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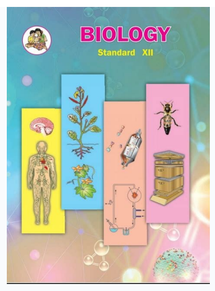

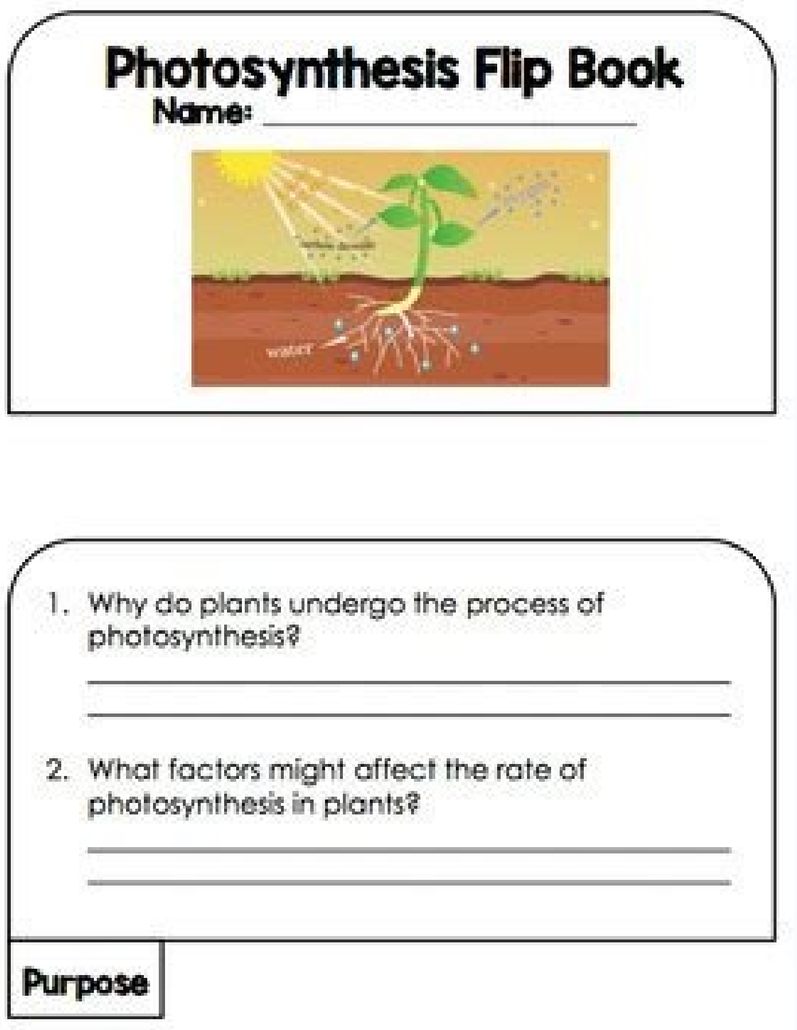

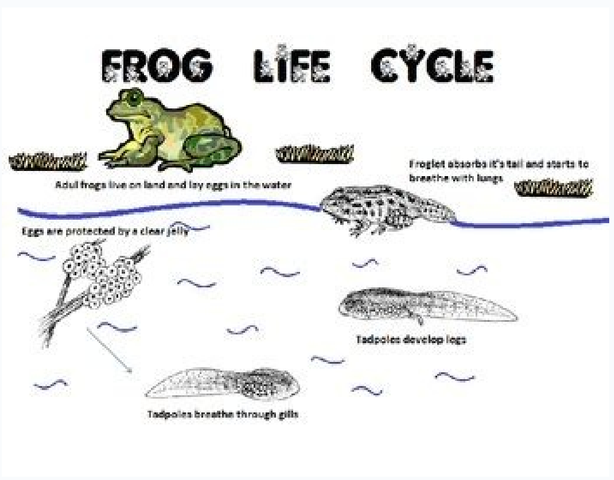

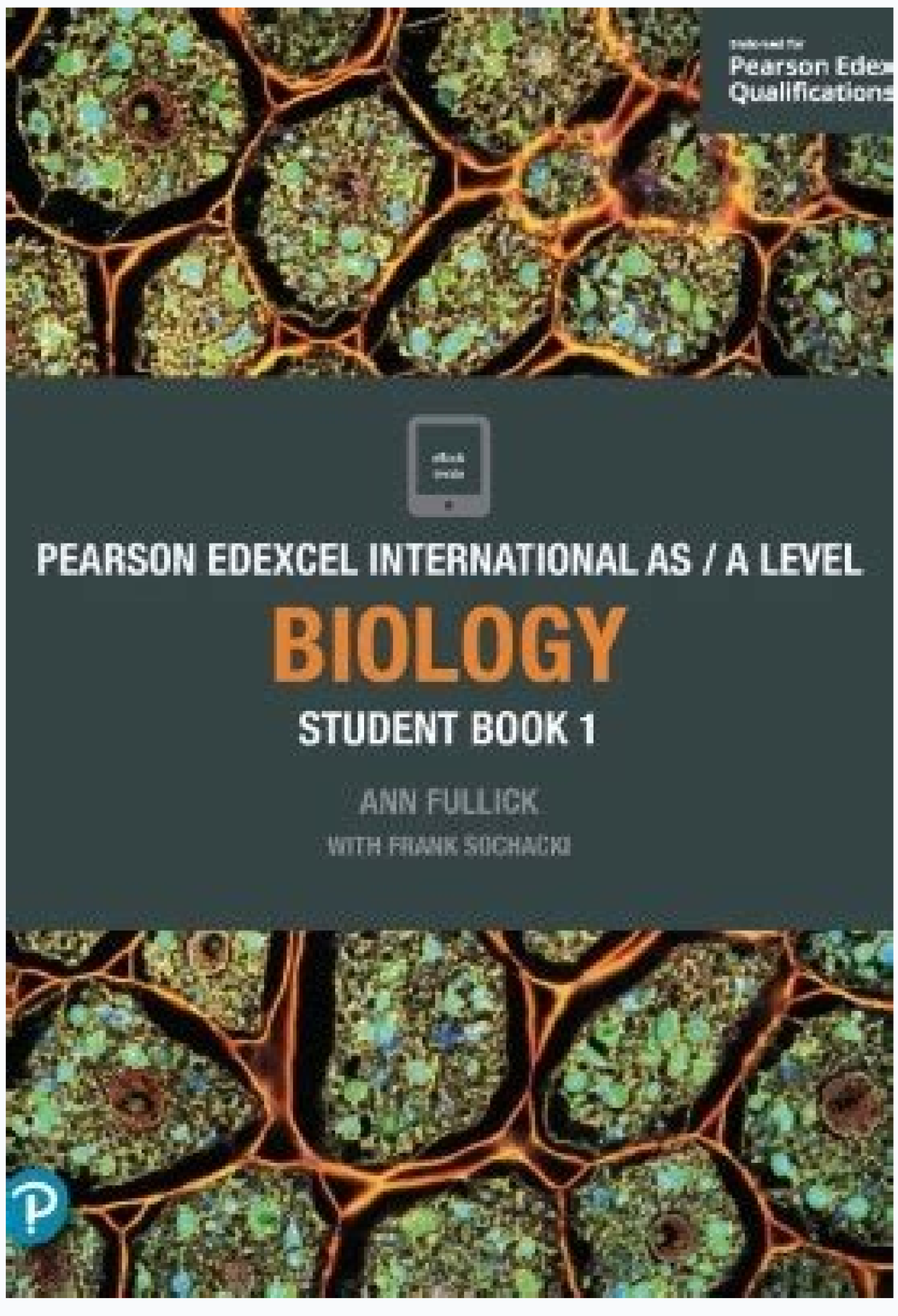

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basics of biology by boniface lisuba pdf download biology notes 10 to 12 biology grade 10 notes distinction in commerce 10-12 pdf geography pamphlet 10-12 pdf download physics pamphlet 10-12 pdf download basics of biology pdf download grade 12 biology textbook pdf download 1. 1 SIMPLY BIOLOGY IN CONJUNCTION WITH ST. LISBON PUBLICATIONS Z A ES 2. 2 BIOLOGY CONTENTS Preface Acknowledgements Introduction 1. LIVING ORGANISMS 1.1 Characteristics of Living Organisms 1.2 Cell Structure, Cell Specialisation, Tissues, Organs, Systems and Organisms 1.3 Transport across Cell Membranes: Diffusion, Osmosis and Active Transport 1.4 Enzymes 1.5 Classification of Living Organisms 2. DRAWING, MEASURING AND MAGNIFICATION 2.1 Drawing 2.2 Measuring 2.3 Magnification 3. 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ECOLOGY 14.1 Some Important Terms 14.2 Energy Flow 14.3 Food Chains and Food Webs 14.4 Ecological Pyramids 14.5 Nutrient Cycles 14.6 Effects of Human Activity on the Environment 14.6.1 Pollution 14.6.2 Deforestation 14.6.3 Desertification 14.6.4 Conservation 14.6.5 The Soil 14.7 Populations 14.8 Biodiversity Preface The writing of this book was inspired by the desire of the author to make an indelible contribution to the educational system of our beloved country, Zambia. The project started in the form of notes that the author was using to teach his Senior Secondary School Biology Classes over a period of nine years. The notes were widely researched and proven through the good grades his students were scoring in Zambian and International Examinations. In addition, they were frequently edited to make them conform to the demands of the Zambian Biology Syllabus produced by the Curriculum Development Centre (CDC). It was not long before there was an outcry to have the notes converted into a book. By that time, the author had been setting examinations for the Examinations Council of Zambia (ECZ) for a considerable number of years. With the help of some of his students, notably Zameer and Shawn Banda, the first manuscript was typed in 2006 and produced in the form of pamphlet. The pamphlet served two purposes. Firstly, it was used for instruction during classes. Most importantly, it was availed to several teachers and pupils who gave invaluable advice. This advice has been taken into account in producing the final copy of this first edition of the book. 4. 4 In a nutshell, the book provides a very solid foundation to beginners and basic experience to those who wish to pursue further studies in Biological Sciences. Acknowledgements I wish to acknowledge the contribution of several individuals and organisation to the development of this publication. Firstly, I thank my former students, Shawn Banda and Zameer, who assisted type part of this work. I am also indebted to a number of former pupils of David Kaunda National Technical High School on whom this material was tried and tested between 2006 and 2009. They were so enthusiastic about the project and inspired me to keep working on it. Special thanks go to Mr. Severian Masesa, the Chief Examiner for the Biology Paper 2 Panel, for using his vast experience in editing this work Introduction INTRODUCTION: WHAT IS BIOLOGY? Biology is defined as the study of living things (organisms). There are several branches of biology such as: Botany (the study of plants) Zoology (the study of animals) Ecology (the study of interactions of organisms with each other and with their non-living environment) Biochemistry (the study of chemical reactions that occur in living organisms) Entomology (the study of insects) CHARACTERISTICS OF LIVING THINGS The characteristics of living things may be summarized by the mnemonic MR. GREFIC. Movement is the process by which a living organism changes its location and posture without external help. The movement of an entire organism from one place to another is also called locomotion. Respiration is the release of energy from food substances inside living cells. There are two types of respiration. These are aerobic and anaerobic respiration. Aerobic respiration is the release of energy from food substances inside living cells in the presence of oxygen. Anaerobic respiration is the release of energy from food substances inside living cells in the absence of oxygen. Aerobic respiration yields more energy than anaerobic respiration. Growth is a permanent increase in size, mass, number of cells and complexity of an organism. 5. 5 Reproduction is the process by which living organisms produce their young ones (offspring). There are two types of reproduction, sexual and asexual. In sexual reproduction offspring are produced by the fusion of male and female gametes (from one or two parents) and are genetically different from their parents. In asexual reproduction the offspring are produced from one parent without involving any gametes and are genetically identical to the parent and each other. Excretion is the removal of toxic metabolic wastes from the cells of the body such as urea, excess salts, excess water, bile pigments and carbondioxide. Feeding/nutrition is the process by which living organisms obtain food. There are two types of nutrition which are autotrophic and heterotrophic. Autotrophic nutrition is the type where an organism makes its own food e.g. green plants. Heterotrophic nutrition is the type where an organism takes in food present in bodies of others. Irritability/sensitivity is the ability to detect and respond to stimuli (singular=stimulus). A stimulus is any change in the environment which causes a response from an organism. Cells are the basic functional units of living organisms. Some organisms are made of single cells e.g. bacteria. Such organisms are called unicellular organisms. Other organisms are made of many cells e.g. fungi, plants and animals. Such organisms are called multicellular organisms. Metabolism/metabolic reactions This is the sum total of chemical reactions that take place inside living cells. There are two types of metabolic reactions, namely anabolic and catabolic reactions. Anabolic reactions are metabolic reactions where large and complex molecules are synthesized from small and simple molecules e.g. photosynthesis, protein synthesis and synthesis of fats. Catabolic reactions are metabolic reactions where large complex molecules are broken down to simpler molecules e.g. respiration, digestion. All metabolic reactions are catalyzed by enzymes. An enzyme is a biological catalyst (a catalyst inside a living organism). MICROSCOPES A microscope is an instrument which is used to make small objects look bigger or magnify small objects which are invisible to the naked eyes. Since most cells are invisible to the naked eye, a microscope is an essential tool in the study of cells. Cells were first discovered by an English scientist called Robert Hooke in 1665. There are several types of microscope. One type is a hand lens. It is a simple microscope made up of a convex lens fitted in a frame with a handle. Most hand lens have numbers such as x 2.5 or x 5. The numbers indicate the magnifying powers. In order to use a hand lens place the object to be viewed on a flat surface, a short distance from the lens itself. Look at the object through the lens. Then move the lens up and down until you see a distinct image. Another type is a compound microscope. It consists of two sets of lenses. The lenses are fitted at the opposite ends of a body tube. The lenses closer to the eye are called eye piece and the ones nearer the object are called the objective lens. The objective lenses are fitted into a revolving nose piece in the order of low power, medium power and high power. Some microscopes however may have only one or two sets of objective lenses. Figure below shows a typical microscope 6. 6 USING A COMPOUND MICROSCOPE In order to view an object, illuminate it first by light, then allow light to pass through the lenses and finally into the eye. The mirror directs the light to the object. Place the microscope slide, with an object to be viewed on the stage and hold it in position by stage clips. Fix the objective lens to be used in line with the eye piece by turning the revolving nose piece. Ensure that a click sound is heared when the objective lens is set in position. Looking from one side of the microscope, keep the eyes at stage level. Then turn the coarse adjustment knob until the low power objectives lens and the object to be viewed are as close to each other as possible. To avoid breaking the slide, do not allow the objective lens to touch the cover slip. Turn the coarse adjustment knob slowly while looking through the eye piece. The turning increases or reduces the distance until a focussed image is obtained. When focussed, always start with low power, then turn to medium power before turning to high power objective lens. In order to obtain a sharp image, slowly turn the fine adjustment knob either clockwise or anti-clockwise. A compound microscope can magnify objects up to one thousand five hundred times (x 1500). MAGNIFICATION Magnification is the number of times the image of the object is enlarged (magnified) as compared to the specimen. For example, a magnification of four (x 4), means that the object is enlarged four times. Magnification has no units. To obtain total magnification, multiply the number on the eye-piece lens by that on the objective lens; i.e. 7. 7 M= power of eye-piece x power of objective lens When the specimen is drawn magnification is calculated using the formula given below. Magnification= size of drawing (image) Actual size of specimen (object) Example: a pupil draw a specimen and the size of the drawing was 103 mm. If the size of the specimen was 53 mm, calculate the magnification. Magnification= size of drawing (image) actual size of specimen (object) = 103 mm 53 mm = 1.9433 Magnification= x 1.9 or 1.9x or 1.9 times or times 1.9 CELLS Cells are too small to be seen by the naked eye. Therefore they are observed using microscopes. A microscope is an instrument used to magnify images of objects that are too small to be seen with the naked eye. There are two groups of microscopes. These are light and electron microscopes. The light microscope shows a simple structure of a cell while the electron microscope shows a detailed or ultrastructure of a cell. A cell is a basic unit of life or basic unit of a living organism or functional unit of a living organism. Simple Structure of a Plant Cell and an Animal Cell Similarities between animal and plant cells They both have cell membranes, cytoplasm and nucleus Differences between animal and plant cells Plant Cell Animal Cell Has cellulose cell wall Does not have cellulose cell wall Has large permanent vacuole Does not have large permanent vacuole Has chloroplasts Does not have chloroplasts Has regular shape and bigger size Has irregular shape and smaller size Detailed structure/Ultrastructure of an Animal Cell 8. 8 Detailed structure/Ultrastructure of a Plant Cell Functions of Cell Parts Nucleus: This part is responsible for controlling cell activities and storage of genetic information on threads of DNA called chromosomes. It is surrounded by a double membrane called the nuclear membrane which has openings called nuclear pores. The inside of the nucleus contains a fluid called the nucleoplasm and a dense body of DNA called the nucleolus. Cell membrane: This part is made of lipids and proteins and is responsible for controlling the substances that enter and leave the cells. It is adapted for this function by being selectively/partially permeable. This means it allows some substances to pass through it but prevents others from passing through. The substances that cross the cell membrane freely include gases (such as oxygen and carbon dioxide) and water because their molecules have small sizes. On the other hand, substances such as urea whose molecules are large do not freely cross the cell membrane but use special carrier proteins to do so. Cytoplasm: This is a jelly-like fluid made of water and dissolved substances such as proteins, salts and sugars. It contains suspended cell structures called organelles and is the site for cell activities. Note: The three parts (nucleus, cytoplasm and cell membrane) are collectively called the protoplasm. The protoplasm is defined as the living part of the cell. Mitochondrion (plural: mitochondria): These are rod-shaped or sausage-shaped structures in the cell. This is where respiration takes place. For this reason mitochondria are called the power house of the cell. 9. 9 Ribosomes: These are small round structures in the cell where protein synthesis takes place. Some ribosomes float freely in the cytoplasm while others are attached to the rough endoplasmic reticulum. Endoplasmic Reticulum: This is a network of membranes used for transportation of substances within the cytoplasm. There are two types of endoplasmic reticulum, namely smooth endoplasmic reticulum and rough endoplasmic reticulum. Rough endoplasmic reticulum has ribosomes on its surface and transports proteins. Smooth endoplasmic reticulum has no ribosomes on its surface and transports lipids. Golgi Bodies: These are a pile of flattened vesicles which modify and carry proteins such as enzymes from the sites of synthesis to the sites of reaction. They are collectively called the Golgi apparatus. Chloroplasts: These are oval-shaped structures found in plant cells. They carry out photosynthesis. They contain a green pigment called chlorophyll which absorbs light energy for photosynthesis. Vacuole: This is a fluid filled space inside the cytoplasm of a plant cell. It contains a fluid called cell sap (a solution of sugars and salts in water) and is surrounded by a membrane called tonoplast. The concentration of the cell sap plays a role in the movement of water into and out of the cell. Cell wall: This is the outermost boundary of the plant cell. It is made of a substance called cellulose. It is important for protection against damage and prevention of bursting when the plant cell gains a lot of water. It also gives shape to the plant cell. It is fully permeable to all substances. Cell Specialization New cells are formed from already existing cells by cell division in an organism. At first, they are all similar in structure. But in order to be suited for their functions they have to undergo cell specialization. This is a process by which a cell undergoes specific changes in structure and chemical composition of the cytoplasm in order to perform a specific function. Examples of specialized cells are ciliated cells, root hair cells, xylem vessels, guard cells, nerve cells, muscle cells, white blood cells and red blood cells. Ciliated cells Functions These are cells found in the inner lining of the respiratory tract and the oviducts. In the respiratory tract they sweep out mucus containing dust particles and germs. In the oviduct they move the ovum towards the uterus. Adaptations Presence of cytoplasmic hairs called cilia A high concentration of mitochondria in the cytoplasm to generate energy for movements of the cilia Root Hair cell: These are cells found near the tips of roots Functions 10. 10 Absorption of water and mineral salts Anchor the plant in the ground Adaptations Has an elongated outgrowth (long extension) which increases the surface area for faster diffusion during absorption. Absence of chloroplast to create more room for absorption. High concentration of mitochondria to provide energy for active absorption/transport of mineral salts. In addition, root hair cells are numerous which further increase their surface area. Xylem Cell Functions Conduction of water and mineral salts Mechanical support of the plant. Adaptations End walls of neighbouring cells broken to form continuous tubes Protoplasm is absent leaving a hollow space in the middle of the cell. Walls are lignified (filled with lignin) to provide mechanical support Muscle Cells Functions Contraction to produce movement Adaptations Abundance of mitochondria to release energy for contraction Presence of actin and myosin filaments in the cytoplasm which carry out contraction. 11. 11 As seen from the diagram, the shapes of the different types of muscles are different from each other Red blood cell (Erythrocyte) Functions Transportation of oxygen and small amounts of carbon dioxide. Adaptations Biconcave disc shape to increase the surface area for diffusion of oxygen. Presence of a red pigment called haemoglobin which has a high affinity (attraction) for oxygen. Haemoglobin combines with oxygen to form oxyhaemoglobin when oxygen concentrations are high (e.g. in the lungs). When oxygen concentrations are low e.g. in the muscles, oxyhaemoglobin dissociates forming haemoglobin and oxygen. Absence of nucleus makes more room for haemoglobin Nerve Cell (neurone) Functions To conduct electrical impulses (nerve impulses) from one part of the body to another. Adaptations Presence of dendrites that collect impulses from neighbouring cells Presence of axon that carries impulses from one end of the neurone to another. Presence of synaptic knob that forms a link with other neurones. Presence of nodes of Ranvier that make impulses move faster Note the part of the neurone having the nucleus and cytoplasm is called the cell body 12. 12 White Blood Cells These are cells that defend the body against infection (diseases). Two examples of white blood cells are phagocytes and lymphocytes. Phagocytes Functions These defend the body against infection by engulfing and digesting germs (foreign bodies). Adaptations Lobed nucleus which makes engulfing of germs easy. Amoeboid movement which makes it possible for them to move towards germs. They have no fixed shape but can change their shapes, making engulfing of foreign bodies possible. Lymphocytes Functions To defend the body against infection by producing antibodies and antitoxins. Antibodies are proteins that destroy germs/foreign bodies while antitoxins are proteins that neutralize poisons from germs. Adaptations Presence of a large nucleus and thin cytoplasm. Guard Cells These are a pair of cells that surround each stoma. Function To control the size of the stoma Adaptations 13. 13 They occur in pairs and each cell has a semicircular (curved) shape when turgid and a straight shape when plasmolysed. Their cell walls are thicker around the stoma than anywhere else; this makes it possible for the stoma to open when these cells absorb water. Phloem Cells Function To transport manufactured food from one part of the plant to another Adaptations End walls between neighbouring cells are perforated to form sieve plates Protoplasm is partly lost leaving behind some cytoplasmic strands Presence of companion cells which supply phloem cells with enzymes and ATP. Palisade Cell Functions Carrying out photosynthesis Adaptations A high concentration of chloroplasts. The cells are longer vertically than horizontally. This allows chloroplasts to migrate upwards or downwards as light intensity changes so that they are not damaged by excess light. 14. 14 Cell Organization A group of specialized cells having the same shape/structure and function make up a tissue. Examples of tissues are epidermis, palisade tissue, spongy tissue, blood, epithelium and bone tissue. A group of tissues performing a specific function make up an organ. Examples of organs are roots, stems, leaves, liver, skin, heart, brain, eyes, ears, kidneys and lungs. What tissues make up each of these organs? A group of organs performing a specific function make up a system. Examples of systems are vascular system, digestive system, excretory system, endocrine system, nervous system, skeletal system, respiratory system and reproductive system. What organs make up each of these systems? A group of systems performing a specific function make up an organism. There are two types of organisms namely: unicellular which has only one cell e.g amoeba and multicellular which has many cells e.g a human being. Levels of cell organization may be summarized as follows: TRANSPORT ACROSS THE CELL MEMBRANE (DIFFUSION, OSMOSIS AND ACTIVE TRANSPORT) Substances enter or leave cells through the cell membrane using three main processes which are diffusion, osmosis and active transport. Diffusion This is the movement of particles from their region of higher concentration to their region of lower concentration (down a concentration gradient). Cell wall Cell membrane cytoplasma vacuole chloroplastnucleus 15. 15 Experiment to Demonstrate Diffusion Materials: A 250 cm3 glass beaker, a long glass tube, a holed rubber bung or stopper, a coloured crystal such as potassium permanganate or copper (II) sulphate and water Method: Set up the experiment as shown in the following diagram First insert one end of the glass tube halfway into the rubber stopper. Place the rubber stopper and glass tube into the beaker, keeping the rubber firmly pressed to the bottom of the beaker. Introduce the coloured crystal of potassium permanganate down the tube. Close the open end of the glass tube with a finger and fill the beaker halfway with water. With one end of the glass tube still closed with a finger, gently lift the glass tube and rubber stopper out of the beaker without disturbing the crystal. Observe what happens in the beaker until there are no further changes. Observations: At the beginning, the clear water and coloured crystal are each clearly visible After some time, the colour of the crystal starts spreading out but some of the water still remains clear. Eventually, all the water is evenly coloured by the colour of the crystal Conclusion: The particles of the potassium permanganate crystal spread out in the water by the process of diffusion. Factors that affect the rate of Diffusion The rate at which particles diffuse is affected by the following factors: Concentration gradient Surface area of diffusion surface Thickness/ distance of diffusion surface Temperature Size of diffusing particles Concentration gradient: This refers to the difference in concentration of particles between two regions. The higher the concentration gradient, the faster the diffusion rate. Surface area of Diffusion Surface: The larger the surface area of the diffusion surface, the faster the rate of diffusion. Thickness of Diffusion Surface: The thinner the diffusion surface, the faster the diffusion rate. Temperature: Increase in temperature increases the kinetic energy of particles causing them to diffuse at a faster rate. Size of Diffusing Particles: The bigger the diffusing particles, the slower the diffusion rate; the smaller the diffusing particles, the faster the diffusion rate. 16. 16 Importance of Diffusion Diffusion is important in living organisms in the following ways: Oxygen moves from the lungs to the blood and from the blood to the tissue cells by diffusion. Carbon dioxide moves from the tissue cells to the blood and from the blood to the lungs by diffusion. Dissolved food moves from the blood into the tissue cells by diffusion. Metabolic wastes such as urea move from the tissue cells into the blood by diffusion. Carbon dioxide needed for photosynthesis by plants moves from the atmosphere into the leaves by diffusion. Oxygen produced during photosynthesis moves out of the leaves to the atmosphere by diffusion. Water vapour moves out of the air spaces of leaves to the atmosphere during transpiration by diffusion. Osmosis Osmosis is the movement of water molecules from a region of higher water potential to a region of lower water potential through a selectively permeable membrane. Water potential is a measure of the capacity or tendency of water molecules to move from one solution to another. Distilled water has the highest water potential. The more concentrated a solution becomes, the less its water potential becomes. A selectively permeable membrane can allow water molecules to pass through because of their small size but cannot allow solute molecules to pass through because of their big size. The following diagram illustrates what occurs during osmosis. Experiment to Demonstrate Osmosis Set up the experiment as shown in the following diagram Mark the initial level of liquid in each of the three glass tubes. Record what happens to the liquid level in each glass tube after five minutes. 17. 17 Observations In A the liquid level drops. In B the liquid level stays the same. In C the liquid level rises. Conclusion During osmosis, water molecules move from a less concentrated solution to a more concentrated solution through a selectively permeable membrane until a dynamic equilibrium is reached. Equilibrium is a state where the number of water molecules moving to either side of the selectively permeable membrane is equal. Osmosis is important in living organisms mainly in movement of water into and out of cells (absorption of water by plants, movement of water from cell to cell e.t.c) Effects of Osmosis in Living Organisms The cells, tissues, organs and systems of living organisms are always exposed to body fluids or solutions of different concentrations. There are three types of solutions an organism may be exposed to, namely hypotonic, isotonic and hypertonic solutions. A hypotonic solution is one whose concentration is lower than the concentration inside a living cell. An isotonic solution is one whose concentration is equal to the concentration inside a living cell. Isotonic solutions have no net osmotic effects in living organisms because a dynamic equilibrium exists between them and the living cells. A hypertonic solution is one whose concentration is higher than the concentration inside a living cell. a) Effects of Osmosis in Animals When an animal cell such as a red blood cell is placed in a hypotonic solution, it gains water by osmosis because the water potential of the hypotonic solution is higher the water potential inside the cell. As a result, it swells and eventually bursts. The bursting of an animal cell due to osmotic gain of water is called cell lysis. When an animal cell is placed in a hypertonic solution, it loses water by osmosis because the water potential inside the cell is higher than the water potential of the hypertonic solution. As a result, it shrinks and crinkles/wrinkles. The shrinking and crinkling of an animal cell due to osmotic loss of water is called crenation. Osmotic loss of water by animal tissues leads to dehydration of the animal. The following diagrams illustrate cell lysis and crenation. Cell lysis and crenation in a red blood cell b) Effects of Osmosis in Plants When a plant cell is placed in a hypotonic solution, it gains water by osmosis because the water potential of the hypotonic solution is higher than the water potential inside the plant cell. As a result, its protoplasm swells and eventually starts pressing against the cell wall. The condition where the protoplasm of a plant cell presses against the cell wall due to osmotic gain of water is called turgidity. A plant cell that is undergoing turgidity is said to be turgid. Why does the plant cell not burst? (Refer to structure of cell wall). When a plant cell is placed in a hypertonic solution, it loses water by osmosis because the water potential inside the cell is higher than the water potential of the hypertonic solution. As a result, its protoplasm shrinks and pulls away from the cell wall. The condition where the protoplasm of a plant cell pulls away from the cell wall due to osmotic loss of water is called plasmolysis. A plant cell that is undergoing plasmolysis is said to be plasmolysed. The following diagrams illustrate turgidity and plasmolysis. 18. 18 When a plant tissue such as a peeled potato tuber is placed in a hypotonic solution, it gains water by osmosis and becomes bigger and more firm. The presence of water in plant tissues forms a hydrostatic skeleton which renders mechanical support to the entire plant When a plant tissue such as a peeled potato tuber is placed in a hypertonic solution, it loses water by osmosis and becomes flaccid/flabby (smaller and weaker). In a living plant, this leads to a condition called wilting. Wilting is the sagging of delicate plant parts such as leaves, flowers and young stems due loss of water. Temporary wilting is one which can be reversed by supplying a plant with water. Permanent wilting can not be reversed even if a plant is supplied with water the plant tissues have already died. Suggest why it is not advisable to apply too much fertilizer on plants. Active Transport The movement of particles against a concentration gradient using energy from ATP. It is the main process by which mineral ions move into and out of cells (e.g. ion uptake by root hairs and uptake of glucose by epithelial cells of the villi). ENZYMES Enzymes are defined as biological catalysts. A catalyst is any substance that speeds up the rate of a chemical reaction without itself being changed by the reaction. Enzymes catalyze chemical reactions in living organisms. Those that work inside of living cells are called intracellular enzymes while those that work outside living cells are called extracellular enzymes. The substances on which enzymes act to form products are called substrates. The part of an enzyme where the substrate fits during an enzyme-catalyzed reaction is called the active site while the other parts of the enzyme are called allosteric sites. A typical enzyme-catalyzed reaction may be represented as follows: Characteristics of Enzymes Most of them are protein in nature They are catalysts They catalyze both forward and reverse reactions. That is why the reactants, intermediates and products in the equation above are linked by half arrows pointing forwards and backwards. They are specific. This means each enzyme acts on only one substrate or a narrow range of related substrates. Enzyme specificity is discussed latter in this booklet. Their activity is affected by temperature, PH, substrate concentration, enzyme concentration, inhibitors and cofactors (coenzymes and activators).Memory aid: SEPTIC Explanation of Enzyme specificity Enzyme + Substrate Enzyme-substrate complex Enzyme + Product 19. 19 One of the theories used to explain enzyme specificity is called the lock-and-key mechanism. This theory states that each substrate fits into the active site of a particular enzyme in the same way a key fits into a specific lock because the two have complementary shapes. The following diagram illustrates the lock-and-key mechanism. Factors that Affect Enzyme Activity (i) Temperature Enzyme activity increases with increase in temperature up to the optimum temperature. This occurs because an increase in temperature results in increase in the kinetic energy of both the enzyme and the substrate, leading to increased interaction between enzyme and substrate and formation of enzyme-substrate complex. At temperatures lower than the optimum, the rate of an enzyme-catalyzed reaction doubles with every increase of 10 o C. The optimum temperature is the temperature at which an enzyme works best. The activity reduces after the optimum temperature because the enzyme gets denatured and loses its catalytic function. Enzyme denaturation is the disturbance of the shape of an enzyme and its active site such that the substrate no longer fits in the active site. Hence the enzyme can no longer carry out its catalytic function. The following graph shows how enzyme activity is affected by temperature. (ii) pH PH is a measure of how acidic or alkaline a substance is. PH values range from 1 to 14. A PH value of 7 is said to be neutral. PH values lower than 7 a said to be acidic while values higher than 7 are said to be alkaline. This means that acidity increases as PH values get lower than 7 and alkalinity increases as PH values get higher than 7. The following diagram illustrates the PH scale. The PH value at which a given enzyme works best is called the optimum PH. Values lower or higher than the optimum PH lower enzyme activity. The optimum PH varies from enzyme to enzyme, depending on the enzyme‟s natural occurrence. For instance, the digestive enzymes of the stomach work best at acidic PH values while those of the duodenum work best at alkaline PH values. A graph of enzyme activity against PH is always symmetrical and has its peak at the optimum PH, as illustrated by the following diagram. 20. 20 (iii) Enzyme Concentration The rate of an enzyme-catalyzed reaction increases with increase in the concentration of the enzyme and remains constant when there are no more free substrate molecules for the enzyme to act on. (iv) Substrate Concentration The rate of an enzyme-catalyzed reaction increases with increase in the concentration of the substrate and levels off (remains constant) when all the enzyme active sites are occupied by the substrate molecules. Additional substrates have no where to fit on the enzymes. (v) Inhibitors An enzyme inhibitor is any substance that slows down or completely stops enzyme activity. Competitive inhibitors bind to the active site of an enzyme and block the substrate from binding there. Non-competitive inhibitors bind to allosteric sites of an enzyme and cause the shape of the active site to change so that the substrate fails to bind. All metabolic poisons are examples of enzyme inhibitors. (vi) Cofactors 21. 21 An enzyme co-factor is any non-protein substance whose presence makes an enzyme active. Organic cofactors are called co-enzymes e.g. vitamins. Inorganic cofactors are called activators e.g. mineral salts. Naming of Enzymes One way of naming enzymes is using the first part of the substrate name and the suffix –ase, as illustrated by the following table. Name of Substrate Name of Enzyme Carbohydrates (i) Starch (amylose and amylopectin) (ii) Maltose (iii) Sucrose (iv) Lactose Carbohydrase (i) Amylase (ii) Maltase (iii) Sucrase (iv) Lactase Proteins (i) Peptide Protease (i) Peptidase Lipids Lipase NB: Most protease enzymes have names ending with –in e.g. pepsin, trypsin and rennin. Some Industrial Applications of Enzymes Enzymes have applications in many industries and professions. A few examples are discussed below. (i) Making of Biological Detergents Enzymes are included in biological detergents so that they can hydrolyze stains of biological origin. The most commonly used enzymes are proteases which breakdown protein stains such as blood and chlorophyll stains, forming colourless amino acids as products. Lipases and carbohydrases may be used to get rid of lipid and carbohydrate stains, respectively, but these are easy to wash even with ordinary detergents. (ii) Brewing and Baking Baking and brewing both make use of the enzyme zymase which is found in yeast. When baking, flour, water, sugar and yeast are mixed to make dough. Yeast secretes zymase which breaks down sugars to form alcohol and carbon dioxide. The carbon dioxide forms bubbles which cause the dough to rise. When brewing cereal seeds are soaked until they start germinating. During the process of germination, starch is broken down to maltose by the enzyme amylase. Maltose is broken down to glucose by maltase. The seeds are dried and ground to form a powder. The powder is boiled in hot water to form a paste. After the past cools, yeast is added. The enzyme zymase from yeast acts on sugars to form alcohol and carbon dioxide. The alcohol is removed from the mixture by distillation. (iii) Making Sweeteners for Food and Drinks In sweetening of confectioneries, glucose is converted into fructose by the enzyme glucose isomerase because fructose is sweeter than glucose. (iv) In the Dairy Industry In the dairy industry, the enzyme rennin is used to coagulate milk during the making of yoghurt and cheese. 22. 22 (v) Tanning of Leather Tanning is a process by which leather is made soft and pliable. Trypsin is utilized to digest proteins in the leather during tanning. (vi) Extraction and Processing of Fruit Juice When extracting juices from fruits enzymes known as cellulases and pectinases are used to increase the juice yield and prevent jellying of the juices, respectively. (vii) Tenderizing of Meat The meat industry makes use of Trypsin to tenderize meat and predigest baby food. CLASSIFICATION OF ORGANISMS Classification is the placing of organisms in groups based on features they have in common. It involves taxonomy, nomenclature and the construction and usage of identification keys Taxonomy The branch of biology where each organism is placed in a series of groups arranged in a hierarchy is called taxonomy. The groups are called taxa (singular: taxon). A taxon is a group of organisms that have similar features. The highest taxon an organism can belong to is a kingdom. Each kingdom is made of related phyla (singular: phylum); each phylum is made of related classes; each class is made of related orders; each order is made of related families; each family comprises a number of related genera (singular: genus) and each genus is made of related species. The species is defined as a group of organisms having similar features and capable of interbreeding to produce fertile offspring. It is the lowest taxon an organism can belong to. The above hierarchy of taxa can be remembered using the following memory aid: Kings Play Chess On Fine Gold Stools. The taxonomies of the human being, lion and maize plant are given in the following table: Taxon Human being Lion Maize Wolf Kingdom Animalia Animalia Plantae Animalia Phylum Chordata Chordata Angiospermophyta Chordata Class Mammalia Mammalia Monocotyledoneae Mammalia Order Primates Carnivora Commelinales Carnivora Family Hominid Felideae Poaceas Canidae Genus Homo Panthera Zea Canis Species Homo sapiens Panthera leo Zea mays Canis lupus Nomenclature Nomenclature is the naming of organisms with scientific names. The system of naming used is called the binomial system of nomenclature. In this system, the biological/scientific name of each organism has two parts. The first part is the name of the genus (generic name) and always begins with a capital letter while the second part is the name of the species (specific epithet). If printed, the name is italicized (e.g. Homo sapiens) but if hand-written, the name is under-lined (e.g. Homo sapiens). This is to indicate that the name is scientifically accepted world-wide. The names are normally in Latin because it was the original scientific language and is universally accepted. When written for the first time, the name must be written in full (e.g. Panthera leo) but if mentioned afterwards, only the first letter of the generic name is written followed by the full specific epithet (e.g. P. leo). 23. 23 Kingdoms There are five kingdoms of living organisms, namely Kingdom Prokaryota (the prokaryotes or bacteria), Kingdom Protoctista (the protoctists or protists such as Amoeba, Plasmodium and Trypanosoma), Kingdom Fungi (the fungi such as yeasts, mushrooms, toadstools and Penicillium), Kingdom Plantae (the plants) and Kingdom Animalia (the animals). Viruses are not assigned a kingdom because they are considered to be on the border-line between living and non-living things. When independent, they behave like non-living particles because they do not metabolize or self-regulate. But once inside a host, they behave like living things by carrying out reproduction. Kingdom Prokaryotae No nucleus; no double-membraned organelles; unicellular; includes all bacteria (singular=bacterium) Kingdom Protoctista Have well defined nucleus; have double-membraned organelles; mainly unicellular (single- celled) or with a cellular level of organization; includes protozoa and algae. Examples of protists are Plasmodium, Amoeba and Trypanosoma. Kingdom Fungi Multicellular; Have well defined nucleus; have double-membraned organelles; cell wall of chitin; non photosynthetic (no chloroplasts); saprophytic nutrition; examples are yeasts, moulds, mushrooms and toadstools. Kingdom Plantae Multicellular; Have well defined nucleus; have double-membraned organelles; cellulose cell walls; photosynthetic (presence of chloroplasts); includes mosses, ferns, conifers and flowering plants. Flowering Plants They have well developed roots, stem, vascular system and leaves; they bear flowers; they bear seeds which are enclosed in fruits. There are two classes: monocotyledonous and dicotyledonous plants. 24. 24 Monocotyledoneae Dicotyledoneae Each seed has one cotyledon Each seed has two cotyledons Have fibrous root system Have taproot system Leaves are long and narrow and have parallel veins Leaves are broad and have branched veins Dull-coloured flowers having three floral parts Brightly coloured flowers having four or more floral parts Vascular bundles are scattered in the stem Vascular bundles arranged in a circle in the stem Examples include all grasses Examples include all legume plants Kingdom Animalia Multicellular; have well defined nucleus; have double-membraned organelles; no cell walls; heterotrophic nutrition; presence of nervous system; presence of anterior and posterior ends; presence of dorsal and ventral surfaces; presence of two lateral surfaces; presence of either radial or bilateral symmetry; includes invertebrates and vertebrates. Invertebrates These are animals without backbones. They include the following phyla: Cnidaria (e.g. sea anemones, corals, hydras and jellyfish): have radial symmetry; have tentacles. Mollusca (e.g. snails, slugs, squids, limpets, mussels and octopus): soft-bodied with a muscular foot; slimy covering; two pairs of tentacles, one with eyes and the other with smell receptors; usually have shells Nematoda (unsegmented roundworms): often microscopic, parasitic and extremely common. Platyhelminths (flatworms such as tape worm and liver fluke): flat, unsegmented and bilaterally symmetrical; mouth present but no anus. Annelida (truly segmented worms e.g. earthworms): long cylindrical bodies; bristle (chetae); clitellum Echinodermata (sea urchins and starfish) Arthropoda (Crustaceans, insects, myriapods and arachnids): theses are animals with jointed appendages, Exoskeleton, Bilateral symmetry, segmented body, Ventral notochord and dorsal heart. (Can be summarized JEBSVD). Crustaceans (e.g. crabs, lobsters, crayfish and woodlice): aquatic or found in damp places; cephalothorax present; two pairs of antennae; three pairs of jaws; exoskeleton not water proof. 25. 25 Insects: 3 body regions (head thorax and abdomen), 2 pairs of wings, compound eyes, 3 pairs of legs, tracheal system for respiration. Myriapods (centipedes and millipedes): terrestrial; herbivorous; one pair of antennae; one pair of jaws; many legs; centipedes have flattened bodies and one leg per segment; millipedes have cylindrical bodies and 2 pairs of legs per segment. Arachnids: 2 body regions (cephalothorax and abdomen); 4 pairs of legs; powerful jaws; spinneret (used for spinning webs in spiders); wings absent; 26. 26 simple eyes; antennae absent; one pair of appendages; one pair of sensory appendages. Identification Keys for the Kingdoms of Living Organisms An identification key is a series of statements about characteristics of organisms which, if followed step by step, makes it possible for identification or classification of organisms. The type of key normally used in Biology called the dichotomous key. In this type of key, there is a series of paired contrasting statements or a branching tree diagram, leading to the identification of the organisms covered by the key. When constructing an identification key, one must always begin by listing the characteristics of the organisms they are trying to identify and then proceed with construction of the key based on the listed characteristics. This presentation attempts to give some practice in the use of an identification key to place organisms in their kingdoms. Exercise You are provided with three specimens labelled A, B and C. Use the identification key provided below to write down the scientific name of each of the three specimens. Identification Key for Specimens A, B and C 1. Organism has simple eyes (go to 2) Organism has compound eyes (Glossina fuscipes) 2. Organism has four pairs of limbs (Euscorpius carpathicus) Organism has more than four pairs of limbs (Scolopendra subspinipes) 27. 27 DRAWING, MEASURING AND CALCULATION OF MAGNIFICATION Observations made on specimens may be reported in the form of fully labelled drawings, depending on the nature of the specimen. The following considerations should be made when drawing specimens and labelling diagrams: Drawing The drawing must be big enough. This means it must be at least 6.0cm at its longest point or occupy about one-third of an A4 page. However, it must still fit within the space provided on the answer sheet and leave space for labels. The drawing must be clean (no dirty rubbings), clear (no double or disconnected lines and no shading) and realistic (a true reflection of the specimen provided and not a mere replica of a text book diagram) Labelling Label as many parts/structures on the diagram as possible. For this reason, is advisable to draw the specimen from the view/side that gives as many details as possible. Pointer lines must touch the part or structures being labelled on the diagram and must never cross each other or else the labels concerned are rejected. Arrowheads are not required on pointer lines. Measurements Unless otherwise instructed, measurement of the specimen size must be taken along the longest part. For circular specimens, the longest line passing through the centre must be used. A line must be drawn along a corresponding part on the drawing/diagram. Measurements must be recorded to one decimal place if in centimetres or no decimal place if in millimetres e.g. it is correct to record 6.0 cm or 60 mm but wrong to record 6 cm or 60.0 mm. The following diagram illustrates a drawing of a transverse section of an orange, taking into account the principles discussed above. Magnification marks: The formula must be correctly stated as: 28. 28 Magnification = Size of Image/Drawing Size of Object/Specimen The substitution must be correctly done with identical units in the numerator and denominator. A substitution where size of specimen is swapped with size of drawing is wrong and makes the rest of the calculation wrong. When the units in the numerator and denominator are not identical, the substitution is rejected along with the rest of the calculation e.g. if an individual measures the specimen size as being 6.4 cm and the corresponding measurement on the diagram is 7.2 cm, the substitution will be correct if written as: 7.2 cm/6.4 cm or 72 mm/64 mm but will be wrong if written as: 7.2/6.4 or 72/64 or 7.2cm/64 mm or 72 mm/6.4 cm. The final answer for magnification must be written to one decimal place with a multiplication sign (X) or the word „times‟ either before or after the magnification and without units. e.g. the answer for the substitution given above is 1.125 but should be written as: X1.1 or 1.1X or times 1.1 or 1.1 times. In summary, the magnification for the above given situation would be calculated as follows: Magnification = Size of Image = 7.2 cm = X 1.1 Size of Object 6.4 cm Exercise: a) Measure the length of the orange cross section specimen:.. b) Measure the length of the orange cross section drawing:.. c) Calculate the magnification of the drawing NUTRITION This is the process by which living organisms obtain food. Modes of Nutrition The following diagram gives a summary of the main modes of nutrition living organisms. There are two main modes of nutrition namely autotrophic and heterotrophic. Autotrophic nutrition is a type of nutrition where an organism makes its own food. Organisms that carry out autotrophic nutrition are called autotrophs. Those that use energy from sunlight to make food are called phototrophs or photoautotrophs (e.g. green plants) while those that use energy from chemical reactions to make food are called chemotrophs or chemoautotrophs (e.g. 29. 29 nitrifying bacteria). Heterotrophic nutrition is where an organism takes food present in the bodies of other organisms. It includes parasitic, saprophytic and holozoic nutrition. Organisms that carry out heterotrophic nutrition are called heterotrophs. Parasitic nutrition is a type of nutrition where an organism known as the parasite lives and feeds off another organism called the host, often causing harm such as disease, physical injury or even death in the process. The parasite is always smaller than the host. There are two types of parasites which are exoparasites (those that live on external surfaces of the body e.g. lice) and endoparasites (those that live inside the body e.g. tapeworms and roundworms) Saprophytic nutrition is a type of nutrition where an organism called the saprophyte feeds on dead and decaying organic matter known as the substrate. The saprophyte feeds by secreting extracellular digestive enzymes from its hyphae. These enzymes hydrolyze the substrate and the saprophyte absorbs the end products. Examples of saprophytic organisms are mould fungi such as Mucor and Rhizopus. Structure of Mucor and Rhizopus The bodies of Mucor and Rhizopus are made of threads called hyphae. A mass of hyphae is called a mycelium. Horizontal hyphae are called stolons; root like hyphae are called rhizoids while those that bear spore cases (sporangia) are called sporangiophores. Each spore case contains numerous spores. Spores are microscopic structures produced asexually which are capable of germinating under favourable conditions. Saprophytes are important in the following ways: They decompose dead organic matter, thereby preventing accumulation of dead bodies They play a role in the recycling of nutrients such as carbon and nitrogen Some saprophytes are used as food e.g. mushrooms. Some saprophytes such as yeast are important in brewing and baking Holozoic Nutrition is a type of nutrition which occurs in animals in a specialized tube called the alimentary canal and involves five stages namely ingestion, digestion, absorption, assimilation and egestion. Ingestion is the intake of food into the mouth; digestion is the breaking down of food; absorption is the uptake of soluble food into the blood stream; assimilation is the usage and incorporation of food in living cells; egestion is the removal of undigested foods from the body through the anus. Symbiosis/Mutualism: This is an association between two different species of organisms where each species benefits the other. Examples of mutualism are: The association between ruminants and the microbes which are found in their guts. The ruminants provide a habitat and gather food which is used by the microbes. 30. 30 The association between legumes and nitrogen-fixing bacteria (Rhizobium sp). The legumes provide a habitat to the Rhizobium while the Rhizobium fixes nitrogen into the legume plant. Nutrients A nutrient is any substance which provides the body with any or all of the following: Energy Material for growth Protection against diseases Proper functioning of the body Classes of Nutrients There are seven classes of nutrients namely: Carbohydrates, lipids, proteins, water, mineral salts, vitamins and roughage. Memory aid: Calipro Wamiviro. Carbohydrates These are nutrients that are made of carbon, hydrogen and oxygen and are a source of energy. Lack of carbohydrates in diet leads to marasmus. They are commonly obtained from plants. There are three classes of carbohydrates, namely monosaccharides, disaccharides, and polysaccharides. (i) Monosaccharides are the simplest carbohydrates and make up the building blocks of carbohydrates. They are also called simple sugars. Groups of monosaccharides include trioses, tetroses, pentoses, hexoses, heptoses and so on. The hexoses are the most famous and include fructose, glucose and galactose (memory aid: FGG). The common name, occurrence and use of each of them are given in the following table. Monosaccharide Common name Natural occurrence Uses Glucose Blood sugar In honey and blood Main substrate of respiration Fructose Fruit sugar In fruits, nectar and honey Attracts and rewards to animals that pollinate flowers and disperse seeds Galactose In milk Source of energy for young mammals (ii) A disaccharide is made of two monosaccharide units chemically combined by condensation. Well-known disaccharides include lactose, maltose and sucrose (memory aid: LMS= Lusaka Music Society). The following table summarizes the common names, natural occurrence and uses of each of them. Disaccharide Common name Natural occurrence Uses Constituent monomers Lactose Milk sugar Milk Source of energy for young mammals Glucose and Galactose Maltose Malt sugar Germinating seeds Source of energy for germinating seeds Glucose units only Sucrose Cane/table sugar Stored in sugar cane, beet root and onions Form in which plants transport Glucose and fructose 31. 31 carbohydrates NOTE: All monosaccharides and disaccharides are collectively called sugars. A sugar is a carbohydrate which has the following characteristics: soluble in water has a sweet taste is crystalline Some of the sugars are also known as reducing sugars This is because they can reduce Cu^{2+} ions to Cu^{+} ions. All monosaccharides and disaccharides except sucrose are reducing sugars. Sucrose is a non-reducing sugar. (iii) Polysaccharides are complex carbohydrates made of more than two monosaccharides chemically combined by condensation. Common polysaccharides include starch, glycogen and cellulose. Starch is the main storage carbohydrate in plants. Excess glucose in plants is converted to starch and stored in cell structures called amyloplasts. Starch is suited for the role of storage molecule in the following ways: It is insoluble in water; hence it cannot be lost from storage cells; It has no osmotic effects It is relatively unreactive It is compact and does not take up much space; It is easily hydrolysed by enzymes when glucose levels are low. The main sources of starch are cereal seeds and tubers, though all plants generally are a source of starch. Glycogen is the main storage carbohydrate in animals. In humans, when there is excess glucose in the blood, the hormone insulin produced by the pancreas causes cells in the liver and muscles to convert the excess glucose into glycogen which is stored in the liver and muscles. The human body can store about 400g of glycogen (roughly 300g in the muscles and 100g in the liver). When glucose levels are low in the blood, the hormone glucagon produced by the pancreas causes muscle and liver cells to convert glycogen to glucose. Glycogen is sometimes called animal starch because its characteristics are similar to starch. It differs from starch by being more branched, making it less dense and easier to digest than starch. This is one reason why animals have a faster metabolic rate than plants. Cellulose is a structural carbohydrate found in cell walls of plants. It has a high tensile strength (does not stretch easily), thereby protecting plant cells and preventing lysis when there is excessive osmotic inflow of water. Animals cannot digest cellulose on their own because they do not secrete the enzyme cellulase which digests cellulose. Those that depend on plant diets have symbiotic relationships with microbes which secrete cellulase. However, cellulose is still useful as roughage which stimulates peristalsis and prevents constipation. Lipids These are nutrients made of the elements carbon, hydrogen and oxygen. However the amount of oxygen in lipids is less than the one found in carbohydrates. They are insoluble in water but soluble in alcohol and organic solvents such as acetone, benzene and chloroform. Edible lipids include oils and fats. Oils are liquid at room temperature while fats are solid at room temp. The building blocks of lipids are glycerol and fatty acids. Each molecule of a fat comprises one molecule of glycerol and three molecules of fatty acids. 32. 32 Uses of Lipids Water proofing- certain organisms such as ducks secrete lipids which prevent their bodies from getting wet with water Insulation- animals have a layer of fat under their skins which prevents heat loss from the body Formation of cell membrane- the cell membrane is made of lipids called phospholipids which can be synthesized from fats and oils Energy source-lipids store a lot of energy which is made available when the supply of carbohydrates in the body is low. In fact lipids store twice as much energy as an equal amount of carbohydrates. The uses of lipids can be summarized by the mnemonic WIFE. Sources of lipids include vegetable oils and animal fats. Proteins All proteins contain carbon, hydrogen, oxygen and nitrogen. Most of them also contain sulphur or phosphorous and a small number of them contain metals such as iron (haemoglobin) and magnesium (chlorophyll). The building blocks of proteins are amino acids. There are twenty amino acids commonly found in living organisms and theses may be divided into two groups namely essential and non-essential amino acids. Essential amino acids are those that the body cannot synthesize but must be part of the diet. Non-essential amino acids are those that the body can synthesize and so are not required in the diet. Amino acids are linked by peptide bonds to make molecules known as peptides. A peptide molecule consisting of two amino acids is called a dipeptide while one with more than two is called a polypeptide. Most proteins are polypeptides. Sources of proteins include meat, fish, milk, eggs and legume seeds such as beans, ground nuts, peas e.t.c Uses of proteins growth and repair of body tissues they are important for making body chemicals such as hormones, enzymes, antibodies, antitoxins, haemoglobin, keratin, melanin, collagen, actin and myosin Water It is an inorganic molecule made of the elements hydrogen and oxygen, its chemical formula is H_2O. Uses of Water It is a universal solvent- where substances needed by the body are dissolved and transported Thermoregulation- water is a coolant when the body gets hot and also helps distribute body heat from active organs Digestion- involved in chemical breaking down of large molecules into smaller ones- also called hydrolysis. It is a component of body fluids- saliva, blood, lymph e.t.c It is a participant in metabolic reactions such as photosynthesis. It makes up the hydrostatic skeleton in some organisms such as worms. It prevents constipation (difficult defaecation due to dryness and hardness of faeces). 33. 33 If water is lacking in the body, an organism suffers from dehydration. In humans insufficient water can also lead to constipation. Mineral Salts These are inorganic substances and are required by the body in small amounts and their absence causes serious deficiency diseases. They are absorbed into the body in the form of ions (charged particles formed when an atom gains or loses electrons). They function as enzyme activators. Examples of mineral salts are calcium and iron. Calcium This is a mineral salt important in the following ways: formation of strong bones and teeth conduction of nerve impulses contraction of muscles an activator of certain enzymes Sources of calcium include milk, eggs, meat and bones. Calcium deficiency leads to a condition known as rickets (the formation of weak and deformed bones) Iron It is a mineral salt which is important in the formation of haemoglobin. Iron deficiency leads to Anaemia. Sources of iron include meat, green vegetables and fruits. Iodine important in the formation of hormone called thyroxine produced in the thyroid glands. This hormone controls metabolic reactions such as respiration. Sources include iodised salt, sea foods, water. Iodine deficiency leads to goitre (swelling in the neck) and stunted growth (dwarfism). Phosphorus Important in the formation of chemical substances called adenosine diphosphate (ADP) and adenosine triphosphate (ATP). It is also responsible for the formation of strong bones and teeth. Souces include meat Vitamins Vitamins are organic molecules required by the body in small amounts and their absence leads to deficiency diseases. They function as co-enzymes. There are two groups of vitamins, namely water soluble (those that dissolve in water i.e. B and C) and fat soluble vitamins (those that dissolve in fats i.e. A, D, E and K) Vitamin C (Ascorbic acid) This is a water-soluble vitamin important for the formation of connective tissues of the body. Vitamin C deficiency leads to a disease called scurvy (characterized by swollen and bleeding gums, poor healing of wounds and painful muscles). Sources of vitamin C include fresh vegetables and fruits. Vitamin C tends to get destroyed by over-cooking and long periods of storage. Vitamin D It is a fat soluble vitamin which is required in the absorption and metabolism of calcium and phosphorous. Deficiency of vitamin D leads to rickets. Sources of vitamin D include fish liver oil, milk and eggs. The skin is also able to synthesize this vitamin when exposed to sunlight. Roughage This is the indigestible part of the diet made of cellulose. It adds bulk to faeces and stimulates peristalsis (wave like motion) along the alimentary canal, thereby preventing constipation. Lack of roughage leads to constipation (difficult defaecation due to hardness and dryness of faeces). The other name for roughage is dietary fibre. Sources include maize, unpolished cereals, fruits etc. 34. 34 Exercise: Write a short essay about the uses, benefits and health hazards associated with food additives including colourings. Food Tests 1. The Iodine Test for Starch (a) If the sample is in solid /powder form Place a small amount of sample on a white tile Add a few drops/2 drops of iodine solution to the sample; then observe and record what happens. (b) If the sample is in solution/suspension form Place 2 cm3 of sample solution into a clean and dry test tube. Add a few drops/2 drops of iodine solution to the test tube and shake; Then observe and record what happens. The possible observations and corresponding conclusions are given in the table below: Observation Conclusion Solution remains yellowish-brown Starch absent Solution turns blue-black Starch present 2. The Benedict’s test for Reducing Sugars This test requires the sample to be in solution form and may be performed on suspensions. If the sample is in solid form, it will first need to be ground /crushed/cut into very small pieces and to be shaken with distilled water for extraction of reducing sugars if they are present. Filter and then proceed with the following test method on the filtrate: Place 2 cm3 of sample solution into a clean and dry test tube. Add 2 cm3 /an equal volume of Benedict’s solution to the sample solution and shake. Gently heat the mixture using a water bath; then observe and record what happens. The possible observations and corresponding conclusions are given in the following table: Observation Conclusion Solution remains blue Reducing sugars absent *Solution turns green/yellow/orange/brick red Reducing sugars present *Only state the final colour observed and not all the colours mentioned in the table. The extent of the colour change indicates the quantity of reducing sugars present i.e. green and yellow colours indicate that little/traces/small amounts of reducing sugars are present, orange indicates that reducing sugars are present and brick red indicates high concentrations of reducing sugars present. 3. The Benedict’s test for Non-reducing Sugars First carry out the Benedict‟s test for reducing sugars. If the colour of the solution remains blue, proceed with the next steps. Place another 2 cm3 of sample solution into a clean and dry test tube. Add 1 cm3 of dilute hydrochloric, heat in water bath for 3 minutes and cool. Add sodium hydrogen carbonate solution or sodium hydroxide solution to the mixture, a little at a time until fizzing stops. Add an equal volume of Benedict’s solution to the mixture. Gently heat the mixture using a water bath; then observe and record what happens. The possible observations and corresponding conclusions are given in the following table: Observation Conclusion 35. 35 Solution remains blue Non-reducing sugars absent Solution turns green/yellow/orange/brick red Non-reducing sugar present 4. The Biuret Test for Proteins This test also works best for solutions and suspensions. Extraction by grinding and shaking with distilled water is therefore necessary where samples are in solid form. The filtrate will then be tested as follows: Place 2 cm3 of sample solution into a clean and dry test tube. Either add 5 drops of sodium hydroxide solution to the sample solution followed by a few/2 drops of copper (II) sulphate solution, drop by drop, shaking and observing after each drop. Or add an equal volume of Biuret solution; then observe and record what happens. The possible observations and corresponding conclusions are given in following table: Observation Conclusion Solution remains blue Proteins absent *Solution turns purple/violet/lilac/mauve Proteins present Only one of these options needs to be mentioned. Candidates are advised to use colour names which are commonly used e.g. it is better to use the name purple or violet instead of mauve or lilac. 5. Testing for Lipids (Fats and Oils) (a) The Emulsion Test Shake a small sample/a drop of sample solution with 2 cm3 absolute ethanol in a test tube. Add a few drops of distilled water to the test tube; then observe and record what happens. The possible observations and corresponding conclusions are given in the following table: Observation Conclusion Solution remains clear Fats/oils absent Emulsion formed/solution turns cloudy Fats/oils present (b) The Grease Spot Test Place a drop of sample/sample solution on filter paper or brown paper. Place a drop of distilled water next to the drop of the sample. Hold the paper against light until the drop of water disappears; then observe and record what happens to the sample spot. The possible observations and corresponding conclusions are given in the following table: Observation Conclusion Sample spot disappears Fats/oils absent Permanent translucent/oily/greasy spot formed Fats/oils present PLANT NUTRITION 36. 36 Photosynthesis This is the process by which green plants manufacture glucose/ starch/ carbohydratesc from carbon dioxide and water in the presence of light energy absorbed by chlorophyll. Oxygen is produced as a by product. This process takes place in leaves and may be summarised by the following word and chemical equations: Word Equation Chemical Equation The products for photosynthesis are glucose and oxygen. The oxygen is released out of the plant while some of it is used for respiration. The glucose formed is metabolically active and takes part in the following reactions: Some of it is used for respiration Some of it is converted to cellulose and becomes part of cell walls Some of it is combined with nitrogen and used to synthesise amino acids Some of it is converted to sucrose in order to be transported Some of it is converted to fats and oils Some of it is converted to nucleic acids The excess is converted to starch for storage LIGHT AND DARK REACTIONS LIGHT REACTION- during this stage light energy absorbed by chlorophyll is used to split water molecules into oxygen and hydrogen. This is called photolysis. Oxygen diffuses into the atmosphere while hydrogen procedes into the dark stage. H_2O DARK REACTION- during this stage hydrogen from the light reaction combines with carbon dioxide forming glucose. NOTE: carbon dioxide comes from the atmosphere by diffusion and water from the soil by osmosis. To determine whether photosynthesis has taken place, the leaves of plants are tested for starch. The steps involved in testing a leaf for starch are: Boil the leaf in water (to kill the protoplasm and make it permeable to Iodine solution) Boil the leaf in alcohol using a water bath. This is to extract the chlorophyll so that it does not interfere with colour changes; a water bath is used because alcohol is highly flammable. However the alcohol also makes the leaf brittle. Place the leaf in warm water to soften it. Spread the leaf on a white tile and add a few drops of Iodine solution this is to test for starch. If the Iodine solution turns blue-black, starch is present and if it remains yellowish brown, starch is absent. Requirements for Photosynthesis oxygen hydrogen 37. 37 These factors that need to be present for photosynthesis to take place are carbon dioxide, water, sunlight and chlorophyll. Those that also affect the rate of photosynthesis are called limiting factors of photosynthesis. Carbon dioxide enters the plant by diffusing through small openings in the leaf called stomata (singular = stoma). Water enters the plant through the roots by osmosis and moves up the plant through xylem vessels. Light energy (mainly solar energy) is captured/trapped and stored by a green pigment called chlorophyll found in the chloroplasts. During photosynthesis, this solar energy is transformed into chemical energy. Since photosynthesis is an enzyme-catalysed reaction, its rate gets affected by all factors that affect enzyme activity. Experiment to show that Carbon Dioxide is necessary for Photosynthesis Destarch a well-watered potted plant by placing it in the dark for at least 24 hours. During this time, all the starch present in the potted plant is used up. Set up the experiment as shown in the following diagram: Place the potted plant in sunlight for 4-6 hours. Test leaves A and B for starch Leaf A turns blue-black (showing the presence of starch), while leaf B turns yellowish brown (showing the absence of starch). This shows that carbon dioxide is necessary for photosynthesis. Exercise: What are the uses of sodium hydrogen carbonate, distilled water and soda lime in this experiment? Experiment to show that light is necessary for Photosynthesis Destarch a well-watered potted plant by placing it in the dark for at least 24 hours. During this time, all the starch present in the potted plant is used up. Set up the experiment as shown in the following diagram: Place the potted plant in sunlight for 4-6 hours. While the plant is in sunlight, draw the selected leaf showing the exposed parts and the covered parts. Test parts A (exposed part) and B (covered part) for starch 38. 38 Part A turns blue-black (showing the presence of starch), while part B turns yellowish brown (showing the absence of starch). This shows that light is necessary for photosynthesis. Experiment to show that Chlorophyll is necessary for Photosynthesis Destarch a well-watered potted plant which has variegated leaves by placing it in the dark for at least 24 hours. During this time, all the starch present in the potted plant is used up. Place the potted plant in sunlight for 4-6 hours. While the plant is in sunlight, draw a selected leaf showing the green parts and the white parts so that they can easily be identified even after chlorophyll has been removed from the leaf. Label the green parts as A and the white parts as B. Test the parts A (green part) and B (white part/ yellow) for starch. Part A turns blue-black (showing the presence of starch), while part B turns yellowish brown (showing the absence of starch). This shows that chlorophyll is necessary for photosynthesis. Measuring the Rate of Photosynthesis This can be measured by counting the number of oxygen bubbles produced by an aquatic plant (e.g. pondweed/Elodea sp) per unit time. A typical setup for such

an experiment is shown in the following diagram. Leaf Structure External Structure Internal Structure (Cross Section) 39. 39 Adaptations of the Leaf for Photosynthesis Thin lamina for easy penetration of light Large surface area to capture as much light as possible Presence of veins/vascular bundles to supply the leaf with water (the xylem) and to transport end products of photosynthesis (the phloem) Presence of stomata for entry of carbon dioxide and exit of oxygen Presence of chloroplasts to absorb light energy for photosynthesis. The highest concentration of chloroplasts is found in the palisade cells, followed by the spongy cells and finally the guard cells. The Importance of Photosynthesis It produces food for all organisms directly or indirectly It maintains the balance (equilibrium) of oxygen and carbon dioxide in the atmosphere by using carbon dioxide from animals and producing oxygen for animals. 1t produces vast amount of energy in woods. Peat. Coal etc. Applications of photosynthesis in Greenhouses A greenhouse is an enclosure with walls of transparent glass or plastic where plants are grown. By having transparent walls, light and heat are allowed to reach the plants. In some green houses, plants are supplied with artificial light from electric bulbs. The walls minimize escape of heat from the greenhouse thereby keeping temperatures high inside the greenhouse for optimum enzyme activity. Sometimes the greenhouse is artificially supplied with carbon dioxide. These factors make a green house more productive than an open piece of land. Plant Storage Organs The food manufactured by plants is normally converted to starch and oils for storage. Oils are mainly stored in seeds e.g. in groundnuts and sunflower. Starch is stored in a range of modified plant organs, some of which are discussed below. (i) Root tuber: This a fibrous root swollen with stored food e.g. sweet potato (Ipomea batatas) tuber (ii) Stem tuber: This is an underground stem swollen with stored food e.g. Irish potato (Solanum tuberosum) (iii) Bulb: A bulb is made of underground fleshy leaves growing from a short stem e.g. onion (Allium sp) (iv) Rhizome: This is a swollen underground horizontal stem e.g. ginger (v) Corm: This is swollen underground and vertical short stem e.g. Crocus sp. (vi) Seed: A sexually produced structure containing a plant embryo and its food store protected by a testa. 40. 40 Mineral Nutrition in Plants Plants require several elements in order to grow properly. These elements are absorbed by the roots from the soil in the form of mineral ions. There are two groups of elements needed by plants for proper growth namely major elements and minor elements. Major elements are required by plants in large quantities. Three examples of major elements are nitrogen, phosphorous and potassium (NPK). Minor elements are needed by the plant in small quantities. Examples of mineral ions needed by plants are magnesium and nitrates. Magnesium This forms part of the chlorophyll molecule. Deficiency causes chlorosis which is characterised by yellowing of leaves beginning from the bottom of the plant. Nitrogen This is absorbed from the soil in the form of nitrate ions (NO- 3) or ammonium ions (NH+ 4). It is important for synthesis of proteins and amino acids. Deficiency leads to stunted growth, weak stems and yellowing of leaves. Potassium Potassium is important for flowering and fruit formation, ion transport and catalyst it is absorbed in the form of potassium ions (K+). Deficiency of potassium causes poor flowering and fruit formation. Phosphorous It is absorbed in the form of phosphate ions (PO3- 4). It is important for the formation of Nucleic acids and ATP. Deficiency leads to purple leaves, stunted growth and poorly developed roots. Effects of Sulphur dioxide Pollution on Plant Nutrition Sulphur dioxide is emitted in industrial and exhaust fumes which are released into the atmosphere. It dissolves in rain water forming sulphuric acid which falls as acid rain. The effects of acid rain on plant growth are: It dissolves away the waxy cuticle, thereby increasing the rate of transpiration and causing the leaves to wilt and die. This stops or reduces the rate of photosynthesis, leading to death of the plants. It damages the root hairs, thereby reducing the rate of water and mineral uptake. In certain European countries, entire forests were wiped out after the industrial revolution due to increased emission of sulphur dioxide. ANIMAL NUTRITION Animals carry out holozoic nutrition. This is a type of nutrition which occurs in animals in a specialized tube called the alimentary canal or digestive system and involves five stages namely ingestion, digestion, absorption, assimilation and egestion. Ingestion is the intake of food into the mouth. Digestion is the breaking down of food. There are two types of digestion, namely physical digestion and chemical digestion. Physical digestion is the break down of large pieces of food into smaller ones. In humans, this process is carried out by teeth in the mouth. It increases the surface area of the food for more efficient enzyme activity and makes food easy to swallow. Chemical digestion is the break down of large molecules of food into smaller ones by enzymes. It makes absorption of food more efficient Absorption is the uptake of soluble food into the blood stream. Assimilation is the usage and incorporation of absorbed food in living cells. Egestion is the removal of undigested food from the body through the anus. The Human Alimentary Canal 41. 41 Digestion of Carbohydrates, Lipids and Proteins Digestion of food substances occurs in the mouth, stomach, duodenum and jejunum. Digestion in the Mouth The following events occur after food has been ingested into the mouth: (i) Chewing: Also called mastication, this is the break down of large pieces of food into smaller ones by teeth. It increases the surface area of the food for more efficient enzyme activity and makes food easy to swallow. (ii) Secretion of Saliva: This is carried out by salivary glands. Saliva is a mixture of water, mucus, the enzymes salivary amylase and lysozyme in a slightly alkaline medium. The water helps in cooling food that is too hot and warming up food that is too cold so that its temperature is favourable for enzyme action. It also softens food for easy chewing e.g. it is easier to chew biscuits after they have been moistened by saliva. The mucus lubricates food for easier swallowing. The slightly alkaline PH is favourable or optimum for the activity of salivary amylase. Salivary amylase starts the digestion of cooked starch to produce maltose. However, only small amounts of starch are converted to maltose in the mouth because food stays for a short time in the mouth. Amylase does not work in the stomach because the PH there is acidic. (iii) Mixing Food with Saliva and formation of Bolus While food is being chewed, the tongue mixes it with saliva. Later, the tongue works with the palate (top of the mouth) to roll the chewed food up into a round semi solid mass called a bolus, in readiness for swallowing. Swallowing and Peristalsis Swallowing is the passage of food or liquids from the mouth to the stomach through the oesophagus. During swallowing, the food bolus moves by a process known as peristalsis. Peristalsis is the alternate contraction and relaxation of circular and longitudinal muscles in a wave-like manner in order to move food along the alimentary canal. Peristalsis is illustrated in the following diagram: 42. 42 Behind the bolus, circular muscles contract while longitudinal muscles relax. Ahead of the bolus, circular muscles relax while longitudinal muscles contract. Digestion in the Stomach The stomach is an elastic bag with a muscular wall and a glandular lining. The entrance of the stomach is guarded by the cardiac sphincter. The exit is guarded by the pyloric sphincter. The following events take place in the stomach; Secretion of gastric juice: Gastric juice is a mixture of pepsin, rennin, hydrochloric acid and mucus. Pepsin breaks down proteins to form peptides. Rennin coagulates milk by converting the soluble protein caesinogen into an insoluble form called casein. This delays the passage of milk to the duodenum giving chance for pepsin to digest milk protein. Both pepsin and rennin are secreted in inactive forms called pepsinogen and prorennin, respectively. Hydrochloric acid activates them into active enzymes and sets an acidic pH which is optimum. It also kills some bacteria and hydrolyses sucrose to glucose and fructose. Mucus protects the lining of the stomach against the acid and pepsin. Churning: This is the mixing of food by rhythmic contraction of the muscles in the wall of the stomach to form a paste called chyme. Temporal Storage of Food: Liquids can stay in the stomach for up to 30 minutes; carbohydrates are kept for about one hour; proteins and lipids stay up to 2 hours. Digestion in the Duodenum The duodenum receives digestive juices from the liver and the pancreas. The liver secretes bile which is temporarily stored in the gall bladder and carried to the duodenum by the bile duct. Bile contains sodium hydrogen carbonate, bile salts and bile pigments. Sodium hydrogen carbonate neutralizes the acidic chyme and then sets an optimum alkaline pH for the enzymes of the duodenum. The bile salts emulsify fats thereby increasing the surface area for the action of lipase. Emulsification is the break down of large drops of fats into small droplets. Bile pigments have no digestive function but add colour to the faeces. The pancreas secretes pancreatic juice which contains sodium hydrogen carbonate, trypsin, lipase and pancreatic amylase. Sodium hydrogen carbonate neutralizes the acidic chyme and then sets an optimum alkaline pH for the enzymes of the duodenum. Trypsin breaks down proteins to form peptides. Lipase breaks down fat molecules to fatty acid and glycerol. Pancreatic amylase breaks down starch to form maltose. Digestion in the Jejunum This secretes Intestinal Juice (succus entericus) which contains Lactase, maltase, sucrase and peptidase. Lactase breaks down lactose to glucose and galactose. Maltase breaks down maltose to glucose. Sucrase breaks down sucrose to glucose and fructose. Peptidase breaks down peptides to amino acids. Digestion is completed in the jejunum. The ileum and Absorption The ileum carries out absorption of digestive end products and is adapted for this function in the following ways: The ileum is very long thereby providing a large surface area for absorption. 43. 43 It has a thin epithelium for more efficient diffusion of food. It has finger like projections called villi (singular: villus) and microvilli which further increase the surface area for absorption. Each villus has a network of capillaries for absorption and transportation of monosaccharides and amino acids Each villus has a lacteal which absorbs and transports fatty acids and glycerol. Diagram of a Villus Assimilation of Digestive end Products After absorption, the digestive end products are transported in the blood to the liver by the hepatic portal vein. The food is then assimilated as follows a) Assimilation of Monosaccharides (Glucose, Fructose and Galactose) Glucose is mainly used as a substrate for tissue (cellular) respiration. If it is in excess, the excess is converted to glycogen which is stored in the muscles and the liver. However the human body stores limited amounts of glycogen i.e. about 400g (300g in the muscles and 100g in the liver). If there is still some excess glucose, it is converted to fat and stored in the adipose tissue under the skin and around delicate body organs such as the brain, heart, liver, kidneys and intestine. These processes are influenced by a hormone called insulin which is secreted by the pancreas. Fructose and galactose are assimilated in the same way as glucose. b) Assimilation of Amino Acids Amino acids are assembled to make the proteins required by the body. Excess amino acids are deaminated by the liver. Deamination is the process by which the amino group of an amino acid is removed and eventually converted to urea by the liver. Ammonia is an intermediate during deamination and is highly toxic. It is quickly converted to urea which less toxic. The 44. 44 remaining part of the amino acid known as the carbon skeleton may be converted to glucose by a process called gluconeogenesis. Urea is toxic if allowed to accumulate in the body. It is carried from the liver by blood and is removed from the body by the kidneys by the process of excretion. c) Assimilation of Glycerol and Fatty Acids Glycerol and fatty acids are chemically combined to make fats which have the following uses in the body: Insulation- animals have a layer of fat under their skins which prevents heat loss from the body Formation of cell membrane- the cell membrane is made of lipids called phospholipids which can be synthesized from fats and oils Energy source-lipids store a lot of energy which is made available when the supply of carbohydrates in the body is low. In fact lipids store twice as much energy as an equal amount of carbohydrates. Excess fats are stored in the adipose tissue under the skin and around delicate body organs such as the brain, heart, liver, kidneys and intestine. The fat under the skin is responsible for insulation while the fat around delicate organs cushions the organs against shocks. Large Intestines These are made of the caecum, the colon and the rectum. The caecum is the point where the ileum is linked to the large intestines. It has a projection at the base known as the appendix, which has no known use in the human body and is considered a vestigial organ. The colon carries out absorption of water from the faeces while the rectum stores faeces temporarily before they are egested and continues the absorption of water. Functions of the Liver The liver is the largest internal organ in the human body and performs a wide range of functions including the following: Destruction of old red blood cells resulting in formation of bile which is important in emulsification of fats. Deamination of excess amino acids resulting in formation of urea. Detoxification of poisons and alcohol by converting them to less toxic substances e.g. hydrogen peroxide is broken down to water and oxygen by the enzyme catalase in the liver. Excess intake of alcohol frequently can lead to a condition called cirrhosis (hardening liver tissue, leading to loss of function) Conversion of excess glucose to glycogen and storage of glycogen, thereby regulating the levels of blood sugar. Manufacture of red blood cells in babies Transamination (the conversion some amino acids to others) Synthesis of plasma proteins such as prothrombin, fibrinogen, globulins and albumin. Storage of some vitamins (e.g. vitamin A) and some mineral ions (e.g. iron) Production of heat through a wide range of exothermic/exergonic reactions. Common Ailments of the Liver Hepatitis: Inflammation of the liver which may result from infection hepatitis viruses. Hepatomegaly: Enlargement of the liver. Cirrhosis: Hardening of liver tissue resulting from poisoning or excessive intake of alcohol. Common Ailments of the Alimentary Canal Diarrhoea: The passage of watery stool, resulting in dehydration and loss of mineral ions from the body. It is caused by intake of food or drinks that are contaminated with pathogens. The pathogens cause inflammation of the intestinal lining leading to diarrhoea. Constipation: Difficult defaecation due to hardness and dryness of faeces, resulting from insufficient roughage and water in diet. It may also result from keeping the faeces in the rectum 45. 45 for too long which causes the rectum to absorb too much water, making the faeces hard and dry. Stomach Ulcers: An ulcer is defined as an open sore that produces toxic matter. Stomach ulcers may result from over-production of pepsin and hydrochloric acid or when the mucus layer in the stomach is not sufficiently thin. This causes the lining of the stomach to be destroyed by the action of pepsin or hydrochloric acid. Piles (haemorrhoids): This is a condition where the veins in the rectum become swollen and eventually burst causing pain and blood-stained stool. It may be caused by frequent constipation. DENTITION Dentition refers to the types, numbers and arrangement of teeth in the mouth of an animal. On the other hand, the term dental formula refers to the numbers and arrangement of teeth according to type on the upper and lower jaw in one half of the mouth. Each tooth has a part that grows above the gum called the crown. The outer part of the crown is covered with a substance called enamel. Enamel is the hardest substance in the body of an animal. The part of the tooth found in the gum region is called the neck while the part that grows below the gum is called the root. Types of Teeth There are four types of teeth namely incisors, canines, premolars and molars. Incisors: These are chisel-shaped teeth used for cutting and biting. Each incisor only has one root. Canine: These are dagger-shaped (pointed) teeth used for tearing flesh, suffocating prey and carrying young ones. Each canine only has one root. In carnivorous animals, the canines are very long and pointed. 46. 46 Premolars: these are broad and ridged teeth used for grinding or crushing food. Each usually has two roots. Molars: these are broad and ridged teeth used for grinding or crushing food. Each molar has from two to four roots. The projections on top of the crowns of premolars and molars are called cusps or ridges Internal Structure of a Tooth An Incisor A Molar Functions of tooth parts: Enamel This is the hardest substance in the body of an animal. It‟s made of Calcium and Phosphate salts and its functions are: Preventing wearing away of the tooth Protecting the tooth from damage It is used as a biting and grinding surface However the enamel can be corroded (dissolved) by acids. Dentine This is a bone-like tissue below the enamel which is made of calcium and phosphate salts, collagen fibres and cytoplasmic strands. It contains fine canals which link the pulp cavity to the enamel. Pulp Cavity This is a space within the dentine which is made of tooth-producing cells, nerves and blood vessels. The nerves make the tooth sensitive to stimuli such as temperature, pH and pressure. The blood vessels supply the tooth with food and oxygen Cement This is a bone-like tissue with fibres that anchor the tooth to the jawbone. Dental Formula (Plural: Dental Formulae) The dental formula is the number and arrangement of teeth according to type on the upper and lower jaw in one half of the mouth of an animal. Examples of dental formulae are: 47. 47 Human being Cat 3 3 2 2 1 1 2 2 mpmci 1 1 2 3 1 1 3 3 mpmci Cow Rat 3 3 3 3 1 0 3 0 mpmci 3 3 0 0 0 0 1 1 mpmci Where i=incisors, c=canines, pm=premolars and m=molars Note that the dental formulae only show the number of teeth present in one half of the mouth. To get the total number of teeth, the numbers in the dental formula must be multiplied by two. Relationship between Dentition and Type of Diet a) Dentition in Carnivore Carnivores are animals that feed predominantly on flesh e.g. lions. Their dentition is specialised in the following ways: Canines are very long and pointed to enable them to tear flesh and suffocate their prey. Presence of carnassial teeth (the last upper premolar and first lower molar) which work like the blades of a scissors to slice meat and shear flesh away from bones. b) Dentition in a Herbivore Herbivores are animals that feed predominantly on vegetation e.g. sheep. Their dentition is specialised in the following ways: Upper incisors are absent and replaced by a horny pad which works in conjunction with lower incisors to grip vegetation and wrench it. There is a space between the incisors and premolars called the diastema. It is used to manipulate food by separating the freshly eaten food from the one that is already being chewed. c) Dentition in an Omnivore Omnivores are animals that feed on both flesh and vegetation e.g. human beings. Their dentition is not specialised for any kind of diet. Tooth Decay Also called dental decay or dental caries, this is a condition where the enamel of teeth is dissolved (corroded) by organic acids produced by fermentation of sugars by bacteria in the mouth forming cavities in the teeth. When cavity reaches the dentine, the tooth starts getting painful. The pain increases further when the cavity reaches the pulp cavity. At this stage, the tooth pains each time the patient takes very hot or very cold foods, becomes infected and may even start having a bad smell due to accumulation of abscess (pus). The condition may be treated by filling the tooth in with cement or having a tooth extraction. Prevention of Tooth Decay Brushing teeth with fluoride toothpaste after every meal Avoiding intake of sugary foods Regular visits to the dentist i.e. at least twice every year (once every six months) Taking foods that are rich in calcium, phosphorus and vitamins C and D Using dental floss to remove food particles from teeth Using teeth properly by avoiding using them for opening bottle tops and the like as this may crack the enamel. TRANSPORT IN FLOWERING PLANTS 48. 48 Plants need a transport system for the following reasons: To carry water and mineral salts from the roots to other parts of the plant To transport manufactured foods from the leaves to other parts of the plant To transport hormones from sites of synthesis to sites of usage The transport system in flowering plants is called the vascular system. This consists of xylem and phloem which are closely associated with a meristematic tissue called cambium. Xylem conducts water and mineral salts from the roots to other parts of the plant and supports the plant mechanically. Phloem transports manufactured foods from the leaves to other parts of the plant. Cambium carries out cell division to produce new cells, including xylem and phloem cells. Arrangement of Vascular Tissues in Dicots and Monocots (a) Cross-section of a Dicot Root Xylem is located in the centre and is star-shaped Phloem is located between the „arms‟ of the xylem (b) Cross-section of a Monocot Root (c) Cross-section of a Dicot Stem 49. 49 (d) Cross-section of a Monocot Stem Uptake/Absorption of Water and Mineral Salts Water and mineral salts are absorbed by root hairs which are found near the tips of roots. Root hairs are elongated outgrowths of epidermal cells of the roots. A root hair cell absorbs water by osmosis and mineral salts by active transport and is adapted for absorption in the following ways: Has an elongated outgrowth which increases the surface area for faster diffusion during absorption. Absence of chloroplast to create more room for absorption. High concentration of mitochondria to provide energy for active absorption/transport of mineral salts. In addition, root hair cells are numerous which further increase their surface area. Structure of a Root Hair Cell Movement of Water from the root hairs to the xylem After being absorbed, water moves from the root hair cell to the xylem using three possible routes namely apoplast (from cell wall to cell wall), symplast (from cytoplasm to cytoplasm) 50. 50 and vacuolar route (from vacuole to vacuole). The movement of water from cell to cell is due to osmosis and transpiration pull. Movement of water up the Plant Water moves up the plant through xylem vessels in a continuous stream known as the transpiration stream. The forces responsible for movement of water in the transpiration stream are transpiration, capillarity, root pressure and guttation. Transpiration (the diffusion of water vapour from plant leaves to the atmosphere through stomata). This creates a suction force that pulls water up the xylem vessels. Capillarity: This is the movement of water into narrow tubes or openings as a result of cohesion (attractive forces between molecules of the same kind) and adhesion (attractive forces between molecules of different substances). Root Pressure: This is the pressure created in xylem vessels due to osmotic gain of water by the roots. This pushes water up the xylem vessels. Guttation: the loss of water drops from the tips and margins of leaves through openings called hydathodes. This creates a suction force that pulls water up the xylem vessels. The following diagram summarises the transpiration stream. Transpiration This is the diffusion of water vapour from leaves to the atmosphere through stomata. In leaves of most plants, there are more stomata on the under-side than on the upper-side. The water moves from the xylem vessels to the mesophyll cells by osmosis then it evaporates from the surfaces of the mesophyll cells into the air spaces and finally diffuses out of the air spaces to the atmosphere through the stomata. Excessive transpiration can lead to plasmolysis of plant cells causing wilting of the plant. Wilting is the sagging of delicate plant parts such as leaves, flowers and young stems due loss of water. Temporary wilting is wilting that can be reversed by supplying a plant with water. Permanent wilting can not be reversed even if a plant is supplied with water but leads to death of the plant. A plant undergoes wilting when the rate of transpiration is higher than the rate of water uptake.

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