HSC Biology
Module 1 – Maintaining A Balance

Focus 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 50-60% of the human body.

- Solvent in which all metabolic reactions take place.
  - Catabolic & anabolic reactions.
  - Polar nature allows it to dissolve many substances (hydrophilic substances).

- Transport medium (95% of plasma).
  - Sugars, salts, hormones, wastes.

Concentration Kept in Narrow Range:

- Amount of water affects the concentration of solutes.
  - Affects ability to diffuse in & out of cells.
  - An isotonic environment allows most efficient functioning of organism.

- Lack of water causes dehydration.
  - Blood pressure falls, circulation fails.
  - Inability to thermoregulate.

Explain why the removal of wastes is essential for continued metabolic activity.

Metabolic Wastes:

- Metabolic processes constantly produce wastes.
  - Disrupt the homeostatic balance in cells.
  - Metabolism slows.
  - Cells become poisoned, enzymes may be denatured.

Ammonia:

- Nitrogenous waste.

- Produced by the breakdown (metabolism) of proteins.
  - When dissolved in water, produces a highly alkaline environment.
    - Enzyme activity affected.
  - Ammonia removed through the kidneys.

Carbon Dioxide:

- Product of cellular respiration.

- Creates an acidic environment; causing reduced enzyme activity.

Identify the role of the kidney in the excretory system of fish and mammals.

The Kidney:

- Control water balance.
- Eliminate nitrogenous wastes.
- Osmoregulation; regulate salt & water concentration.
- Stabilise the internal environment.
  - Filter the blood, reabsorb required nutrients.
- Excrete hormones.
  - *eg.* Aldosterone.

Fish Kidney:

- Excrete ammonia across the gills.
- Freshwater fish:
  - Excrete hypertonic urine.
- Marine fish:
  - Excrete isotonic urine.

Explain why the processes of diffusion and osmosis are inadequate in removing dissolved nitrogenous wastes.

Diffusion:

- Too slow for normal functioning.
- Non selective (random movement of molecules).
- Passive (will not work against a concentration gradient).

Osmosis:

- Movement of water only.
  - Water moves out of body, wastes remain.
- Passive (will not work against a concentration gradient).
- Random movement of molecules.

Distinguish between active and passive transport and relate these to processes occurring in the mammalian kidney.

***Active Transport*:**

- Involves the expenditure of energy provided through the process of ATP splitting.
  - Moves against concentration gradient or chemical or physical properties may prevent active transport
    - *eg.* Hydrophobic lipids or large proteins.

- Endocytosis is 1 form of active transport.
  - Specific proteins in membrane binds with substance to carry it through.

***Passive Transport*:**

- No energy required.

- Substance move with the concentration gradient (many towards none).

Explain how the processes of filtration and reabsorption in the mammalian nephron regulate body fluid composition.

Filtration:

- The nephron is the functional unit of the kidney.
  - Approximately 1million in each kidney.
  - Found in the outer cortex & central medulla.

- Blood flows into the nephron under high pressure.
  - Network of capillaries known as the glomerulus carries blood.
    - Thin walls of capillaries & high pressure cause all substances to leave the blood.

- Filtration is non selective; all components are removed except erythrocytes & large proteins.

Reabsorption:

- Feedback mechanisms determine the quantities of substances reabsorbed.

- Substances re-enter through distal & proximal tubules, the loop of Henle & the collecting duct.

- All excess nutrients & wastes removed for excretion.

Outline the role of the hormones, aldosterone and ADH (anti-diuretic hormone), in the regulation of water and salt levels in blood.

Aldosterone:

- A steroid hormone produced in the adrenal cortex of the adrenal gland located on the kidney.

- Aldosterone is synthesised from cholesterol by the enzyme aldosterone synthase.

- Regulates the flow of Na^+ & K^+ ions back into the blood.
  - Aldosterone is released when a drop in blood pressure is detected, causing more ions to enter the blood.
  - This causes water to follow, restoring blood pressure.

Vasopresin:

- Produced in the hypothalamus.

- Released when a high concentration of solutes in the blood is detected.

- ADH acts to increase the permeability of the distal tube walls, allowing more water to re-enter the blood.

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:

- The maintenance of metabolic & physiological functions in response to variations in the environment.
  - Occurs in the absence of homeostasis.

Importance:

- Enantiostasis is important in animals that live in estuarine environments where salt concentrations constantly change.

Osmoconformers:

- Organisms that allow their body's osmotic pressure to vary with the environment.
- Don't maintain homeostasis.
- Concentrations of internal fluids remain isotonic to external fluids.
- Vary the concentration of solutes within cells to maintain functioning.

Eg. Sharks are osmoconformers. They are euryhaline; meaning they can tolerate changes in salt concentration.

Osmoregulators:

- Maintain homeostasis regardless of the concentration of the external environment.

Eg. Freshwater & marine fish regulate their internal environment to maintain homeostasis.

Describe adaptations of a range of terrestrial Australian plants that assist in minimising water loss.

Plant Adaptations:

- Aim to:
  - Increase water taken in by the roots.
  - Decrease water lost through evaporation.

Extensive underground root systems
Close stomata when temperature reaches a certain threshold
Hard leaves with a thick waxy cuticle
Surface with crystalline appearance
Thick bark
Hairs or other similar structure - Reduces airflow over the surface, decreasing evaporation
Reduced leaves & branchlets, false leaves performing photosynthesis
Extra thickening of cell walls throughout branches - Prevents wilting even when large quantities of water are lost

Gather, process and analyse information from secondary sources to compare the process of renal dialysis with the function of the kidney.

Dialysis:

- Means to separate.

- Simulates the role of the nephron in the kidney.
  - Separates molecules from the blood.

- Prevents waste products of metabolism building up.
  - High concentrations can lead to tiredness, weakness, loss of appetite.

- Sustains the life of people with impaired kidney function.

Renal Dialysis:

- Removes wastes in blood by diffusion across a semipermeable membrane.

- Blood drawn out of a vein, into dialysing solution.
  - Moves through plastic tubing into the machine.
    - A bundle of semipermeable fibres that allow wastes to pass out into dialysing solution.

- Clean blood taken back into the blood stream.

Peritoneal Dialysis:

- Undertaken in the peritoneal cavity of the body.

- Dialysing solution put into peritoneal cavity through a catheter.
  - Natural membrane lining of the cavity is semipermeable.

The Kidney:

- Filters the entire blood volume once every ½ an hour.

- Faster & more efficient than dialysis.

Present information from secondary sources to outline the general use of hormone replacement therapy in people who cannot secrete aldosterone.

Addison's Disease:

- Inability to secrete aldosterone from the adrenal cortex.
  - Caused by shrinking or destruction of the adrenal gland.

- Water balance unable to be maintained.
  - Blood volume & pressure drops.
  - Dehydration occurs.
  - Body functions disrupted.

- Treatment:
  - Patient takes fludrocortisone.

Analyse information from secondary sources to compare and explain the differences in urine concentration of terrestrial mammals, marine fish and freshwater fish.

Animal	Urine Concentration	Reason
Terrestrial Mammal	Concentrated, volume varies depending on availability. (Desert mammals highly concentrated).	Problem of conserving water while removing nitrogenous waste.
Marine Fish	Highly concentrated.	Problem of osmosis. Concentration of ions lower in the body than in the water. Water diffuses out, salts diffuse in. Excess salts excreted through gills, little urine excreted. Large amounts of water drank to replace it.
Freshwater Fish	Dilute	Concentration of dissolved ions higher in the body, water diffuses in. Must remove excess water through large quantities of dilute urine.

Use available evidence to 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 mammals.

Ammonia:

- Highly toxic.
  - Removed immediately.
- Product of most aquatic animals.
- Immediate product produced from the breakdown of amino acids.
- Highly soluble in water.
  - Requires large quantities of water to be safely removed.

Urea:

- 10,000 times less toxic than ammonia.
- Can be stored in body fluid for a limited time.
- Produced by mammals, sharks, amphibians.
- Highly soluble in water.
  - Small amounts of water required to remove it.
- Produced from the breakdown of amino acids.
- Major source of water loss in mammals.

Uric Acid:

- < toxic than urea & ammonia.
- Stored in the body for extended time.
- Product of terrestrial animals.
  - Birds, reptiles, insects.
- Highly insoluble in water.
  - Minimal water required to remove it.

Spinifex hopping mouse	Terrestrial	Urine in concentrated form. Arid environment. Drinks little H_2O.
Wallaroo	Terrestrial	Concentrated urine. Efficient excretory system. Recycles N & urea to make concentrated urea. Survives in an arid environment.
Insects	Terrestrial	Uric acid. Insects covered in a cuticle impervious to H_2O. Conserve H_2O by producing a dry paste of uric acid.

Process and analyse information from secondary sources and use available evidence to discuss processes used by different plants for salt regulation in saline environments.

Halophytes:

- Plants adapted to live in a salty environment.
  - Able to tolerate higher levels of salt than other organisms.
  - Have mechanisms to control the levels of salt.

Mechanisms:

- Salt barriers.
  - Tissues in roots & lower stems stop salt from entering the plant, but allow water to enter.

- Secretion.
  - Able to concentrate salt & secrete it through glands on the leaves; where it is washed off.

- Salt deposits.
  - Salt deposited in old tissue which is disregarded.

Eg.

- Grey mangrove secretes salt.
- Salt marsh plants use salt deposits.

Perform a first-hand investigation to gather information about structures in plants that assist in the conservation of water.

- Location & number of stomata.
- Arrangement, shape & size of leaves.
- Phyllodes / cladodes rather than leaves.
- Thick, waxy cuticles.
- Hairy leaves.
- Leaves reduced to spines.
- Leaves rolled inwards.
- Reflective leaf surface.

Eg. Boab tree.
- Large H_2O storage in trunk.
- Drop leaves when H_2O is scarce.
- Large root system.

Eg. Xanthorrhoea (grass tree).
- Long, thin stem.
  - Diverts H_2O to roots.
- Small surface area on leaf reduces H_2O loss.

Eg. Eucalypts.
- Thick, waxy cuticle.
- Vertical leaves.
- Reflective leaves.
- Thick trunk to hold H_2O.
- Large root system.