9.2 - Maintaining a Balance:

1. Most organisms are active within a limited temperature range:

- *Identify the role of enzymes in metabolism, describe their chemical composition and use a simple model to describe their specificity in substrates:*
  - Role of enzymes in metabolism:
    - Metabolism refers to all the chemical reactions occurring in organisms
    - Enzymes are biological catalysts which increase the rate of chemical reactions
    - Without enzymes, metabolism would be too slow to support life
  - Chemical composition of enzymes:
    - Most enzymes are made up of protein
    - Proteins are composed of long chains of amino acids joined together by peptide bonds
    - These long chains are called polypeptide chains
    - Proteins consist of one or more polypeptide chains
  - Structure of enzymes:
    - In enzymes, the polypeptide chain is folded into a 3-dimensional globular shape
    - Part of the enzyme is called the active site. This part attaches to the substrate
    - The substrate are the molecules the enzymes acts upon
  - Specificity of enzymes:
    - Enzymes are highly specific in their action; this means that each enzyme acts on one substrate only
    - This is because the shape of the active site of the enzyme matches the shape of the substrate material
    - The molecules the enzyme act upon are called the substrate
    - The substrate molecules bind to the active site and a chemical reaction occurs
    - The products are the substances that the substrate(s) become. One substrate can be split, or two substrates can be joined
  - Models to explain specificity:

  - The Lock and Key Model suggests that the substrate fits exactly into the active site of the enzyme like a key fits into a lock. It assumes that the enzyme had a rigid and unchanging shape.
  - The Induced Fit Model states that the binding of the substrate to the enzyme 'induces' a temporary change in shape of the enzyme. The new shape of the enzyme better accommodates the shape of the substrate and a reaction occurs.

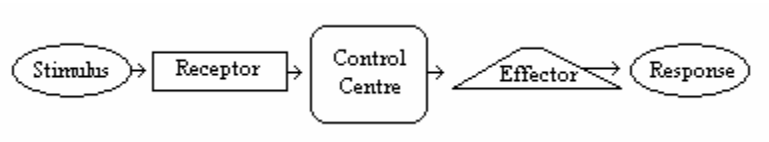
- *Identify the pH as a way of describing the acidity of a substance:*
  - The substance that makes a solution acidic is hydrogen ions
  - pH is a measure of the acidity or the alkalinity of a substance
  - pH is a measure of the concentration of hydrogen ions per litre of solution
  - The pH scale is from 0 to 14: a pH of 7 is neutral (pure water); above 7 is alkaline and below 7 is acidic
- *Explain why the maintenance of a constant internal environment is important for optimal metabolic efficiency:*
  - Enzymes are essential for proper metabolic function in an organism
  - However, enzyme efficiency is affected greatly by certain factors
  - These include:
    - Temperature:
    - pH:
    - Substrate concentration:
  - Enzymes work best within a limited range
  - Therefore, a constant and stable internal environment is needed so that enzymes will always be working at an optimum rate, and thus metabolism will be a optimum efficiency
- *Describe homeostasis as the process by which organisms maintain a relatively stable internal environment:*
  - Homeostasis is the process by which the body maintains a stable internal environment
  - Multicellular organisms regulate their internal environment in order to remain healthy

- The internal environment of cells are kept within certain limits by the coordinating systems of the body
- These systems monitor all the activities of cells, their requirements and the wastes they produce
- This is called homeostasis.

- *Explain that homeostasis consists of two stages*
  - *Detecting changes from the stable state;*
  - *Counteracting changes from the stable state:*

- Detecting Changes:
  - The body needs to maintain a 'stable state' in order to function properly
  - Changes, or deviations, from the stable state are caused by the external and internal environment
  - Any change, or information, that provokes a response is called a STIMULUS
  - RECEPTORS detect stimuli; organisms then react to the change
  - There are two types of receptors within the body:
    - *Disturbance receptors:* These receptors, usually in the skin, detect changes caused by the external environment
    - *Misalignment receptors:* These receptors detect changes from the body's stable state.
  - Examples of external stimuli: light, day length, sound, temperature, odours
  - Examples of internal stimuli: levels of CO_2, oxygen levels, water, wastes, etc.
  - Receptors can range from a patch of sensitive cells, to complex organs like the eyes and ears of mammals
- Counteracting Changes:
  - After receptors detect changes, organisms can then react to the change
  - When a change affects the organism's normal/stable state, the response is *homeostatic*
  - This type of response will counteract the change to ensure the stable state is maintained
  - EFFECTORS bring about responses to stimuli
  - Effectors can either be muscles or glands

- Muscles bring about change by movement
- Glands bring about change by secreting chemical substances



- *Outline the role of the nervous system in detecting and responding to environmental changes:*
  - The nervous system works to regulate and maintain an animal's internal environment and respond to the external environment
  - The nervous system is made up of two parts:
    - Central Nervous System: This part acts as the CONTROL CENTRE for all of the body's responses. It coordinates all the responses. It is made up of the brain and the spinal cord. It receives information, interprets it and initiates a response.
    - Peripheral Nervous System: This is a branching system of nerves that connects receptors and effectors. This system transmits messages from the central nervous system and back. It acts as a communication channel.
  - The nervous system works with another system called the *endocrine system*
  - This system produces hormones in response to certain stimuli
- *Identify the broad range over which life is found compared with the narrow limits for individual species:*
  - *Ambient temperature* is the temperature of the environment
  - The range of temperatures over which life is found is broad compared to the narrow limits for individual species
  - Organisms on Earth life in environments with ambient temperatures ranging from less than 0ºC (eg bacteria in snow) to more than 100ºC (eg bacteria in boiling hot springs of undersea volcano vents)
  - However, individual organisms cannot survive this entire range of temperatures
  - Eg, mammals can only survive temperatures from about 0 - 45ºC
  - This means that life is found in a very wide range of temperatures, but individual species can only be found in a narrow temperature range

- *Compare responses of named Australian ectothermic and endothermic organisms to changes in the ambient temperature and explain how these responses assist in temperature regulation:*
  - ECTOTHERMS are organisms that have a limited ability to control their body temperature. Their cellular activities generate little heat. Their body temperatures rise and fall with ambient temperature changes. Most organisms are ectotherms. Examples are plants, all invertebrates, fish, amphibians and reptiles
  - ENDOTHERMS are organisms whose metabolism generates enough heat to maintain an internal temperature independent of the ambient temperature. Examples are birds and mammals
  - EXTENSION (Not really needed but anyway…)
    - Poikilotherms are animals whose body temperatures are always changing. True poikilotherms have temperatures that are the same as the environment. An example is jellyfish. Poikilothermy is often assumed to be the same as ectothermy; however, this is incorrect. Some ectotherms, like snakes, can regulate their temperatures using behaviour to maintain a stable temperature.
    - Homeotherms are animals with stable body temperatures. Most endotherms are also homeotherms.
    - The poikilotherm/homeotherm classification system was based on the stability of the body temperature of the organism. This system is now redundant.
    - The ectotherm/endotherm system uses the organism's source of body heat as a way of classification. This system is accepted today.
  - BEHAVIOURAL ADAPTATIONS:
    - Migration: Animals can move to avoid temperature changes. Many birds that spend spring and summer in Australia migrate before the temperature becomes cold.
    - Hibernation: To survive cold conditions, many animals hibernate; that is they remain in a sheltered spot, their metabolism slows and the body temperature drops. Aestivation is the 'hibernation' of organisms in heat conditions. Bogong moths migrate to spend the summer months in caves in the Australian Alps

- Shelter: Animals seek shelter to avoid extreme conditions. They can dig burrows or seek shelter in caves or crevices. They can shelter to avoid high temperatures or avoid low temperatures. An example is the central netted dragon
- Nocturnal Activity: Brown snakes can change into nocturnal animals when the temperature becomes very hot. Many desert animals sleep in burrows during the day and are active at night
- Controlling Exposure: Animals can reduce the amount of their body they expose to the sun, to reduce the amount of heat absorbed.

– STRUCTURAL AND PHYSIOLOGICAL ADAPTATIONS:
  - Endotherms have more structural & physiological adaptations for temperature control than ectotherms. Most ectotherm adaptations are behavioural
  - Insulation: Fur in mammals and feathers in birds maintain a layer of trapped air as insulation. This air reduces heat exchange with the environment. Contracting the muscles of the hairs or feathers makes it lift up, increasing the amount of air that can be trapped. Some mammals grow a thick coat in winter and lose it in summer. Animals in cold conditions have a permanent layer of fat as insulation.
  - Metabolic Activity: In cold conditions, metabolic activity increases, as this produces heat; shivering and muscle activity increase heat. In hot conditions, heat from metabolism need to be lost.
  - Control of blood flow: Controlling the flow of blood to extremities can be used to reduce heat loss with the environment
  - Counter-current exchange: Used by endotherms in cold conditions. Blood vessels from extremities and those going to extremities are placed next to each other and they pick up heat from each other.
  - Evaporation: Endotherms can keep cool by controlling the rate of water evaporation. Dogs pant, birds flutter a throat membrane and humans sweat. Kangaroos can lick their arms to cool themselves.

- *Identify some responses of plants to temperature change:*
  – Plants respond to change by altering their growth rate.

- In extreme heat or cold, plants can die, but leave behind dormant seeds.
- Plants may die above the ground, but leave bulbs, roots, rhizomes or tubers to survive underground. These then sprout when favourable conditions return
- Vernalisation: this means that some plants need exposure to cold conditions before they can flower
- Seed dispersal is also stimulated sometimes by fire
- Reflective leaf surfaces can also keep a plant cool
- The orientation of the leaves of a plant can also reduce water loss

- *Identify data sources, plan, choose equipment or resources and perform a first-hand investigation to test the effect of:*
  - *increased temperature*
  - *change in pH*
  - *change in substrate concentrations on the activity of the named enzyme(s)*
- However, enzyme efficiency is affected greatly by certain factors
- These include:
  - Temperature:
    - Sensitivity to temperature relates to the protein structure of enzymes
    - As temperature increases, enzyme activity increases, up to the optimum temperature
    - This is because the enzyme and substrate molecules are moving faster (more kinetic energy) and therefore more collisions between enzyme and substrate occur
    - At high temperatures, the shape of the enzyme changes, and some of the enzymes can no longer accommodate the substrate. Activity decreases. However, if the temperature cools down, activity will start again
    - At VERY high temperatures, the enzyme is denatured; i.e. the chemical bonds holding the protein molecule together are broken and the shape is permanently changed. The enzyme is destroyed, can no longer

accommodate the substrate, and will remain inactive even if the temperature returns to the optimum

- pH:
  - Enzymes work best at an optimum pH
  - This is usually within a very narrow range
  - Extremes of acidity or alkalinity can affect the bonds holding the 3D globular shape of the enzyme
- Substrate concentration:
  - An increase in substrate concentration will increase the reaction until all enzyme active sites are occupied. Then the reactions will proceed at a maximum rate.

- *Gather, process and analyse information from secondary sources and use available evidence to develop a model of a feedback mechanism:*
  - *Homeostasis* involves the detection of the change in the environment and the response to that change
  - The *mechanism* that brings about this change is called FEEDBACK
  - In feedback systems, the response alters the stimulus
  - In living organisms, the feedback system has 3 main parts:
    - Receptors: A type of sensor that constantly monitors the internal environment
    - Control Centre: Receives info from the receptors and determines the response
    - Effector: Restores the set value. Keeps environments stable.
  - An example of a feedback system would be the control of body temperature
  - There are two types of temperature receptors in the body:
    - *Disturbance detectors:* These receptors detect changes in the skin temperature, caused by external conditions
    - *Misalignment detectors:* These receptors monitor the temperature of the blood as it circulates
  - These receptors send their information to the control centre
  - The temperature control centre in mammals is the *hypothalamus*
  - The hypothalamus responds by initiating responses to increase or decrease temperature, until it goes back to the set value (which is 37ºC)

– Temperature control responses:

Keeping Warm	Keeping Cool
Shiver to generate heat	Sweating; evaporation loses heat
Hair muscles erect; insulation	Blood vessels dilate; increased blood supple, more heat lost
Increased appetite	Hair relaxes, less insulation
Blood vessels constrict; less blood flow, less heat loss	Decrease in metabolism
Increase in metabolism	Less exercise

- *Analyse information from secondary sources to describe adaptations and responses that have occurred in Australian organisms to assist in temperature regulation:*

Adaptation/Response	How It Assists Temperature Regulation	Australian Examples
MIGRATION	Animals move to avoid temperature extremes	Sharp-tailed sandpiper
HIBERNATION	Some animals remain in a sheltered spot, their metabolism slows; body temperature drops	Bogong moths
SHELTER	Animals dig burrows or shelter in caves to escape high temperatures	Central netted dragon
NOCTURNAL	Animals are active at night to escape high temperatures during the day	Hopping mice
CONTROLLING EXPOSURE	- Ectotherms expose larger/smaller surface area to the sun to control radiation - Endotherms may huddle together to keep warm	Brown snake
INSULATION	Fur/feathers maintain an insulating	Superb parrot

	layer of trapped air that slows down heat exchange with the environment	
METABOLIC ACTIVITY -Endotherms only	In cold conditions keeps the body warm. In hot conditions may be reduced.	Humans
CONTROL OF BLOOD FLOW to the skin and extremities	More blood flowing to the surface allows heat loss by radiation or less blood flowing reduces heat loss	Humans
COUNTER-CURRENT EXCHANGE	Blood vessels leading to and from the extremities are close together. Chilled blood in veins picks up heat from arteries	Platypus
EVAPORATION	As moisture evaporates, heat is lost from the body, eg: sweating, panting, kangaroos lick forearms and as spit evaporates, it cools the skin.	Grey kangaroo

2. Plants and animals transport dissolved nutrients and gases in a fluid medium:

- *Identify the forms in which each of the following is carried in mammalian blood:*
    - *Carbon Dioxide*
    - *Oxygen*
    - *Water*
    - *Salts*
    - *Lipids*
    - *Nitrogenous wastes*
    - *Other products of digestion*

– The mammalian circulatory system has four main functions:
  - TRANSPORT: The major function of the circulatory system is to transport water, gases, nutrients and wastes.
  - BLOOD CLOTTING: This complex mechanism repairs damage to blood vessels and seals wounds to prevent loss of blood
  - DEFENCE AGAINST DISEASE: White blood cells help to fight infection in the body. Antibodies provide immunity against further attack
  - TEMPERATURE REGULATOIN: The flow of blood distributes heat around the body. Control of the amount of blood passing close to the skin helps control heat loss from the body.

– Composition Of The Blood:
  - PLASMA: This make up 55% of the volume of the blood. It is sticky, straw-coloured and slightly salty. It is made up of 90% water. Other substances found in the plasma include:
    - salts (as ions)
    - plasma proteins (including antibodies, clotting factors, lipid transporters)
    - products of digestion (sugars, amino acids, hormones, etc)
    - waste products (carbon dioxide, urea)
  - BLOOD CELLS:

- Red Blood Cells:
  - Also called erythrocytes
  - Shape is bi-concave discs, thinner at centre than at edges
  - Contains the pigment *haemoglobin*
  - Their function is to transport respiratory gases; mainly oxygen
  - They have no nuclei; they only live for 3 months. After this they are destroyed in the liver or spleen.
  - 5-6 million in every millilitre of blood.
  - They are produced in the bone marrow
- White Blood Cells:
  - Also called leucocytes
  - Shape is irregular; can change shape
  - Their function is to defend against disease
  - The two main types of leucocytes are *phagocytes* and *lymphocytes*
  - PHAGOCYTES surround and ingest foreign bodies, bacteria and dead cells and collect around areas of infection or injury
  - LYMPHOCYTES act only on specific foreign material. They make antibodies which help the body's defence against disease.
  - They are much less common than red blood cells
  - Only 4 – 12 thousand per mL of blood
  - They are the largest blood cell
  - They have nuclei, unlike red blood cells
  - They are produced in the lymph nodes and glands.
- Platelets:
  - They are fragments of old cells
  - Their function is to make the blood clot
  - They are the smallest blood cell
  - No nucleus
  - Made in the bone marrow.

- LYMPH and INTERSTITIAL FLUID:

- Lymph is blood without red blood cells, platelets and large plasma proteins. It runs in lymph vessels.
- Interstitial fluid is the fluid that runs in between your body cells.

– Transporting Substances In The Blood:

- CARBON DIOXIDE:
  - It is produced as a waste product of respiration in body cells. After entering the bloodstream it may:
    1. Be converted into carbonic acid which is then changed into hydrogen carbonate ions. This change from carbon dioxide to carbonate ions happens on the red blood cells. Then they are just transported in the plasma **(only 70% of the carbon dioxide)**.

Carbon Dioxide + Water ⟶ Carbonic Acid ⟶ Hydrogen Ions + Hydrogen Carbonate Ions

$$CO_2 + H_2O \longrightarrow H_2CO_3 \longrightarrow H^+ + HCO_3^{-1}$$

    2. Binds to haemoglobin in erythrocytes forming *carbaminohaemoglobin* **(only 23% of the carbon dioxide)**.
    3. Be dissolved directly in the plasma **(only 7% of the carbon dioxide)**.
- OXYGEN:
  1. Oxygen is needed in the body for respiration. It is brought in across the respiratory surfaces of the lungs.
  2. It binds with haemoglobin in red blood cells, forming *oxyhaemoglobin.*
- WATER:
  1. Water is the solvent of plasma
  2. It makes up 60% of the volume of blood
- SALTS:
  1. These are transported by dissolving in the plasma
  2. E.G. sodium, potassium, magnesium, etc
- LIPIDS:
  1. Digested lipids are changed into *triglycerides* (this happens in the lining of the small intestine).

2. Triglycerides, together with phospholipids and cholesterol, are wrapped in a coat of protein to form a package called a chylomicron.
3. These are released into the lymph and eventually pass into the veins

- NITROGENOUS WASTES:
  1. Wastes such as ammonia are changed in urea
  2. Urea is transported dissolved in the plasma
- OTHER PRODUCTS OF DIGESTION:
  1. Includes amino acids, sugars, glycerol and vitamins
  2. They are mainly water soluble and transported in the plasma

- *Explain the adaptive advantage of haemoglobin:*
  - Structure of haemoglobin:
    - Globule-shaped protein containing four polypeptide sub-units
    - 4 polypeptide chains:
      1. 2 identical alpha chains
      2. 2 identical beta chains
    - Each polypeptide encloses an IRON-containing structure, called the HAEM group (4 HAEM groups altogether)
    - The haem groups combine with the oxygen.
  - Oxygen fuses with haemoglobin where the concentration of oxygen in the blood is low; that is, in the lungs.
  - It makes an unstable compound – oxyhaemoglobin
  - One haemoglobin molecule can carry four molecules of oxygen
  - $Hb + 4O_2 = Hb(O_2)_4$
  - Where oxygen is needed, the oxygen bond easily breaks and the oxygen is used.
  - Adaptive Advantage:
    - Mammalian cells need a lot of energy and therefore must have a continual supply of OXYGEN for RESPIRATION
    - Oxygen is not very soluble in water
    - Blood is a WATERY liquid; if oxygen was carried only by being dissolved in blood plasma, 100 ml of water would only be able to carry 0.2 ml of oxygen

- The presence of haemoglobin increases the oxygen carrying capacity of blood by 100 times. Now 100 ml of blood can carry 20 ml of oxygen.
- Dissolved only ----> 0.2 ml O_2 / 100 ml blood
- Haemoglobin ----> 20 ml O_2 / 100 ml blood
- This ability of blood to carry large quantities of oxygen gives mammals a considerable survival advantage
- It allows mammals to be active, as well as grow large.

- *Compare the structure of arteries, capillaries and veins in relation to their function:*
  - ARTERIES:
    - Carry blood away from heart (high blood pressure)
    - The pressure created by the heart's pumping creates great stress in the arteries
    - This is why the arteries are *thick walled, elastic and muscular*.
    - The arteries are not motionless; they have muscle fibres in them which can contract and relax.
    - This contracting maintains the pressure on the blood, so that the blood travels in spurts towards the body tissues (the contracting and relaxing also creates the pulse on your wrist or neck).
    - The muscle fibres of the arteries also maintain the rate of the flow of blood.
    - Arteries usually carry oxygenated blood
    - Arteries lead to arterioles (small arteries).
  - CAPILLARIES:
    - Capillaries are an extension of the inner layers of the arteries and veins
    - They join arterioles and venules (small veins)
    - Capillaries are only one cell thick, and are so narrow, that only one red blood cell can pass at a time.
    - Capillaries surround all tissue cells
    - Thus, they provide a very large surface area over which exchange of materials between blood and body can occur.
  - VEINS:
    - Veins carry blood back to the heart

- The capillaries join to form venules, which join to form veins
- Veins are not under a lot of stress - blood pressure is low
- This is why they have *thinner walls than arteries, less muscle and a wider diameter.*
- Since there are no thick muscular walls to keep the blood pulsing along, the veins have a series of valves which prevent the blood from back-flowing on its way back up to the heart.
- The veins also run through muscles, such as your leg muscles, and as you use these muscles, they press on the veins, pushing blood through the veins.

- *Describe the main changes in the composition of the blood as it moves around the body and identify tissues in which these changes occur:*
  - PULMONARY CIRCUIT:
    - Blood flows from heart to lungs and then back to the heart
    - Blood is under lower pressure than in the systemic circuit
    - However, the rate of blood flow is faster
    - Very little body fluid is formed
    - The blood, having just returned from the body, contains high CO_2 levels and low oxygen levels
    - In the lungs, blood loses CO_2 collects oxygen
  - SYSTEMIC CIRCUIT:
    - Blood flows from the heart to the body (except the lungs) and returns back to the heart
    - Blood is under high pressure due to contractions of the left ventricle of the heart, but pressure gradually lessens
    - Blood pressure forces some fluid out of blood to become body fluid
    - In the tissues:
      1. Blood gives up oxygen and other ions and nutrients
      2. Waste products, eg urea, CO_2, enter the blood
  - KIDNEYS:
    - Blood loses urea and has the composition of water and salt balanced
  - INTESTINES:

  - Blood collects the products of digestion
  - Levels of glucose, lipids, and amino acids rise
- LIVER:
  - Regulates the level of glucose in blood
  - Excess glucose is converted to glycogen and is stored
  - Converts excess amino acids to urea

- *Outline the need for oxygen in living cells and explain why the removal of carbon dioxide from cells is essential:*
  - All living cells need oxygen for respiration.
  - As a result of respiration, carbon dioxide is produced
  - When carbon dioxide dissolves in water, it makes carbonic acid.
  - This means that if a lot of carbon dioxide is produced, the body cells (and the blood and lymph) will become acidic
  - As studied before, enzymes can only function within a specific pH range
  - So an increase in carbon dioxide will result in a lowering of pH, which will affect the overall metabolism of the body.
- *Describe current theories about processes responsible for the movement of materials through plants in xylem and phloem tissue:*
  - XYLEM:
    - Transport of water is passive and depends on *transpiration* and the physical properties of water:
      1. Transpiration: Evaporation of water from the leaf cells through the stomates initiates the pull of the TRANSPIRATON STREAM. Water is then drawn up the xylem tubes to replace this loss
      2. Cohesion: Water molecules tend to bind together, forming a continuous column in the xylem, which replaces any loss
      3. Adhesion: Water molecules stick to the sides of the xylem tubes (cellulose walls).
    - The movement of water through narrow tubes is called CAPILLARITY
    - It is caused by the two forces of COHESION and ADHESION

– PHLOEM:
  - Movement of organic molecules, eg sugars, amino acids and hormones, in the phloem is called *translocation.*
  - Materials are transported both up and down the stem. Materials are distributed especially to the *growing points* and *reproductive structures*, including developing fruits and seeds
  - Flow of materials in the phloem is an active process that requires energy
  - It is thought to occur by a mechanism called the source-path-sink system and is driven by a gradient generated osmotically
  - Theory 1: *The source-path-sink system*
    1. Sugars and other mineral nutrients are 'loaded' into phloem sieve tubes of the leaves:
       - SYMPLASTIC LOADING: Sugars and nutrients move in the cytoplasm from the mesophyll cells to the sieve elements through plasmodesmata. (NOTE: Plasmodesmata have not been found in all plants)
       - APOPLASTIC LOADING: Sugar and nutrients move along the cell walls to the sieve tube. Then they cross the cell membrane by active transport.
    2. As sugars enter the phloem the concentration of phloem sap increases and the. This causes the entry of water by osmosis from the surrounding cells. This resulting pressure causes water and dissolved solutes to flow towards a SINK.
    3. A sink is a region of the plant where sugars and other nutrients are actively begin removed from the phloem. As sugars move out of the phloem, water flows out with them. This reduces the pressure in the sieve cells at the sink region.
  - Theory 2: Sugars are moved through the phloem by CYTOPLASMIC STREAMING and ACTIVE DIFFUSION within the sieve tubes.

- *Analyse information from secondary sources to identify current technologies that allow measurement of oxygen saturation and carbon*

dioxide concentrations in blood and describe the conditions under which these technologies are used:

Technology	How it Works	The Conditions It Is Used
Pulse oximeter	• Measures O_2 • Device like a peg sits on the finger and measures the transmission of light through tissues • Measures the amount of oxygen in arterial blood • There is a large difference between red light absorbed by haemoglobin compared to oxyhaemoglobin	• Used to measure the oxygen saturation of the blood in patients undergoing any procedure that requires anaesthesia or sedation or those whose breathing or circulation is abnormal
Arterial blood gas (ABG) analysis	• Measures O_2 and CO_2 • Uses electrochemical methods • Measures partial pressure (or the concentration) of O_2 and CO_2 in the blood • Measures saturation of oxygen (which is the amount of oxygen combined to haemoglobin compared to the maximum) • Measures levels of bicarbonate and pH (which show CO_2 levels) • This analysis evaluates how effectively the lungs are delivering oxygen and removing carbon dioxide	• Used when there are signs of dangerously low oxygen or high carbon dioxide levels • Helps for diagnosing as well as monitoring patients • Helpful for monitoring patients under anaesthesia, in intensive care, in accident or emergency facilities and for premature babies • Eg, a patient in a coma can have their blood gases regularly monitored

- *Analyse information from secondary sources to identify the products extracted from donated blood and the uses of these products:*
  - Whole blood is rarely given to patients
  - Usually only certain products of blood are given.
  - RED BLOOD CELLS: Used to increase the amount of oxygen that can be carried to the body's tissues; given to anaemic patients, or people whose bone marrow do not make enough red blood cells
  - PLATELETS: Used to make the blood clot; is given to people with cancer of the blood (leukaemia or lymphoma). Patients undergoing chemotherapy, whose blood does not make enough platelets, are given this.
  - PLASMA: This liquid portion of the blood, is given to people with clotting disorders (such as haemophilia), and also used to adjust the osmotic pressure of the blood (to pull fluids out of tissues).
  - WHITE BLOOD CELLS: Infection fighting component of the blood. Very rarely given, but are used when cell count is very low
  - IMMUNOGLOBINS: Also called gamma globulins, immune serum, or antibodies, these are also infection fighting parts of the blood plasma. Given to people who have difficulty fighting infections, eg AIDS sufferers.
- *Analyse and present information from secondary sources to report progress in the production of artificial blood and use available evidence to propose reasons why such research is needed:*
  - The problems of using real blood:
    - Shortage of real blood
    - It has to be 'cross-matched'. This is because, if you receive the wrong type of blood, it can be fatal. This is a great disadvantage in emergency situations.
    - It has to be free of infectious agents. Only blood that is free of bacteria and infectious agents (such as HIV) can be used. Testing the blood is costly.
    - It has a short shelf-life. Because red blood cells only survive for 3 months, the blood has a short life span (blood can only survive for 3-4 weeks).
  - Some proposed replacements for blood:

- Perflurochemicals:
  - Synthetic and inert
  - Cheap to produce
  - Can dissolve 50 times more oxygen
  - Free of biological materials, therefore no risk of infections
  - BUT - must be combined with other materials to mix in with the bloodstream (eg lecithin).
- Haemoglobin Based Oxygen Carriers (HBOCs):
  - Made from haemoglobin extracted from red blood cells
  - Haemoglobin is not contained in membrane - cross matching unnecessary
  - Can be stored for a long time
  - BUT - haemoglobin tends to oxidise to a different form, break down, and can no longer carry oxygen.
- Dextrose Solution:
  - Made of 4% glucose solution in a fluid with equal salinity to blood
  - Only used to restore blood pressure after accidents.

3. Plants and animals regulate the concentration of gases, water and waste products of metabolism in cells and in interstitial fluid:

- *Explain why the concentration of water in cells should be maintained within a narrow range for optimal function:*
  - Water makes up around 70-90% of living things; it is essential for life
  - Water is the solvent of all metabolic reactions in living cells, and sometimes directly takes part in it (eg. Respiration)
  - RECALL:
    - *Isotonic*: Concentration of solutes outside the cell is the same as inside the cell. No overall movement of water.
    - *Hypertonic*: Concentration of solutes is greater outside the cell than inside. Water tends to move out of the cell.
    - *Hypotonic*: Concentration of solutes is greater inside the cell than out. Water tends to move inside the cell.
  - Living cells work best in an isotonic environment.
  - Any change in the concentration of solutes will result in a change in the levels of water in cells.
  - This usually results in death.
  - This is why the concentration of water must be kept constant: To ensure the proper functioning of living cells.
- *Explain why the removal of wastes is essential for continued metabolic activity:*
  - As a result of metabolism, many waste products are formed (eg CO_2)
  - If these were allowed to accumulate, they would slow down metabolism and kill the cells
  - This is why they need to quickly be removed, or converted into a less toxic form.
  - When proteins and amino acids are broken down (in a process called deamination), a nitrogenous waste called ammonia, is produced
  - Ammonia is highly toxic and must be removed or changed to a less toxic form

- *Identify the role of the kidney in the excretory system of fish and mammals:*
  - The primary role is osmoregulation.
  - This is the regulation of salt and water levels in the body
  - Fish do not excrete nitrogenous wastes through the kidneys; they use their gills
  - Their urine contains mainly excess water and salts
  - Mammals' urine contains urea as well as water and salts
  - The kidneys ensure that the concentration of blood and interstitial fluid is constant
- *Distinguish between active and passive transport and relate these to processes occurring in the mammalian kidney:*
  - Active transport uses energy to transport substances across a membrane it would normally not be able to cross due to a diffusion gradient or its own properties
  - Passive transport is the movement of substances across a membrane without energy expenditure.
  - A kidney is made up of around a million nephrons.
  - A nephron is made up of a Bowman's capsule, connected to a proximal tubule, leading to the loop of Henle, which connects to the distal tubule. This all connects to the collecting duct which leads to the bladder.
  - The nephrons are densely surrounded by capillaries
  - Three processes occur in the nephrons (kidneys):
    - Filtration: Within the Bowman's capsule is the glomerulus, a dense clump of capillaries. The blood pressure here is so high that fluid and substance from the blood are forced into the Bowman's capsule, and form a fluid called the *glomerular filtrate*. It contains:
      - Substances the body can reuse: Glucose, water, amino acids, etc
      - Wastes: Urea and poisons.
    - Reabsorption: The substances the body can reuse are reabsorbed into the capillaries surrounding the nephron. Eg, vitamins and hormones. This is active transport and requires energy. Some other substances passively re-enter the blood. Eg, water and salts. This occurs in the proximal and distal tubules and in the loop of Henle.

- Secretion: This is the process where the body actively transports substances from the blood into the nephron. This is active transport.

- *Explain how the processes of filtration and reabsorption in the mammalian nephron regulate body fluid composition***:**
  - The nephron is a regulatory unit; it absorbs or secretes substances in order to maintain homeostasis.
  - This regulation maintains the constant composition of body fluids.
  - Proximal Tubule:
    - Bicarbonate ions are reabsorbed into the blood, hydrogen ions are secreted out. This maintains the pH of the blood.
    - Drugs, such as aspirin, penicillin and poisons are secreted out of the blood
    - Regulation of salts occurs here. Sodium ions are actively reabsorbed and chlorine ions follow passively. Potassium ions are also reabsorbed
  - The Loop of Henle: It has a descending limb and an ascending limb
    - In the descending limb, it is permeable to water, not salt.
    - Water passes out of the nephron by osmosis
    - In the ascending limb, the walls are permeable to salt, but not water
    - Salt passively passes out in the bottom, thin-walled section, but is actively passed out in the top, thick-walled section.
  - The Distal Tubule:
    - Selective reabsorption of sodium ions and potassium ions occurs here again, to regulate the pH of the blood, and the concentration of salts.
  - The Collecting Duct:
    - This is the end of the nephron, and connects to the ureters.
    - The walls are permeable to water only, and water is transported out accordingly to the needs of the body
    - The final filtrate is called urine.

- *Outline the role of the hormones, aldosterone and ADH (anti-diuretic hormone) in the regulation of water and salt levels in blood:*
  - ADH (Anti-Diuretic Hormone):

- Also called vasopressin
- Controls the reabsorption of water by adjusting the permeability of the collecting ducts and the distal tubules.
- It is made in the hypothalamus in the brain, but stored in the pituitary gland
- Receptors in the hypothalamus monitor the concentration of the blood:
  - *High Salt Concentration:* ADH levels increased, collecting ducts and distal tubules become more permeable to water, more water reabsorbed, concentration returns to normal. (Concentrated urine)
  - *Low Salt Concentration:* ADH levels increased, collecting ducts and distal tubules less permeable, less water absorbed, concentration returns to stable state. (Dilute urine)
- ADH does not control the levels of salt in the blood. It only controls the *concentration* of salt through water retention.

– Aldosterone:

- Produced and released by the adrenal glands, which sit above the kidneys
- Controls the amount of salt in the blood by regulating the reabsorption of salt in the nephrons
- *High Salt Levels:*
  - High blood volume and blood pressure due to water diffusing in.
  - Levels of aldosterone decreased.
  - Less salt reabsorbed, less water diffusing in
  - Salt level decreased, blood volume and pressure decreases
- *Low Salt Levels:*
  - Low blood volume and blood pressure due to water diffusing out.
  - Levels of aldosterone increased.
  - More salt reabsorbed, more water diffusing in
  - Salt levels increase, blood volume and pressure increase

- *Define enantiostasis as the maintenance of metabolic and physiological functions in response to variations in the environment and discuss its*

importance to estuarine organisms in maintaining appropriate salt concentrations:

- Enantiostasis is the maintenance of metabolic and physiological functions in response to variations in the environment.
- An estuary is where a river meets the sea, and freshwater mixed with saltwater
- This can cause a wide range of salinity levels in the area
- Organisms must be able to cope with these varying conditions to survive
- Animals can move to avoid changes, but plants must have mechanisms to help them cope with these changing environmental conditions.
- In other words, organisms in estuaries have special adaptations that allow them to maintain their metabolic and physiological functions in a changing environment

- *Describe adaptations of a range of terrestrial Australian plants that assist in minimising water loss:*
  - Extensive root systems reach underground water
  - The ability to close stomates when temperatures rise to a certain level
  - Hard leaves with a thick or waxy cuticle
  - Shiny leaves to reflect sunlight
  - Thick bark
  - Hairy leaves to reduce evaporation
  - Small leaves or false, photosynthesising leaves
- *Identify the regions of the mammalian kidney involved in the excretion of waste products:*
  - The kidney is made up of three sections, the pelvis, the medulla and the cortex
  - The cortex contains the glomeruli. It is very dark red due to the capillaries
  - The cortex is involved in the filtration of blood
  - The medulla contains the nephron tubules, as can be observed by the striped appearance of the medulla
  - This section is involved in the reabsorption and secretion of substances
  - The pelvis is where all the collecting ducts connect to

- The collecting ducts reabsorb water
- The renal artery, renal vein and ureters are all connected to the pelvis.

- *Compare the process of renal dialysis with the function of the kidney:*
  - People with dysfunctional kidneys are not able to remove wastes such as urea
  - They have to undergo renal dialysis to regulate their blood
  - The two forms of dialysis are:
    - Haemodialysis:
      - The blood is extracted from the body from a vein and passed into a dialyser, which is a bundle of hollow fibres made of a partially permeable membrane
      - The dialyser is in a solution of dialysing fluid, which has similar ion concentrations of blood
      - The dialyser only allows wastes to pass through, and not blood cells and proteins. In this way it is similar to the filtrations stage of the nephron
      - The wastes diffuse into the solution, and it is constantly replaced
      - The anti-clotting agent, heparin, is also added to prevent clotting
      - The blood is then returned to the body
    - Peritoneal Dialysis:
      - This occurs in the body
      - Dialysis solution is introduced into the peritoneal (abdominal) cavity through a catheter
      - The lining of the peritoneal cavity is a natural semi-permeable membrane and has its own rich blood supply
      - The wastes diffuse into the solution, which is replaced.
- *Outline the general use of hormone replacement therapy in people who cannot secrete aldosterone:*
  - The adrenal gland secretes aldosterone, without which the body would not be able to regulate salt and water concentrations, causing severe dehydration

- Fludrocortisone is an artificial hormone which can be used as a treatment for people who cannot secrete aldosterone (due to a damaged adrenal gland; Addison's disease).

- *Analyse information from secondary sources to compare and explain the differences in urine concentration of terrestrial mammals, marine fish and freshwater fish:*
  - **Freshwater Fish:**
    - Osmotic Problem: They are hypotonic to their environment. Water will tend to diffuse INTO their bodies. Salts will diffuse out.
    - Role of Kidney: Removes excess water. Produces large amounts of dilute urine. Kidneys also reabsorb salts. They also rarely drink water.
    - Urine: Large amount but dilute.
  - **Marine Fish:**
    - Osmotic Problem: Hypertonic to environment. Water diffuses out. High salt levels present in the water
    - Role of Kidney: Continually drinks water. Kidneys reabsorb water, while excreting salts. Small amounts of concentrated urine. Sale is also excreted across gills.
    - Urine: Small, concentrated amount.
  - **Terrestrial Mammals:**
    - Osmotic Problem: Water needs to be conserved.
    - Role of Kidney: Regulates concentration of blood, while at the same time excretes urea and conserves water.
    - Urine: Concentration changes with the availability of water, as well as temperature and water loss through sweat. Water levels in blood rise, urine amount rises, and concentration decreases and vice versa.
- *Explain the relationship between the conservation of water and the production and excretion of concentrated nitrogenous wastes in a range of Australian insects and terrestrial animals:*

- *Aquatic Animals and Fish:* These organisms directly release ammonia into the environment. This uses a lot of water, but they have no need to conserve it. Ammonia is very water soluble and is excreted through the gills.
- *Terrestrial Animals:* Releasing ammonia would be unfeasible due to lack of water. Instead, land-dwellers change ammonia into less toxic forms and release it periodically. Mammals change it into UREA and release it as urine.
- *Birds:* Birds change ammonia into URIC ACID, a whitish paste which uses hardly any water. This is lighter than using urea, and helps in flight.

- *Process and analyse information from secondary sources and use available evidence to discuss processes used by different plants for salt regulation in saline environments:*
  - Grey Mangroves:
    - *Salt Exclusion:* Special glands in the mangroves can actively exclude the salt from the water, so that the water absorbed has a lower salt concentration than the water in the environment.
    - *Salt Accumulation:* Salt is accumulated in old leaves that drop off, so that the salt is out of the plant's system
    - *Salt Excretion:* Salt can be excreted from the underside of the leaves of the mangrove plants.