S.5 BIOLOGY NOTES

Chemicals of life – continuation

ACID, BASES AND PH

An acid is a compound which liberates hydrogen ions when dissociated in water; e.g. HCl.

$HCl_{(aq)} \longrightarrow H^{+}_{(aq)} + Cl^{-}_{(aq)}$

In a given volume of water, a small but definite proportion of water molecules dissociate to form ions. This occurs when hydrogen atom from one water molecule is transferred to the next (oxygen atom of the next one). The reaction yields hydroxyl ions and hydroxonium ions.

$H_2O(l) + H_2O(l) \longrightarrow H_3O^{+}_{(aq)} + OH^{-}_{(aq)}$

Each hydroxonium ion can be thought of as hydrogen ion and a water molecule combined as a single unit. The hydrogen ions in water are always present in a combined form and do not exist separately. For simplicity the equation for the ionization of water is written as:

$H_2O(l) \rightleftharpoons H^{+}(aq) + OH^{-}(aq)$

Pure water contains exactly an equal number of hydrogen ions and hydroxyl ions, in addition to many undissociated water molecules. However, substances dissolved in water often affect the balance of hydrogen and hydroxyl ions; e.g. an acidic substance increases the number of hydrogen ions in solution while the base combines with hydrogen ions and in effect removes them from solution. The effect on hydrogen ions and hydroxyl ions balance in solution affects the P^H. The strength of an acid depends on the extent of dissociation. The acidity of an acid is expressed as its P^H; i.e. $P^H = -Log_{10} [H^+]$.

P^H values practically range from 1 to 14. At 25^0C, pure water has a P^H of 7 called neutral P^H. Acid solutions have P^H less than 7 while alkaline solutions have P^H greater than 7.

BASES:

A base is a compound which can combine with hydrogen ions liberated by acid dissociation.

$H+ (aq) + HCO_3^- (aq) \longrightarrow H_2CO_3 (aq)$

Bases that dissolve in water are called alkalis. These molecules are proton acceptors, removing protons from aqueous solutions and so increasing the P^H. The basic solutions therefore have a higher concentration of hydroxyl ions.

Certain solutions called P^H buffers, result into changes in P^H so that the P^H of the solution remains constant. E.g. hydrogen carbonate ions can combine with either hydrogen ions or hydroxyl ions.

$H+ (aq) + HCO_3^- (aq) \rightleftharpoons H_2CO_3 (aq)$

$\overline{O}H (aq) + HCO_3^- (aq) \rightleftharpoons H_2O(l) + CO_3^{2-} (aq)$

In this way, hydrogen ions and hydroxyl ions added to a solution containing hydrogen carbonate ions are absorbed and do not affects the overall P^H level.

Other buffers of P^H in living systems include phosphate ions, dihydrogen phosphate ions, amino acids and proteins.

Equation

This is important for two reasons:

(i) It eliminates accumulation of hydrogen ions which increase acidity and kills the cells.

(ii) Cells and tissues function properly around the neutral P^H and cannot tolerate fluctuations of P^H of more than a unit or two. Besides the P^H of the fluid must be kept constant.

SALTS:

Salts are normally found in the body and dissolve in water. They are mainly mineral salts, consisting of compounds of metals with nonmetals or nonmetal radicals. E.g. Sodium chloride dissolves in water according to the following equation:

Equation

Although sodium ions and chloride ions are the most common ions, other ions found in the body are magnesium ions, calcium ions, copper (II) ions, iron (II) ions, iron (III) ions and anions like sulphate, nitrate, carbonate, iodide ions, phosphate ions, etc.

General functions of mineral elements:

a. They are constituents of various chemicals. E.g. Nitrogen and sulphur are part of proteins, calcium is part of plant cell wall, like calcium pecpate and phosphorous is part of ATP.
b. They are constituents of structures. E.g. Nitrogen and sulphur make proteins, phosphorus is part of phospholipids; which is part of plasma membrane.
c. They are constituents of enzymes. Enzymes are protein and contain nitrogen. Also some enzymes contain metal ions such as copper and iron. Iron (II) ion is found in enzyme catalase and serves as the catalytic centre of the enzyme.
d. They are constituents of certain biological pigments of importance. Iron (II) ion is found in hemoglobin which transports oxygen in mammalian blood circulatory system. Magnesium ion is a constituent of chlorophyll which traps radiant energy during photosynthesis. Iron is a constituent of cytochrome which is an important pigment in energy release during respiration.
e. They serve as determinants of anion-cation balance in cells. Sodium, potassium and chloride ions determine anion-cation balance in nerve cells, muscles and sensory cells where they are involved in impulse transmission.
f. They serve metabolic activators. Certain ions that come from mineral salts activate other ions. E.g. Magnesium activates enzymes in phosphate metabolism. Phosphorous in form of phosphate is required for the activation of sugar molecule before it is broken down in cell respiration.
g. They determine the osmotic pressure of cells and body fluids. Mineral salts together with other solutes determine the osmotic pressure of body fluids.

MINERAL SALTS REQUIREMENTS OF PLANTS:

The carbohydrate made during photosynthesis is a starting point for the manufacture and formation of chemical compounds that occur in plants. This leads to production of a wide range of substances like proteins, nucleic acids and productions of these substances need a source that supplies elements like nitrogen, sulphur and phosphorous. These elements come from mineral salts absorbed by plants from soil water and are divided into two groups:

(a) Macro nutrients/ minerals: these are elements that are needed in large amounts in the body.
(b) Micro nutrients/ minerals: which are needed in small amounts in the body.

MACRO NUTRIENTS

Element	Form in which it is absorbed	Function in plants	Effect of deficiency
Nitrogen N	Nitrate and ammonium ions	-Synthesis of amino acids, proteins and chlorophyll. -Is a constituent of hormones like auxin, vitamins and co-enzymes	-Stunted growth. -Small and under development of plants with yellow leaves a condition called chlorosis
Phosphorus P	Phosphate and orthophosphate/dihydrogenphosphate	-formation of nucleic acids ATP,ADP and some protein used in phosphorylation -component of cell membrane in the form of phospholipids -Activates enzymes.	Stunted growth with poorly developed roots. Plant develop leaves with dull dark green leaves.
Magnessium Mg	Magnessium ion.	Formation of chlorophyll.-activates enzymes in phosphate metabolism.	-chlorosis ie yellowing of leaves.
Calcium Ca	Calcium ion	-formation of cell wall in the form of calcium pectate. -Activation of certain enzyme. -Needed for the development of roots and stem apices.-Needed for selective permeability of cell membrane. Needed for translocation of carbohydrates and amino acids.	-stunted growth.-Death of growing points in shoot and root systems
Iron Fe	-iron11 -Iron111	-Synthesis of chlorophyll-Activates catalase. -Synthesis of ferredoxin cytochrome that is involved in the electrone carrier system in the light reaction of photosynthesis	Chlorosis of leaves with veins remaining green

Potassium K	Potassium ion	-synthesis of amino acids and proteins. Activates enzymes in photosynthesis and respiration-Constituent of sap vacuoles that allows osmotic uptake of water by cells,there by making them turgid. -Needed for active transport across cell membrane. Needed incellmembrane formation	Yellowing of leaves at margines.-Premature death of plants.
Sulphur	Sulphate ion	-Synthesis of amino acids and proteinsComponent of co-enzymes like acetyl co-enzymeA.	-yellowing of buds and new leaves. -Poor root development..
Sodium	Sodium ion	Maintains osmotic and anion-cation balance across membranes. Is aconstituent of sapvacuole which maintains turgidity in plant cells	
Chlorine	Chloride ion	Involved in the light stage of photosynthesis. Maintains anion-cation balance in cells.	

MICRONUTRIENTS/MINERALS

Element	Form in which it is absorbed	Function in plants	Effects of deficiency
Boron B	Borate ions and tetraborate ion	Needed for the uptake of calcium ions by roots. -Needed for mitotic cell division in meristems of shoot tip	-Death of young shoot and abnormal growth. -Browning of shoots.
Copper Cu	Copper11	-constituent of enzymes cytochrome oxidase and tyrosinase.	Yellowing of shoots die back at an early stage in citrus and other

		-component of respiratory pigment haemocyanin. -Needed in certain pathways in respiration and photosynthesis.	trees. -Inhibition of photosynthesis and respiration
Manganese Mn	Manganese11 ion	Activates carboxylases	Greying of leaves. Shoots die-back.
Molybdenum	………………	Needed for the reduction of nitrates to nitrites in the formation of amino acids Needed for nitrogen fixation by prokaryotes	Growth retardation leading to reduced crop yields.
Silicon	……………..	Cell wall formation in grasses	Stunted growth. E.g. Cereal straws.
Aluminum	……………	Needed for cell division	Absence causes upset in cell division.
Zinc	Zinc ion	- Activates carboxylases. - Needed for auxin production	-Small leaves and stunted stems.

Note

- Soil needs potassium after heavy nitrogen manuring(addition of manure containing nitrogen).

- Nitrogen is frequently deficient in heavily used soil, so there is need for an external supply of it from nitrogen fertilizers like NPK

- Little amount of calcium is present in acidic soils and is needed for aeration of clay soils.

- Phosphorus is frequently deficient in alkaline soils or little amount of it is usually present in soil with ph greater than 7.

- Magnesium is deficient in acid soils.

- Iron is usually not available in clay soils.

- Zinc is often deficient in acid soils.

- Boron is easily washed away by heavy rains**.**

NINERAL REQUIREMENT FOR ANIMALS

Mineral elements are inorganic food constituents required in small quantities, but lack of them affects the normal functioning of the body leading to deficiency diseases. These elements are classified into essential and non-essential elements.

Essential elements are those needed in greater quantities in the body. They are also referred to as macro-elements or major elements.

Non-essential elements are those needed in minute/small quantities in the body they are also called micro elements or minor elements.

table showing mineral salt requirements by animals and effect of their deficiency.

Mineral element	**Food source**	**Importance or function**	**Effect of deficiency**
Nitrogen	protein food lean meat fish milk eggs.	-synthesis of proteins, nucleic acids amino acids. synthesis of insulin hormone -constituent of vitamins and chlorophyll. Formation of muscle, hair, skin and nails. Constituent of pophyrins.	-kwashiorkor -stunted growth. -oedema (swelling of limbs).
Suphur	-lean meat, fish, milk, eggs and other protein foods	-component of proteins and co-enzymes like acetyco-enzymes. -gives protein tertiary structure by forming sulphur bridges between polypeptide chains. -needed for cellular respiration and during detoxification.	non has been described in animals.

Phosphorus P	-protein foods, lean meat fish eggs milk, poultry nuts, bakery products, soft drinks and dairy products	-synthesis of proteins and other complex compounds like ATP, ADP and nucleic acids. -formation of bones, teeth. -constituent of cell membranes. Component of intracellular fluids important in acid-base balance. -component of enzymes.	-rickets (bone malformation). -general weakness. loss of calcium ions Poor bone mineralization due to loss of calcium ions.
Fluorine	added into drinking water	-constituent of bones and teeth. -prevents dental carries.	-weak teeth develop in children since it associates with calcium forming calcium fluoride which strengthens teeth and prevents teeth decay. -bleeding gums and tooth decay.
Calcium Ca	-milk cheese, greens, vegetable, fish, bread, eggs, fortified orange juice, cholate.	-formation of bones, shells and their hardening. -needed for muscle contraction and blood clotting. Needed for permeability of cell membrane during nerve impulse transmission. Needed for stability of cell membranes. -cellular metabolism. Cofactors for some enzymes.	-brittle bones and teeth. -rickets and delayed muscle contraction. -delay in blood clotting. -muscular spasm (a sharp pain in the muscle or muscle crump).
Iron Fe	Liver, green vegetables, eggs, kidneys, milk, g.nuts, cocoa, beans, fish, and cheese.	Component of haemoglobin and cytochrome molecules. -constituent of certain enzymes like dehydrogenase, decarboxylase, peroxidase and catalase. -forms part of haem group in respiratory pigments such as haemoeryth ring, myoglobin and chlorocrurim.	-reduced red blood cell count resulting into anemia.
Iodine	-sea fish, cheese, iodized	-formation of thyroxin hormone in the thyroid gland.	-goitre. reduced growth

	salts and other sea foods and most vegetables grown near seas.	-control of metabolism.	
Sodium Na	Table salt, green vegetable, cheese, fatty fish, yoghurt, roasted beef, fresh peas, frozen peas.	Needed for maintaining the electrical osmotic and cation-anion balance across cell membranes. Needed for active transport of some materials across cell membranes. -required for the activity of excitable tissues. Needed for the functioning of kidneys, nerves and muscles.	-muscle cramps i.e. sharp pain in muscles.
Iodine I	-sea fish, cheese, iodized salt and other sea foods, seaweeds and most vegetables grown near seas.	-formation of thyroxin hormone in the thyroid gland. -control of metabolism.	Goitre. -reduced growth.
Chlorine Cl	-table salt, seaweeds, olives vegetables lettuce and chlorinated water.	-maintenance of tissue fluids, blood and lymph. Needed for the formation of HCl in gastric juice. -facilitates transport of carbon dioxide of blood during chloride shift.	-muscle cramps.
Potassium K	-vegetables, yellow bananas, fresh fruits, milk beans potatoes, tomatoes and orange juice.	-required for the activity of excitable tissues. -maintains the electrical osmotic and anion-cation balance across cell membranes. -needed in nerve impulse transmission. -needed for active transport of certain materials across cell membranes. -needed for protein synthesis and respiration.	-confusion. -loss of appetite. -constipation-muscle crump -increased urinary calcium excretion.

Zinc **Zn**	meat, eggs, sea foods, seeds of pumpkin	-regulates the use and distribution of ions like calcium and magnesium. -protein metabolism-development of sexual organs and their functions. -wound healing. -DNA synthesis. -activates enzymes e.g. carbonic anhydrase.	-growth retardation -poor sexual drive and development of sexual organs. -white spots on the nails and change in hair structure.
Copper **Cu**	green vegetables.	-constituent of some enzymes e.g. cytochrome oxidase in the electron transport system -a component of respiratory pigment of haemoglobin-essential mineral present mainly in bones.	-menkes' disease caused by failure of copper absorption
cobalt		component of vitamin B_{12} which is important in the synthesis of RNA, nucleo-proteins and red blood cells.	-not yet known clearly but it is kwon to cause pernicious anemia.
Manganese **Mn**		-an activator of certain enzymes eg phosphatases. -growth factor in bone development.	-bone deformation.
Magnesium **Mg**	-green vegetables, nuts legumes, water melons, chocolate.	an activator of some enzymes e.g. ATPase. -component of bones and teeth. -contributes to RNA and DNA when the cell is multiplying. -decrease blood pressure.	-bone malformation **NB** excess magnesium causes diarrhea, general weakness for people with kidney failure. -body weakness. -poor heart function (rapid heartbeat). -muscle cramps
Selenium	-vegetables,fish, liver,shellfish,redmeat grains,eggs,chi	-making special proteins called antioxidant enzymes. these enzymes play a role in preventing cell damage. -protects the body after	-abnormal heart muscle functioning, condition called keshan disease.

	ckens,garlic,wheat,brewedyeast,enriched bread.	vaccination.	-results in myxedematous endemic cretinism which results in mental retardation.

ORGANIC COMPOUNDS

Organic compounds make up the structure of body of plants and animals and they regulate chemical processes which takes place in the body. They are made of carbon as the basic unite. Carbon is tetra valent. The variety of complexity in size of organic compounds is caused by carbon atoms which form the skeleton to which other atoms are attached.

Sometimes the carbon is a straight line as in fatty acids and sometimes it's in a branched chain and also sometimes its inform of rings as seen in simple sugars.

The other atoms found in association with carbon are oxygen and hydrogen which are principle elements plus nitrogen and sulphur in proteins and nucleic acids.

Many large organic compounds are formed by combination of small molecules called monomers to form complex molecules called polymers by a process called polymerization.

CARBOHYDRATES

CARBOHYDRATES compose of a large group of organic compounds which contain carbon, hydrogen and oxygen and which are either aldehydes or ketones. they include sugars and starch.

General formula $C_X(H_2O)_y$ or $(CH_2O)_n$. Where x=number of carbon atoms, y=number of oxygen and hydrogen atoms, n=number of C, H and O atoms.

Functionally, carbohydrates are used in storage and energy production in respiration. However, they also enter into composition of important structures. Carbohydrates are divided into 3 groups namely; Monosaccharides, disaccharides and poly saccharides**.**

MONOSACCHARIDES

These are simple sugars which have between 3 to 10 carbon atoms per molecule. They are usually classified according to the number of carbon atoms they contain. However he most important types in living organisms are 3-carbon sugars called trioses, 5-carbon sugars called pentoses and 6-carbon sugars called hexoses.

Monosaccharides are group of sweet, soluble crystalline molecules of relatively low molecular mass. They are named with the suffix-ose.

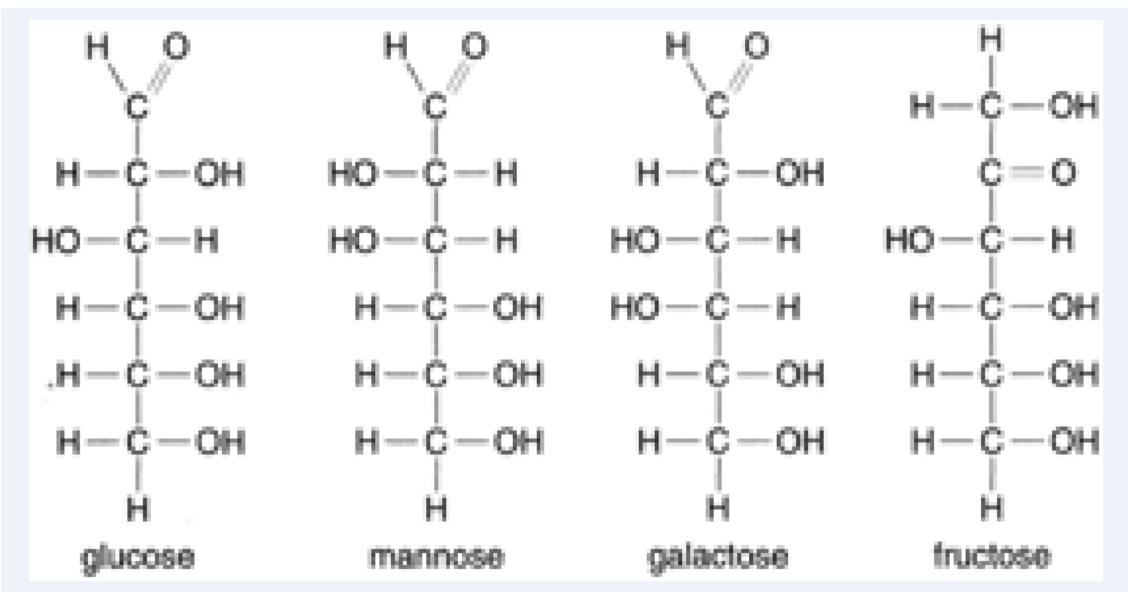
HEXOSE SUGARS

Hexose sugars have a molecular formula $C_6H_{12}O_6$.They are the most common sugars in the mammalian body and they include; glucose, fructose, galactose, mannose etc. of these, the commonest is glucose, the rest are fructose and galactose.

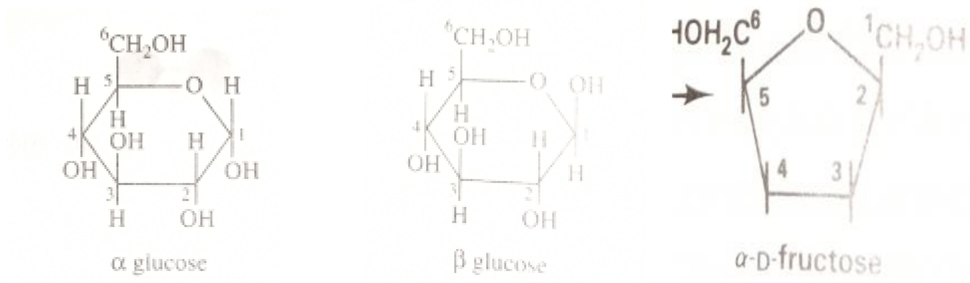
STRUCTURES OF MONOSACCHARIDES

Glucose being the best known monosaccharide has the formula $C_6H_{12}O_6$.All but one of the 6-carbon atoms possesses one hydroxyl group. The remaining carbon atom form part of the aldehyde group. Monosaccharides can be represented by straight carbon chain structures or ringed structures.

Examples of straight chained structures of Hexose



Ringed structures of hexose



Glucose can be represented by straight chained structure comprising of 6-carbon atoms. These are numbered beginning at the carbon of the aldehyde group. Glucose in common with other hexoses and pentoses easily form stable ring structures. At any one time most molecules stabilizing rather than open chains. In case of glucose, carbon atom number 1 may combine with oxygen atom on carbon atom 5 forming a6-sided structure called pyranose ring. In case of fructose, it is carbon atom number2 which links with oxygen on carbon atom5 giving a5-sided structure called Furanose ring.

Both glucose and fructose can exist in both pyranose and Furanose.

Most pentose and Hexose sugar molecules can exist in form of rings in addition to their straight chain forms. This is a very important feature of carbohydrates chemistry because the rings structure produced are the sub units needed in building up complex carbohydrates, powdered dry glucose exists in straight chain form. However, when glucose molecules are dissolved as shown above. These ring structures are more stable in solution so that at equilibrium, almost all of the molecules are present as ring, with the straight chain formed being relatively short-lived intermediate.

properties of Monosaccharides.

They are sweet.

They are soluble.

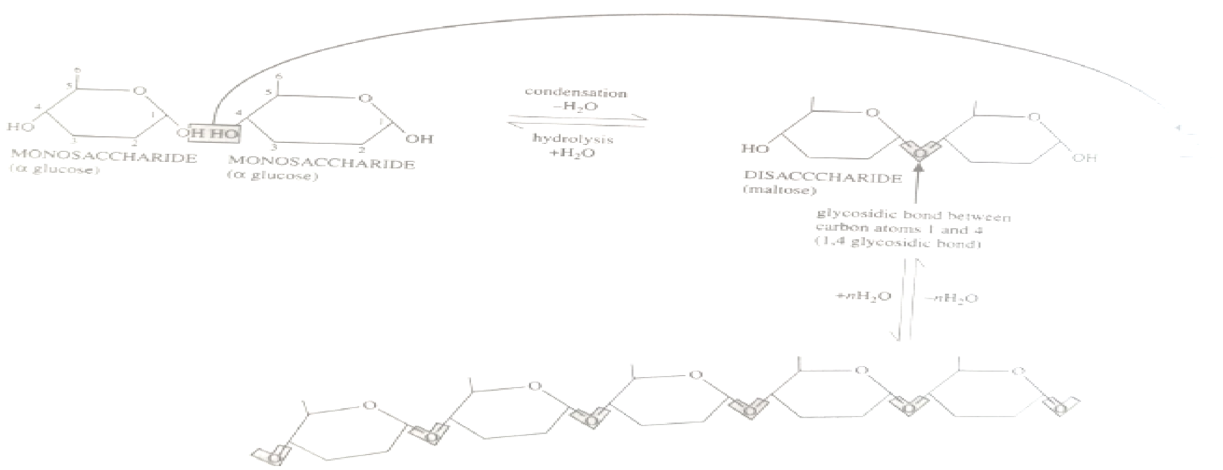
They are crystalliable i.e. they can form crystals.

They reduce Benedict’s reagent or Fehlings1 and 11.

2. DISACCHARIDES

These are sugars that consist of two Monosaccharides units joined to form a single molecule. They often occur as intermediates either in the breaking down or building up of polysaccharides. Other disaccharides are reducing while others are non-reducing eg maltose reduces Benedict’s solution. Maltose consists of two molecules of a-glucose joined by a glycoside linkage.

In living organisms, linkages of this type are formed in several distinct steps, with each step being controlled by each enzyme. Reactions where two Monosaccharides units join together with a loss of water molecule is called condensation reaction. This reaction is important in building up of many complex biological molecules including disaccharides, nucleic acids, polysaccharides and proteins. The complementary process whereby complex molecules are split into their component part is called hydrolysis and requires the addition of water.

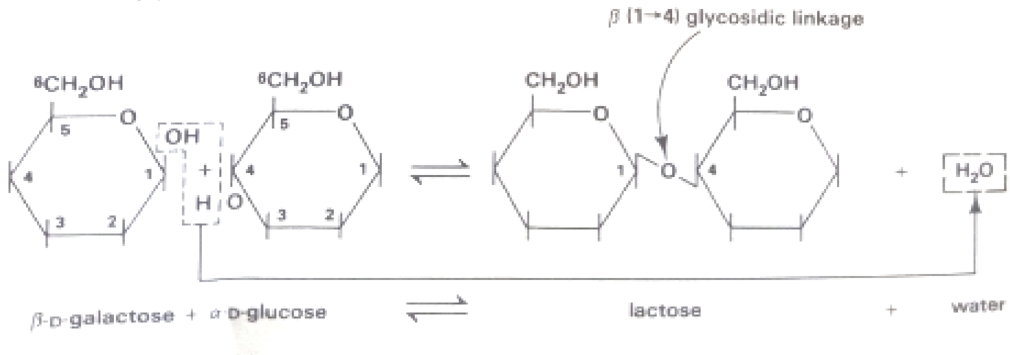


Sucrose is a disaccharide which consists of glucose and fructose joined by a 1,2 glycoside linkage this particular linkage affects the chemical properties of monosaccharide sub-units so that their reducing properties are best.

Sucrose is the only common non-reducing sugar and must be hydrolyzed into its monosaccharide before it will be hydrolyzed into its monosaccharide before it will give a positive result with Benedicts test. In many plants, sucrose is used for transporting food reserves after it is extracted from sugar cane and sugar beet and is important to humans both in the production of ethanol.

Lactose found in mammalian milk consists of galactose and glucose molecules formed by b-1-4glycoside linkage. This linkage changes the orientation of the second sub-unit so that it is upside down, compared with the second glucose unit in maltose.

(b) Lactose



Note. That the projecting CH_2OH groups of lactose lie respectively above and below the plane of the molecules.

POLYSACCHARIDES

Polysaccharides are complex carbohydrates with large molecules consisting of chains of Monosaccharides units joined together under normal conditions, Monosaccharides linkup through glycosidic bonds to form polysaccharides. It is a long chain which may be folded or branched and the total number of monosaccharide units is variable.

Polysaccharides do not taste sweet and are either insoluble in water or form a colloidal solution only. As a result, they can accumulate without affecting the normal metabolism and are widely used as storage and structural material. The most important polysaccharides are; starch, glycogen and cellulose.

STARCH

Starch is the main food storage material of plants it's not a pure substance but is instead a mixture consisting of un-branched chain of molecules of a polysaccharide called amylase and the branched chain of a second polysaccharide called a mylopectin.

Starch molecules are called polymers, meaning that they consist of a chain of repeating units. The repeating units in this case are all individual glucose molecules. These are formed by a-1,4 linkage so that all the glucose are in the head up position. This configuration allows the amylose molecule containing a total of 250-3000 glucose units, to adopt a stable coiled shape called a-helix. This structure has 6-glucose units per turn and is held together by hydrogen bonds between adjacent turns.

By chance, the space in the middle of the helix has just the correct dimension to accommodate iodine molecules which interact with the glucose units in the helix causing a slight change in their position. This leads to the formation of a characteristic blue coloured complex and provides the basis for the procedure of testing with iodine solution on presence of starch.

Starch consist of folded chain of a-glucose and are packed together to form starch grains. Starch is abundant in potato tubers, cassava seeds.

Amylopectin differs from amylase only by having a branching structure and each branching starts with 1,6 -glucoside Linkage. This branching occurs at the interval about every 24-30 glucose units, greatly increasing the number of terminals where additional glucose units can be added or where the enzyme breakdown can begin. Amylopectin which forms up to 80 of starch can be rapidly built up or degraded by amylase enzyme to keep supplies of simple sugars in the plant at the correct level.

Starch is ideal as a storage material because it cannot diffuse out of cells and has little or aggregations of molecules called starch grains. They occur particularly in chloroplasts or in specialized structures such as seeds and potato tubers.

GLYCOGEN

This is the storage polysaccharide most common in animals. It has a molecular structure very similar to that of a mylopectin but branches more often, about once every 8-12 glucose units. Glycogen consists of a branched chains of a-glucose linkage 1-4 and 1-6glycosidic bonds.

Glycogen is more soluble than starch and they exist in the cytoplasm as granules. They are mainly found in liver and muscles.

CELLULOSE.

Cellulose is a polysaccharide consisting of b-glucose molecules joined by the 1-4 glycosidic bonds. The hydroxyl group of the monomer units sticks outwards from the chain in all directions. These hydroxyl groups can also form hydrogen bonds with the neighboring chains resulting in a three dimensional lattice.

Cellulose is the most a abundant of all organic compounds in living organisms because it’s the main structural material in plant cell walls.

Cellulose is a polymer of glucose units attached to each other by b-1-4linkages.This comparatively small change completely transforms the properties of the resulting polysaccharide. A simple cellulose molecule may contain as many as 300-1500 sugar units. This structure cannot be coiled to form helix but are instead flat ribbons; with total length of about 5.This structure encourages hydrogen bonding between adjacent parallel molecules so that long threads called micro fibrils are formed. The micro fibrils are embedded in the matrix. The strength of the glycosidic bonds and the cross linkages makes the cellulose tough. The matrix also contain hemicelluloses which are short polysaccharide that binds together on the cellulose. Micro fibrils are completely insoluble and ideal as structural component.

Micro fibrils in the cell walls of green plants are arranged in overlapping layers. This gives particularly tough and rigid structure. Plant cell walls are permeable to water because the matrix is strongly hydrophilic. Sometimes cells walls are reinforced with second polysaccharide material called lignin, which is deposited in the space between the cellulose micro fibrils.

USES/FUNCTION OF MICROFIBRILS:

_Provides raw materials for making paper, cellophane and rayon

-cellulose nitrate is used in making liguifiers, films and explosives.

-Used in making fibric and other materials i.e. from cotton.

LIGNIN:

This is a polymer of many sugars and amino acids. They are normally deposited on the xylem vessels, tracheids and in the schlerenchyma cells. Once it is deposited .it renders the cell impermeable to water and solutes. Functionally, lignin gives mechanical strength because of the lino-cellulose composition.

CHITIN

This is the structural material of insects' skeletons and is derivative of a carbohydrate. It is a polymer of b-1-4 linked subunits but the subunits themselves differ from glucose by having one of either hydroxyl groups replaced by a more complex _NHCOCH3 group. This difference means that there is even more hydrogen bonding chains than in cellulose making chitin extremely tough and resilient.

AMINO SUGARS

These are sugars which contain nitrogen. These are mucopolysaccharides. They are found in the basement membranes of epithelial, matrix of connective tissue, synovial fluids, cell wall of prokaryotes, chitin, and fungal hyphae.

LIPIDS AND WAXES

The molecules of fats, oils and waxes contain the chemical elements carbon, hydrogen and oxygen. The same elements precisely occur in the carbohydrates but the relative amounts in fats and oils are quite different, in particular for less oxygen is present. This greatly reduces the possible number of polar hydroxyl groups in molecules of fats and helps to explain their less solubility in water.

WAXES:

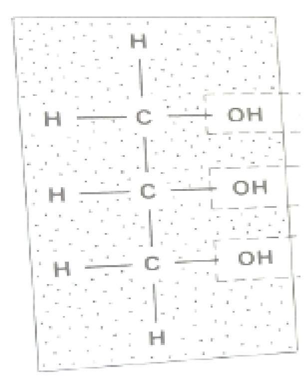
Waxes also contain ester linkages, but each molecule contains only one fatty acid subunit and this is linked with the molecules of along chain alcohol instead of with glycerol. Waxes are used to water proof the external surfaces of both plants and animals, usually in order to reduce water loss e.g. waxy cuticle of leaf surfaces and of insects.

LIPIDS(FATS AND OILS).

Lipids include fats and oils and at room temperature fats are in solid form and oils are in liquid form. Lipids are built up from two basic types of sub units namely fatty acids and glycerol.

structures of glycerol and fatty acids sub units of fats and oils:

a) **Glycerol**

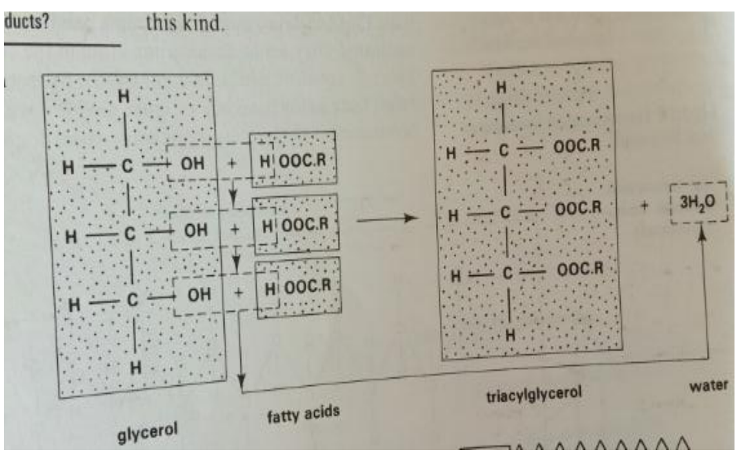


glycerol

b) Stearic acid- a structured fatty acid.***(Assignment; draw the structure of stearic acid and linoleic)***

c)Linoleic-an unsaturated hydrocarbon.

Glycerol is apolyhydroxyl alcohol or polyol and form glyceride when they are joined to fatty acids sub units. Structures called monocle and triglycerides are formed when a single glycerol molecules is joined to one, two or more three of the fatty acids sub units



Triglyceride structures, typical of fats and oils is formed when condensation reactions take place between the hydroxyl (alcohol) groups of the glycerol molecule and the---COOH groups of the three fatty molecules. in living systems, several enzymes controlled steps are required for the reaction. The new linkage formed are consistent with the general formulary for an ester, usually written as R-COOR Where R and R’ can be replaced by any organic group and they are therefore called ester linkages. Although the three fatty acids are often identical, a mixture of types is possible so that different triglyceride systems can be produced.

All fatty acids molecules consist of a—COOH or carboxyl group attached to one end of a hydrocarbon chain. This contains between 4to24 carbon atoms and is normally un-branched although it may be either saturated or unsaturated chains contain repeating CH2groups joined by single bonds, as in the molecule of stearic acid. While unsaturated chains contains contain double bond in the form CH—CH-groups as in trioleic acid. General formula of fatty acids is $CH_3(CH_2)NCOOH$.

Therefore fats and oils can be identified as;

-Fats are triglyceride which is solids at room temperature; they often contain only saturated fatty acids,

-Oils are triglycerides which are liquids at room temperature and usually contain un saturated fatty acids.

FUNCTIONS OF LIPIDS

1 provides energy on combustion .by mass they provide 17kj per gram. This is because of numerous C-C and C-H bonds that represent a large reservoir of stored chemical energy which can be released and used by cell when required.

2 It is a storage substance or materials, partly because of their limited solubility in water and partly because of numerous C-C and C-H bonds that characterize their structures. Being thick and insoluble, it provides a convenient form in which rich molecules are stored for use when need a rise.

3 It enters into the composition of certain structures of animals and plants eg plasma membrane. In this way, it combines with the phosphoric acid to form phospholipids which makes the bimolecular layer in the plasma membrane. The dermis of the skin also contains large quantities of sub cutaneous fats.

4 A part from being a storage compound, it prevents heat loss.

5 are constituents of waxy cuticle of plants and insects, its water repelling property makes the cuticle water proof.

6 Mechanical protection of delicate organs in the body.

7 source of food. Essential fats like linoleic acids cannot be synthesized in the body and must be supplied in the diet mainly from vegetables and seeds which are un saturated.

Other fats can be synthesized inform of carbohydrates and proteins.

CHEMICAL TESTS FOR FATS AND OILS

1 Emulsion Test;

Grind tissue sample in ethanol to dissolve away fats and oil. Filter off and add 2cm of extract to 2cm of water in a test tube.

Results;

Milky white emulsion formed.

PHOSPHOLIPIDS

These are lipids which have phosphate group attached to their molecules. They are important compounds because a long with proteins, they form the essential components of cell membranes.

Structure of phospholipid molecules

The structure of phosphor lipids shown above shows that the molecules of fatty acids link to the molecule of glycerol in the way as in fats and oils. The third position on the glycerol molecule is occupied by phosphate group which links the glycerol to an additional molecule, usually complex alcohol. In phospholipids, the phosphate and nitrogen groups make up the head which is hydrophilic.

STEROIDS

These are biological compounds with molecular structures containing rings of atoms. They have similar properties like fats. For example, they are insoluble in water but soluble in organic compounds. They differ in structures from lipids. Each steroid contains four fused carbon rings which vary according to the type of carbon chains.eg

Steroids have important biochemical and physiological roles. .Some plants ,steroids can be converted into both animal hormones in the presence of revent enzymes.

Table showing steroids and their functions;

STERIODS	FUNCTION
cholesterol	- Major component of cell membrane - Raw material for manufacture of many other steriods
Bile acids e.g. cholic acid	In the form of bile salts, they emulsify fats during digestion
Corticosteriods(hormone manufactured in the cortex region of adrenal glands)	They are involved in stress responses(flight and fight).
Oestrogen and progesterone	Reproductive hormones in female mammals.
testosterone	Reproductive hormone in male mammals
Calciferal	Promotes calcium and phosphate absorption from small intestine.
ecdysone	Hormone causing moulting

Note

Steroids substances are rare in plants.

Plants do not contain cholesterol but phytosteriods

Fats and steroids are made by smooth endoplasmic reticulum.

Cholesterol is found in plasma membranes in various organelles. It mixes readily with fats and gives it ability to absorb water.

PROPERTIES OF LIPIDS

Lipids are insoluble in water but soluble in organic solvents, like alcohol.

Oils are liquids at room temperature but they melt easily.

PROTEINS

Proteins are complex organic molecules that are found inside cells. Sometimes sulphur and phosphorus are present including other elements. Proteins play a vital role of being component of structure of organisms.

Proteins occur as enzymes, hormones and haemoglobin.

BUILDING UP OFPROTEIN

PROTEINS ARE BUILT UP from subunits called amino- acids. There are twenty naturally occurring amino acids and they contain amino group and carboxyl groups. The amino acids are further divided into essential and non essential amino acids.

Essential amino acids are those that cannot be synthesized by the body and there for must be supplied in the diet.

Non-essential amino acids are those which can be synthesized by the body.

Structure of amino acids

All amino acids have an amino group (-NH2), a carboxyl group (-COOH) and a hydrogen atom all bonded to a central carbon atom. The different types of amino acids differ from each other in the nature of R attached to their molecules. The simplest amino acid is glycine where R in the structure above is a hydrogen atom i.e.

The table showing major amino acids that make up proteins

The 20 amino groups above are classified into five chemical classes and based on their side groups.

1) n on polar amino acids such as leucine, often have R-groups that contain $–CH_2$or $–CH_3.$
2) Polar uncharged amino acids such as threonin, have R-groups that contain oxygen (or only hydrogen
3) Charged amino acids such as glutonic acids have R-groups that contain acids or bases.
4) Aromatic amino acids such as phenylamine have R-groups that contain an organic ring with alternating single and double bonds.
5) Special function amino acids have unique individual. Methionine is often the first amino acid in the chain of amino acids, proline causes links in the chain and cysteine links chains together.

Each amino acid affects the shape of protein differently depending on the chemical nature of its side chain group eg portions of a protein chain with numerous non-polar amino acid tend to fall into the interior of the protein by hydrophobic exclusion.

Formation of proteins **by amino acids**

Amino acids unit to form proteins. The first step involves combination of two amino acids in a condensation reaction forming a dipeptide with loss of a water molecule.

Dipeptide

This is a molecule former by condensation reaction between two amino acids. Molecules in a dipeptide linked together by peptide bond. Continued condensation reaction by dipeptids leads to formation of polypeptides. A particular polypeptide may be composed of up to 100dipeptideS

The number of possible ways in which amino acids combine is infinite. The individuality of a protein depends on the sequence of amino acids comprising of its polypeptide chain together, pattern of branching, folding and cross linking. The total number of amino acids varies from few to several thousand e.g. serum globulin which has molecular mass of 140000.

Protein structure

a) primary structure;

This refers to the sequence of amino acids along a polypeptide chain.

b) Secondary structure;

This refers to the folding and cross linkages of the polypeptide chains through hydrogen and sulphur bonds to form helical structure .It shows the way a polypeptide chain are folded and coiled to form helix.

b) Tertiary structure ;

This refers to how helices are again folded up to give rise to a tertiary shape.

c) Quaternary structure;

Refers to how the protein sub units are arranged forming a structure. When two or more polypeptide chain are associated to form a functional protein, the individual chains are referred to as subunits of protein. The subunits need not to be the same. Haemoglobin for example is a protein of two a-chain sub units and two chains of b-chain. A protein sub units arrangement is called its quaternary structure.

CLASSIFICATION OF PROTEINS ACCORDING TO STRUCTURE

External shape of protein molecules;

Proteins are either spherical in shape hence called globular proteins or they are rod-like hence called fibrous proteins.

1) GLOBULAR PROTEINS;

In globular proteins, polypeptide chains are tightly folded into a spherical shape. these are vital for enzyme formation .They are relatively more soluble and readily goes in colloidal suspension e.g. haemoglobin ,myoglobin.

Functions of globular proteins

i) Maintains the composition of the protoplasm in cells.

Ii) It is a vital constituent of the plasma membrane.

They are constituents of structures such as microtubules and microfilaments.

They form enzymes. They function of enzymes is related to the molecular configuration of proteins of which they are made and the ready combination of proteins with other molecules. in this way, proteins act as regulators.

FBROUS PROTEINS;

These consist of helical poypeptide chains which are long and parallel to one another with cross linkages at many points a long their length.

Properties of fibrous proteins;

i) Adopts secondary structure as the most important structure.

ARE INSOLUBLE IN WATER.

A LONG THE PARALLEL, polypeptide chains cross linked at intervals forming long fibres or sheets.

Are resistant to PH change and temperature.eg of fibrous proteins are collagen fibres (tendons, bones, connective tissues), myosin (in muscles), silk (spider web),keratin(hair, horn feathers, nails).

Functionally they form structural functions in cells and organisms as seed in the above structures.

INTERMEDIATE PROTEINS

These are fibrous but soluble e.g. fibrinogen which forms insoluble fibrin when blood clots.

Classification of proteins according to compositions

i) Simple protein;

Here only amino acids form their structures e.g. globular and fibrous proteins.

ii) Conjugated proteins.

Are proteins combined with another compounds which are non proteins. They are complex compounds consisting of globular proteins which are tightly bound to a non-protein material. The non protein component is called the prosthetic group.

Conjugated Protein	Prosthetic Group	Location
phosphoprotein	Phosphoric acid	Casein of milk, vatellin of egg york
Glycoprotein	carbohydrate	Mucin (component of saliva).
Nucleprotein	Nucleic acid	Component of virus, chromosomes and ribosome structure.
chromoprotein	pigment	Haemoglobin-haem (iron-containing pigment). -Phytochrome (plant pigment). -Cytochrome (respiratory pigment).
Lipo protein	Lipid	Membrane structure -Lipid transported in blood as lipoprotein.
Flavoprotein	FAD(Flavin adenine dinucleotide)	-Important in electron transport chain in respiration
Metal protein	Metal	E.g. nitrate reductase, The enzyme in plants which converts nitrate to nitrite.

CLASSIFICATION OF PROTEINS ACCORDING TO FUNCTION

Proteins are also important in membranes where they function as enzymes, receptor sites and transport sites.

Type	Example	Occurrence
Structural(These form part of the body of an organism)	-Collagen -keratin -Elastin -Viral coat proteins	-Component of connective tissue, bone, tendons and cartilage. -Component of skin, feathers, nails, horns. -Components of elastic connective tissue. -Wrap up nucleic acids of versus
enzymes	-Trypsin -Ribolose-bisphosphate - carboxylase -Glutamine	-Catalyses hydrolysis of proteins. Catalyses carboxylation Catalyses synthesis of amino acids glutamine from glutonic acid and ammonia.
Hormones/signal proteins	-insulin and glucagon ACTH	Regulates glucose metabolism Stimulates growth and activity of adrenal cortex
Transport protein	Serum albumin	-transport of fatty acids and lipids in blood
Respiratory pigments	Haemoglobin myoglobin	-transports oxygen in veterbrate blood -stores oxygen in muscles
Defensive/protective protein	-antibodies	-forms complexes with foreign proteins. -forms fibrin in blood clotting -involved in blood clotting mechanism
Contractile proteins(involved in movements)	Actin myosin	Stationary filaments in myofibrils Moving filaments in myofibrils of muscles.
Storage protein	- albumin -casein -snake venom -diptheria toxin	Egg white protein -milk protein. Enzymes. Toxin made by diphtheria bacteria.

CHARACTERISTICS OF PROTEINS

i) They are irreversibly destroyed by heat i.e. they undergo denaturation at high temperature.

ii)proteins are insoluble and they form colloidal suspension, due to large size of their molecules.

iii) Proteins are amphoteric i.e. they exhibit both acidic and basic properties.

iv) They are large sized molecules therefore have high molecular weight.

v) They are highly specific in their reactions.

vi) They can undergo hydrolysis forming amino acids and this can be brought about by enzymes or strong acids.

vii)They have the ability to combine with other non-protein substances forming complexes or conjugated protein.

Viii)They have very large surface area since they have strong capacity to absorb water from other substances. For this reason, they are important in holding molecules in position into the cell and als maintaining molecular organization in the protoplasm .other non-protein compound. called the prosthetic group .e.g. of conjugated proteins are haemoglobin, the prosthetic group is haem, in egg yolk. The prosthetic group is phosphoric acid, in nucleoprotein, the prosthetic group is nucleic acid and in mucus, synovial fluid, eukaryotic cell walls, matrix of connective tissue, the prosthetic group of the glycoprotein is the carbohydrate.

FUNCTIONS OF PROTEINS

Proteins form body structures e.g. collagen a component of connective tissues bones, tendins cartilage.

They form enzymes e.g. Ribulose bisphosphate which catalyses carboxylation of Ribulose (addition of carbondioxide to Ribulose)during the dark stage of photosynthesis in plant, tryosin catalyses hydrolysis of proteins.

Proteins are needed for transport within the body e.g. haemoglobin which transports oxygen in veterbrate blood

Proteins are needed for movement and support e.g. Elastin gives strength and elasticity to connective tissues, myosin and actin allow muscles to contract leading to movement and locomotion.

Proteins form hormones e.g. insulin and glucagon hormones that regulate the amount of blood sugar in the body.

Also needed for sensitivity in the body e.g. Rhodopsin, a photoreceptor in the eyes.

Essential in reproduction e.g. it forms component of chromatin that give structural storage functions eg casein is a storage protein in milk, albumen is storage protein in eggs.

Proteins also protect the body e.g. fibrinogen which is a precursor of fibrin in blood clotting.

Proteins perform defensive functions e.g. toxin like snake venom is used bit snakes for protection.

VITAMINS

These are organic compounds required in food in small amount and are used for metabolic activities of the body. They consist of mixed assortments of chemicals which share chemical function. Generally plants synthesis their vitamins but animals need them in food except vitamin D which is made in the skin and activated by ultraviolet rays in the sun.

Vitamins are divided into two main groups

i) Fat soluble vitamins

ii) Water soluble vitamins.

Table showing principal vitamins, source, function, deficiency diseases and symptoms in human diet

FAT SOLUBLE VITAMINS

Vitamin	**source**	**function**	**Deficiency disease**
Vitamin A(Retinol)	Liver, milk products, vegetables, ox-kidney	-control normal epithelial structure and growth. -essential for the formation of visual pigment e.g. Rhodopsin which aids night vision.	-Night blindness. -Dry skin, cornea also becomes dry and mucus membrane degenerate. -Permanent blindness may occur if the vitamins is not added to the diet a condition known as xerophthalamia.
D(calciferal**)**	-Dairy products, fish, egg yolk, margarine.	-It increases the absorption of calcium and phosphorus in the intestine. -concerned with calcium metabolism. -important in bone and teeth formation.	-Soft bones in children as a result of failure of growing bones to calcify. -Bowlegs are common features in children and knock knees in older ones. Deformation of pelvic bones in adolescent girls may occur which can lead to complications to those girls when they give birth. -osteomalacia,

			an adult condition where bones are painful and spontaneously fracture may occur.
E(Tocopherol)	Milk, liver, egg yolk, margarines and vegetables.	-protects fatty acids and cell membrane from oxidation. -in rats, it affects muscles and the reproductive system and prevents haemolysis of red blood corpuscles.	-can cause sterility in rats. -muscular dystrophy. -anemia due to increase haemolysis of red blood corpuscle
K(phylloquinone**)**	Pig liver, tomatoes, cabbages, synthesized by bacteria in large intestine.	-Synthesis of blood clotting factors for e.g. needed in the final stage of prothrombine synthesis in the liver.	-severe bleeding. -mud deficiency leads to prolonged clothing times. -serious deficiency leads to blood failure to clot a condition called hae mophilic. -anemia.

WATER SOLUBLE VITAMINS

B_1(thiamine)	wheat, yeast extract liver, kidney grains, meat and legumes	-required as a coenzyme for decarboxylation of pyruvic acid to acetyl coenzyme A. Acids chemical change in respiration especially krebs' cycle.	-beriberi, -impaired growth of children,. Nerve and heart disorders.
B_2(riboflavin)	Yeast extracts, eggs milk, liver cheese.	-it is part of co-enzyme FAD which play metabolic role e.g. electron transport.	-Ariboflavinosis i.e. inflammation of skin. Eye irritation and sores at the corners of the mouth.
B_3(Nicotinic acid)	Meat, fish, wheat liver lean meat, grains and yeast extract	-forms co-enzymes NAD and NADP required as hydrogen acceptors in cell respiration. -forms part of coenzyme A	-pellagra -dermatitis(sores on skin) -Inflamation of the nerves. -mental disorder.
B_5(panthothenic acid)	Yeast, eggs ,and many different kinds of foods	-forms co-enzyme A which activates certain carboxylic acids in cell metabolism.	Fatigue, poor neuromotor coordination. -muscle cramps.
B_6(pyridoxine)	Cereals, meat, eggs , liver, ox-kidney, all grains, vegetables, fish and beans.	Phosphorylated pyridoxine acts as a co-enzyme for amino acid and fatty acid metabolism.	-anemia depression and irritability. -convulsion, diarrhea, and vomiting.
B_{12}(Cyanocobalamine or cobalamine)	-red meat, dairy products eggs, fish .	Formation of red blood corpuscles. -co-enzyme in the	-pernicious anemia.

		synthesis of nucleic acid.	
Folic acid	Liver, greens and kidney.	-it's a co-enzyme in amino acid and nucleic acid metabolism. -formation of red blood corpuscles.	-anemia particularly in woman (pregnant). -diarrhea.
Biotin.	Yeast, liver, kidney, egg white and synthesis by intestinal bacteria, meat and vegetables.	-co-enzyme in fat and amino acid metabolism. -it is involved in protein synthesis, carboxylation and transamination. -used as a co-enzyme for a number of	-Dermatitis -muscle pains -depression and nausea.
C(Ascorbic acid)	Citrus fruits, green vegetables, potatoes and tomatoes.	-essential for collagen fibre synthesis. -formation of intercellular materials. -concerned with metabolism of connective tissues and production of strong skin. -important in forming cement of teeth, connective tissues of blood vessels. -concerned with increased resistance to disease.	-Scurvy i.e. the skin of gums becomes weak and bleeds. -wounds fail to heal Connective tissues fail to form. -there is anemia. -heart failure. -breakdown of skin and blood vessels leading to bleeding.

