Nutrition

Food is the source of materials required by an organism to provide the energy to stay alive, grow and reproduce.

All living organisms require food:
- for energy (for heat & to drive chemical reactions & for continuity of life),
- to provide the necessary building materials for growth, maintenance & repair of cells.
- to control chemical reactions in cells.

A balanced diet should contain 2/3 carbohydrates, 1/6 protein, 1/6 fat, minerals, vitamins & water.

Energy value of food

- 1 kcal = 4.2 kJ.
- 1 kJ is the amount of energy required to raise the temperature of 1kg of water by 1°C.
- 1g carbohydrate = 16kJ of energy / 1g protein = 17 kJ/ 1g fat = 38 kJ
- 1g alcohol = 29kJ
- Daily food intake should contain enough kJ energy to keep all internal activities in the body going and enough to carry out external work.
- The total amount of food intake depends on age (young people needing more than older individuals), level of activity, health and gender. Males need more food than females because they have a higher ratio of muscle to fat.
- More energy intake is needed during pregnancy to compensate for fetal growth. The same is true for lactation.
- Recommended allowance = 9600kJ for 16-year-old girls and 12600 kJ for boys. It is important to reduce fat intake when trying to control weight.
- Climate - More kJ required in colder weather/climates to maintain body temperature.

Chemical Composition of Food

The most important chemical elements found in food and required by all living organisms are split into three groups depending on the amounts needed:
1. **Macronutrients** – Those needed in larger quantities. The six most common are Carbon (C), Hydrogen (H), Nitrogen (N), Oxygen (O), Phosphorus (P), and Sulfur (S).
2. **Micronutrients** – These are needed in smaller quantities. Some of the most common are Sodium (Na), Magnesium (Mg), Chlorine (Cl), Potassium (K), and Calcium (Ca). Most are obtained in the form of dissoved salts.
3. **Trace Elements** – Those needed in very small quantities. The main three are Iron (Fe), Copper (Cu), and Zinc (Zn).

Biomolecules are organic compounds made in living organisms. There are four types of biomolecules in food: Proteins, Carbohydrates, Lipids and Vitamins.

Carbohydrates

Structure

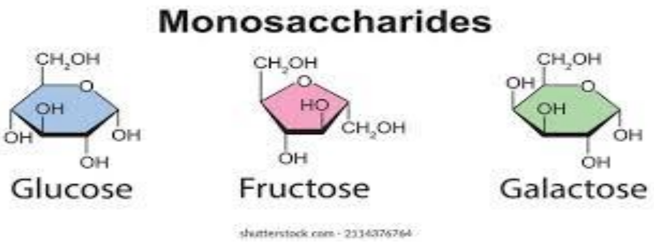
Carbohydrates consist of simple sugars. General Formula: $(CH_2O)_n$ (Ratio 1:2:1)

Elements

Carbon:Hydrogen:Oxygen (C:H:O)

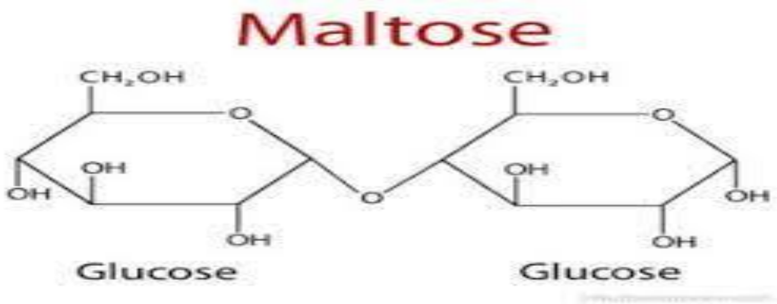
Carbohydrates are divided into three groups according to the number of sugar units in each molecule;

- **Monosaccharides**: Made up of single sugar units. Differ from each other mainly by the arrangement of hydrogen and oxygen atoms within the molecule.



(1)

-**Disaccharides:** Made up of groups of two sugar units joined together.



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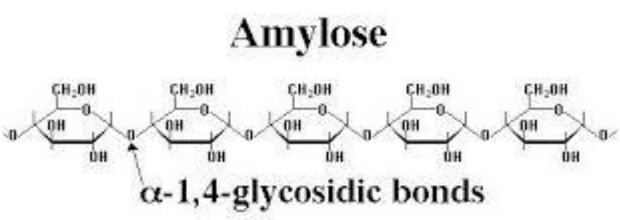
- **Polysaccharides:** These are macromolecules made up of many sugar units. Digestion of polysaccharides and disaccharides produces monosaccharides.



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Functions

- Sources of quickly available energy used in respiration e.g., glucose found in energy drinks. The equation for the aerobic respiration (using oxygen) of glucose is

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{Energy (Catabolic}$$

Reaction)
- Sources of dietary fibre are also called roughage. This is the indigestible portion of food derived from plants. It has two main components;
a. Soluble Fibre: Fibre which dissolves in water. Ferments in the colon, by the action of bacteria, into gases and physiologically active by-products. Sources include peas, oats, beans and most fruits.
b. Insoluble Fibre: Fibre which does not dissolve in water. Absorbs water as it moves through the digestive system, easing defecation and preventing constipation. Reduces the risk of bowel cancer. Sources include most vegetables and bran.

- Storage Polysaccharides: How organisms store any excess sugars to be used when they are needed at a time when they cannot be obtained or produced. Animals convert glucose into glycogen, which is stored in the liver and the muscles. Plants convert glucose into starch where it is stored in the roots and the leaves.
- Structural Polysaccharides: Used to build tissues. For example, cellulose in plant cell walls and chitin in insect exoskeletons.

Practical Activities

To test for Starch – Method
Take sources rich in starch (Bread, potato, Pasta)
As a control, take sources with no starch (Egg whites, Apple)
Add a few drops of iodine solution to each substance.

-In the foods where starch is present, the iodine solution turns from brown to blue-black.
-In the foods where no starch is present, the iodine solution will stay orange-brown.

To test for reducing Sugar – Method
Pour a source of reducing, such as glucose solution or a colourless soft drink into a test tube.
To act as a control, put an equal amount of water into a separate test tube.
Add a few cm^3 of Benedict's Solution to each test tube and mix.
Place both test tubes in a hot water bath and leave to stand for a few minutes.

Results
- The test tube containing the glucose plus Benedict's solution turned from blue to orange/red, showing the presence of reducing sugar.
- The test tube containing the water plus Benedict's solution remained blue as it is a non-reducing sugar solution.

Lipids

Structure

Basic unit of lipids are triglycerides. A lipid consists of 1 glycerol & 3 fatty acids.

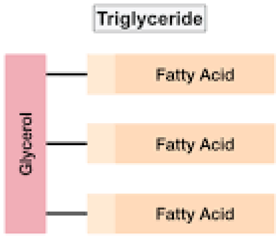


Fig 1. The Structure of a Triglyceride.

(4)

Elements

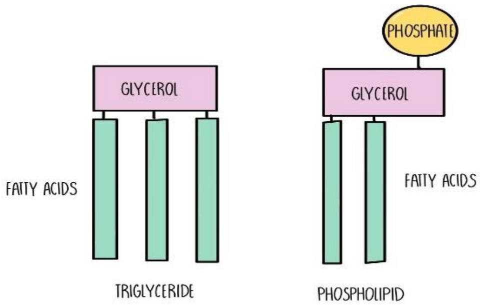
Carbon, Hydrogen and Oxygen.

Lipids (Triglycerides) come in two forms;

- Fats: Solid at room temperature. Fats are saturated, which means that all the carbon-to-carbon bonds are single bonds. Most found in animals than plants. A diet rich in saturated fats can lead to high cholesterol which can cause heart attacks and strokes.
- Oils: Liquid at room temperature. Oils are unsaturated or polyunsaturated which means they contain one or many carbon-to-carbon double bonds. Commonly found in plants and less likely to raise cholesterol levels but are still fattening.

Functions

- Lipids are a concentrated source of energy and, gram-for-gram, fat has much more energy than carbohydrates.
- Used to store energy more than immediate requirements. This is done by depositing the fats in cells that surround organs and under the skin(subcutaneous fat). Too much fat stored in the liver(fatty liver disease) can impair liver function and is potentially dangerous.
- Main structural role of fats is in the formation of the membranes of cells and cell organelles. These are slightly different to fats and oils as one of the fatty acids has been replaced by a phosphate group.
- The phosphate end of the molecule is soluble in water (hydrophilic) and the fatty acid end is soluble in fats and oils (hydrophobic). These molecules are called phospholipids.



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- Lipids play a role in the protection of delicate organs such as the kidneys. A layer of fat surrounds and cushions the organs.
- Under the skin there is a layer of subcutaneous fat, which plays a major role in heat insulation. Women have a thicker layer of fat than men, which is responsible for their more rounded shape. In seals and whales, this layer of fat is known as blubber.

Practical Activities

Test for Lipids – Method

Take sources rich in lipids (Butter or Vegetable Oil)
As a control, take a substance with no lipid (Water)
Rub each substance onto brown paper and leave to dry

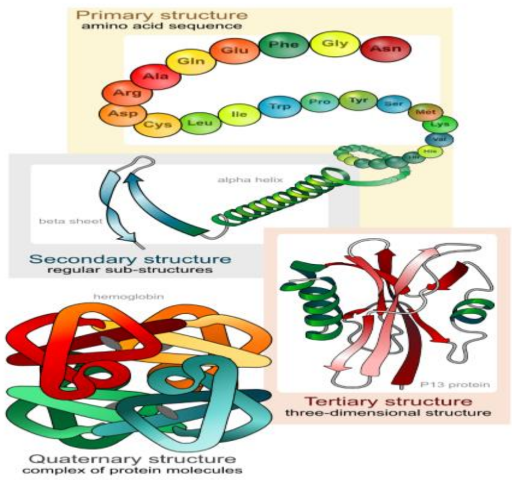
Results

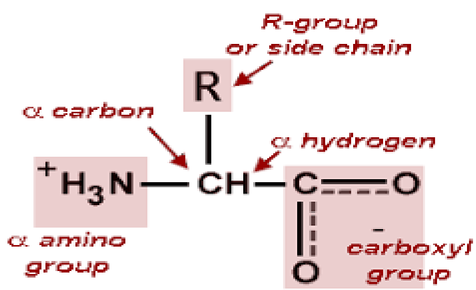
-The translucent stain caused by the water disappears when it has dried.
-The translucent stain caused by butter/oil is permanent, showing lipid is present.

Proteins

Structure

Consists of repeating units of amino acids. There are about 20 different amino acids linked together in polypeptide chains to form proteins.
Basic unit = amino acid





(6,7)

-NH_3 = amino group

-COOH = carboxylic acid group

-R = variable

Amino Acids can be divided into groups;
-Essential: Amino acids that cannot be synthesised by the organism. Must be obtained from the diet.
- Non-essential: Amino acids that can be synthesised by the organism and so are not required in the diet.

There are approximately nine million species living on earth, each species is thought to have at least one protein unique to it. This large number is produced by different combinations of the amino acids in very long chains. Each peptide bond between each pair of amino acids has a particular direction, and, as a result, each protein folds into its own unique and complex shape. It is the shape of the protein that is responsible for its properties.
Protein is found in meat, fish, egg whites, milk, and seeds such as peas and beans.

Elements
Carbon:Hydrogen:Oxygen:Nitrogen:Sulfur:Phosphorus

Functions
- Proteins have many functions and are divided into two categories based on their functions.
a. Structural proteins: The building blocks of tissues, e.g., actin and myosin make muscle. Collagen, a strong elastic protein, is a connective tissue that holds structures together. Keratin makes hair.
b. Physiological proteins: Needed to control the working of organisms. They fall into two main categories:
- Enzymes – Biological catalysts. They control the rate of all chemical reactions within the organism. They mostly speed up reactions, but some slow down reactions, and they are called inhibitors.
- Hormones- Produced by endocrine glands in one part of the body. From there they diffuse into the blood and are carried to another part of the body, where they affect the activity of other glands and structures.

Practical Activities

To test for protein – Method
Take a sample of food rich in protein (Egg white, Cheese, Chicken Breast)
As a control take a food that does not contain protein (White Rice)
Place the samples in two labelled test tubes
Add biuret solution to each test tube and shake

Results
- The test tube containing protein turns from blue to purple
- The test tube that does not contain protein remains blue

Vitamins

Vitamins are required by the body in tiny amounts. They are necessary for the proper functioning of cells, tissue growth, cell production and maintaining health.

Vitamins A, D, E and K are fat-soluble and stored in the liver.
Vitamins C and B are water-soluble.

Vitamin-deficiency Diseases *Need to know one Water-Soluble and one Fat-Soluble**

Vitamin	Source	Function	Deficiency Disease
A	Carrots, meats (especially beef liver and animal fats)	Formation of the visual pigment rhodopsin	Night Blindness
B (Complex)	Bacteria in large intestine, legumes, wholegrains, brewer's yeast	Energy production, development of foetal nervous system	Beriberi (swollen stomach), Pellagra (photosensitivity)
C	Citrus fruits, green vegetables, red peppers	Formation of skin and blood vessels	Scurvy (bleeding gums and hair loss)
D	Dairy products, formed by the skin when exposed to sunlight	Absorption of Calcium in gut	Rickets in children, osteomalacia in adults
E	Vegetable oils, nuts, and seeds	Antioxidant	Haemolytic anaemia
K	Bacteria in large intestine and green vegetables	Synthesis of clotting proteins	Bleeding and easy bruising

Minerals

Minerals are elements usually absorbed in the forms of ions in dissolved salts. The symptoms of mineral deficiency differ between plants and animals.

Know table in detail

Mineral	Source	Use	Deficiency Disease
Calcium (Ca)	Dairy products e.g., cheese, milk; hard water; fish	Bones, teeth. Calcium pectate in middle lamella - holds cell walls together	Osteoporosis – weakening of bones.

Magnesium (Mg)	Wholegrain cereal, green vegs, cheese, soil water	Bones & teeth. Enzyme co-factor. Nerve/muscle action. Makes ATP. Makes chlorophyll in plants.	Weak bones General weakness. Poor growth
Iron (Fe)	Liver, meat, spinach, nuts, egg yolk, legumes	Haemoglobin	Anaemia

Water

Water is essential for life. A person deprived of food can last for months, but if deprived of water will die within two weeks or less. Water is essential for the following:

- Solvent: Wide ranging solvent. Dissolves ionic compounds, such as sodium chloride and other salts, that supply us with the minerals we need. It can also dissolve covalent compounds, such as glucose, urea, hormones, and enzymes. Oxygen dissolves in water covering the alveoli and diffuses into the water of the blood plasma before being collected by haemoglobin.
- Transport medium: Water carries a variety of things around the body of plants and animals, including

a. Nutrients such as minerals, amino acids, and glucose in the blood of animals and sap in the phloem of plants

b. Waste materials such as Carbon Dioxide and urea in the blood

c. Hormones such as oestrogen and adrenalin in blood and IAA in phloem in plants

d. Heat produced in the muscles, liver and brain. It is particularly good at this because it has a high heat capacity. It plays an important role in cooling the body when sweat evaporates.

- Body fluids: Water is a main component in body fluids, such as blood and semen.
- Medium in which reactions occur: Chemical reactions occur more rapidly between substances in solution than between solids, so almost all reactions in the body occur in water.

Energy Transfer Reactions

Energy transfer reactions can be divided into two types:

- Catabolic Reactions: Break down complex molecules into simpler molecules and release energy in the process. Respiration and digestion are the two most common examples of catabolism.
- Anabolic Reactions: Use energy from either the environment or from catabolism

to build up more complex molecules out of simple molecules. Photosynthesis and protein synthesis are two of the most common.

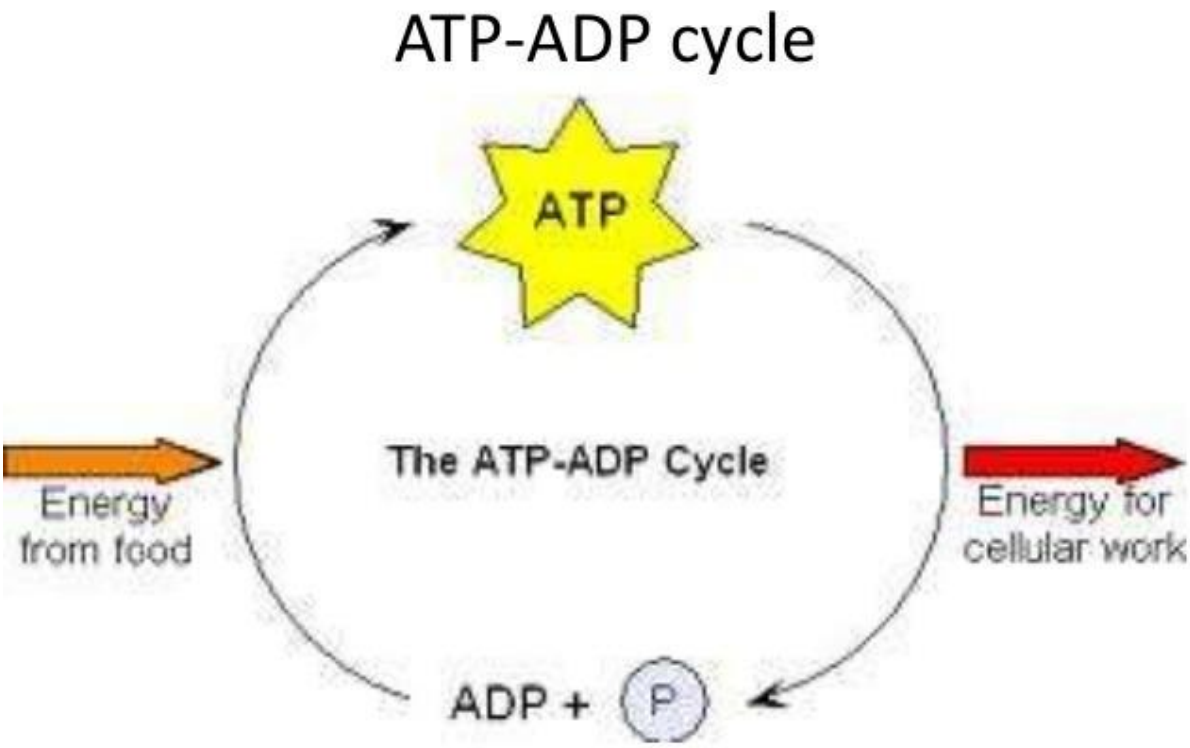
The energy produced by catabolism is in the form of ATP(Adenosine triphosphate). ATP stores and transports energy within the cell. It is made when energy is used to attach a third phosphate group to ADP(Adenosine Diphosphate).

ADT + P + Energy = ATP

When energy is required, this third phosphate group breaks off and releases the stored energy. The ADP and P are then free to be used again to form more ATP.

ATP = ADP + P + Energy

This process is known as the Energy Cycle.



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Exam Questions

2015 – HI – Section A – Question 1

1. Answer any five of the following parts (a) to (f):
(a) What name is given to the simplest units of carbohydrates? Monosaccharides
(b) Name a catabolic process that produces these simplest units. Digestion
(c) The general formula of carbohydrates is Cx(H2O)y. What is the most common value of y in the carbohydrates used for energy by human cells? Six
(d) Name a structural polysaccharide found in plants. Cellulose/Pectin
(e) Name a polysaccharide, other than the one referred to in part (d), commonly found in plants. Starch
(f) Which carbohydrate is always found in DNA? Deoxyribose

2014- HI – Section A- Question 2

2. (a) The following biochemical reactions took place in some living cells: (i) A B + C + D Is this an example of anabolism or catabolism? Catabolism
(ii) Fat Fatty Acids + Y Identify X and Y. X = Lipase Y = Glycerol
(b) (i) How does a phospholipid differ from a fat?
Phospholipid: Two fatty acids and a phosphate group
Fat: Three fatty acids
(ii) Name a fat-soluble vitamin. A, D, E, or K
(iii) State a disorder due to a dietary deficiency of the vitamin referred to in (b) (ii).
Vitamin A – Night Blindness
(iv) Give any two functions of minerals in organisms.
Formation of bone (magnesium and calcium)
Formation of haemoglobin (iron)

2012- HI – Section A- Question 1

1. Answer five of the following: (a) Name a monosaccharide. Glucose
(b) Give the formula of the monosaccharide referred to in (a). $C_6 H_{12}O_6$
(c) Name a polysaccharide that can be formed from the monosaccharide referred to in (a). Amylose
(d) Give one way in which an amino acid differs from a monosaccharide, in terms of chemical composition. Amino acids contain nitrogen
(e) What do carbohydrates and fats have in common, in terms of chemical composition? Carbohydrates and fats both contain the elements carbon, hydrogen, and oxygen.
(f) How may one fat differ from another, in terms of chemical composition?
Different fats contain different fatty acids

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