Life Sciences Grade 11 Chapter 8 Excretion IN Humans

Life Sciences (High School - South Africa)

CHAPTER 8: EXCRETION IN HUMANS

8: Excretion in humans

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Introduction

An accumulation of waste is dangerous to the cells, tissues, organs, systems and the body as a whole. The human body is designed to effectively remove waste.

This chapter will briefly look at excretion in various organs, the substances excreted by each and the origins of these substances. There will be a detailed focus on the human urinary system and the structure and functioning of the human kidneys. It is these organs that filter the blood, regulate water and salt levels and play an important role in the control of blood pH levels.

Kidney functioning can be weakened by diseases, lifestyle choices and accidental injuries. Renal or kidney failure can be effectively treated with dialysis or kidney transplants which are successfully carried out in many hospitals in South Africa.

Key terminology

excretion	the removal or elimination of metabolic waste from an organism
secretion	the release of a useful substance (enzymes, saliva) from cells or glands
egestion	the removal of undigested food solid waste from the digestive tract in the form of faeces = defaecation
metabolism	chemical reactions that take place within every cell of the body. these can be building up (anabolic) or breaking down (catabolic) reactions
renal	relates to the kidney
deamination	removal of an amino group from amino acids

Excretory organs

In human digestion, carbohydrates, proteins, fats and vitamins are broken down into their simplest form and enter the blood stream to be utilized where they are needed.

Excretory waste products include CO_2, H_2O, bile pigments, urea and mineral salts. Table 1 summarises how they are produced, the organs involved in their excretion and the final products of excretion.

Table 1: Excretory organs and their waste / excreted product

Waste products	Origin	Excreted product
Lungs		
carbon dioxide and water vapour	cellular respiration	CO_2 and $H_2O(g)$ in exhaled air
Skin (sweat glands)		
mineral salts, traces of urea, water	extracted from the blood	perspiration (sweat)
Liver		
urea	deamination of excess amino acids	Faeces
bile pigments	breakdown of haemoglobin	
Colon		
bile pigments, excess mineral salts	from the breakdown of haemoglobin in the liver	Faeces
Kidney		
urea	deamination of excess amino acids in the liver	Urine
mineral salts	excess taken in with food	
water	excess water consumed and taken in as food	

The urinary system

Key terminology

osmoregulation	the control of water levels in the body
adipose	fat tissue
aorta	the main artery leaving the heart, supplying body with blood
renal artery	brings oxygenated, unfiltered blood to the kidneys
renal vein	carries deoxygenated, filtered blood, from the kidneys
renal capsule	outer membrane covering the kidney

The two kidneys, two ureters, bladder and urethra form the urinary system. The renal blood supply, including an extensive network of blood capillaries, ensures that a steady flow of blood reaches and leaves the kidneys.

The kidney performs the following four **main functions** of the urinary system

- **Osmoregulation** – regulation of levels of H_2O in body fluids
- **Excretion** – removal of nitrogenous waste e.g. urea
- **Regulation of pH** of body fluids
- **Regulation of salt** concentration of body fluids

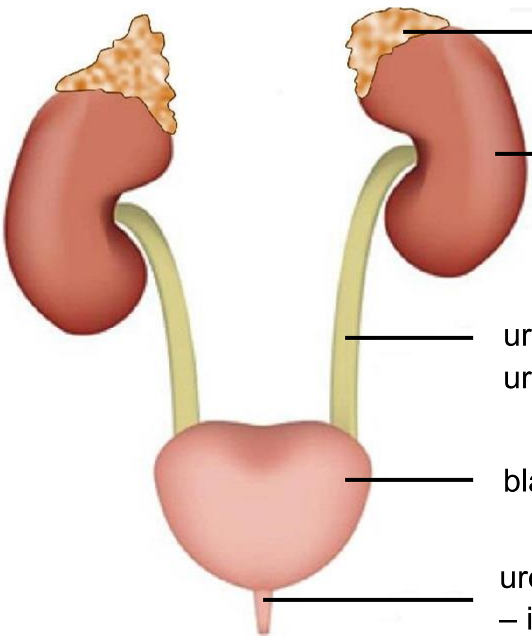


Figure 1: Structure and functions of the different parts of the urinary system

The structure of the kidney

- The kidneys are bean shaped structures (Figure 2) that are found half-way down the back just under the ribcage.
- They weigh between 115 and 170 grams each depending on the age and gender of the person and are about 11 cm long.
- The kidneys are protected by adipose (fat) tissue and each kidney is covered by a renal capsule which protects the kidney and its internal structures from infections.
- Blood carrying waste products but rich in oxygen, is taken to the kidneys by the renal artery which branches off the aorta.
- The blood is filtered by the kidney.
- Deoxygenated blood with the waste products removed, leaves the kidney through the renal vein.

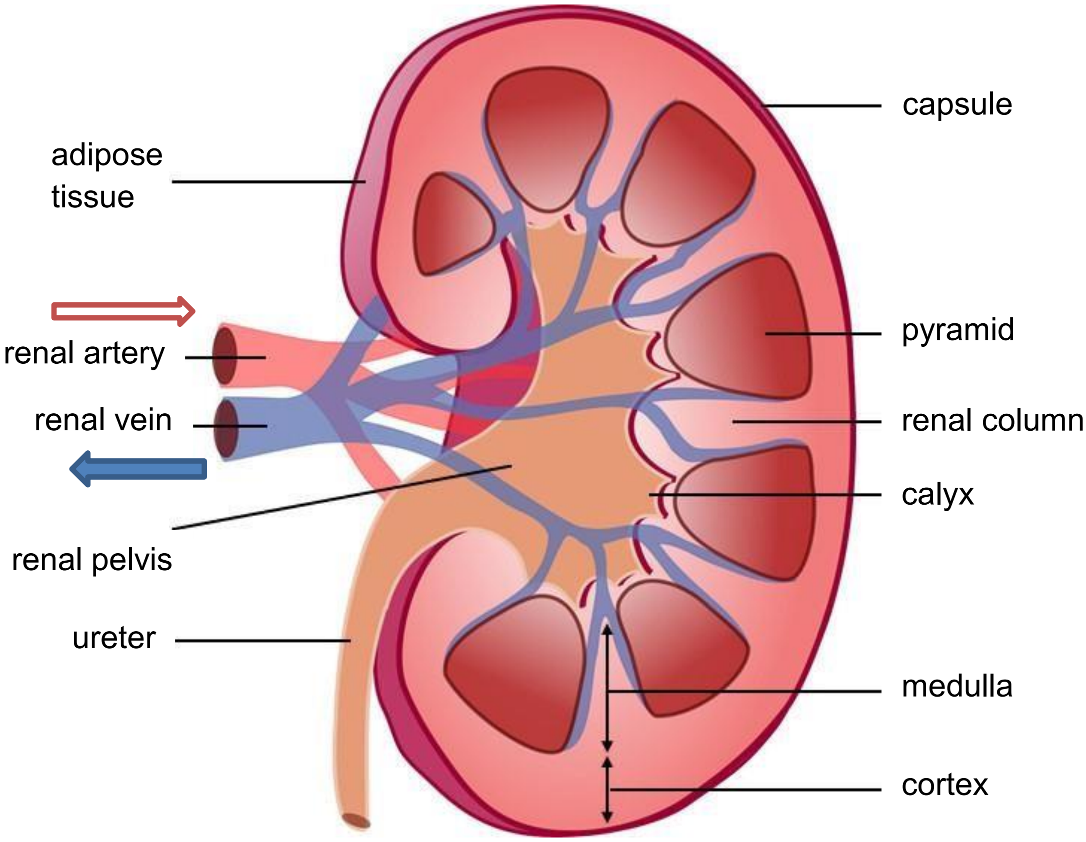
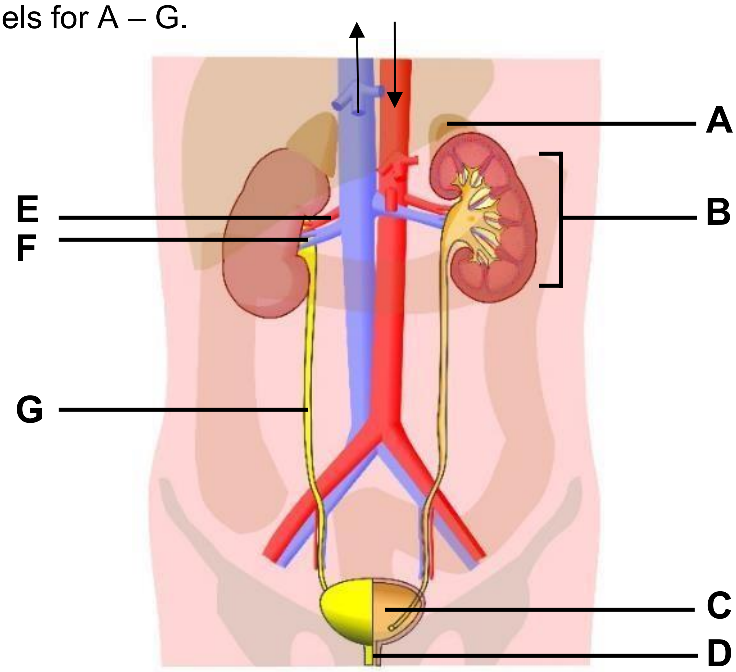


Figure 2: Longitudinal section through a kidney

Activity 1: Excretory organs

1. Supply a caption for the diagram below. (1)
2. Supply labels for A – G. (7)



3. What type of blood does E bring to the kidney? (1)
4. What is the function of the part labelled C? (1)

5. Name 4 important functions of the part labelled B. (4)
6. What 2 substances does the part D carry in adult males? (2)

(16)

Activity 2: Sheep kidney dissection

Dissection of a sheep's kidney, showing the external and internal structure:

Aim: To examine the external and internal structure of a mammalian kidney and related structures.

What you will need:

- sheep kidney (obtained from local butchery)
- a sharp scalpel or knife, a dissecting needle and a pair of scissors
- a dissection board, dissecting pins, and a hand lens
- disposable rubber gloves and soap
- a ruler, some white paper, writing paper and pen, tissue paper

Instructions

1. Lay out the sheep kidney on the dissection board. Remove the excess fat off the kidney.
2. Measure the length and width of the kidney.
3. Identify the 3 separate tubes entering and leaving the kidney. [renal artery; renal vein and the ureter]
4. The renal artery will have thicker walls than the renal vein.
5. Remove the thin strong membrane structure that covers the kidney.
6. Cut along the longitudinal axis of the kidney and open it up into two halves.

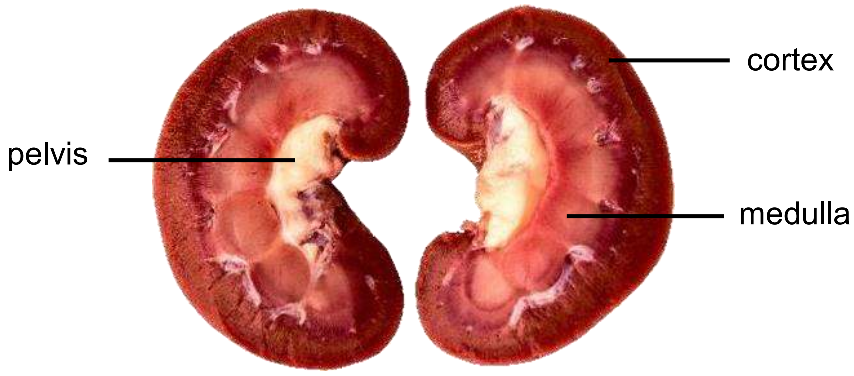


Figure: Longitudinal section through lamb kidney (internal structure)

7. Identify the outer cortex. This should be a deep red-brown colour.
8. Identify the light pink medulla region. Observe the appearance of this area by using a hand-lens.
9. Identify the pelvic region. This is creamy white in colour. It is the point where the 3 tubes enter/leave the kidney.
10. Clean all the apparatus and your workstation. Discard the dissection material as the teacher instructs.
11. Wash your hands thoroughly and answer the activity questions.

Questions:

1. Draw a line diagram of a longitudinal section through the kidney. Label the sections you can observe from your dissection and the colours you see. (6)
2. State the function of the (a) fat around the kidney?
   (b) renal capsule around the kidney? (2)
3. Explain why it is an advantage to have two kidneys instead of one. (2)
4. Name the artery that transports blood to the kidney. (1)
5. Where does the ureter lead to and what is its function? (2)

(13)

The structural and functional unit of the kidney

Key terminology

nephron	the microscopic functional unit of the kidney
podocytes	specialised cells lining the Bowman's capsule in the kidney
afferent arteriole	blood vessel bringing blood from the renal artery into the bowman's capsule of the nephron and forming the glomerulus
efferent arteriole	blood vessel taking blood from the glomerulus and into the peritubular capillary
glomerulus	a dense capillary network in the Bowman's capsule of the kidney
Bowman's capsule	a cup-shaped structure surrounding the glomerulus
Malpighian body / renal corpuscle	made up of the glomerulus plus Bowman's capsule
proximal convoluted tubule	the folded portion of the nephron that lies between Bowman's capsule and the loop of Henle

distal convoluted tubule	the folded portion of the nephron between the loop of Henle and the collecting tubule.
peritubular capillaries	tiny blood vessels, supplied by the efferent arteriole, that travel alongside nephrons allowing reabsorption and secretion between blood and the inner lumen of the nephron.

The kidneys are highly complex filtration organs. Once in the kidney the renal artery branches into narrower blood vessels until they are in contact with the core functional unit of the kidney, **the nephron** (Figure 3 and 4 below).

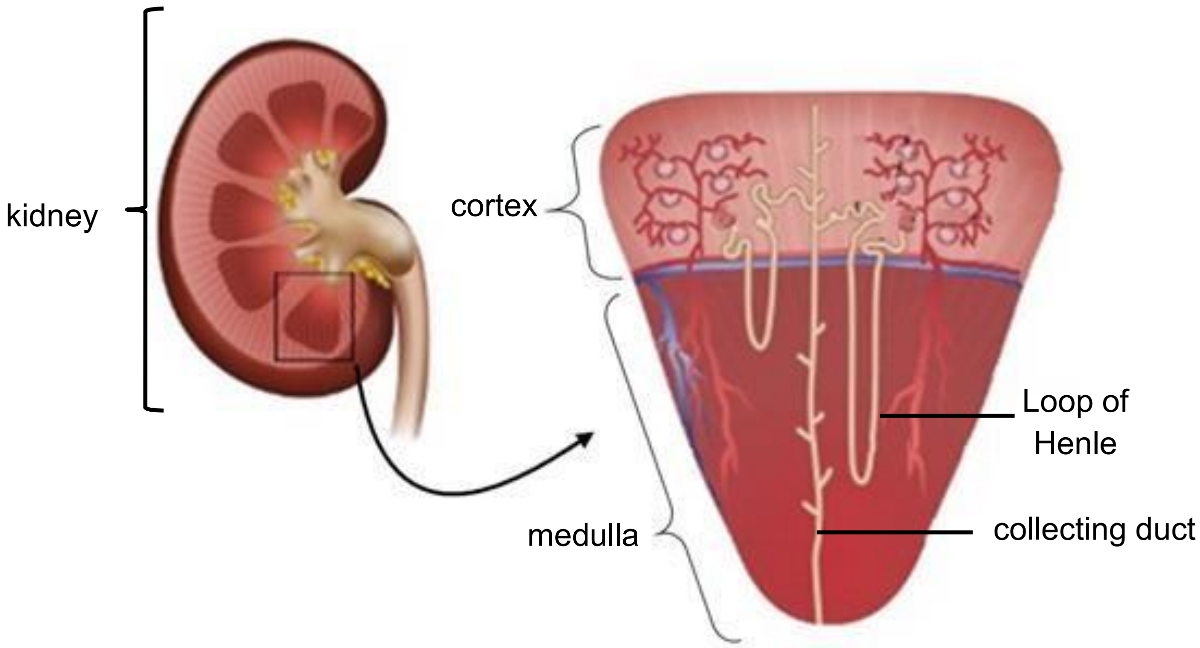


Figure 3: Kidney and position of the nephrons

Nephrons are **microscopic** coiled structures made up of tubes, arterioles, capillaries and ducts. Each human kidney has about 1 million nephrons.

Their main function is to filter the blood, regulate the waste, water and other important substances the body needs.

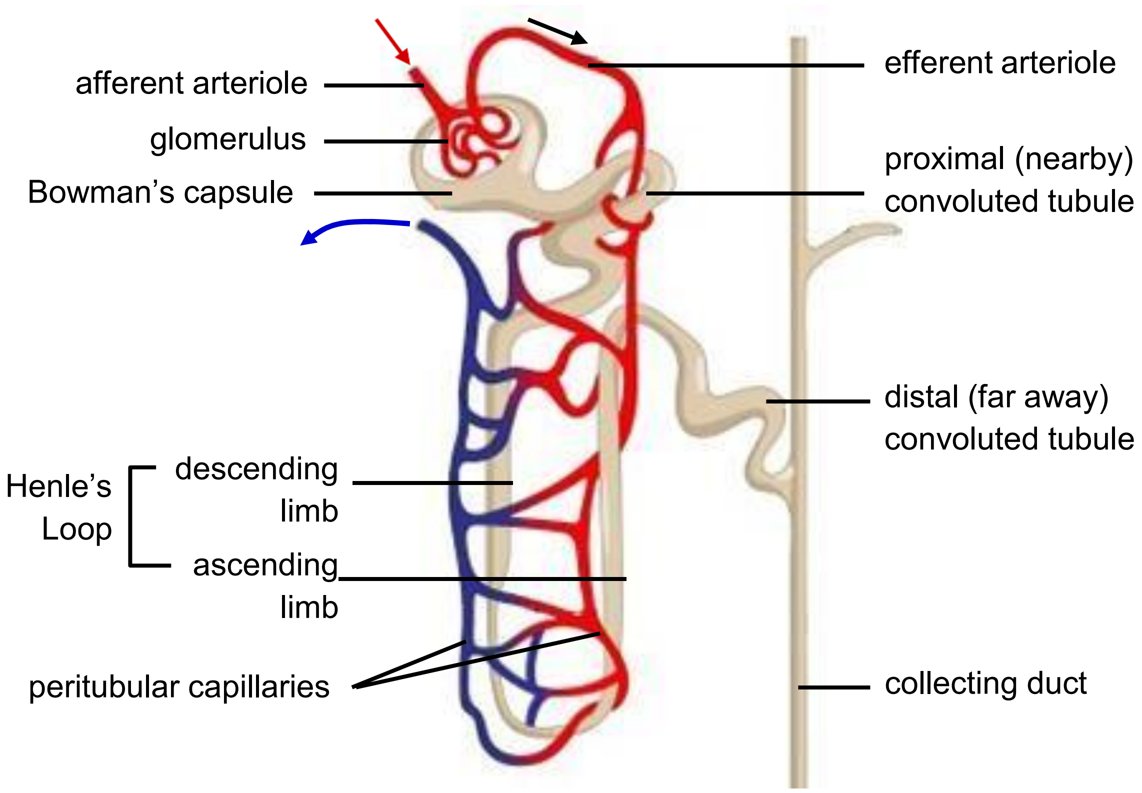


Figure 4: The structure of the nephron

The nephron can be divided into 2 separate sections – the **Malpighian body** (Figure 6) and the **renal tubule**.

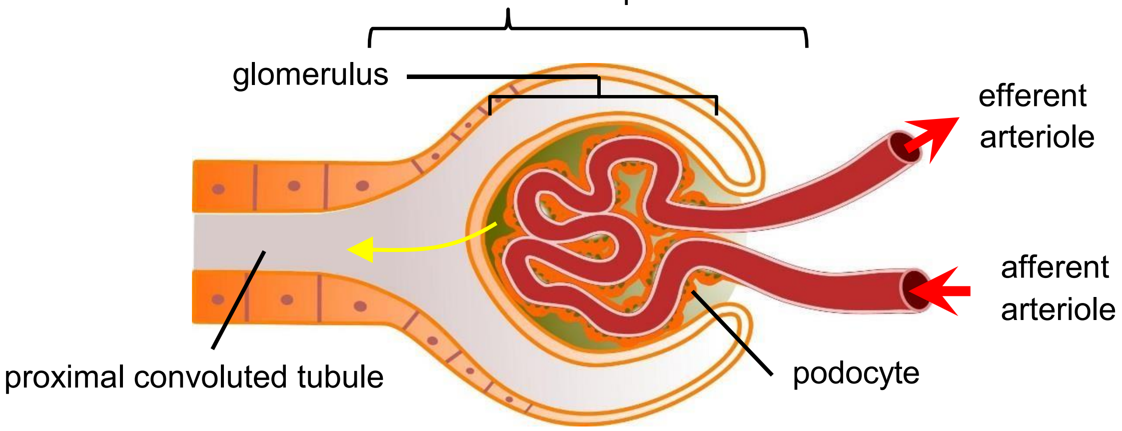


Figure 5: Malpighian body of the nephron

1. The **Malpighian body** (renal corpuscle) (Figure 6) occurs in the cortex region of the kidney: it includes the cup-shaped **Bowman's capsule** and a dense capillary network in the hollowed-out region of the capsule called the **glomerulus**.

   The inner lining of the Bowman's capsule has special cells called **podocytes**. These cells have finger-like extensions that wrap around the capillaries of the glomerulus. There are slits between these extensions to allow substances to pass through.

2. The **renal tubule:** This includes the **proximal** (first, or close to) **convoluted tubule** in the cortex, the **loop of Henle** which runs into the medulla and the **distal** (second, or distant, far from) **convoluted tubule** back in the cortex (see also Figure 4 / 5 above). The distal tubule feeds into the collecting ducts that lead to the pelvic region of the kidney. The renal tubule is surrounded by a secondary capillary network known as the **peritubular capillary network**.

   Cuboidal epithelial cells line the renal tubule and have microvilli extensions on their surface. Each of these cells has a rich supply of mitochondria. Energy supplied by cellular respiration can be used to move substances against a gradient.

Kidney functions performed by the nephron

Key terminology

hypertonic	a relatively low water and a high salt concentration
hypotonic	a relatively high water and a low salt concentration
permeable	allows substances to flow easily
dehydration	loss of water

The formation of urine involves the following (see Figure 6 below):

1. glomerular filtration or ultrafiltration
2. tubular re-absorption
3. tubular secretion
4. excretion

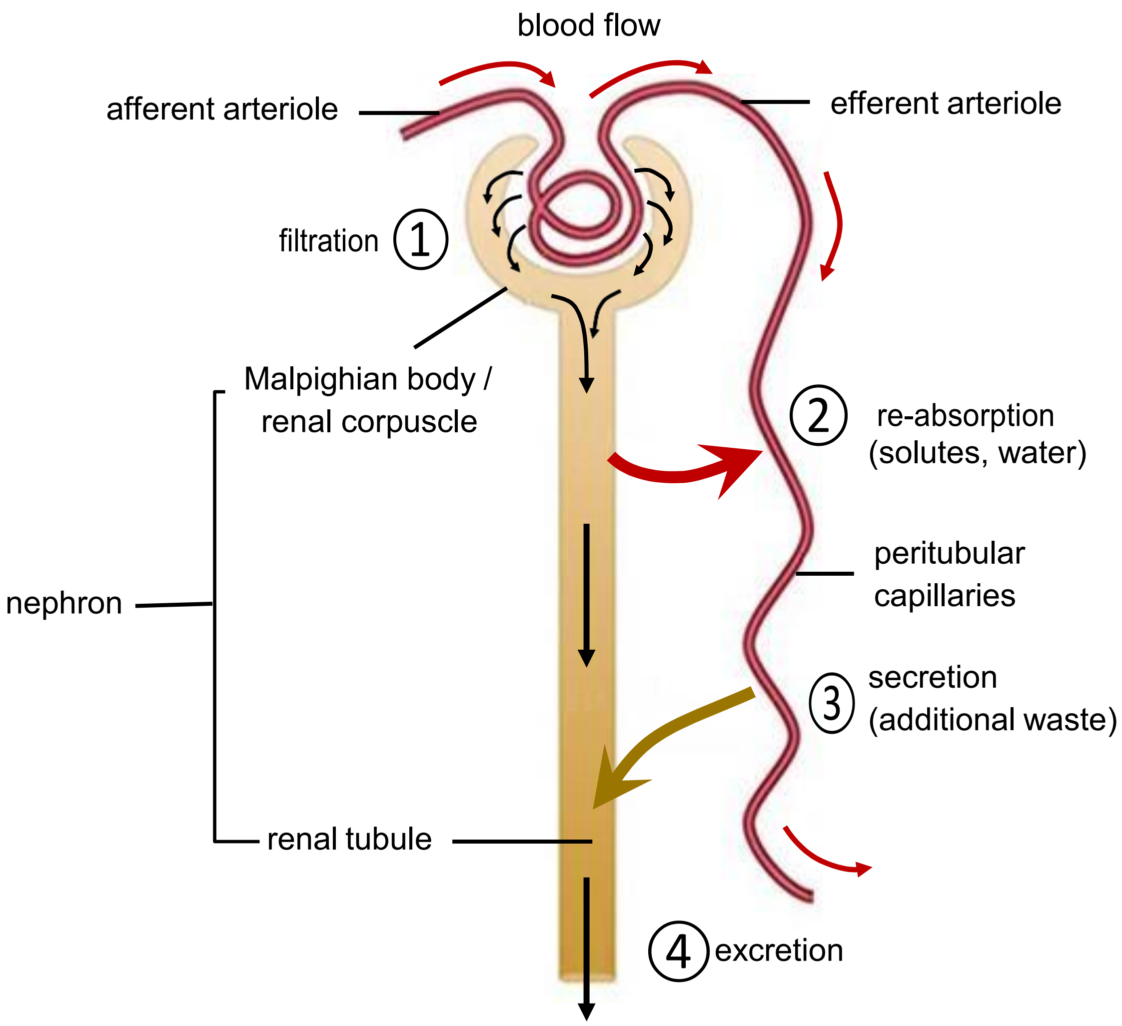


Figure 6: Diagram of the location of the main processes as they occur in the nephron

Figure 7 below is a summary of the composition of human blood. It will help your understanding of kidney functioning

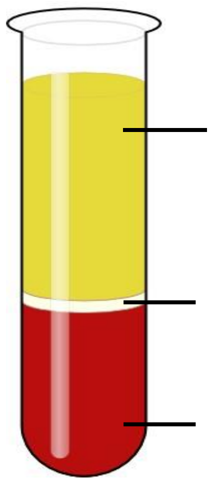


Figure 7: The composition of human blood

1. Glomerular filtration

Glomerular filtration takes place in the Malpighian body of the nephron. Blood enters the glomerulus from the renal artery in the afferent arteriole and leaves the glomerulus in the efferent arteriole.

Various adaptations of the Malpighian body ensure that filtration takes place.

- The afferent arteriole is wider than the efferent arteriole. This results in the blood being put under high pressure forcing the plasma with dissolved substances into the capsular space of the Bowman's capsule.
- The walls of the glomerulus capillaries are thin and consist of a single layer of squamous epithelial cells. This together with the podocytes found on the inner wall of the Bowman's capsule make ultra-filtration possible.
- Only the smaller dissolved substances travel through the filtration slits between the podocytes. Larger proteins remain in the blood.
- Bowman's capsule is cup-shaped to enlarge the contact area with the glomerulus.

The formation of the glomerular filtrate is a non-selective process, i.e. both useful (e.g. glucose, amino acids, vitamins, minerals and water) and waste substances (e.g. urea and uric acid) are filtered through into the capsule.

2. Tubular re-absorption

Tubular re-absorption takes place in the **proximal convoluted tubule** and involves an **active re-absorption** of the glucose, amino acids, vitamins and other important substances that ended up in the glomerular filtrate.

About 65% of the water also moves back into the blood of the peritubular capillaries by osmosis. This process prevents dehydration and any unnecessary loss of important substances.

Why is tubular re-absorption efficient?

Active transport needs energy. Cuboidal epithelial cells lining the tubules have many mitochondria (site for cellular respiration). Microvilli on these same cells increase surface area for maximum re-absorption. The movement of water is by the passive process of osmosis. The fluid in the renal tubule is now called tubular filtrate.

The **Loop of Henle** (Figure 8) ensures that water is conserved and recovered from the filtrate and returned to the blood. The cells lining the ascending loop of Henle are impermeable (block movement) to water. Salt is actively pumped out of the loop and into the medulla tissue of the kidney. The medulla becomes hypertonic (very salty) which means it has a low water potential (water does not want to leave). A steep gradient develops between the tubular filtrate and the medulla tissue.

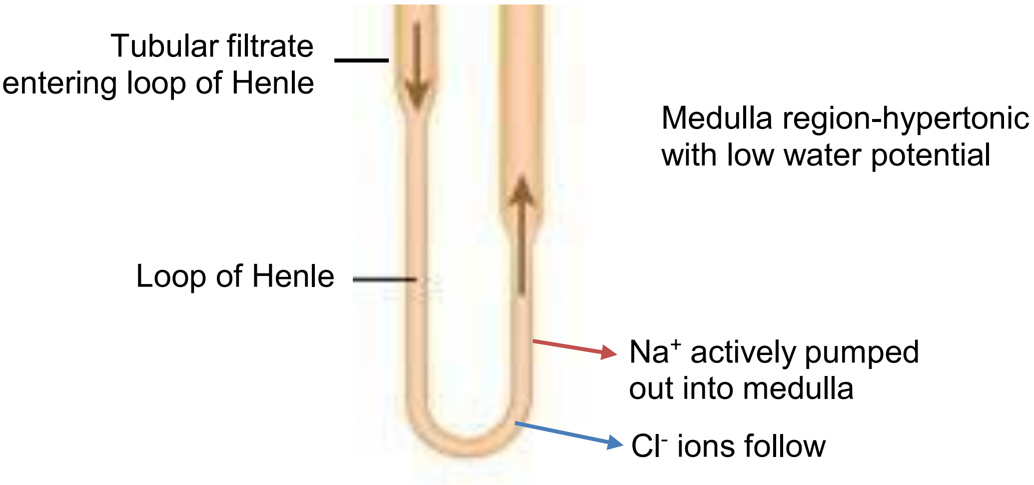


Figure 8: Section of a Loop of Henle where a steep gradient is created to conserve water (Sodium ions (Na^+) are actively pumped out and the chloride ions (Cl^-) follow.)

The **distal convoluted tubule** and the **collecting ducts** are very permeable to water so when the filtrate enters these areas water flows passively by osmosis into the medulla tissue and back into the blood of the peritubular capillaries. The amount of water that moves out of the filtrate is determined by the level of hydration of the body fluids and is regulated by the antidiuretic hormone (ADH).

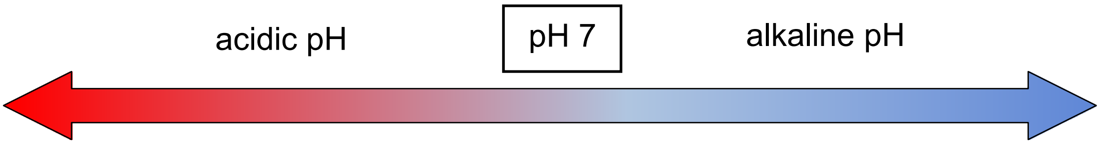
3. Tubular secretion

Tubular secretion involves the **active removal** of unnecessary substances from the blood in the peritubular capillaries into the tubular filtrate in the distal convoluted tubule. The substances removed include:

- creatinine
- ammonia
- potassium ions (K^+)
- hydrogen ions (H^+)
- sodium ions (Na^+)
- bicarbonate ions
- drugs e.g. penicillin

Homeostatic control of the blood pH

The ability of the distal convoluted tubule to take up hydrogen and bicarbonate ions is important in the **regulation of the pH** of the blood. Homeostasis is maintained.



Low pH in the blood due to **high hydrogen ion** (H^+) **concentration** Hydrogen ions move from blood in peritubular capillaries and into distal convoluted tubule Less hydrogen ions in the blood pH returns to normal (pH 7,4)	**High pH** due to **high bicarbonate** (HCO_3^-) **ion concentration** Bicarbonate ions move from the blood in the peritubular capillaries and into the distal convoluted tubules Less bicarbonate ions in the blood pH returns to normal (pH 7,4)

Figure 9: Homeostatic control of blood pH

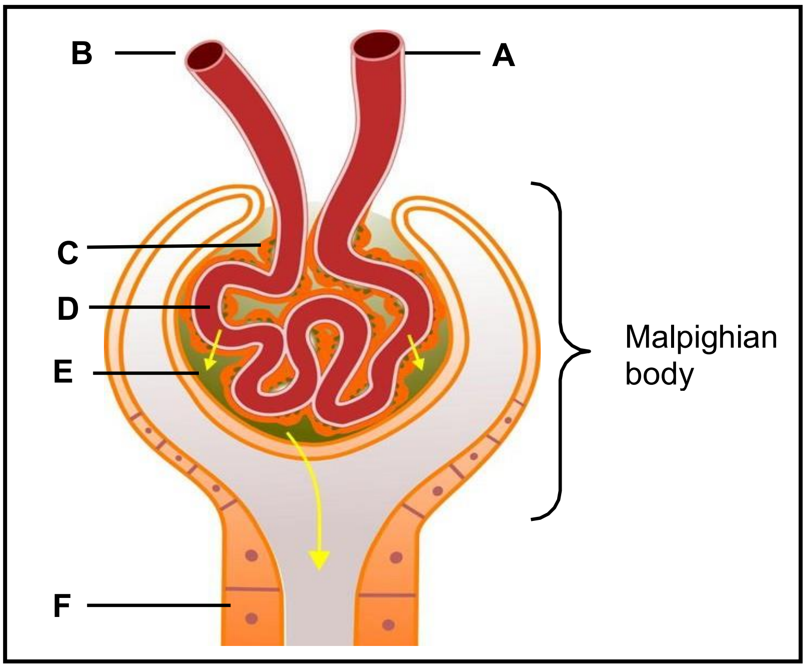
4. Excretion of urine

The filtrate that enters the collecting duct is now called **urine**. Urine consists of urea, excess water and salts. Useful substances should not be excreted in the urine.

Urine collects from all the collecting ducts in the **medulla region** and empties into the **pelvic region** of the kidney. Urine passes down the **ureter** and into the bladder. The bladder has muscles that control the release of urine into the urethra and **urination** occurs.

Activity 3: Nephron – Malpighian body

1. Structure and function of Malpighian body.



1.1 Supply labels for A – F. (6)

1.2 What two structures make up the Malpighian body? (2)

1.3 What cell types line the structures D and F? (2)

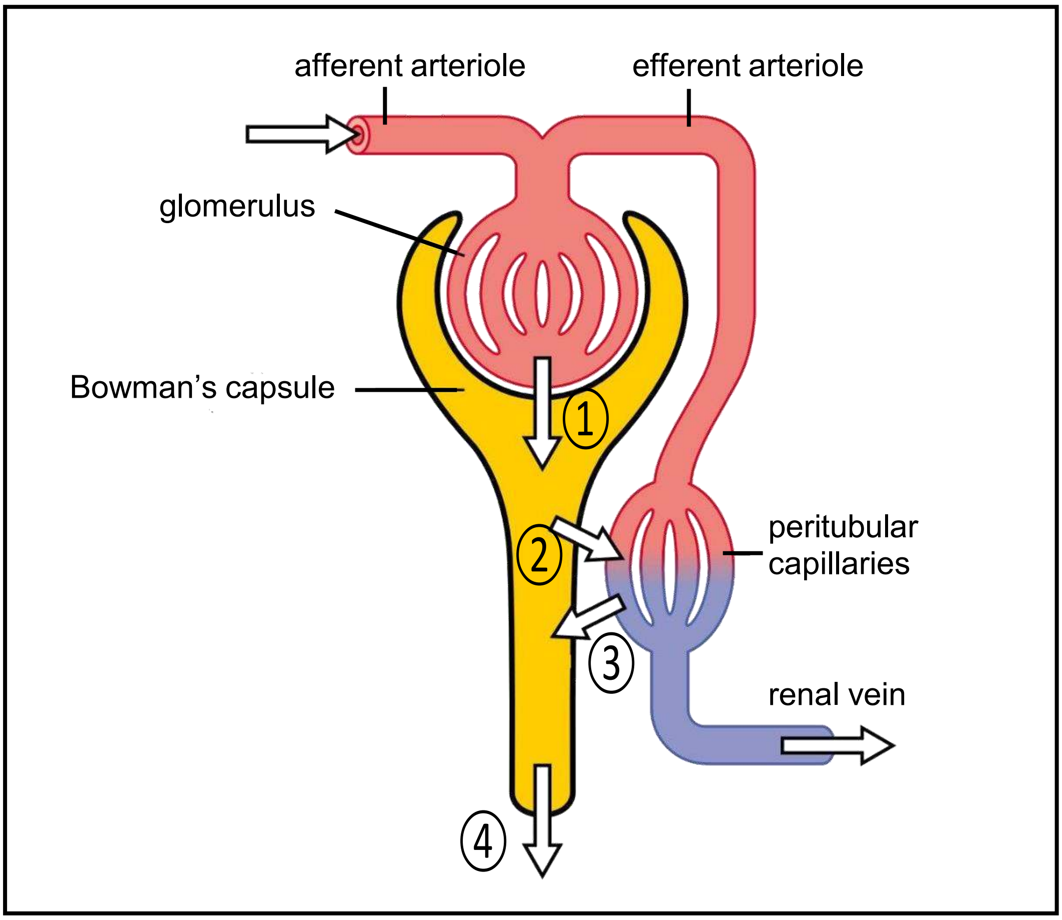
1.4 What difference do you notice between structures A and B? (1)

1.5 C has features that assist in the filtration function of the Malpighian body. Name these 2 features. (2)

1.6 Name four substances found in structure E. (4)

(17)

2. Functions of the nephron:



2.1 Name the processes shown at 1, 2, 3 and 4. (4)

2.2 Mention 3 substances that move back into the blood at process 2. (3)

2.3 Process 3 helps in homeostasis. What does it control? (1)

2.4 What would you expect to be present in urine in a healthy person? (3)

2.5 Explain why a person who regularly smokes marijuana will test positive for the drug with a urine test? (2)

2.6 Suggest two ways in which the nephrons of a desert mammal would differ from human nephrons. (2)

(15)

Homeostatic regulation by the kidneys

The human body has the ability to maintain a stable internal environment – this is homeostasis. It is important that the body's temperature is kept within a narrow range of around 37°C. The pH of the body fluids needs to be regulated and the composition of these fluids need to be kept within certain limits for effective metabolism.

The kidney is involved in 3 homeostatic mechanisms:

- the regulation of **pH** of the blood (considered above)
- the regulation of **water** levels (osmoregulation)
- the regulation of **salt** levels in the blood

Osmoregulation

The homeostatic control of water and salt levels in blood and tissue fluid is known as osmoregulation. ADH is produced by the hypothalamus and secreted from the pituitary gland and helps to limit water loss in the urine and prevent dehydration (see Table 2 and Figure 10).

Table 2: Osmoregulation

Too little water in the blood	Too much water in the blood
Dehydration is when the blood and tissue fluid are short of water	**Overhydration** occurs when the blood and tissue fluids are very dilute.
This can be brought about by excessive exercise, hot temperatures, increased sweating or decreased water intake.	This can be because of cooler temperatures, little exercise with no sweating and an excessive intake of water.
This low level of H_2O is detected by the hypothalamus of the brain.	Water levels are elevated, and this is detected by the hypothalamus.
The pituitary gland releases antidiuretic hormone (ADH)	The pituitary gland releases less ADH.

The hormone is transported in the blood to the kidney. The permeability of the collecting duct and the distal convoluted tubule is increased.	Collecting ducts and distal convoluted tubules in the kidney become less permeable.
More H_2O is absorbed and passed into the blood.	Less H_2O is absorbed into the blood.
The blood becomes more dilute and less, concentrated urine is excreted.	Less water leaves the collecting duct and more, dilute urine is excreted.

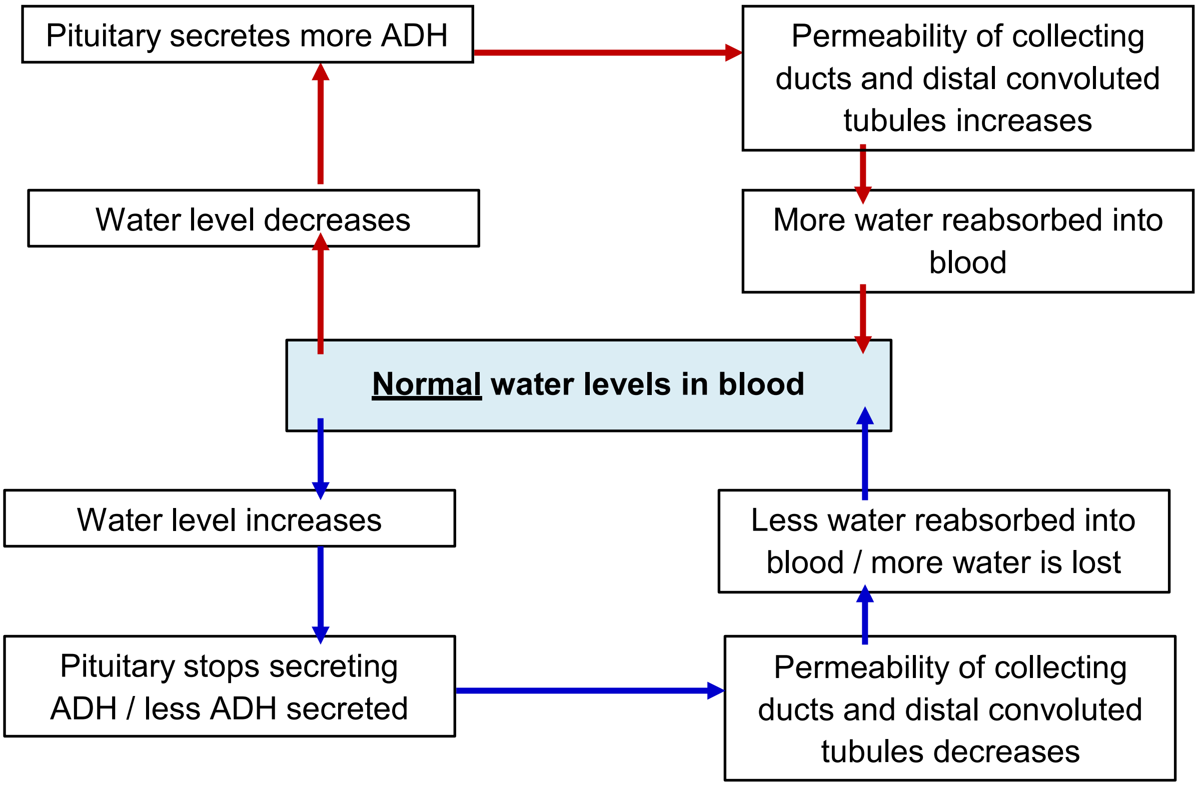


Figure 10: Homeostatic control of water in the body fluids

Alcoholic and caffeine containing drinks act as diuretics (they cause you to lose water by urinating frequently). ADH acts in an opposite way as it helps the body retain water.

Regulation of salt levels in the blood

The blood and tissue fluids are affected by the presence of solutes (dissolved substances). Sodium and potassium are salts that are found in the body fluids. Sodium is important in the body for good nerve and muscle functioning. Constant levels must be maintained (see Table 3 and Figure 11).

Table 3: Homeostatic control of salt concentrations

Low salt levels in blood and tissue fluids make these fluids **hypotonic**	Elevated **salt levels** in the blood / tissue fluids make these fluids **hypertonic**.
Receptor cells in the afferent and efferent arterioles of the glomeruli of the kidney will detect decreased Na^+ levels.	Receptor cells in the afferent and efferent arterioles will detect an increased presence of Na^+.
The adrenal gland in the kidney secretes the hormone aldosterone.	The adrenal gland will stop releasing aldosterone.
Aldosterone stimulates the reabsorption of Na^+ from the filtrate and back into the blood.	Na^+ will not be reabsorbed.
Less sodium is excreted in the urine.	More sodium is excreted in the urine.

The blood and tissue fluid returns to normal and HOMEOSTASIS is maintained. The homeostatic cycles for control of salt levels in the blood are illustrated in Figure 11.

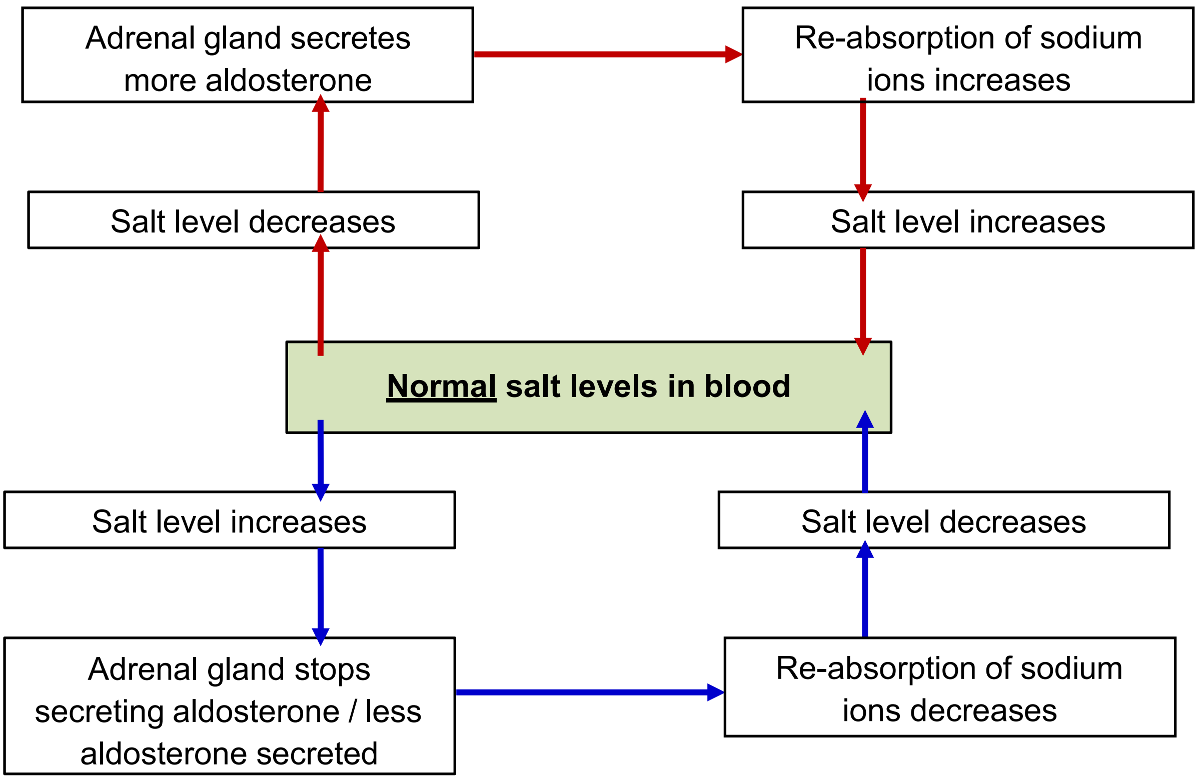


Figure 11: Homeostatic control of salt concentrations

Kidney diseases

Kidney diseases (see Table 4) can be life-threatening and require different treatments. Ineffective kidney function results in an imbalance of salts, water and pH in the blood which may reach toxic levels.

Kidney failure can happen over a period of time due to a chronic condition e.g. diabetes. A sudden injury, kidney infection or severe dehydration can lead to acute kidney failure. Severe cases of kidney failure require dialysis or even a kidney transplant.

Table 4: Diseases affecting the kidneys

kidney stones	Hard calcium granules that form in the pelvic region of the kidney. Caused by a diet high in protein, sugars and coca cola, dehydration and / or inherited conditions. Symptoms include severe back pain and blood in the urine
kidney failure	Caused by the abuse of pain medication and illegal drugs. Long term kidney damage may occur.
bilharzia infection	This disease is common in Africa, South America and Asia. It is caused by a parasitic flatworm**,** *Schistosoma***,** which is found in rivers and dams. The worm larvae which are hosted by snails in the water, attach to the skin of a human. They travel in the blood stream and then release their eggs. These eggs damage the kidneys, ureters and the bladder. The infected person will pass blood in the urine, have a fever and rashes, will be tired and often anaemic. Bilharzia can be prevented by avoiding infected water and treatment to ease the symptoms are available.

Dialysis treatment for chronic and acute kidney failure

A dialysis machine is sometimes called an artificial kidney machine. Dialysis (Figure 12) involves a process where a patient's blood is passed through a filtration system and returned to the body. Certain hospitals in South Africa have dialysis centres and patients have to book a time because of the demand for these machines. Dialysis is an expensive treatment and is scarce in the public health hospitals.

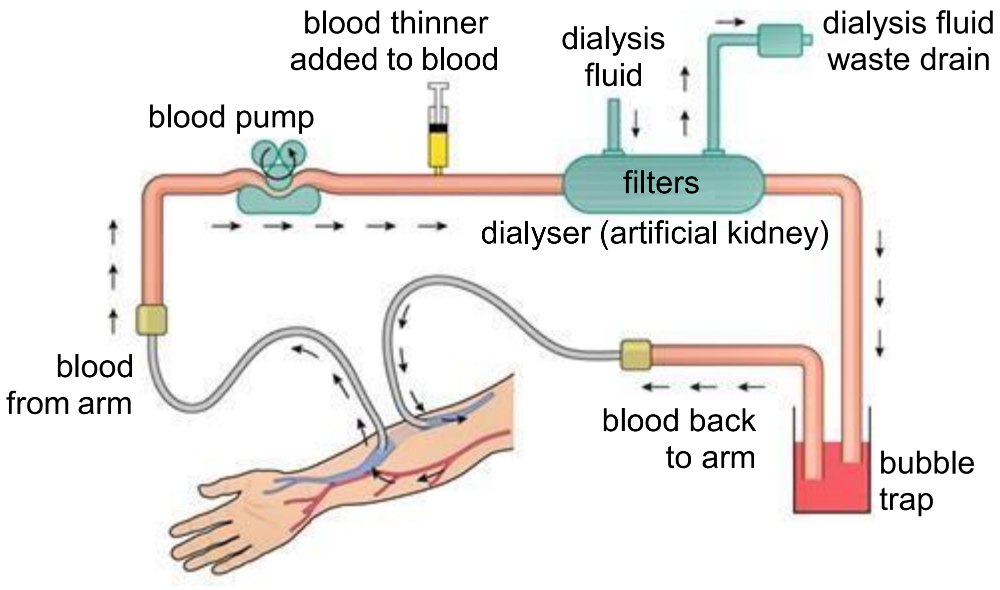


Figure 12: Functioning of a dialysis machine

Dialysis has the following disadvantages:

- Dialysis is time consuming and expensive.
- The patient is often tired after dialysis and cannot work.
- Dialysis cannot remove all the waste in the blood.
- The only long-term solution to kidney failure, is a kidney transplant.

Kidney transplants

A patient with both kidneys seriously damaged could be considered for a kidney transplant. A donor donates one of their kidneys to the patient with kidney failure (the recipient).

A person would be a suitable donor if he or she has the same blood group (A, B, AB or O) as the intended recipient, and if they have a very close tissue match. The ideal donor would be a blood relative of the patient.

The recipient might reject the donated kidney and is given immunosuppressive drugs to reduce the chances of organ rejection. These drugs can have bad side-effects and there is often a shortage of organ donors.

There are legal and ethical aspects of organ donation that need to be considered by donors and recipients in South Africa.

Excretion in humans: End of topic exercises

Section A

Question 1

1.1 Various options are provided as possible answers to the following questions. Choose the correct answer and write only the letter (A- D) next to the question number (1.1.1 – 1.1.5) on your answer sheet, for example 1.1.6 D

1.1.1 Which of the following is the correct sequence of activities that occurs during kidney functioning?

A pressure filtration→ excretion → re-absorption
B re-absorption → pressure filtration → excretion
C excretion → pressure filtration → re-absorption
D pressure filtration → re-absorption → excretion

1.1.2 Which of the following is part of the circulatory system of blood?

A glomerulus
B convoluted tubules
C Loop of Henle
D Bowman's capsule

1.1.3 Which of the following will cause the kidneys to reabsorb more sodium ions?

A A decrease in blood pressure
B An increase in the volume of blood
C Constriction of the afferent arterioles
D A decrease in the amount of ADH secreted

1.1.4 If a drop in pH of the blood occurs, the kidneys will…

A increase the absorption of urea
B decrease the absorption of sodium ions
C decrease the secretion of hydrogen ions
D increase the re-absorption of bicarbonate ions

1.1.5 Which ONE of the following is a direct cause of kidney damage?

A High cholesterol
B Too little physical exercise
C Drinking hot tea
D High blood pressure

(5 × 2) = (10)

1.2 Give the correct **biological** term for each of the following descriptions. Write only the term next to the question number.

1.2.1 The process of filtering the accumulated waste products of metabolism from the blood of a patient whose kidneys are not functioning properly.
1.2.2 The functional and structural unit of the human kidney.
1.2.3 The control of water content and salt balances in the blood and tissue fluid.
1.2.4 Specialised cells with filtration slits found lining Bowman's capsule.
1.2.5 A network of capillary blood vessels inside Bowman's capsule.
1.2.6 Blood vessel that carries purified deoxygenated blood away from the kidney.
1.2.7 Outer fibrous membrane that protects the kidney against infection.
1.2.8 Tube that transports urine from the bladder to outside the body.
1.2.9 The blood vessel that carries oxygenated blood filled with waste to the kidney.
1.2.10 Part of the kidney where the Malpighian bodies are found.

(10 x 1) = (10)

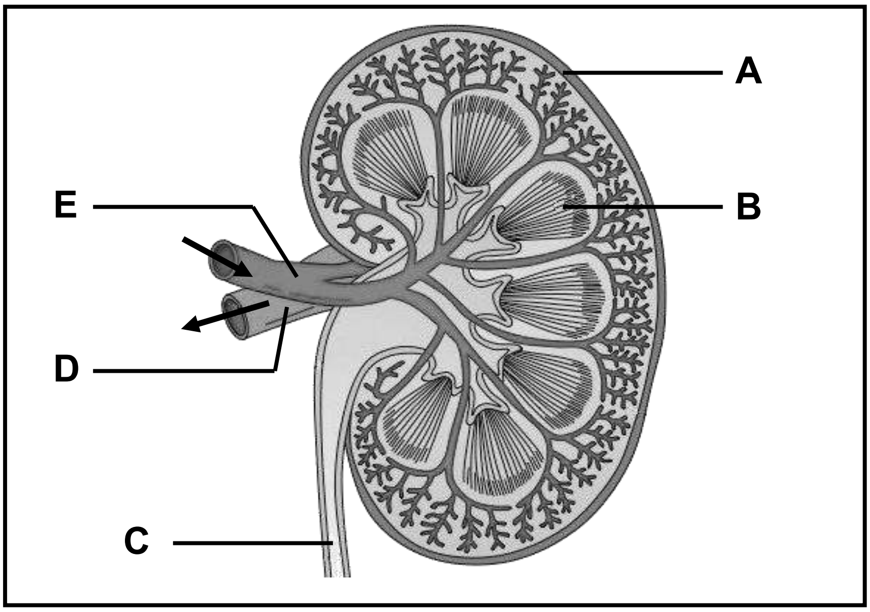
1.3 Indicate whether each of the descriptions in COLUMN I applies to **A ONLY**, **B ONLY**, **BOTH A AND B** or **NONE** of the items in COLUMN II. Write **A only**, **B only**, **both A and B** or **none** next to the question number.

Column I	Column II
1.3.1 Blood leaving the kidney contains more of this substance than the blood entering the kidney	A: amino acids B: carbon dioxide
1.3.2 Affected by bilharzia	A: kidneys B: lungs
1.3.3 Osmoregulation	A: ADH B: TSH

1.3.4 Tube that carries urine from the kidney to the bladder.	A: ureter B: urethra
1.3.5 The hormone(s) secreted by the adrenal gland to regulate the salt concentration of the blood.	A: ADH B: aldosterone

(5 × 2) = (10)

1.4 Study the longitudinal section through the human kidney and answer the questions that follow.



1.4.1 Label parts A, B and C. (3)

1.4.2 Which labelled part becomes a site of obstruction to the flow of urine when a pellet or renal stone is dislodged. (1)

1.4.3 Mention two ways in which kidney stones can be prevented. (2)

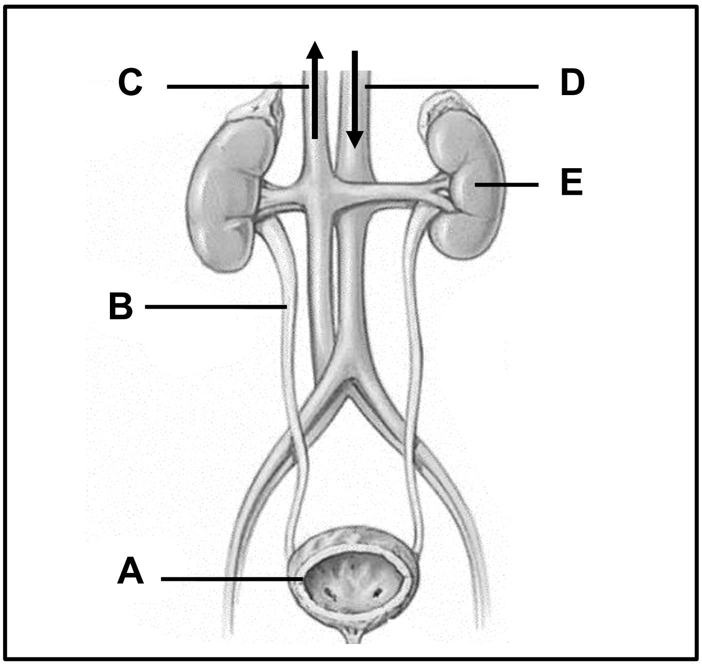
1.4.4 Mention one way in which kidney stones can be treated. (1)

1.4.5 State the name and letter of the blood vessel that contains a higher percentage of waste products. (2)

1.4.6 Which one of the labelled blood vessels has the lowest blood pressure? (1)

(10)

1.5 The diagram below shows the structure of the human urinary system.



1.5.1 Give labels for the following parts:

a) B (1)

b) E (1)

c) A (1)

1.5.2 Mention ONE difference between the composition of the blood in C and D. (2)

1.5.3 Although bilharzia it is not a notifiable disease in South Africa, in 2015 approximately 2 million children were infected with it. More than 200 million people worldwide have bilharzia. There is no vaccine for the disease, but treatment can reduce its impact on the body.

a) Name the parasite that causes bilharzia. (1)

b) The kidneys, ureters and bladder are affected by the parasite. Name 3 symptoms of the disease. (3)

c) What should you avoid doing if you are in an infected area in South Africa? (1)

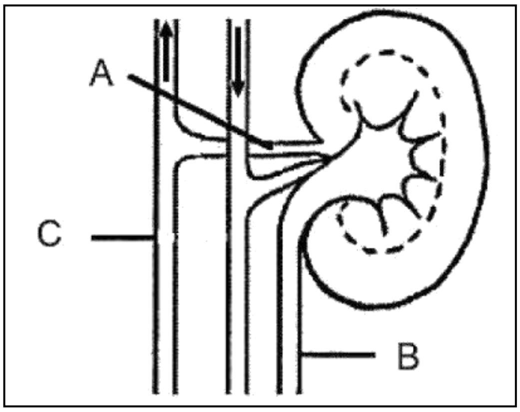
(10)

Section A: [50]

Section B

Question 2

2.1 The accompanying diagram shows part of the excretory system of the human body. Study the diagram and the table below before answering the questions that follow.



2.1.1 Identify the labels marked A, B and C. (3)

The table below shows the composition of fluid in Structure A and Structure B of the diagram.

	Structure A	**Structure B**
Component	**Concentration (%)**	**Concentration (%)**
Urea	3	200
Glucose	10	0
Amino acids	5	0
Salts	72	150
Proteins	800	0

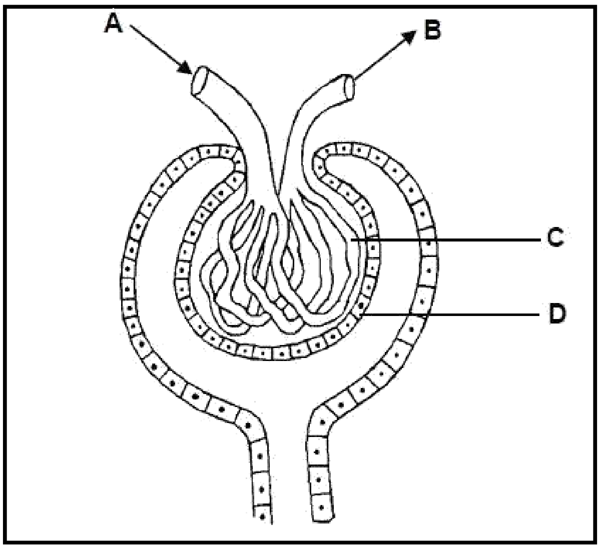
2.1.2 By comparing the contents of structures A and B, what conclusion can be drawn regarding the functions of the kidney? (1)

2.1.3 Would you consider that the person with the medical report shown above suffers from diabetes mellitus? Explain your answer. (4)

2.1.4 Which organic substances in the table are considered to be useful? Give a reason for your answer. (4)

(12)

2.2 Study the diagram below and answer the questions that follow.



2.2.1 In which region of the kidney would you find this structure? (1)

2.2.2 Name the process in urine formation that occurs in this structure. (1)

2.2.3 Identify the part C. (1)

2.2.4 Describe two structural adaptations of part C for the process in question 2.2.3 above. (4)

2.2.5 Part A is wider than part B. What is the importance of this? (2)

2.2.6 Name the hormone secreted when there is a storage of water in A. (1)

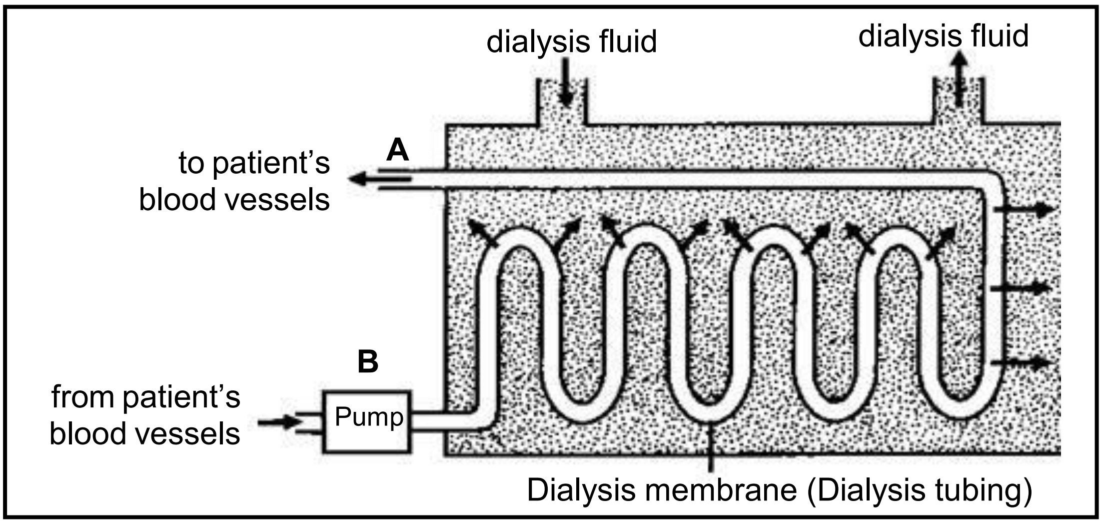
2.2.7 Describe how the hormone named in question 2.2.6 plays its role under such conditions. (3)

(13)

[25]

Question 3

3.1 An extract on renal failure and its treatment is given below (the diagram represents a dialysis machine, used to treat patients with renal failure).



Extract:
Kidneys can become so damaged that they no longer function properly, and we say that the person has renal failure. People with severe renal failure can be treated by dialysis, using a dialysis machine, to purify the blood. Dialysis is the separation of molecules by size, the smaller molecules diffusing through a dialysis tubing (selectively permeable membrane). The process takes between three and six hours and needs to be done two or three times a week.

3.1.1 Describe what *renal failure* is. (2)

3.1.2 Which process is illustrated in the diagram above? (1)

3.1.3 At what point in the diagram (A or B) would you expect the highest concentration of urea? (1)

3.1.4 Describe how blood is purified in the dialysis machine. (2)

3.1.5 Explain why dialysis tubing needs to be selectively permeable. (2)

3.1.6 Renal failure affects the osmoregulatory function of the kidney, so that it no longer excretes water efficiently. Explain the effect of renal failure on the patient's blood pressure. (3)

(11)

3.2 Study the following table that shows the flow rate and concentration of certain substances taken at regions A, B, C and D of the nephron in the human kidney.

Part of nephron	Flow rate (cm^3/min)	Solute concentrations ($g/100\ cm^3$)				
		Proteins	**Glucose**	**Sodium ions**	**Ammonium salts**	**Urea**
A	4	0	0	0,6	0,04	1,80
B	200	0	0,10	0,72	0	0,05
C	4	0	0	0,3	0	0,15
D	2000	7	0,10	0,72	0	0,05

3.2.1 State, with a reason, which of the following parts (A, B, C or D) of the nephron represents the following:

a) afferent arteriole (2)

b) Bowman's capsule (capsular space) (2)

c) Loop of Henle (2)

d) Collecting duct / Duct of Bellini (2)

3.2.2 Explain the difference in the flow rate between B and D. (4)

3.2.3 State two functions of the kidneys, other than pH regulation, that can be supported by the data given. (2)

(14)

[25]

Section B: [50]

Total marks: [100]