Section A: Living Organisms and the Environment

Describe the characteristics of living organisms.

- What are living organisms?
  - Living organisms are made up of chemicals in units known as cells.

- What are non-living organisms?
  - Non-living things are made up of materials such as metal, stone and plastic.

- Living organisms possess seven features.

- Acronym for the seven (7) features of living organisms are: **MR NIGER/ GRIMNER**
  - **M- movement**
  - **G- growth**
  - **R- respiration**
  - **R- respiration**
  - **N- nutrition**
  - **I- irritability**
  - **I- irritability**
  - **M- movement**
  - **G- growth**
  - **N- nutrition**
  - **E- excretion**
  - **E- excretion**
  - **R- reproduction**
  - **R- reproduction**

- **Movement:**
  - Living organisms must move around in order to search for and obtain sufficient food supplies.
  - An advantage of moving around allows for selection of food sources.
  - Movement of the entire body is referred to as locomotion.

- **Respiration:**
  - This involves the release of energy from food.
  - All body activities require the use of energy. Even when asleep the body requires energy to keep the body parts working.
Without energy life would cease to exist since this allows for work to be done.

When oxygen from the air combines with food, energy is released into the body as well as waste products such as water and carbon dioxide which are excreted.

**Nutrition:**

- This is the taking in of food into the body to make energy and provide the materials for building up the body parts.
- Some of the food is used to build up parts allowing the body to grow or can be used to replace worn-out parts.
- The energy that is stored in the food is released so that the body can do work.

Without energy and the ability to produce new parts the body would stop working and result in death.

**Irritability:**

- This is the detection of changes in the surroundings. It is the ability to detect and react to changes outside the body as well as to internal changes. These changes are called a stimulus which can produce a reaction as a response.

- There are five sense organs which detect and respond to a stimulus. They are:

<table>
<thead>
<tr>
<th>#</th>
<th>Sense Organ</th>
<th>Detection</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Eyes</td>
<td>Sight</td>
</tr>
<tr>
<td>2</td>
<td>Nostrils/nose</td>
<td>Scent/smell</td>
</tr>
<tr>
<td>3</td>
<td>Skin</td>
<td>Touch</td>
</tr>
<tr>
<td>4</td>
<td>Tongue</td>
<td>Taste</td>
</tr>
<tr>
<td>5</td>
<td>Ears</td>
<td>Sound</td>
</tr>
</tbody>
</table>
Growth:
- This is an increase in weight or size as a result of producing more cells.
- This includes the replacement of worn out parts of the body but this cannot be measured.

Excretion:
- When processes occur in the body this results in waste products being produced. This must be removed since it is poisonous and may cause harm to the body. The removal of waste products as a result of metabolism (body activity) is called excretion.
- **N.B.** the removal of undigested food from the intestine is called elimination or egestion and **NOT** excretion.

Reproduction:
- This is the ability to produce new individuals. The young are produced by the development of an embryo in living organisms which occurs as a result of the fusion of two special cells (sex cells) by the process of sexual reproduction. It allows for the survival of the human race.
- Asexual reproduction occurs when organisms reproduce without the fusion of sex cells e.g. budding when cells divide in yeast, spores in fungi and bulbs in plants.

- **Naming of Organisms:** (Binomial Nomenclature)
  - A system of naming organisms is developed due the large number of different kinds of organisms. This is relevant so that different types of organisms are not mixed up so they are given two names.
  - Example: Humans are given the name *Homo sapiens* (always displayed in *italics*). Genus: first letter is always capitalized *(Homo)*
Species: first letter never capitalized (*sapiens*)

- Organisms that normally breed with each other are placed in the same species.
- Taxonomy: Classification of species

Kingdom
Phylum
Class
Order
Family
Genus
Species

Acronym: **Keep Pots Clean Or Family Gets Sick**

- Mammals have mammary glands; young are born fully developed and are cared for. They have a diaphragm, maintain a constant body temperature and have sweat glands, hair, a large brain, two sets of teeth and external ears.

- Humans are special because they have a large intelligence with a large forebrain. Vocal cords allow for speech, they are bipedal to free the hands, with opposable thumb for holding tools.

- Animals that carry disease pathogens are called vectors. An organism that causes a disease is called a pathogen. Example: the mosquito is a vector for carrying the pathogen responsible for dengue virus.
Compare the structures of an unspecialized plant and animal cell and selected microbes.

- Below shows a labeled diagram of a typical plant cell:

![Typical Plant Cell Diagram]

- Below shows the labeled diagram of a typical animal cell:

![Cross-Section of an Animal Cell Diagram]

- Microbes are virus, bacteria and some fungi.
  - Below shows a labeled diagram of a virus:

![Virus Diagram]
- Below shows a labeled diagram of a bacteria:

- Below shows a labeled diagram of a fungi (yeast cell):
State the functions of cell structures.

- Table showing the functions of basic cell structures:

<table>
<thead>
<tr>
<th>Organelle (Cell part)/ Structure</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protoplasm (Cell part) / Structure</td>
<td>This is made up of the cytoplasm and nucleus</td>
</tr>
<tr>
<td>Cytoplasm</td>
<td>This is where metabolic (chemical reactions) activities take place</td>
</tr>
<tr>
<td>Nucleus</td>
<td>This contains chromosomes with genes responsible for making proteins. Contains DNA, a genetic material</td>
</tr>
<tr>
<td>Vacuole</td>
<td>Fluid filled spaces in the cytoplasm</td>
</tr>
<tr>
<td>Mitochondria</td>
<td>This releases energy from food during respiration. ADP $\rightarrow$ ATP</td>
</tr>
<tr>
<td>Endoplasmic Reticulum</td>
<td>Allows passage of substances in the cell and has ribosomes attached</td>
</tr>
<tr>
<td>Ribosomes</td>
<td>Makes protein from amino acids</td>
</tr>
<tr>
<td>Cell membrane</td>
<td>Allows substances in and out of the cell by diffusion, osmosis and active transport, keeps the cell contents in the correct proportions and helps support when the cell is full of fluid.</td>
</tr>
<tr>
<td>Cellulose cell wall (plants only)</td>
<td>Helps support the plant cell when it is full of fluid. Prevents it from bursting.</td>
</tr>
<tr>
<td>Chloroplast (plants only)</td>
<td>Photosynthesis occurs. This is where sugars are made from water and carbon dioxide.</td>
</tr>
</tbody>
</table>

- Table showing the differences between a plant and animal cell:

<table>
<thead>
<tr>
<th>Feature</th>
<th>Animal</th>
<th>Plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell Wall</td>
<td>Not present as animal cells only have a plasma membrane</td>
<td>Cell wall present along with an inner plasma membrane</td>
</tr>
<tr>
<td>Chloroplast</td>
<td>Not present</td>
<td>Present in plant cells that photosynthesize</td>
</tr>
<tr>
<td>Carbohydrate storage</td>
<td>Glycogen</td>
<td>Starch</td>
</tr>
<tr>
<td>Vacuole</td>
<td>Not usually present. Small temporary vacuoles sometimes found.</td>
<td>Large fluid-filled vacuoles often present. Surrounded by a membrane called the tonoplast. This control substances moving from the cytoplasm to the vacuole and visa-versa.</td>
</tr>
<tr>
<td>Shape</td>
<td>Able to change shape. Usually rounded</td>
<td>Fixed shape. Usually rather irregular.</td>
</tr>
</tbody>
</table>
Identify selected cells which make up the human body

Table below showing the diagram and function of specialized cells which make up the human body:

<table>
<thead>
<tr>
<th>Cell</th>
<th>Diagram</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epithelial</td>
<td><img src="image1" alt="Diagram" /></td>
<td>They form a layer and protect the cells below them from injury</td>
</tr>
<tr>
<td>Sperm</td>
<td><img src="image2" alt="Diagram" /></td>
<td>This cell has a long tail which helps it to move about. When it unites with the egg cell (ovum) a baby is formed.</td>
</tr>
<tr>
<td>Egg (ovum)</td>
<td><img src="image3" alt="Diagram" /></td>
<td>This is the largest cell in the woman’s body. It does not move on its own and will develop into a baby when united with the sperm cell.</td>
</tr>
<tr>
<td>Nerve</td>
<td><img src="image4" alt="Diagram" /></td>
<td>These cells are very long. They carry information (impulse) from one part of the body to another.</td>
</tr>
<tr>
<td>Muscle</td>
<td><img src="image5" alt="Diagram" /></td>
<td>These are usually cylindrical or spindle-shaped. They cause some parts of the body to move by contracting.</td>
</tr>
</tbody>
</table>
Explain the importance of cell specialization in humans

- **Cell Specialization:**
  - Is the building blocks of organisms
  - A cell is a basic structure of life
  - Cells have important structures that allow them to function
  - Multi-cellular organisms have many cells
  - These cells forms specialized systems to carry out life processes

- **Cell specialization is important:**
  - Because it makes multicellular organisms possible
  - Without specialization all cells will be alike
  - Tissues, organs and organ systems would not exist
  - Life processes in multicellular organisms would not occur

- **Cell differentiation:**
  - Some cells in the body develop in order to perform one special function. This is called differentiation of cells. These differentiated cells forms tissues.

  ➢ **Tissues:**
  - A tissue is a group of the same kind of cells together with any substances these cells may make (secretions).
  - There are four main kinds of tissues:
    1. Epithelial- forms coverings and linings of the body
    2. Connective- helps join the internal organs of the body together
    3. Nervous- serves to conduct impulses
    4. Muscle- contains cells that can contract and cause movement
These groups of cells are different in both their structure and function from each other.

- **Organs:**
  - An organ is a part of the body that functions as a unit
  - It is various kinds of tissues grouped together in organs

- **System:**
  - A system consists of groups of organs that work together.

- Table below showing the type of system and organ respectively.

<table>
<thead>
<tr>
<th>Type of system: group of organs that work together</th>
<th>Type of organ: localized functional part of the body</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digestive</td>
<td>Stomach, intestines, liver, pancreas</td>
</tr>
<tr>
<td>Respiratory</td>
<td>Trachea, lungs, bronchus</td>
</tr>
<tr>
<td>Circulatory</td>
<td>Heart, arteries, veins, capillaries</td>
</tr>
<tr>
<td>Skeletal</td>
<td>Skull, girdles, limb bones</td>
</tr>
<tr>
<td>Excretory</td>
<td>Kidneys</td>
</tr>
<tr>
<td>Reproductive</td>
<td>Testis, ovary</td>
</tr>
<tr>
<td>Nervous</td>
<td>Brain, spinal cord</td>
</tr>
</tbody>
</table>
Distinguish between Osmosis and Diffusion

- **Osmosis:**
  - This is the process where water molecules move from a high concentration to lower concentration (more dilute solution) through a partially/semi-permeable membrane.
  - Tiny pores in the membrane allow fairly free passage to small molecules so that water can diffuse through. Larger sugar molecules cannot pass through these pores.
  - A partially permeable membrane allows only certain molecules to pass through.

- **Diffusion:**
  - This is the movement of molecules/ions from an area of high concentration to a low concentration until the molecules/ions are evenly distributed.
Explain the importance of osmosis diffusion and active transport in living systems.

- Table showing the importance of osmosis, diffusion and active transport in living systems:

<table>
<thead>
<tr>
<th>Process</th>
<th>Importance</th>
</tr>
</thead>
</table>
| Osmosis | - Osmosis is a special type of diffusion, cell membrane is a **partially permeable membrane** which facilitates the movement of **water**
  - It is an important process in all biological system where water is involved, water is the medium of transport since everything is transported in the blood, phloem and xylem must be soluble in water
  - Fluid balance of different compartments of the body is maintained
  - Chemical reactions occur in water: cytoplasm is mainly water so that chemical reactions can take place
  - Plants store water soluble substances such as minerals, ions and sugars in cell vacuoles
  - Examples: Allows for movement of substances across cells
    1. Absorption of water by plant roots
    2. Reabsorption of water along the kidney tubules which contributes to the regulation of urine excretion
    3. Reabsorption of tissue fluid into the blood capillaries which contributes to blood volume
    4. Absorption of water along the alimentary canal- stomach, small intestines and the colon |
| Diffusion | - Substances can pass across cell membranes by diffusion, this is how many substances move from place to place
  - Substances are taken into the body by diffusion
  - Example: Many substances enter and leave the cell by diffusion.
    1. After inhalation, oxygen diffuses into the capillaries while carbon dioxide diffuses from the vessels to the air sacs in the lungs
    2. Some digested food passes from the small intestines into the blood capillaries by diffusion.
    3. Carbon dioxide diffuses from the air (higher carbon concentration) into the cells in the leaves (lower carbon concentration)
    4. Oxygen produced diffuses from the cells in the leaves (higher oxygen concentration) into the air (lower oxygen concentration) |
### Active Transport

- Active transport is the movement of molecules/ions from a region of **lower to higher** concentration across a membrane against a concentration gradient and requires energy (ATP).
- Cells that move ions against their concentration gradient such as root hair cells have a large number of mitochondria to produce energy required for active transport.
- Factors such as oxygen concentration, glucose concentration, and temperature which affect the rate of respiration also affect the rate of active transport.
- Examples:
  1. Uptake of mineral ions by root hairs.
  2. Uptake of glucose and amino acids by epithelial cells of villi.
  3. Reabsorption of glucose, amino acids, and salts in the kidneys.

### Osmosis

- **Aim:** To investigate the movement of water by osmosis through potato tissue.

  **Method:**
  1. Cut a large potato in half and peel the skin off 2 cm of the uncut end.
  2. Cut a hollow in the cut end of each potato.
  3. Drop one potato in boiling water for 2 mins to kill the cells.
  4. Half fill the hollows with a concentrated sugar solution and place the potatoes in a trough of distilled water.
  5. Examine after 24 hours.

- **Questions:**
  1. What happens to the level of fluid in the hollow of the potato? Explain your observation using the theory of osmosis.
  2. What has been destroyed in the boiled potato to affect osmosis?
  3. What would happen if water had been put in the hollows and sugar solution in the trough?
- Investigation of Osmosis using potato strips

Osmosis can be easily demonstrated in biological systems using potato strips, water and salt or sugar solution.

Apparatus & Materials

- 3 Potato strips (5 x 1 x 1) cm (or potato cylinders/cores of equal length e.g. 5 cm diameter, made with a cork borer)

- 2 Petri dishes with equal volumes of solutions A and B; A = sucrose or salt solution (hypertonic solution); B = distilled water (hypotonic solution)
- 1 empty petri dish (control)
- paper towels
- Stop watch or timing device
- top pan balance
- ruler

Procedure

1. Observe each strip by feeling it, noting whether it is turgid or flaccid. Record this.
2. Weigh and measure each potato strip, recording the initial mass and length.
3. Place a strip in each Petri-dish, taking care not to mix the strips. Start the timer.
4. Remove the strips after 15 minutes and dab on tissue.
5. Weigh each strip and measure each potato strip, recording the final mass and length.
6. Observe each strip by feeling it, noting whether it is turgid or flaccid. Record this.
7. Perform % difference calculations for the mass and length using the formula:
   \[ \text{(final - initial) } \times 100\% / \text{ initial} \]
Record your results in a table in your book like the one below:
Table showing results of experiment to demonstrate osmosis using potato strips:

<table>
<thead>
<tr>
<th>Medium</th>
<th>Initial</th>
<th>Final</th>
<th>% Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>Description (turgid/flaccid/other)</td>
<td></td>
<td>NA</td>
</tr>
<tr>
<td>Mass (g)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length (cm)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salt Solution</td>
<td>Description (turgid/flaccid/other)</td>
<td></td>
<td>NA</td>
</tr>
<tr>
<td>Mass (g)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length (cm)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air (Control)</td>
<td>Description (turgid/flaccid/other)</td>
<td></td>
<td>NA</td>
</tr>
<tr>
<td>Mass (g)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length (cm)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Strips in water

- **Description** - Turgid
- **Mass** - The increase in mass of the potato strip in water is due to the movement of water molecules into the plant cells via osmosis. Water molecules in the Petri-dish are at a higher concentration than water molecules in the cytoplasm of cells and so move along their concentration gradient into the cells. As more water molecules are present in cells - and water has mass - the final mass of the potato strip will be greater than the first.
- **Length** - The decrease in length is also due to the movement of water molecules via osmosis. More water molecules occupy more space - volume - and push against the cell membrane and the proximate cellulose cell wall. The push of the water molecules result in expansion in all dimensions, including length. The expansion is limited - and regulated by the cellulose cell is inelastic. The push/force acting upon the surface area of the rigid cell produces turgor pressure (recall pressure is force acting per unit area), and hence strips are turgid.
Terms related to osmosis:
1. Solvent and solute = solution
2. Solvent: a liquid in which other substances can dissolve e.g. water. Solute: chemical dissolved in solvent.
3. Hypotonic: Solutes in cell more than outside. Outside solvent will flow into cell.
4. Isotonic: Solutes equal inside and outside of cell.
5. Hypertonic: Solutes greater outside cell. Fluid will flow out of cell.
7. Plasmolysed: cell loses water
8. Flaccid: soft/loose

Effects of varying external fluid concentrations on red blood cells:

**Haemolysis** (Dilute solution): Much water enters the cell, which blows up and bursts.

**Turgid**: Solution is same concentration as blood plasma; water enters and leaves the cell for a firm shape.

**Plasmolysed/Crenation** (Concentrated solution): Water leaves the cell so it collapses.

Effects of varying external fluid concentrations on plant cells:

- Explain if the plant cell will eventually burst in a dilute/hypotonic solution. Give a reason for your answer.
Diffusion:
Aim: To investigate diffusion in liquids.
Method:
1. Half fill a jar with water.
2. Drop a few crystals of food coloring/ KMnO₄ in the water.
3. Observe the crystals as they dissolve.
4. Explain your observations using the theory of diffusion.

Active Transport:
- The sodium/potassium (Na⁺/K⁺) pump is an example of active transport in animals.
- The pump transports Na⁺ ions out of the cell and K⁺ ions into the cell. Thus keeping the concentration of sodium lower inside the cell as compared to outside and the concentration of potassium higher inside the cell as compared to outside.
- The pump is driven by hydrolysis (chemical breakdown of a compound due to the reaction with water) of ATP.
- This pump uses 30% of the energy available to any one animal cell.
- The pump is a transmembrane carrier protein made up of 4 subunits (2 large and 2 small proteins).

Metabolism is the chemical reactions that occur in cells.
Anabolism is building up processes.
Catabolism is breaking down processes.
Enzymes are chemicals or proteins made by cells, which speed up the rate of chemical actions in the body.
**Explain the process of photosynthesis**

- **Photosynthesis:**
  - This is the process by which green plants and some other organisms use sunlight (light energy) to make nutrients from carbon dioxide (from the air) and water (from the soil).
  - Photosynthesis in plants generally involves the green pigment chlorophyll and produces oxygen as a by-product. The light energy is absorbed by the green pigment called chlorophyll. The site for photosynthesis to occur is in the chloroplast.

  ➢ **Requirements for photosynthesis:**
    1. Light: this is necessary for some chemical reactions to take place in the light reaction stage.
    2. Carbon Dioxide: this is necessary for plants to synthesize proteins. The only form of carbon dioxide used by plants for photosynthesis is from carbon dioxide in air or in solution in water. Carbon dioxide is produced by plants by the process of cellular respiration.
    3. Water: hydrogen is required for the production of carbohydrates. Water is the only source of hydrogen to plants. Water is always sufficient for photosynthesis since it is obtained from the waste product of respiration and from transpiration stream.

  ➢ **Chemical reaction for photosynthesis:**
    Word equation: Carbon dioxide + water $\rightarrow$ glucose + oxygen
    Chemical equation: $6 \text{ CO}_2 + 6 \text{ H}_2\text{O} \rightarrow \text{C}_6\text{H}_12\text{O}_6 + 6 \text{ O}_2$

  ➢ **Photosynthesis is composed of two (2) stages.**
    1. Light reaction stage: (first stage)
       - Chlorophyll absorbs light energy and water molecules are split into hydrogen and oxygen.
    2. Dark reaction stage: (second stage)
       - The energy that the chlorophyll has absorbed is used to make carbon dioxide which is combined to the hydrogen from the water molecules.
       - This stage does not require light.
Products of Photosynthesis and their fate:
- The two main products of photosynthesis are; oxygen and glucose.
- The oxygen produced diffuses out into the air.
- The glucose is turned into other substances inside the plant. These include:
  - Sucrose (a type of sugar): this is transported to other parts of the plant
  - Starch: is used to store energy
  - Cellulose: to make cell walls
  - Amino acids: to make proteins for the repair of cell and growth of new cells
  - Fats & oils: is used to store energy
Investigate the effect of light and chlorophyll on the production of starch

- **Experiment:**
  - To show that carbon dioxide, light and chlorophyll are required for photosynthesis and starch is made.

1. Four potted plants (e.g. geranium) are labelled A, B, C and D respectively. They are left in the dark (in a cupboard) for 24 hours so that photosynthesis stops. After 24 hours the plants are treated as follows:

   - **Plant A**: The control is left in light.
   - **Plant B**: Is placed under a bell jar (1) containing potassium hydroxide pellets (2) that absorb and remove carbon dioxide from the air. (3) Glass sheet smeared with Vaseline.
   - **Plant C**: Is left in the dark.
   - **Plant D**: Has variegated leaves (parts are white because they lack chlorophyll) and is left in the light.

![Diagram of plant treatments](image)
2. After a few hours a leaf from each plant is removed and tested for starch as follows:
3. Each leaf is placed in boiling water for a few minutes to kill it.
4. The leaf is put in a boiling tube with alcohol (ethanol) ensuring that it is fully covered. The tube is put in a beaker of very hot water. This is the process whereby the chlorophyll is removed from the leaf so that any starch present will be detected.
5. The leaf is then placed on a white tile and potassium iodide (iodine) solution is added from a dropper.
6. Starch is detected by the presence of a blue-black coloration.

**Questions:**
1. Why are the plants placed in the dark to stop photosynthesis at the start of the experiment?
   - Placing the plants in the dark stops photosynthesis, all the starch is used up so the leaves lack starch at the start of the experiment.
2. State which plant leaves show the presence of starch. If present or absent, explain why.
   - Plant A in normal conditions of light, carbon dioxide and chlorophyll makes sugar by photosynthesis and then it is changed to starch. This is the control and starch is present, showing that starch is made in the process of photosynthesis.
   - Plant B lacked carbon dioxide and so the leaf tested lacks starch.
   - Plant C lacked light and so the leaf tested lacks starch.
   - Plant D shows starch only present in the green chlorophyll parts of the leaf, not the white parts. So chlorophyll is necessary for photosynthesis.
Explain the ways in which other living organisms depend on plants directly or indirectly for food.

- **Plants:**
  - Are autotrophs, which means they make their own food.
  - They use energy from sunlight to make glucose and other substances.
  - Plants are **producers** because they produce food that other organisms can use.

- **Animals:**
  - They cannot make their own food. They are heterotrophs which mean that they rely on food made by other organisms.
  - They rely on food that is made by plants.
  - Animals are **consumers**.
  - Animals depend on plants directly for food since they consume plant material directly such as cereals, vegetables and fruits.
  - Animals depend on plants indirectly for food since the food in which they consume may depend directly on plant material. E.g. A human consuming any form of meat. The animals that the meat was derived on were depending on plant material to build up their body mass.
Explain the principles of a food chain.

- **Food chain:**
  - A food chain links the organisms through which food (energy) is passed in a community.
  - Organisms in each link feed on the organisms in the link before it, and are in turn eaten by the organisms in the link following it.
  - A food chain consists of a producer, herbivore, carnivore and omnivore.
  - The trophic level describes the position an organism occupies in a food chain, ‘what it eats’ and ‘what eats it’.

- **Producer:**
  - A food chain has a plant at the start which is called a producer. The food chain always starts with a plant. It initiates the chain. Organic matter is first produced by plants by the process of photosynthesis.

- **Herbivores:**
  - Plants are eaten by herbivores. They are plant eaters only.

- **Carnivores:**
  - Herbivores are eaten by carnivores. Flesh eaters only.

- **Omnivores:**
  - Some animals such as humans are omnivores, because they feed on both plants and animals.

- **Primary Consumers:**
  - These are usually the animals that feed on plants (Herbivores)

- **Secondary Consumers:**
  - These are usually the animals that eat herbivores (Carnivores)

- **Decomposers:**
  - At the end of every food chain are the decomposers. These are bacteria and fungi which break down the remains of animals and plants and in return the mineral nutrients return to the soil. Decomposers are not always shown in the food chain.
- **Energy Losses:**
  - The arrows in a food chain show how energy is transferred from one organism to the next.
  - Each organism in the food chain uses some energy. This energy is lost from the food chain as heat to the surroundings.
  - This means that there is less energy available the further you go along the chain.
  - Due to the less energy available at higher trophic levels, not many animals can be supported. This is why big carnivorous animals are rare.
  - Herbivores are more common since there is more energy available to them.

- **Pyramid of Numbers:**
  - This is the number of organisms in a food chain which can be represented graphically in a pyramid.
- **Pyramid of Biomass:**
  - This is a more accurate indication of how much energy is passed on at each trophic level.
  - Biomass is the mass of living material in each organism multiplied by the total number of organisms in that trophic level.

![Biomass Pyramid Diagram]

- **Pyramid of energy:**
  - This is a graphical model of energy flow in a community.
  - The different levels represent different groups of organisms that might compose a food chain.

![Energy Pyramid Diagram]
Construct a food chain from a selected habitat.

- **Terrestrial habitats:**
  - Terrestrial habitats are ones that are found on land, like forests, grasslands, deserts, shorelines, and wetlands. Terrestrial habitats also include man-made habitats, like farms, towns, and cities, and habitats that are under the earth, like caves and mines.
  - Example:

- An apex predator is a predator residing at the top of the food chain.

- **Aquatic habitats:**
  - An aquatic habitat is a habitat with water. It includes areas that are permanently covered by water and surrounding areas that are occasionally covered by water. Estuaries, rivers, and marshes are examples of aquatic habitats.
  - Example:
Identify the trophic level of organisms in the food chain.

- **Trophic Levels:**

<table>
<thead>
<tr>
<th>Trophic Level</th>
<th>Where It Gets Food</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Trophic Level: Producer</td>
<td>Makes its own food</td>
<td>Plants make food</td>
</tr>
<tr>
<td>2nd Trophic Level: Primary Consumer</td>
<td>Consumes producers</td>
<td>Mice eat plant seeds</td>
</tr>
<tr>
<td>3rd Trophic Level: Secondary Consumer</td>
<td>Consumes primary consumers</td>
<td>Snakes eat mice</td>
</tr>
<tr>
<td>4th Trophic Level: Tertiary Consumer</td>
<td>Consumes secondary consumers</td>
<td>Hawks eat snakes</td>
</tr>
</tbody>
</table>

- **Food Web:**
  - This is a network of food chains representing the feeding relationships among organisms.
Describe the recycling of carbon and nitrogen in nature.

- **Carbon Cycle:**
  
  - **Photosynthesis:**
    - Plants take in carbon dioxide and use it in photosynthesis.
    - They make carbohydrates such as glucose which can later be changed into fats or proteins.
  
  - **Respiration:**
    - Plant cells are always respiring. Animal cells also respire.
    - Glucose and oxygen is combined with oxygen to release energy that can be used.
    - The carbon in the glucose becomes part of a carbon dioxide molecule which is then released into the air.
    - Equation for respiration:
      
      \[
      \text{Glucose} + \text{Oxygen} \rightarrow \text{carbon dioxide} + \text{water} \\
      C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O
      \]
    - Animals get their carbon from the food that they eat, in carbohydrates, fats and proteins. These are originally made by plants.
  
  - **Decomposers:**
    - Waste materials from animals, such as urine and faeces, as well as other dead bodies, contain carbon.
    - Some of the bacteria and fungi that live in the soil are able to feed on the nutrients in these materials. They are called decomposers.
    - When decomposers respire, they release carbon dioxide into the air.
  
  - **Combustion:**
    - When the remains of living organisms are burnt, such as wood from trees, the carbon compounds in them combine with oxygen in the air and carbon dioxide is released.
    - This also occurs when fossil fuels are burnt. Fossil fuels are formed from dead organisms that lived millions of years ago. They contain a lot of carbon.
The Carbon Cycle:
The Nitrogen Cycle:

- Why do organisms need nitrogen?
  - Proteins contain carbon, hydrogen, oxygen and nitrogen.
  - In photosynthesis, plants make carbohydrates. Carbohydrates contain carbon, hydrogen and oxygen.

- Plants and Nitrogen:
  - Approximately 80% of the air is composed of nitrogen gas (N\textsubscript{2}). But nitrogen gas is very unreactive. So although plants are surrounded by lots of nitrogen gas, they cannot use it.
  - Plants can only use nitrogen when it has reacted with:
    - Nitrate ions (NO\textsubscript{3}\textsuperscript{-})
    - Ammonium ions (NH\textsubscript{4}\textsuperscript{+})
  - Plants get nitrate ions and ammonium ions from the soil. They absorb them through their root hairs, by diffusion or by active transport. Root hairs near the tips of roots absorb the water and mineral ions that a plant requires.

- Nitrogen Fixation:
  - Nitrate and ammonium ions are made by nitrogen fixation. This is where nitrogen gas is changed into a compound of nitrogen that is more reactive.
  - Lightning also causes nitrogen fixation. When lightning flashes through the air, it makes nitrogen gas and oxygen gas react together to form nitrate ions. These fall to the ground dissolved in raindrops.
  - Plants belonging to the pea and bean family are called leguminous plants. They have little swellings on their roots, called root nodules, where bacteria live. These bacteria can change nitrogen gas into ammonium ions. They are called nitrogen-fixing bacteria.
  - Examples of nitrogen fixing bacteria are; Clostridium and Azotobacter are non-symbiotic nitrogen-fixing bacteria, while those in the genus Rhizobium are symbiotic bacteria.

- Animals and Nitrogen:
  - Animals, such as ourselves, cannot use ammonium or nitrate ions. We obtain our nitrogen from the proteins that we eat. These proteins are made by plants.
Soil Microorganisms:
- Decomposers such as bacteria and fungi, feed on waste materials from plants and animals, and on dead bodies.
- They change the nitrogen containing compounds in these substances into ammonium ions.
- Other bacteria in the soil change ammonium ions into nitrate ions. They are called nitrifying bacteria.
- Examples of nitrifying bacteria are; Nitrosomonas, Nitrosococcus, Nitrobacter and Nitrococcus.

Recycling Nitrogen:
- Nitrogen is recycled by passing from one organism to another.
- One group of bacteria, called denitrifying bacteria, changes nitrates to nitrogen gas.
- Examples of denitrifying bacteria are; Serratia, Pseudomonas, and Achromobacter.

The Nitrogen Cycle: