CONTEXT POINT 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 is essential for metabolic processes to occur – the concentration of water must be kept constant to maintain pH and substrate concentrations, as well as other conditions necessary for cellular reactions. The loss of water from cells reduces their ability to keep compounds dissolved in solution, so metabolic processes are significantly _____ or even stop.

- Water is used in homeostasis for body t_____ maintenance such as in evaporation.

- Water can l_____ and cushion internal organs so that they are not easily damaged.

- Water is used to excrete various molecules such as u_____.

- It keeps gas exchange surface moist such as the a_____ so that gas exchange can take place.

- Water is a reactant in many chemical reactions, such as photosynthesis and respiration. Without water these reactions would not take place.

QUESTION 36
Water is an essential chemical for living things. Explain why it is so important to organisms. (4 marks)

_____

_____

_____

_____

_____

_____

_____

_____

_____

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

  Some metabolic reactions produce _____ wastes that must be removed from cells as they can harm enzymes slowing down chemical reactions, change the pH and interfere with the transport of substances across cell _____. If the metabolic activity of the cell is interrupted then the cell will not function properly and the health of the organism will be compromised.

  Waste products from cellular reactions include ammonia, urea, carbon dioxide, excess salts, excess w_____ and excess hydrogen ions. If left to accumulate, these wastes will eventually kill the cell.

QUESTION 37
Why is waste removal essential for metabolic activity to continue?

A Waste products prevent the entry of essential nutrients into the cell.

B Metabolism of waste products produces chemicals that kill cells.

C Waste products alter the internal chemical environment of the cells and the metabolic processes would stop.

D Retention of waste products causes cells to lose water by osmosis and they become dehydrated.

QUESTION 38
Identify one waste product found in cells and explain why its removal is essential for continued metabolic activity. (2 marks)

_____

_____

_____

_____

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

The kidney has two main roles. One of the kidney's roles is to maintain a stable concentration of water in the blood stream. This is known as _____.

The other is to remove waste from the body. This is known as _____.
(Note that the lungs and skin are also organs of excretion. The lungs excrete water and carbon dioxide and the skin excretes water and inorganic salts.)

OSMOREGULATION

Osmoregulation is the regulation or maintenance of water concentration (and hence also the concentration of salt solutes in water) in the body in order to maintain homeostasis. Water is regulated mostly by the action of the kidney and various hormones.

EXCRETION

Amino acids (from protein) cannot be stored in the body and are broken down – deanimated – in the liver into various forms of _____ wastes.
The various forms of nitrogenous wastes excreted are:

- Urea (Humans)
- Uric acid (Reptiles, birds and insects)
- _____ (Fish and invertebrates)

Deamination removes the amino group (the part containing nitrogen) from urea. Nitrogenous wastes are the main products excreted by the kidney. Other wastes include any drugs in the blood such as caffeine or alcohol.

QUESTION 39
The concentration of urea changes as blood moves through the body. In which organ does the concentration decrease?

A Heart
B Kidney
C Stomach
D Intestine

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

The kidney is an essential part of excretion in some organisms because diffusion and osmosis are not adequate alone.

DIFFUSION

Diffusion is the movement of particles from an area of high concentration to an area of low concentration. No energy is required for diffusion to take place as the concentration gradient provides the means for the particles to move.

Diffusion is too _____ and would not be adequate in multi-cellular organisms (as it is in microscopic organisms with a large SA/V ratio) where it would need to take place across several cell membranes. It is also n____-s_____ and would therefore be an ineffective filter to remove selected waste from the blood.

OSMOSIS

Osmosis is the diffusion of water across a semi-permeable _____. The water moves from an area of high water concentration to an area of low water concentration. No energy is required for osmosis to take place as the concentration gradient provides the means for the water molecules to move.

Osmosis alone would mean that only _____ could enter and leave the blood and solid wastes would remain in the body. This means that in humans for example, urea would not be removed from the blood.

QUESTION 40
Explain why diffusion and osmosis alone are not effective in removing dissolved nitrogenous waste in some organisms. (2 marks)

_____

_____

_____

_____

_____

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

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

ACTIVE TRANSPORT

Active transport moves substances against the concentration gradient i.e. from an area of low concentration to an area of high concentration. Active transport requires the release of energy from ATP (breaking down to ADP + P) before it can take place.

PASSIVE TRANSPORT

Passive transport does not require the input of energy as the mass movement of particles is with the concentration _____, that is, from an area where they are high in concentration to an area where they are low in concentration.

THE MAMMALIAN KIDNEY

The mammalian kidney uses firstly _____ and then active transport when it carries out its role of excretion of waste products from the blood.

We have two kidneys; one located each side of abdomen. The renal artery leads to the kidney. The renal vein leads away from kidney. A ureter joins each kidney to the bladder. The urethra carries urine out of the body from the bladder.

Figure 7 – Position of Kidneys

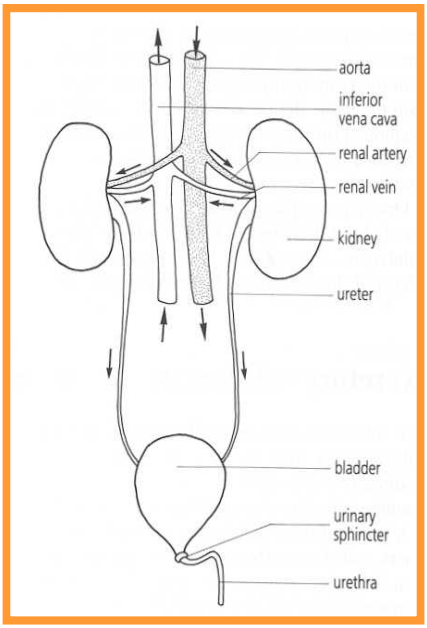
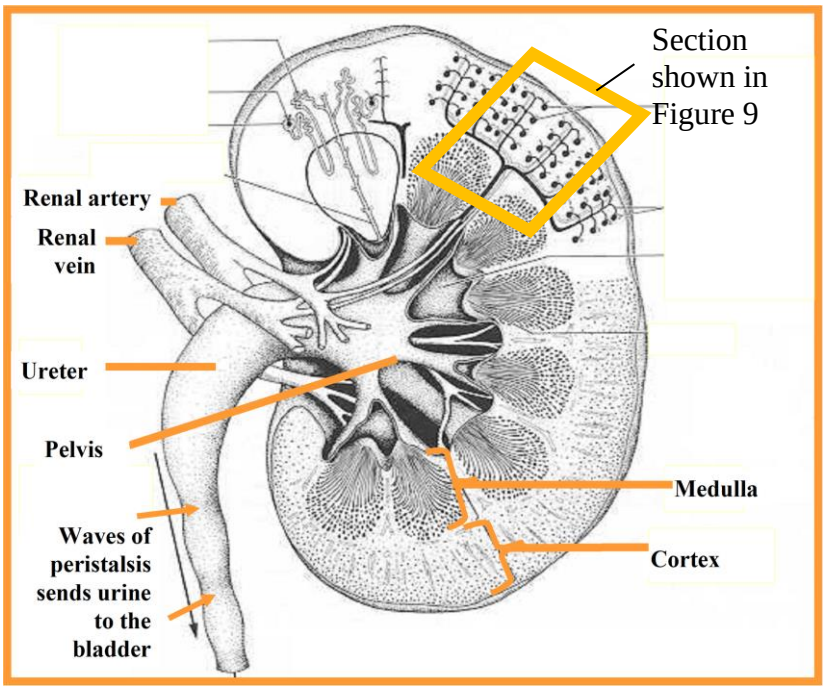


Figure 8 – Kidney Cross Section



The kidney has three main layers, the _____ on the outside (dark red), the _____ in the middle (paler colour), and the _____ in the centre (white).

The _____ is the functional unit of the kidney and performs the role of 'cleaning the blood'. It does this by _____ and _____.

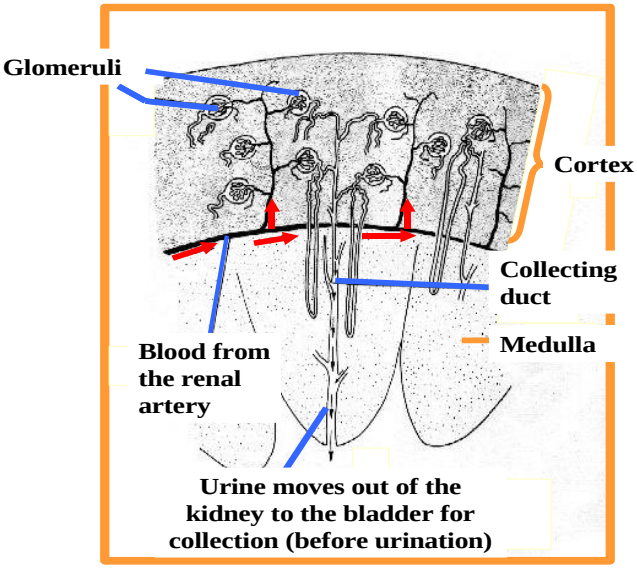


Figure 9 – Kidney Cortex showing Nephron Filtering

FILTRATION

Filtration takes place in the cortex of the kidney from the _____ to the Bowman's _____. The glomerulus is a dense capillary network where blood comes in from the arteriole under pressure. Small molecules – water, urea, glucose, amino acids, ions – are forced through the wall of the capillary into the Bowman's Capsule. Large molecules and cells – red and white blood cells and large proteins – remain in circulation as they are too large to cross into the Bowman's Capsule. The molecules are therefore filtered according to their size.

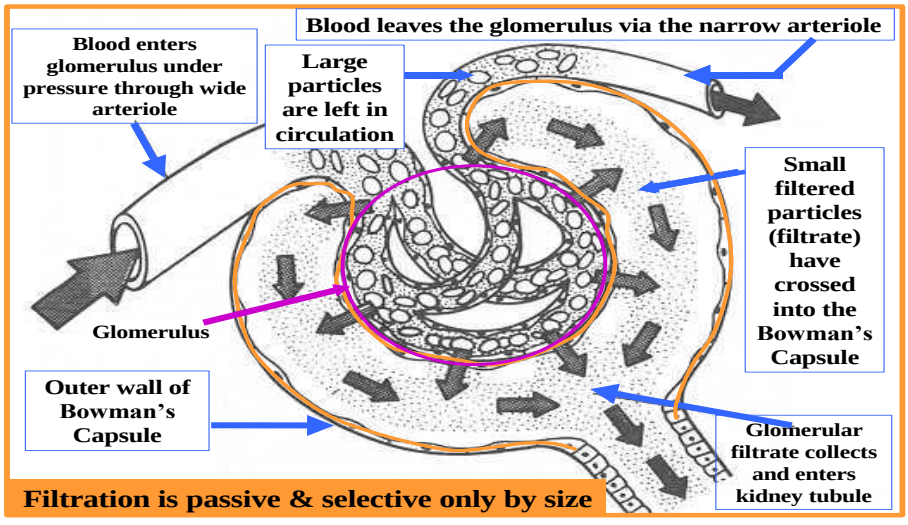
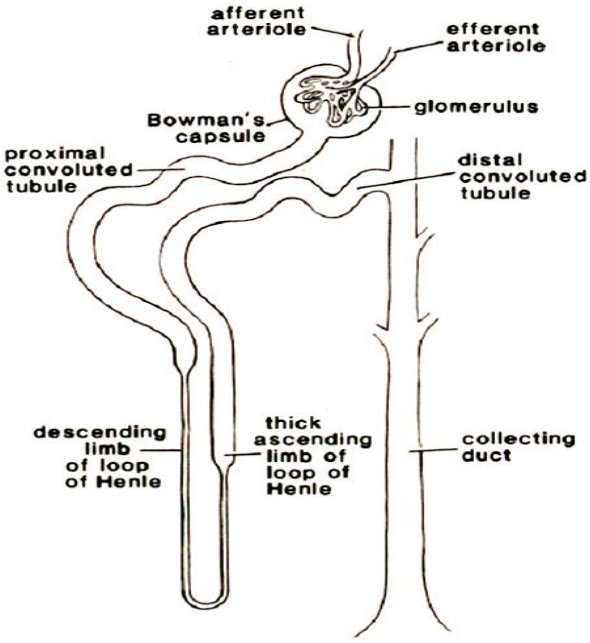


Figure 10 – The Glomerulus and Bowmans Capsule

REABSORPTION

As the filtrate passes through the kidney tubule, active reabsorption (requires energy) of useful materials – most salts, all glucose, all amino acids, some water – takes place. The materials that are not reabsorbed – such as urea – stay in the kidney tubule and leave the nephron via the collecting duct.

Figure 11 – The Nephron



PASSIVE TRANSPORT IN THE MAMMALIAN KIDNEY

Filtration: Water, urea, glucose, amino acids, and ions move passively from the glomerulus to the Bowmans capsule during filtration.

Reabsorption: Some water, some salts and some urea moves by _____

_____ from the kidney tubule into the surrounding blood vessels during reabsorption.

ACTIVE TRANSPORT IN THE MAMMALIAN KIDNEY

Filtration: No active transport used.

Reabsorption: Most salts, all glucose, all amino acids and some water is actively moved from the kidney tubule back into the _____ where it is needed. Some ions and toxins in the blood can be moved actively into the kidney tubule ready for excretion.

QUESTION 41
On the diagram of the nephron above:

(a) Circle the area where filtration takes place.

(b) Shade the area where reabsorption takes place.

(2 marks)

QUESTION 42
Which of the following statements best descries active transport?

A Active transport requires less energy than passive transport.

B Active transport is the movement of solute from an area of high concentration to one of low concentration.

C Active transport is the movement of solute from an area of low concentration to one of high concentration.

D Active transport is the movement of water from an area of low solute concentration to high solute concentration through a semi-permeable membrane.

QUESTION 43
Which statement best describes a function of nephrons?

A Filter waste products from the blood.

B Remove carbon dioxide from the blood.

C Collect urine from the blood.

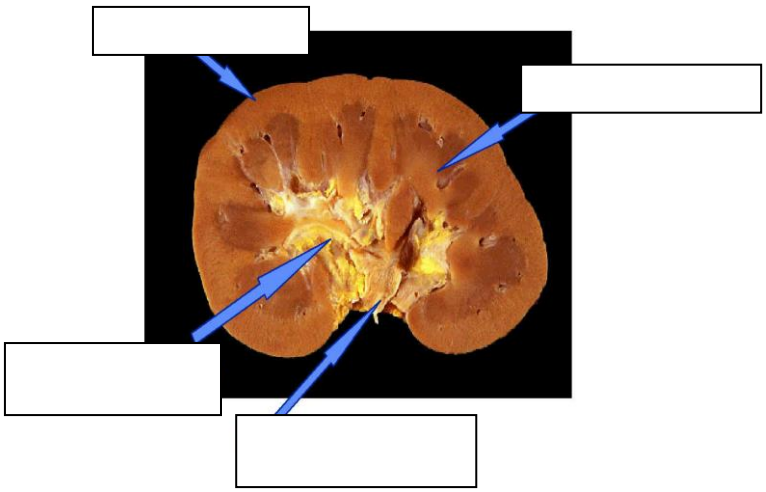
D Remove the waste products directly from the cells in the blood.

- **Perform a first-hand investigation of the structure of a mammalian kidney by dissection, use of a model or visual resource and identify the regions involved in the excretion of waste products.**

FIRST HAND INVESTIGATION

In class you will have either dissected a mammalian kidney or used a model or visual resource such as photos to identify the regions involved in excretion.

QUESTION 44
Label the parts of a mammalian kidney below.



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

SECONDARY SOURCE INVESTIGATION

In class you will have gathered information from various secondary sources, extracted the information needed to compare renal dialysis with kidney function.

HAEMODIALYSIS

Haemodialysis treatment involves the person's blood being passed through a machine that contains a filter and dialysate. Blood enters the machine where urea moves by diffusion from the blood, across the filter (a semi-permeable membrane), into the dialysate. Once the blood is filtered it is returned to the person. Hemodialysis can be done at home or in a dialysis centre. Patients with renal failure are required to undertake dialysis about three times a week for 4 to 6 hours at a time.

ANALYSE

Prepare a table to compare the two processes.

QUESTION 45
Compare the process of renal dialysis with the function of the kidney. (4 marks)

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

ANTI-DIURETIC HORMONE

Anti-diuretic hormone (ADH) is made in the hypothalamus and stored in the pituitary gland. It is released by the pituitary gland and travels by the bloodstream to the kidney. ADH causes the kidney to _____ water from the tubule back into the blood. If the body contains enough water, then little ADH is present in the blood. If the water concentration is too low, ADH is released to restore the osmotic balance. ADH increases the _____ of the membranes of the distal tubules and collecting ducts to water. Therefore, more water is reabsorbed.

ALDOSTERONE

Aldosterone is a steroid hormone secreted by the adrenal gland. Aldosterone's function is to regulate the _____ of sodium and potassium ions in the kidney. When blood pressure is low due to low sodium levels, aldosterone is released into the blood causing more sodium to be reabsorbed from the nephron to the blood. Water then flows from the nephron into the blood by osmosis. This results in an increase in blood pressure.

QUESTION 46
What is the role of ADH?

A It increases the amount of water reabsorbed in the kidney.

B It increases the amount of sugar reabsorbed in the kidney.

C It decreases the amount of water reabsorbed in the kidney.

D It decreases the amount of sugar reabsorbed in the kidney.

QUESTION 47
Name one hormone that you have studied during your course and explain its role in the regulation of water or salt levels in the blood. (5 marks)

- **Present information to outline the general use of hormone replacement therapy in people who cannot secrete aldosterone.** 

SECONDARY SOURCE INVESTIGATION

In class you may have presented information as a talk, poster, PowerPoint, summary etc on using HRT in people who cannot secrete aldosterone.

HRT FOR ALDOSTERONE

Aldosterone is a mineralocortocoid (group of hormones similar to aldosterone) which acts on the kidney to promote the reabsorption of sodium ions into the blood and excretion of potassium ion, and therefore increases the water content of the blood, maintaining normal blood pressure. People who cannot secrete aldosterone suffer from Addison's disease, and they cannot regulate their _____ and _____ balance properly, causing blood volume and blood pressure to drop. Other symptoms include weight loss, fatigue and skin discolouration. By taking drugs such as Florinef to replace the aldosterone not being produced, the disease can be managed effectively. Without the replacement hormone, the low blood pressure and sodium levels, along with higher levels of potassium, can be life-threatening.

QUESTION 48
Outline the use of hormone replacement therapy in people who cannot secrete aldosterone.
(4 marks)

- **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

Enantiostasis is applicable to any organism that lives in a _____ environment. Estuarine fish, invertebrates and mangroves are all examples of organisms that carry out enantiostasis due to the change in salt concentration of their environment.

WHY IS IT IMPORTANT TO ESTUARINE ORGANISMS?

These organisms have to tolerate changes in salt concentration in order to survive.

_____ maintain the concentration of their internal fluids at approximately the same level as the external environment. Organisms in rock pools are often osmoconformers. Estuarine crabs and sharks use small organic molecules such as non-essential amino acids to vary the concentrations in their cells to match the environment. Osmoregulators, such as most fish, are able to control salt levels in their bodies and maintain homeostasis.

A small number of fish such as some eels and salmon can live in both freshwater and saltwater environments. Their _____ and kidneys function like those of freshwater fish in fresh water and saltwater fish in salt water. Salmon change their physiology before entering fresh water. In the ocean their bodies tend to dehydrate in the seawater. They constantly drink seawater, using a salt gland to extract the salt, so that they do not get dehydrated. The opposite is true in fresh water, their bodies tend to take on water and become bloated. So, in fresh water salmon stop drinking and begin to process large amounts of urine to rid their bodies of the extra water.

Salinity fluctuates for organisms on a rock platform. Many organisms seek refuge under a shell while the tide is out. Mussels close their valves and keep a salt concentration close to that of seawater in their mantle cavity.

QUESTION 49

(a) Define the term *enantiostasis*. (1 mark)

_____

_____

_____

(b) Outline the method used by one estuarine animal to maintain appropriate internal salt concentration. (4 marks)

_____

_____

_____

_____

_____

_____

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

SECONDARY SOURCE INVESTIGATION

In class you would have researched the different urine concentrations of terrestrial mammals, marine fish and freshwater fish and analysed the information by comparing it.

TERRESTRIAL MAMMALS

Terrestrial mammals are not surrounded by water so they excrete small quantities of _____ urine in order to conserve water.

MARINE FISH

Marine fish live in a hypertonic (high salt) environment. This means that their cells can lose water and they are constantly at risk of _____. They therefore produce small amounts of concentrated urine.

FRESHWATER FISH

Freshwater fish live in a hypotonic (low salt) environment. This means that their cells gain water easily. They produce lots of _____ urine to get rid of the excess water.

ANALYSE

Construct a table to present the information.

QUESTION 50
A biologist studied the concentration of urine produced by terrestrial mammals, a fresh water fish and a marine fish. Which row of observations would be the most likely for these organisms in their natural environment?

	Terrestrial mammal	**Freshwater fish**	**Marine fish**
A	Produces dilute urine	Produces concentrated urine	Produces dilute urine
B	Produces concentrated urine	Produces dilute urine	Produces dilute urine
C	Produces dilute urine	Produces concentrated urine	Produces concentrated urine
D	Produces concentrated urine	Produces dilute urine	Produces concentrated 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.**

SECONDARY SOURCE INVESTIGATION

You should have used available evidence to explain the relationship between the conservation of water and the production and excretion of nitrogenous wastes in a range of Australian insects and terrestrial mammals.

MAMMALS

Australian mammals, including marsupials and monotremes, convert ammonia to _____, which dissolves in water to form _____. Urea is less toxic than ammonia, so it can stay in the body longer than ammonia. Mammals that need to conserve water produce very concentrated urine.

INSECTS

Australian insects convert ammonia to uric _____, which is not very soluble and is not toxic. This is absorbed by the Malphigian tubules, which are found between the insect's mid-gut and hind-gut. The low pH causes the uric acid to precipitate out as crystals. The production of uric acid as a waste molecule means that even less water is lost during excretion.

QUESTION 51
The Australian hopping mouse, Notomys *alexis*, is a desert animal. It produces urine that is very concentrated. Why this is an advantage?

A It needs to conserve water.
B It is nocturnal and only drinks at dusk.
C It has a high intake of salt in its specialised diet.
D In needs to excrete large amounts of water to survive.

QUESTION 52

(a) Explain the relationship between conservation of water and nitrogenous waste concentration for ONE named Australian mammal. (2 marks)

_____

_____

_____

(b) Explain the relationship between conservation of water and nitrogenous waste concentration for ONE named Australian insect. (2 marks)

_____

_____

_____

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

FIRST HAND INVESTIGATION

In class or during an excursion you would have examined the structures in plants that assist in salt regulation in saline environments.

_____ play an important part in the life of an estuary as they are a nursery for junior fish and prevent erosion of the shoreline. Pneumatophores project up from the main roots and absorb oxygen from the air.

Mangroves have three ways to cope with salt: Exclusion, secretion and accumulation.

- Exclusion – special tissues act as a barrier to salt uptake.
- _____ – salt is released through special glands on the leaves and deposits are washed from the leaves during rain. E.g. Dry Mangrove and River Mangrove.
- Accumulation – salt is accumulated in older tissue and then discarded. E.g. Milky Mangrove.

QUESTION 53
Describe the features of a named plant found in extremely saline conditions that allows it to survive. (3 marks)

_____

_____

_____

_____

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

REDUCED LEAVES

Small leaves such as in the Hakeas have a smaller surface area to reduce the amount of water that can be lost.

SUNKEN STOMATES

Wollemi pines have their stomates in _____ so that the humidity in the area just outside the stomate is more humid that in the environment. This allows transpiration to take place with reduced water loss.

WAXY CUTICLE

Many species, such as eucalypts have a thick waxy cuticle that prevents _____ loss from the leaf.

HAIRY LEAVES

The paper daisy has fine hairs on the stems and leaves that trap water and increase the humidity in the area around the stomate.

LEAF CURL

Porcupine grasses curl their leaves when it is hot so that their stomates are on the _____. This helps protect the leaf from evaporation.

CAM (CRASSULACEAN ACID METABOLISM) PLANTS

Pig face plants close their stomata during the day decreasing transpiration. They open them again at night in order to take in carbon dioxide for _____.

QUESTION 54
Spinifiex is also called porcupine grass because its leaves can curl up into a needle shape. The stomates are located in sunken grooves on the underside of the leaf and are enclosed as the leaf curls up. Which process do these adaptations best reduce?

A Conduction
B Pollination
C Translocation
D Transpiration

QUESTION 55
Describe an adaptation in a named plant that minimises water loss. (2 marks)

_____

_____

_____

_____

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

FIRST HAND INVESTIGATION

In class or during an excursion you would have examined the structures in plants mentioned in the dot-point above that assist in the conservation of water.

QUESTION 56
Identify two safe work practices needed during this investigation. (2 marks)

_____

_____

_____

_____