(ii) Sodium (Na)	(i) Initiates and maintains contraction of heart. (ii) Essential for normal functions of cells. (iii) Essential for contraction of muscles. (iv) Excites nerves. (v) Maintains osmotic balance and normal functioning of blood.
(iii) Chlorine (Cl)	(i) Constituent of gastric juice. (ii) It maintains acid-base balance.
(iv) Calcium (Ca)	(i) Helps in the formation of bone and teeth. (ii) Maintains neuromuscular excitability and cardiac muscle contractility. (iii) Prevents tetany. (iv) Helps in blood clotting.
(v) Phosphorus (P)	(i) Helps in the formation of bone and teeth. (ii) Formation of phospholipids. (iii) Formation of ATP.
(vi) Magnesium (Mg)	(i) Maintains neuromuscular activity. (ii) Activator of enzymes. (iii) Maintains cholesterol level in blood.
(vii) Sulphur (S)	(i) A constituent for hair and nails. (ii) For insulin and glutathione. (iii) For the formation of cartilage, melanin and other proteins.

MICRO MINERAL – The minerals that are present at low levels in the body or required in smaller amount in the diet are known as micromineral. They are sometimes also called as essential trace minerals.

Role of micromineral in human body :

Name of mineral	**Functions in human body**
(i) Manganese (Mn)	(i) Helps in the formation of thyroxin hormone. (ii) Formations of urea. (iii) Essential for the utilization of thiamine (Vitamin B_1). (iv) In the metabolism of carbohydrate.
(ii) Copper (Cu)	(i) Helps in the metabolism and absorption of iron. (ii) Helps in normal haemoglobin and thus RBC formation. (iii) Helps in the metabolism of ascorbic acid.
(iii) Cobalt (Co)	(i) Cobalt is the component of Vit B12 which helps in the red blood cell formation.
(iv) Zinc (Zn)	(i) Zn effects the transfer of CO_2 from tissue to lungs. (ii) Constituents of digestive enzymes which helps hydrolysis of proteins.
(v) Iron (Fe)	(i) Helps in the formation of haemoglobin (in blood), myoglobin (in muscle). (ii) Formation of enzymes involved in respiratory process.
(vi) Boron (B)	(i) Helps in transport of carbohydrates in the blood. (ii) Probably helps in growth of the body.
(vii) Iodine (I)	(i) Iodine helps to form thyroid hormones. (ii) Iodine in the form of thyroid hormone regulates BMR, body temperature, body growth, etc.
(viii) Fluorine (F)	For proper development of bone and teeth.
(ix) Molybdenum (Mo)	It helps in the conservation of uric acid.

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