8.3 - Pattern in Nature:

1. Organisms are made of cells that have similar structural characteristics:

- *Outline the historical developments of the cell theory, in particular, the contributions of Robert Hooke and Robert Brown:*
  - The cell theory has three main points:
    - Cells are the smallest units of life
    - All living things are made up of cells
    - All cells come from pre-existing cells
  - The first 2 points are from Theodor Schwann and Matthias Schleiden, and the last point from Rudolf Virchow
  - The main points in the historical development of the cell theory are:
    - 1485 - Leonardo da Vinci used glass lens to study small objects
    - 1600 - The first compound microscope was made by Hans and Zacharias Janssen
    - 1665 - ROBERT HOOKE observed cork cells using a compound microscope and described 'little boxes or cells distinct from one another'
    - 1676 - Anton von Leeuwenhoek described unicellular organisms in pondwater
    - 1831 - ROBERT BROWN observed the nucleus in plant and animal cells
    - 1839 - Schleiden and Schwann formulated the cell theory that all living things are made up of cells. Schwann was the first scientist to see yeast cells producing new cells
    - 1858 - Virchow stated: 'where a cell exists, there must have been a pre-existing cell, just as the animal only arises from an animals and the plant only from a plant.'
    - 1880 - Walter Flemming described cell division (mitosis) from observations on living and stained cells
- *Describe evidence to support the cell theory:*
  - Robert Hooke's observation of cork cells, and Leeuwenhoek's observation of many types of unicellular cells proved that living things were made up of cells

  - Walter Flemming's observation of cell division - mitosis - proved that cells come from pre-existing cells
- *Discuss the significance of technological advances to developments in the cell theory:*
  - Without technological advances, the development of the cell theory could not have happened
  - The main areas of advancement have been in the invention and further development in the design of the microscope and the techniques used in the preparation of specimens
  - The microscope enabled us to see cells, opening the doors for the development of the cell theory
  - The staining of cells (specimen preparation) enabled the division of the nucleus in cell division to be observed
  - Thus technological advances go hand in hand with the development of the cell theory
- *Identify cell organelles seen with current light and electron microscopes:*
  - A light microscope uses light and focuses with lenses to see small objects
  - An electron microscope uses electron beams and focuses them with electromagnets to see small objects
  - Total magnification = eyepiece magnification x objective lens magnification
  - The organelles of a cell are the 'little organs' that perform a particular function for the cell. Each organelle does something different
  - Every organelle is either made up of or enclosed in organelles
  - The protoplasm is all the contents of the cell
  - Organelles seen under a LIGHT MICROSCOPE:
    - Cell Membrane: Sometimes called the plasma membrane, this is the organelle that surrounds the whole cell. It is flexible and holds all the contents of the cell. It also regulates what substances go in or out of a cell
    - Nucleus: Contains the genetic information of a cell (chromosomes). The information in chromosomes is used to control the development and the functioning of the whole cell

- Nuclear Membrane: This membrane surrounds the nucleus and holds the chromosomes in. It is composed of a double-membrane, and has large pores in it, to allow large molecules in and out
- Cytoplasm: This is simply the contents of the cell between the cell membrane and outside the nucleus
- Vacuoles: Found only in plant cells, this sac-like organelle is used as food storage for the plant. It contains cell sap, which is made of water and dissolved substances such as sugars and salts. In some cells, the vacuole takes up 80-90% of the cell volume
- Cell Wall: Also found only in plant cells, this organelle surrounds the whole cell outside the cell membrane. It provides strength, protection, support and shape to the plant. Cell walls are non-living - they are made of a network of cellulose microfibrils cemented together in pectin and other substances
- Chloroplasts: This organelle is only founding plants. It can only be seen under very strong light microscopes. This organelle is the food production site in plants (it carries out photosynthesis).

– Organelles seen under a ELECTRON MICROSCOPE:
  - Nucleolus: It is an organelle within the nucleus. It is the region where the genes for ribosomal RNA are found and is the site of ribosome formation
  - Mitochondria: An organelle found in the cytoplasm composed of many folded layers of membrane. It is the site of respiration and the production of energy
  - Ribosomes: Tiny organelles found in the cytoplasm or on endoplasmic reticulum. They are responsible for protein synthesis
  - Endoplasmic reticulum: It is a system of membranous sacs and tubules connected to the nuclear membrane. It provides an internal surface for many chemical reactions in the cell and provides a series of channels for materials to be moved. Rough endoplasmic reticulum has ribosomes attached to it. Rough ER is involved in protein synthesis. Smooth ER has no ribosomes and is involved in lipid manufacture and inactivation of drugs

- Lysosomes: These are small spherical organelles that consist of a membrane surrounding highly acidic contents. They are used to break down wastes or old organelles and are involved in digestion
- Centrioles: These are found in pairs in animal cells, and are involved in the formation of the spindle for mitosis
- Golgi body: Consists of stacks of flattened membrane sacs. It chemically modifies, stores and distributes substances made by the endoplasmic reticulum. These 'packages' are then secreted into the cell or moved out of the cell

- *Identify the relationship between the structure of cell organelles and their function:*
  - NUCLEUS: Has large pores in nuclear membrane to allow large molecules, such as genetic information and proteins to move in and out
  - MITOCHONDRIA: The inner membrane is greatly folded. This increases the surface area greatly, thus increasing the rate of reactions. This produces more energy for the cell
  - ENDOPLASMIC RETICULUM: Is composed of many folded layers of membranes. The many folds increases the surface area, providing a surface for many chemical reactions to occur
  - CHLOROPLASTS: The many layered membranes of the chloroplasts, which contain pigments, increase the surface area for photosynthesis to take place. This increases the amount of sugars produced.
- *Use available evidence to assess the impact of technology, including the development of the microscope on the development of the cell theory:*
  - The development of the cell theory depended entirely on the microscope
  - There would be no cell theory without the microscope.
  - With this tool, it was observed that all living things were made up of cells; unicellular organisms were discovered.
  - Using the stronger electron microscope, it was observed that - even though cells are made up or organelles - cells are the smallest units of life
  - The development of better design of microscopes, and better specimen preparation had a huge impact on the development of the cell theory

2. Membranes around cells provide separation from and links with the external environment:

- *Identify the major groups of substances found in living cells and their uses in cell activities:*
  - Organic molecules contain carbon. Most inorganic molecules don't
  - Inorganic substances in the body:
    - Water: The most abundant inorganic substance in the body. 70% of the body's molecules are water. Most reactions in cells require water. Nutrients and wastes are carried around in water. It has many other uses in the body.
    - Oxygen gas: Used to release energy in the body
    - Salts: These are usually in the form of ions, such as chlorides, phosphates and sulfates of various metals. Their uses include:
      - Calcium Ion: Builds bones, teeth, helps blood clot and proper nerve and muscle functions.
      - Iron Ion: Carries oxygen in red blood cells.
      - Phosphate Ion: Part of the energy carrier ATP. Also part of nuclei acids.
      - Sodium Ion: Functioning of nerves.
  - Organic Substances in the body include:
    - Carbohydrates: Compounds composed of C, H and O. The number of hydrogens is always double the number of oxygen.
      - USES: An energy source in cells; also used in structure in plants (cellulose)
      - The three groups of carbohydrates are monosaccharides, disaccharides and polysaccharides.
      - Monosaccharides are the simplest carbs. They consist of only one unit of sugar. Examples are glucose, fructose and ribose. Monosaccharides are the basic building blocks of more complex carbs
      - Disaccharides are simple carbohydrates composed of 2 units of sugar. An example is sucrose (table sugar) made of glucose and fructose.
      - Polysaccharides are complex carbohydrates made up of many sugar units joint into a huge molecule. An example is starch, which is a food store in plants. One starch molecule is made of 2000-3000 glucose molecules

- Lipids: They are compounds made of the same elements as carbohydrates; that is, carbon, hydrogen, and oxygen. There is usually very little oxygen in lipids. They have more than twice the energy of carbs
  - USES: Used as stores of energy, used as water-proof coating on leaves, makes up part of the cell membrane
- Proteins: Proteins consist of carbon, hydrogen, oxygen and nitrogen (C, H, O and N).
  - USES: Needed for growth and repair, make up a major part of the body's structure. Vital to the structure and function of cells. Are essential for metabolism (all chemical reactions in cells) as enzymes are made up of proteins.
  - Made up of long chains of amino acids, joined together by peptide bonds
  - There are 20 different amino acids
  - The 3D shape of a protein determines which amino acids are on the outside of the protein, and this determines the protein's characteristics
  - When a protein is heated, the structure changes, and the protein's behaviour and characteristics are changed
- Nucleic Acids: Are made up of carbon, hydrogen, oxygen, nitrogen and phosphorus (C, H, O, N and P). They include DNA and RNA
  - USES: They determine heredity in organisms. Is needed for the manufacture of proteins.
  - Are made up of groups of nucleotides; a nucleotide is made up of a nitrogen base, a pentose sugar and a phosphate
  - Deoxyribonucleic Acid (DNA) is mostly found in chromosomes
  - Ribonucleic Acid (RNA) is found throughout the cell
  - DNA contains deoxyribose sugar. RNA contains ribose

- *Identify that there is movement of molecules into and out of cells:*
  - Molecules are continually moving in and out of cells
  - Raw materials are needed and wastes need to be expelled
  - The cell continually exchanges materials with its external environment

- *Describe a current model of the membrane structure and explain how it accounts for the movement of some substances in and out of cells:*
  - Every cell is surrounded by a cell membrane (or plasma membrane)
  - This membrane regulates what enters or leaves the cell
  - The cell membrane is differentially permeable; i.e. only certain substances can cross over it.
  - Cell membranes can form, reform and change and appear very dynamic
  - The cell membrane is 40% lipid and 60% protein
  - The current model of the cell membrane is the FLUID MOSAIC MODEL:
    - According to the model, the cell membrane is a thin sheet composed of 2 layers (a bilayer) of special lipids called phospholipids
    - The bilayer is very fluid and the lipids can move about easily
    - Other lipids such as cholesterol are also found in it.
    - Proteins are scattered throughout the membrane. They are of 2 types:
      - Integral proteins: they go through both layers and come out on both sides
      - Peripheral proteins: attached to the integral proteins inside or outside
  - The way that this model accounts for substances moving in and out of cells is al follows:
    - <u>Passive Transport:</u> This is movement of substances across that membrane that requires no energy. This includes:
      - *Diffusion:* This involves the diffusion of substances, such as water and oxygen, through the membrane, from high to low concentration. The substances diffuse right through the phospholipid layers
      - *Facilitated Diffusion:* This involves the diffusion of substances into the cell, but not directly through the phospholipid layer. These substances diffuse through integral proteins in the cell membrane.
    - <u>Active Transport:</u> Molecules cannot pass through the cell membrane at times because of their properties; eg they may be too large, they may be stopped by the diffusion gradient, they carry electrical charges, etc. In active transport, specific carrier proteins bind to these molecules and bring them inside the cell. This requires the use of energy. *Endocytosis* is a form of active transport

where large molecules are transported across a membrane. 3 types of endocytosis include:

- *Pinocytosis:* The material being transported is a liquid
- *Phagocytosis:* The material being transported is a solid
- *Receptor Mediated Endocytosis:* The molecules bind to specific receptor sites in the membrane called coated pits.

- *Compare the processes of diffusion and osmosis:*

Diffusion	**Osmosis**
Involves random movement of particles	Involves random movement of particles
Movement of substance from high concentration to low concentration	Movement of substance from high concentration to low concentration
Requires no energy	Requires no energy
Does not need to involve a differentially permeable membrane	Always involves a differentially permeable membrane
Involves liquids and gases	Involves only water

- *Explain how the surface area to volume ratio affects the rate of movement of substances into and out of cells:*
  - As mentioned earlier, cells obtains their nutrients through their cell membranes
  - The surface area of the membrane has to fulfil the requirements of the whole volume of the cell.
  - If the cell becomes larger, the surface area to volume ratio becomes smaller, and the surface area of the cell membrane is not enough to fulfil the needs of the whole cell
  - This places a restriction on the size of cells
  - If the surface area to volume ratio is large, movement of substances is efficient
  - If surface area to volume ration is small, movement of substances is slow and inefficient, and is not enough for the cell
  - This is how SA:V affects the movement of substances in and out of cells

- *Plan, choose equipment or resources and perform a first-hand investigation to gather information and use available evidence to identify the following substances in tissues:*
    - *Glucose*
    - *Starch*
    - *Lipids*
    - *Proteins*
    - *Chloride ions*
    - *Lignin*

– Glucose Test:
  - Place 4 ml of sample in a test tube
  - Add 4 ml of Benedict's solution
  - Heat gently in a water bath
  - If the solution turns orange-brown, there is glucose present

– Starch Test:
  - Place sample in a test tube
  - Add 5 drops of iodine solution
  - If the iodine turns purple, there is starch present

– Lipid Test:
  - Place a drop of sample on a piece of brown paper
  - If the paper becomes clear, the substance is a lipid

– Protein Test:
  - Place 4 ml of sample in a test tube
  - Add 5 ml of sodium hydroxide and 5 drops of copper sulfate (this is called the Biuret solution)
  - If the solution becomes light purple, there is protein present

– Chloride Ions Test:
  - Place 4 ml of sample in a test tube
  - Add 4 drops of silver nitrate
  - If the solution turns milky white (precipitate formed), chloride ions are present

- Lignin Test:
  - Add 3 drops of toludine blue to the sample
  - If the toludine changes from blue to blue-green, lignin is present

- *Perform a first hand investigation to model the selectively permeable nature of a cell membrane:*
  - An experiment was performed as follows:
    - A cellulose bag was filled with starch solution
    - It was placed in a jar of water with iodine present
    - Left overnight, the starchy solution in the cellulose bag turned purple
    - This proved that the iodine solution travelled through the bag (by osmosis)
    - This successfully modelled the selectively permeable nature of the cell membrane
    - The cellulose bag was the cell membrane and the starch was the cytoplasm

3. Plants and animals have specialised structures to obtain nutrients from their environment:

- *Identify some examples that demonstrate the structural and functional relationships between cells, tissues, organs and organ systems in multicellular organisms:*
  - Multicellular organisms are made up of many cells.
  - CELLS are the smallest unit of life. They perform specific functions:
    - E.g. muscle cell - its job is to contract or relax
  - TISSUES are groups of cells with similar functions. They perform functions as a group of cells:
    - E.g. muscle tissue - made up of muscle cells, job is to contract or relax
  - ORGANS are made up of groups of tissues that function as a whole:
    - E.g. the stomach - made of muscle tissues, is moves to churn food
  - ORGAN SYSTEMS are groups of organs that function together as a coordinated system to perform a role for the body
    - E.g. digestive system - made up of organs such as the stomach
- *Distinguish between autotrophs and heterotrophs in terms of nutrient requirements:*
  - Autotrophs are organisms that <u>make their own food</u> through photosynthesis:
    - *Nutrient requirements*: Autotrophs, such as plants, require the substances necessary for photosynthesis. These are water, carbon dioxide and sunlight. They also need oxygen and sugars for respiration
  - Heterotrophs are organisms that <u>consume other organisms</u> for nutrition:
    - *Nutrient requirements:* Heterotrophs require other organisms to feed on, such as how herbivores eat plants, and carnivores eat meat. They also need oxygen for respiration and water for life.
- *Identify the materials required for photosynthesis and its role in ecosystems:*
  - Photosynthesis is the process by which plants create glucose
  - This synthesis of organic compounds from inorganic compounds is a process all living things ultimately depend on

- Plants make food through photosynthesis, herbivores eat plants, carnivores eat herbivores, and the food chain continues. However, they all begin with plants
- The materials needed for photosynthesis are water, CO_2, and chlorophyll

- *Identify the general word equation for photosynthesis and outline this as a summary of a chain of biochemical reactions:*
  - The general word equation for photosynthesis is:

    Carbon dioxide + Water $\xrightarrow{SUNLIGHT\text{–}And\text{–}CHLOROPHYLL}$ **Sugar and Oxygen**
  - The chemical equation for photosynthesis is:

    $$\mathbf{6CO_2 + 12H_2O \longrightarrow C_6H_{12}O_6 + 6O_2 + 6H_2O}$$
  - Photosynthesis is thought to occur in two stages:
    - *Light Reactions of Photosynthesis:*
      - Only this stage requires sunlight
      - Light absorbed by chloroplasts is used to split water molecules
      - This process is called <u>photolysis</u>
      - In this process, the water molecule is split into oxygen and hydrogen
      - This process occurs on the thylakoids of chloroplasts
    - *Light-Independent Reactions of Photosynthesis***:**
      - Also called the carbon-fixation stage
      - Hydrogen released from the first reaction is joined with carbon dioxide to form sugars
      - This process requires energy
- *Explain the relationship between the organisation of the structures used to obtain water and minerals in a range of plants and the need to increase surface area available for absorption:*
  - <u>Obtaining water and minerals</u>:
    - In aquatic environments, water and minerals are absorbed across the whole surface of the plants
    - However, for terrestrial (land) plants, water and minerals are obtained through root systems

- Root systems must have a very large surface area to absorb enough nutrients for the whole plant
- They achieve this through having a branching structure and many root hairs
- The root system can also be used to anchor the plant
- Many different types of root systems exist
- <u>Different types of roots used to absorb nutrients are:</u>
  - TAP ROOTS: These types of root systems have one main root, called the tap root, from which side roots come out from. Tap roots many penetrate deeply into the soil. Sometimes the taproots act as storage organs and swell up, such as carrots.
  - FIBROUS ROOTS: These root systems form networks of roots close to the soil surface. They can spread out widely to support the plant, and provide a large surface area for absorption of mineral ions and water
  - MYCORRHIZA: This is where the root system is associated with fungi in a symbiotic relationship. The fungi provides the plants with additional mineral nutrients and the plant provides carbon based products for the fungi
  - AERIAL ROOTS: In areas like water logged estuaries or swamps, plants produce roots that grow above the ground. These roots help with gas exchange
- <u>External Root Structure:</u>
  - The root system of a plant is usually below the ground
  - Roots do not photosynthesise, and do not have leaves or buds
  - The growing points of roots are protected by root caps
  - As roots grow throughout the soil they branch out and provide a large surface area for absorption as well as an anchor for the plant
  - Most of the absorption occurs in the root hairs of the root
- <u>Internal Root Structure:</u>
  - The basic root structure is made up of the three parts: the epidermis, the cortex and the vascular tissue

- *Epidermis:* The outer layer of the root. It lacks a cuticle. In young roots, the epidermis is covered with a slimy coating or sheath called *mucigel*
- *Cortex:* The cortex is in between the epidermis and the vascular tissue. It acts as a storage area for excess materials, and has air spaces for gas flow
- *Vascular Tissue:* In roots, it forms a cylinder in the centre. It is made of xylem and phloem vessels. It transports water and nutrients

- *Explain the relationship between the shape of leaves, the distribution of tissues in them and their role:*
  - Obtaining sunlight and carbon dioxide:
    - The specialised leaf structure of the plant used for obtaining light and carbon dioxide is the leaf
    - Most of the photosynthesis of plants occurs in leaves
    - The *lamina* is the blade of the leaf
    - The *petiole* is the part that attaches it to the stem
    - External Leaf Structure:
      - *Arrangement:* Leaves are usually arranged along the stems in a way that exposes them to the maximum amount of sunlight. They are usually positioned so that sunlight strikes the upper part of the leaf
      - *Shape:* Most leaves are broad, thin and flat. This gives them a large surface area for the capture of sunlight and gas exchange needed for photosynthesis and respiration
    - Internal Leaf Structure:
      - *Cuticle:* This is a waxy layer over the surface of the leaf. It is waterproof and provides shape and protection. It plays an important part in reducing water loss in terrestrial plants
      - *Epidermis:* It is a single protective layer of cells on the upper and lower side of leaves. It is transparent to allow light to pass through
      - *Stomates:* These are pores in the leaf that can open and close. When open, they allow gas exchange, but this results in water loss
      - *Mesophyll:* Mesophyll are the cells in the middle of the cell, in between the upper epidermis and lower epidermis. There are two types:

- Palisade Mesophyll: They are regularly arranged, elongated and packed with chloroplasts. Most of the photosynthesis occurs in these cells
- Spongy Mesophyll: Situated under the palisade, but above the lower epidermis. Contains less chloroplasts, and are randomly arranged with large air spaces to allow gas exchange.

➢ *Veins:* Veins are tubes of vascular tissue in plants. They form a branching network in the leaves, providing structure and shape. Vascular tissue:

- XYLEM: Transports water and minerals from roots to leaves
- PHLOEM: Transports products of photosynthesis to the rest of plant

- *Describe the role of teeth in increasing the surface area of complex foods for exposure to digestive chemicals:*
  - Animals are heterotrophic; they get nourishment from the external environment
  - The digestive system is the system responsible for breaking down food to a size where they can be used by cells
  - There are two parts of digestion:
    - *Mechanical Digestion:*
      - ➢ This involves breaking food down through mechanical means.
      - ➢ The teeth are the most important means of mechanical digestion.
      - ➢ The role of teeth is to break food down into smaller pieces to increase the surface area of the food.
      - ➢ The greater the surface area, the better the digestive chemicals can act on the food
      - ➢ The stomach is also involved with mechanical digestion
    - Chemical digestion:
      - ➢ This involves the use of enzymes to chemically break food down
      - ➢ Amylases - enzyme that acts on carbohydrates
      - ➢ Proteases - enzyme that acts on proteins
      - ➢ Lipases - enzyme that acts on lipids

- *Explain the relationship between the length and overall complexity of digestive systems of a vertebrate herbivore and a vertebrate carnivore with respect to:*
    - ➢ *The chemical composition of their diet*
    - ➢ *The functions of the structures involved*

– Herbivores:

- The main component of a herbivore's diet is plant material
- Most of the mass of plant material is made up of cellulose
- They have flat teeth to grind the fibrous plant material
- Plant material is difficult to breakdown compared to animal material
- Herbivores use the help of micro-organisms to help digest the cellulose
- This digestion can occur in two place:
    - ➢ FORE-GUT FERMENTERS: This type of herbivore (e.g. cows) digests their food in a chamber before the stomach called the *rumen*
    - ➢ HIND-GUT FERMENTERS: This type of herbivore (e.g. horses) digests its food in a chamber after the small intestine called the *caecum*
- Compared to meat, plant material is low in energy
- Plants also take longer and is harder to digest than meat
- This means that herbivores have to constantly eat to survive
- The digestive systems of herbivores are a lot larger and longer than that of carnivores. This is because plants take longer to digest

– Carnivores:

- The main component of their diet is meat
- Meat is high in energy, and is relatively easy to digest
- This means that the digestive systems of carnivores are short compared to herbivores and also have to specialised organs like the caecum or rumen
- They have very short large intestines, as the meat has already been absorbed in the small intestine

4. Gaseous exchange and transport systems transfer chemicals through the internal and between external environments of plants and animals:

- *Compare the roles of respiratory, circulatory and excretory systems:*
  - Respiratory Systems:
    - All organisms respire to produce energy; this requires oxygen
    - Plants photosynthesise to produce food; this requires carbon dioxide
    - These processes require gases from the external environment
    - Respiratory systems are the systems that allow gas exchange for the organism
    - Respiratory systems must be thin and moist, and have a large surface area, so that gases can DIFFUSE freely
    - They also bring together the internal and the external environment
    - Aquatic organisms expose their respiratory systems to the environment
    - Terrestrial organisms have their respiratory systems enclosed, to reduce water loss by evaporation
  - Circulatory Systems:
    - In unicellular organisms, all nutrients needed can be diffused from the external environment over their surface area
    - Wastes can just be removed from cells by diffusion as well
    - However, in multicellular organisms, the surface area is not great enough to provide nutrients for all the organisms cells
    - Circulatory systems are used to carry nutrients to all the body's cells, and to carry wastes away
    - The flow of materials is usually maintained by a pump (such as the heart)
    - Circulatory systems can be open or closed (see below)
  - Excretory Systems:
    - Excretion is the removal of metabolic waste products from an organism
    - The metabolic processes constantly produce wastes. If they were allowed to accumulate, the organisms would be poisoned by its own wastes and die
    - The main waste products of organisms are: carbon dioxide made in respiration (excreted by respiratory system) and nitrogenous wastes made during the

breakdown of proteins and nucleic acids (excreted as ammonia, urea or uric acid)

- *Identify and compare the gaseous exchange surfaces in an insect, a fish, a frog and a mammal:*
  - Insects:
    - Insects have a system of branching tubes within their bodies called *tracheae*
    - Tracheae are open to the external environment by *spiracles* (these are pores along the body of the insect).
    - The tracheae branch throughout the tissues of the insect, bringing air directly to the body cells
    - As insects are small, the surface area of tracheae is sufficient for the organism
  - Fish:
    - The respiratory system in fish are called gills
    - The gills have a plentiful blood supply (they are very red), and so the gases diffuse directly into the blood supply
    - The gills are made up of many finger-like filaments; this creates a large SA
    - The water enters the mouth, flows over the gills and out of the operculum
    - Diffusion of oxygen in and carbon dioxide out occurs at the same time, as water only flow in one direction
  - Frogs:
    - Frogs have two respiratory surfaces: skin and lungs
    - There is a well-developed blood supply to the skin of frogs
    - This enables the diffusion of gases directly through the skin
    - Oxygen from the air diffuses into the moist skin and is transferred by the blood to the heart, where it is pumped to the rest of the body
    - Frogs also have simple lungs, with smaller surface areas than mammals
    - The lungs hang in the abdominal cavity and air passes in and out by the pumping movement of the floor of the mouth (buccal pump)
  - Mammals:
    - The gas exchange organs are the lungs
    - They are inside the body to prevent drying out

  - The surface area is very large, as the lungs are divided into lobes, which are divided into bronchioles which end up as alveoli
  - The is a very plentiful blood supply, to endure efficient diffusion of gases

- *Explain the relationship between the requirements of cells and the need for transport systems in multicellular organisms:*
  - In unicellular organisms, all nutrients needed can be diffused from the external environment over their surface area
  - Wastes can just be removed from cells by diffusion as well
  - However, in multicellular organisms, the surface area is not great enough to provide nutrients for all the organisms cells
  - Transport systems are used to carry nutrients to all the body's cells, and to carry wastes away
  - Transports systems provide all the needs of organisms
- *Outline the transport system in plants, including:*
    - *Root hair cells*
    - *Xylem*
    - *Phloem*
    - *Stomates and lenticels*
  - Gas Exchange:
    - Plants exchange gases (CO_2 and O_2) with the environment for respiration and photosynthesis
    - In land plants, the leaves and stems have specialised structures for gas exchange
    - STOMATES:
      - These are located on leaves of plants
      - They are pores in the leaf which enable the diffusion of gases
      - They are present on the upper and lower sides of leaves, but mainly on the lower side
      - Stomates receive the gases needed for photosynthesis (not respiration)

- Stomates can open and close: When open, gas exchange occurs in the leaf and photosynthesis occurs, but when they close, the rate of photosynthesis slows
- The opening and closing of Stomates is controlled by guard cells, and this is dependent on stimuli such as: *light, low CO_2 levels, an internal clock, water deficiency, and high temperatures.*

- LENTICELS:
  - These are pores on the woody stems of plants.
  - The gases needed for respiration are diffused through lenticels
  - Carbon dioxide also diffuses out

– <u>Nutrients and Water:</u>

- In flowering plants, the transport system is called vascular tissue, or conducting tissue
- Vascular tissue is made up of *xylem* and *phloem*
- Xylem and phloem together in the leaves are called veins
- Xylem and phloem together in roots is called stele
- In flowering plants, no plant cell is far from vascular tissue
- XYLEM:
  - Transport water and mineral ions up the plant stem to the leaves
  - Consists of dead cells, whose cross-walls (connection between cell walls) have been broken away, creating a continuous tube
  - Xylem also gives strength and rigidity to the plant
- PHLOEM:
  - Transport the products of photosynthesis (sugars) throughout the whole plant.
  - Made of long columns of 'sieve tube cells', which have holes in their cell walls, so that the cytoplasm is mixed and diffusion of sugars occurs.
  - Organic material in the phloem is transported up and down the plant
- ROOT HAIRS:
  - These structures are on the surface of the roots
  - They provide a large surface area for water to diffuse into the plant

- Water enters the plant via the root hairs and then enters the xylem

– Transpiration:

- Transpiration is the loss of water from a plant through the stomates in leaves
- When stomates are open, gases flow in for photosynthesis. However, at the same time, water is lost by evaporation. This water loss is transpiration
- As water is lost, more water flows in through the roots
- The constant flow of water from roots, to vascular tissue, to leaves and into the air is called the *transpiration stream*
- Some plants have adaptations to reduce transpiration, such as sunken stomates, small leaves or hairy leaves.

- *Compare open and closed circulatory systems using one vertebrate and one invertebrate as an example:*

– Open Circulatory System:

- Invertebrates such as molluscs and arthropods have open systems
- This involves the movement of body fluids (or haemolymph) around the whole body by a simple pumping system
- Haemolymph bathes the tissues and accumulates in large spaces in the animal
- The fluid is pumped to the front of the animal and slowly flows to the back
- The pressure is very low and fluids circulate slowly
- Open systems suit smaller animals
- EG:
  - A insect, such as a fly, has an open circulatory system
  - The 'heart' (called a dorsal longitudinal vessel) contracts and fluid flows to the front of the insect
  - The fluid flows through the tissues of the body and enters the 'heart' again through a series of holes
  - The fluid is then pumped again to the rest of the body

– Closed Circulatory System:

- Large animals such as vertebrates and squids have closed systems
- The closed circulatory system consists of a muscular pump (heart) that forces a liquid (blood) through a series of tubes (blood vessels)

- These tubes carry materials rapidly throughout the body
- No body cell is far from a blood vessel
- The nutrients, wastes and gases are all carried in blood
- The nutrients must first diffuse into the body fluid (called lymph) before it can be used.
- Closed systems meet the needs of large active animals
- EG:
  - Humans have closed circulatory systems
  - The heart pumps blood around the body in veins and arteries
  - The body cells receive nutrients from the blood from the veins

- *Identify factors that affects the rate of transpiration:*
  - The higher the TEMPERATURE the higher the rate of transpiration
  - The faster the WIND the higher the transpiration
  - More LIGHT more transpiration
  - The water content in the SOIL affects rate water is taken up
  - The higher HUMIDITY the *lower* the rate of transpiration
- *Use available evidence to discuss, using examples, the role of technologies, such as the use of radioisotopes in tracing the path of elements through living organisms:*
  - Radioactive isotopes, which are forms of elements which are radioactive can be used to trace biochemical pathways
  - As the radioactive elements take the same pathway as non-radioactive elements, the pathways can be traced using techniques such as photographic paper
  - Thallium-201 is used in diagnosing damaged heart muscle. As it will only accumulate in healthy heart muscle, it will reveal areas that need the be treated

5. Maintenance of organisms requires growth and repair

- *Identify mitosis as a process of nuclear division and explain its role:*
  - Mitosis is often said to be the process by which a cell divides into the cells
  - However this is not entirely true; this process is made up of two parts:
    - Mitosis is just the process where the *nucleus* divides into two separate nuclei
    - Cytokinesis is the division of the cytoplasm forming two new cells
  - The role of mitosis is the GROWTH and REPAIR of multicellular organisms
  - It also provide reproduction for unicellular organisms
- *Identify the sites of mitosis in plants, insects and animals:*
  - Plants:
    - Plant cells capable of mitosis are called *meristematic* cells
    - Mitosis occurs in:
      - *Root tips and stem tips:* This results in increase in length of plant
      - *Cambium cells:* These are cells in between the xylem and phloem. Mitosis here results in increased thickness of the plant
  - Insects:
    - Mitosis occurs when the insects changes (metamorphosis) from larvae into adult. The stage is called the pupal stage
    - In pupal form, the larval cells break down, and adult cells (called imaginal discs) undergo mitosis to create a massive transformation from larvae to adult
  - Animals:
    - Mitosis occurs in many places including skin cells, hair cells and nail cells
    - Blood cells are also constantly being made in the bone marrow
    - The cells lining the digestive tract are also constantly replaced
- *Explain the need for cytokinesis in cell division:*
  - Division of the cytoplasm (cytokinesis) usually occurs immediately after mitosis
  - This is necessary to ensure that chromosome numbers remain constant
  - After mitosis, 2 sets of chromosomes are made, so cytokinesis ensures that two cells with the normal amount of chromosomes are made
  - Cytokinesis occurs like this:

- ANIMALS:
  - Occurs during a process called cleavage
  - A ring of microfilaments constricts the centre of the cell until it splits
- PLANTS:
  - The dividing plate - or cell plate - forms across the centre of the cell
  - This splits the cell into two new cells
  - The cell plate forms the new cell wall

- *Identify that nuclei, mitochondria and chloroplast contain DNA:*
  - Nuclei contain DNA in the form of chromosomes
  - These contain genetic information that determines heredity
  - It also has information in producing proteins, which in turn determines our characteristics
  - Mitochondria have a set of DNA of their own
  - It is a ring of DNA, like in a procaryotic cell.
  - Chloroplasts also have a circular ring of DNA in their own structure
- *Describe the sequence of changes in the nucleus of plant or animal cells in mitosis:*
  - *Interphase:* The cell is not dividing, but the chromosomes are duplicating. The chromosomes are not visible
  - *Prophase:* The chromosomes condense and become visible as 2 joined strands, called chromatids, joined at a centromere. The nuclear membrane breaks down
  - *Metaphase:* The chromosomes line up at the centre of the cell, by a spindle (system of microtubules). The chromatids separate
  - *Anaphase:* The single stranded chromosomes move to the opposite poles of cell
  - *Telophase:* The spindle disappears. Two new nuclear membranes appear