

Excretion in humans

Excretion in various Organs

Learning Outcome: Tabulate various Excretory organs and Their secretions and Excretions

Importance of excretion

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 removal or elimination of metabolic waste from an organism is known as **excretion**.

Excretory waste products include CO₂, H₂O, 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.

ACTIVITIES/WORKSHEETS/EXAM TYPE QUESTIONS

QUESTION 1

Identify the excretory organs labelled 1 to 5.

(5)

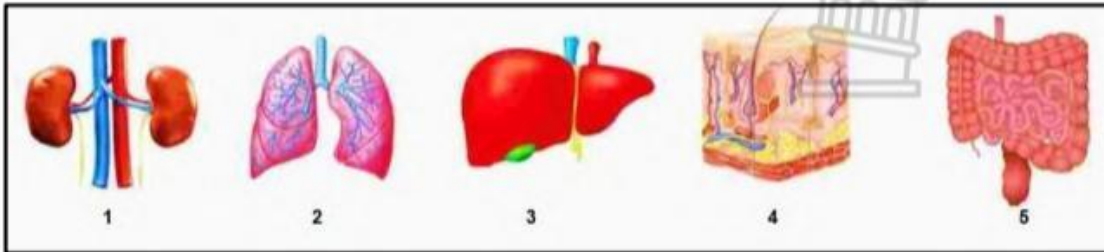


Table 1: Excretory organs and their waste / excreted product

Waste products	Origin	Excreted product
Lungs		
carbon dioxide and water vapour	cellular respiration	CO ₂ and H ₂ O(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

Learning Outcome: The structure of the Urinary system: position Of kidneys, ureters, Bladder, urethra.

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.

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 Structure and Function of the kidneys:

- The kidneys are bean shaped structures (Figure 2) found at the back just under the ribcage.
- They 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** (free of the waste products) , leaves the kidney through the **renal vein**.

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

- **Osmoregulation** – regulation of levels of H₂O in body fluids
- **Excretion** – removal of nitrogenous waste e.g. urea
- **Regulation of pH** of body fluids
- **Regulation of salt** concentration of body fluids

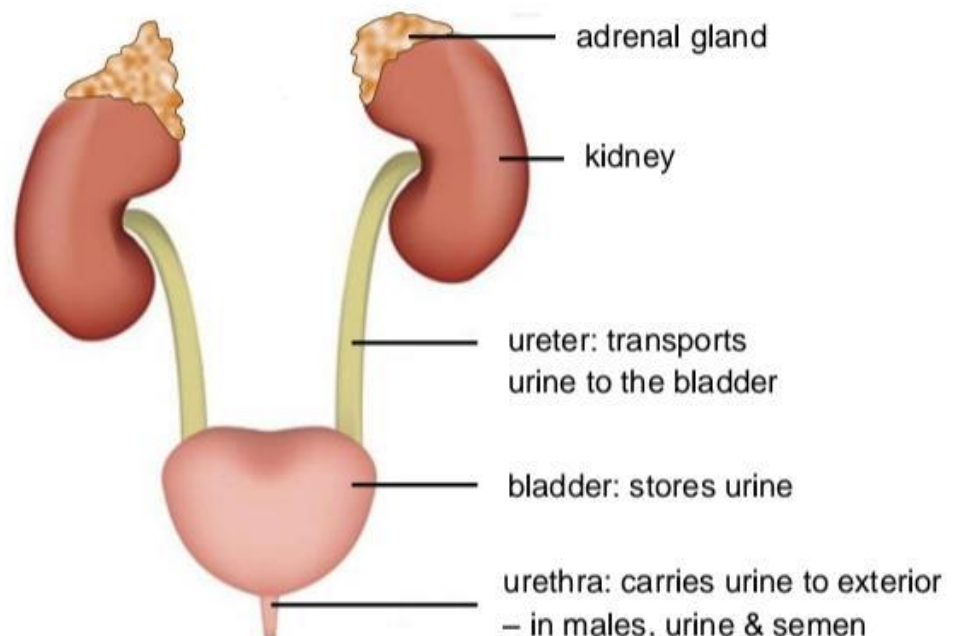


Figure 1: Structure and functions of the different parts of the urinary system

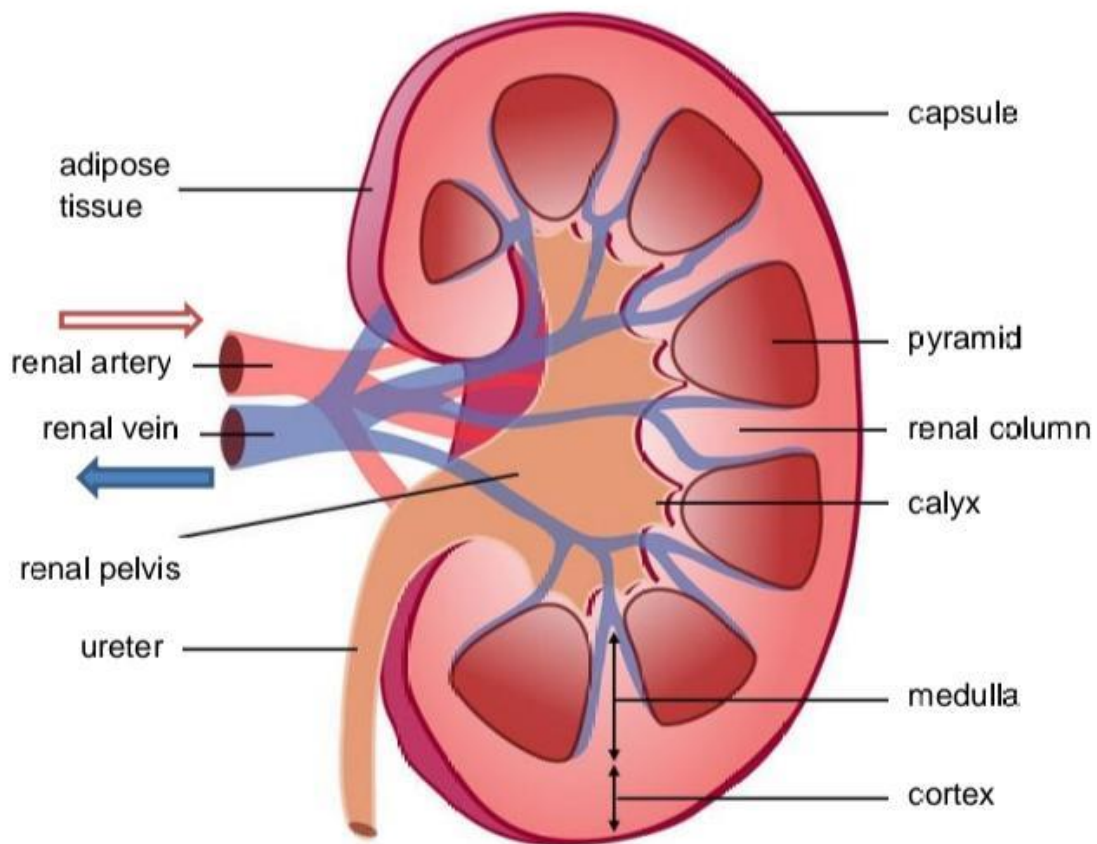


Figure 2: Longitudinal section through a kidney

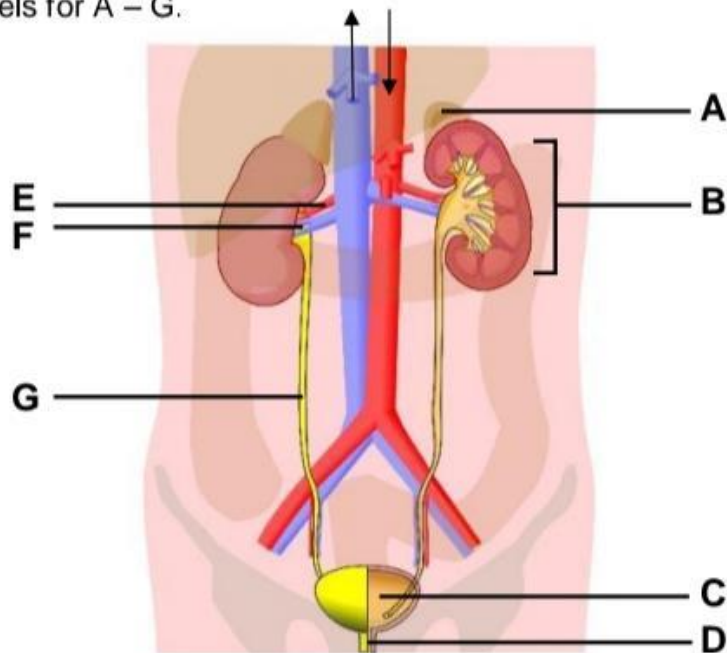
Activity 1: Excretory organs

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)

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

Learning Outcome:-Kidney:

- *structure And functioning,*
- *Removal of urea and Excess water and Salts,*
- *Re-absorption Of glucose and some Salts*

The nephron is the functional unit of the kidney. It is surrounded by narrow blood vessels branching from the renal artery.

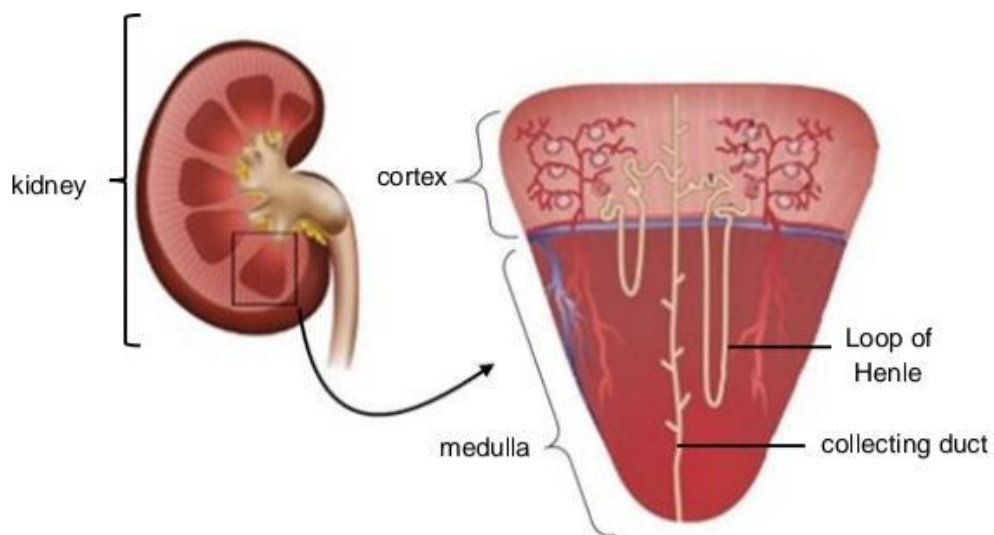


Figure 3: Kidney and position of the nephrons

The structure of the nephron:

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

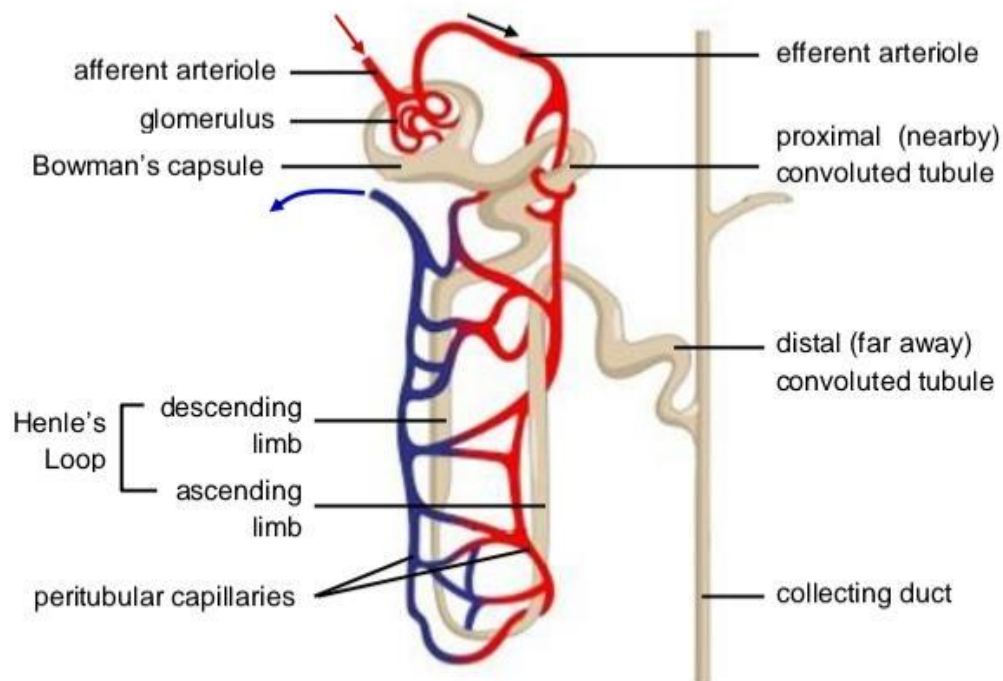


Figure 4: The structure of the nephron

The nephron can be divided into 2 separate sections : the **Malpighian body** (Figure 5) and the **renal tubule**.

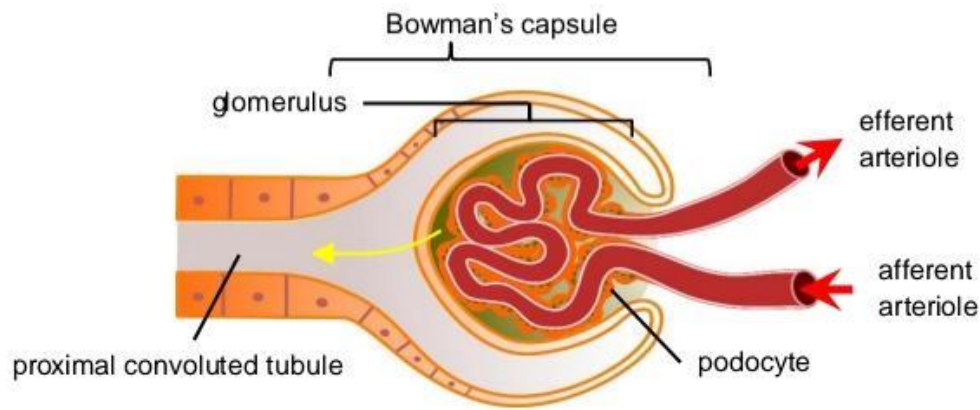


Figure 5: Malpighian body of the nephron

1.The Malpighian body:

- 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**.
- The renal tubule is surrounded by a secondary capillary network known as the **peritubular capillary network**.
- Lined by **Cuboidal epithelial cells** which have microvilli extensions on their surface. Each of these cells has a rich supply of mitochondria.

The distal tubule feeds into the collecting ducts that lead to the pelvic region of the kidney. Energy supplied by cellular respiration can be used to move substances against a gradient.

The function of the nephron:

The main function of the nephron is to filter the blood, regulate the waste, water and other important substances the body needs, thus forming the urine.

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

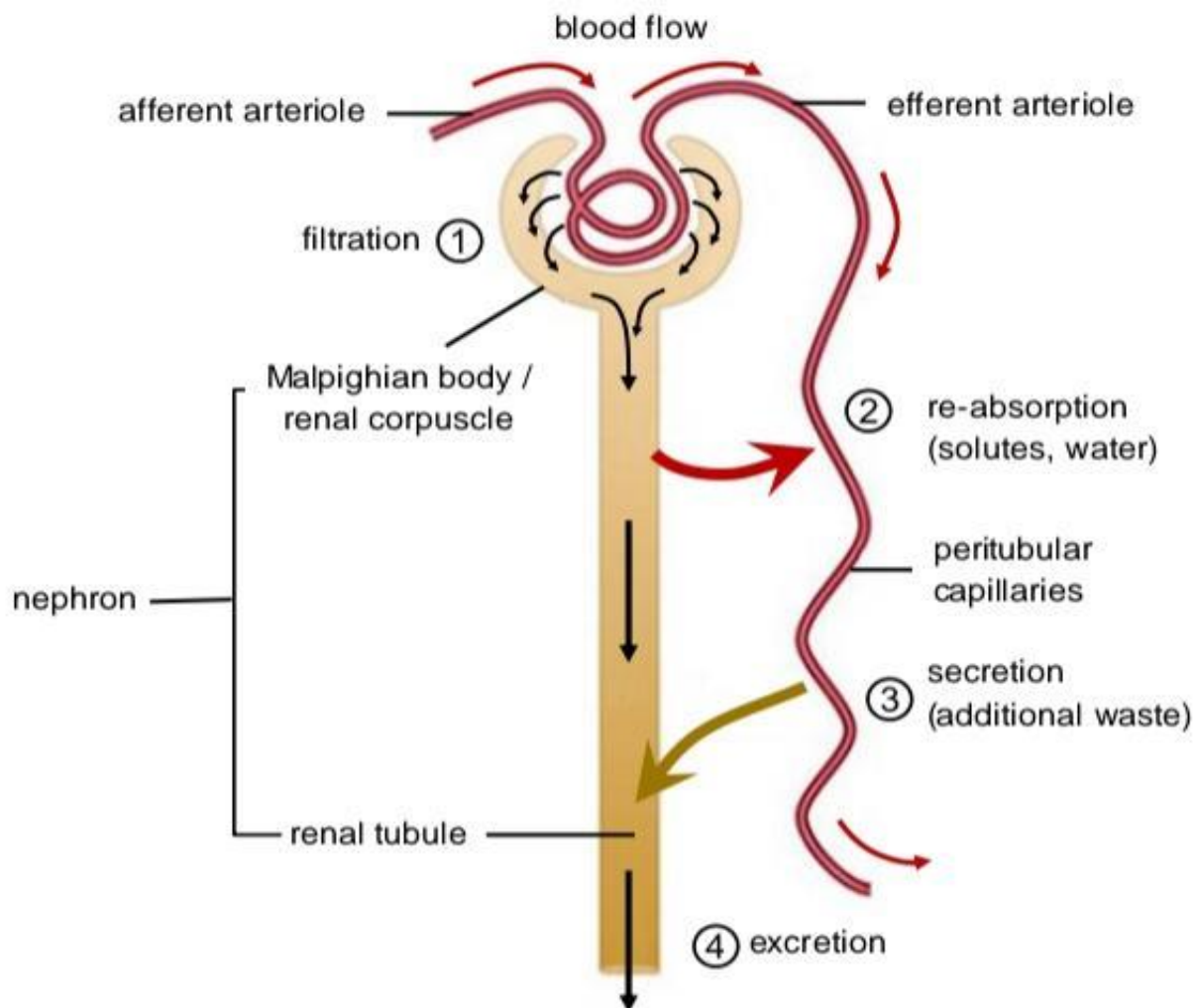
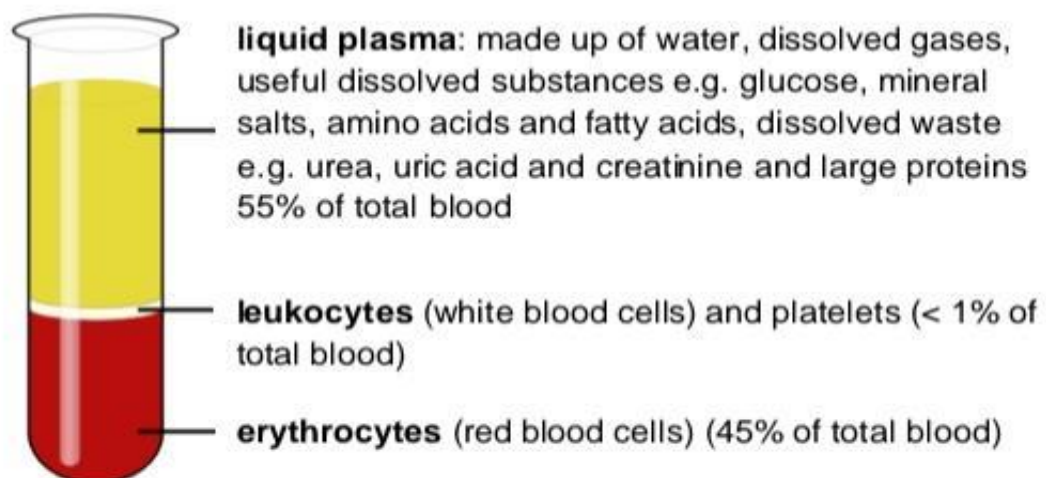


Figure 6: Diagram of the location of the main processes as they occur in the nephron

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



1. Glomerular filtration or ultrafiltration

- Takes place in the Malpighian body of the nephron.
- Process: 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.

- **Wide afferent arteriole:** The afferent arteriole is wider than the efferent arteriole. This creates high pressure in the blood which forces the plasma with dissolved substances into the capsular space of the Bowman's capsule.
- **Thin walls of glomerular capillaries:** The walls of the glomerulus capillaries are thin and consist of a single layer of Squamous epithelial cells which makes ultra-filtration possible.

- **Filtration slits:** Allows only smaller dissolved substances to travel through while large proteins remain in blood.
- **Cup-shaped Bowman's capsule:** To enlarged the contact area with the glomerulus.

Explain what this statement means: Glomerular filtration is a non-selective process.

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:

- Takes place in the proximal convoluted tubule.

Process: involves an active re-absorption of the glucose, amino acids, vitamins and other substances that ended up in the glomerular filtrate.

Why is tubular re-absorption efficient?

- **Cuboidal epithelial cells** lining the tubules have many mitochondria (site for cellular respiration) which **provide energy** needed for **active transport**.
- **Microvilli** on these same cells **increase surface area** for maximum re-absorption.
- Cells lining the **loop of Henle block movement of water**, ensuring that water is recovered back into the blood.
- Salt is pumped out of loop of Henle to Medulla tissue of kidney, creating a **hypertonic environment** that retains water by osmosis.

3. 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**.

pH control:

regulation of the pH of the blood is achieved by the ability of the distal convoluted tubule to take up **hydrogen** and **bicarbonate** ions.

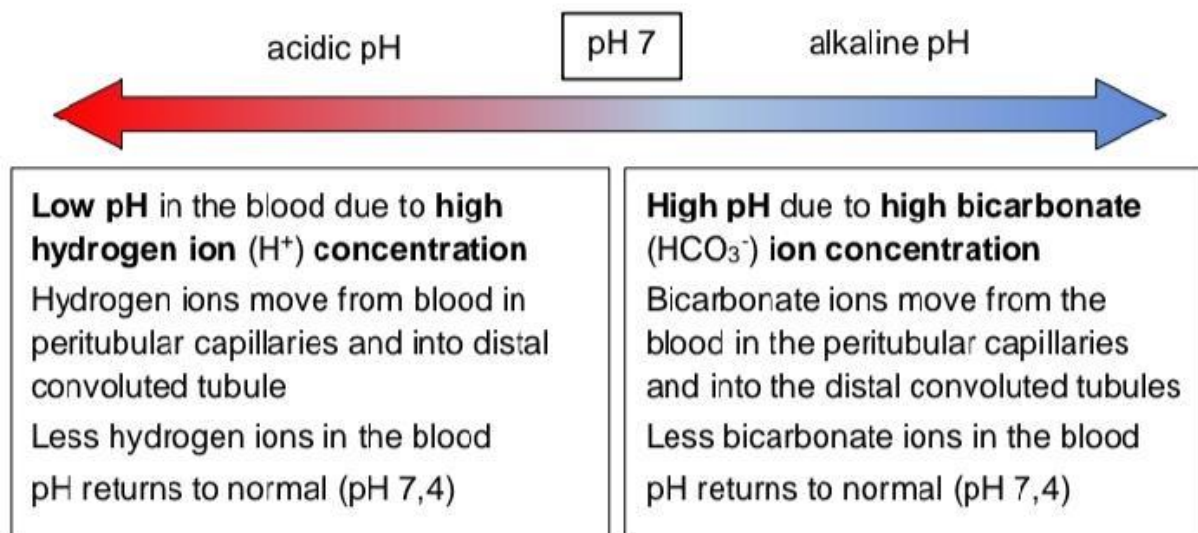


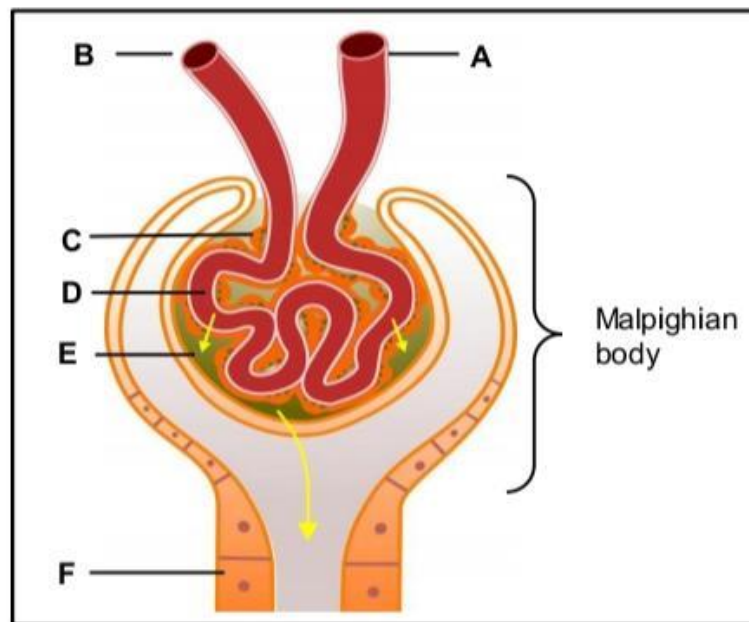
Figure 9: Homeostatic control of blood pH

4. Excretion of urine:

Urine-the filtrate that enters the collecting duct, 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.

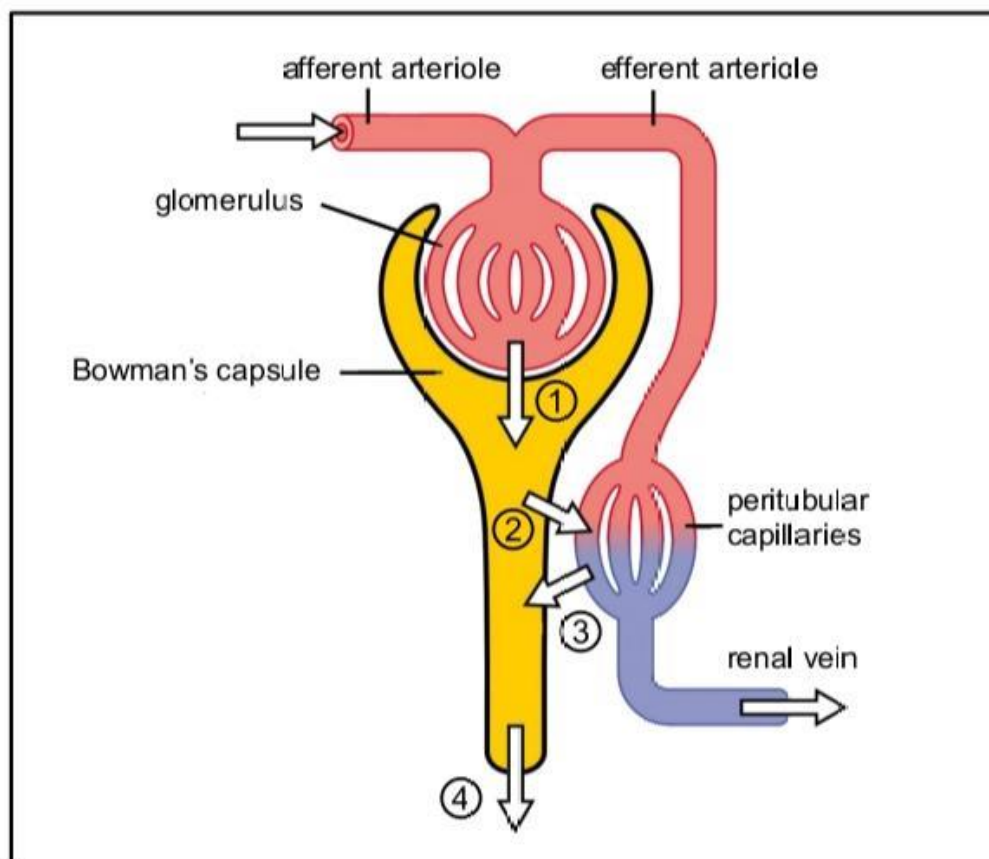
Activity 3: Nephron – Malpighian body

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)
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Homeostatic Control

Learning Outcome :Role of ADH and Aldosterone

The kidney is involved in 3 homeostatic mechanisms:

- The regulation of pH of the blood.
- The regulation of water levels (**osmoregulation**)
- The regulation of salt levels in the blood

Osmoregulation :The regulation of water levels.

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 ₂ O 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 ₂ O is absorbed and passed into the blood.	Less H ₂ O 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.

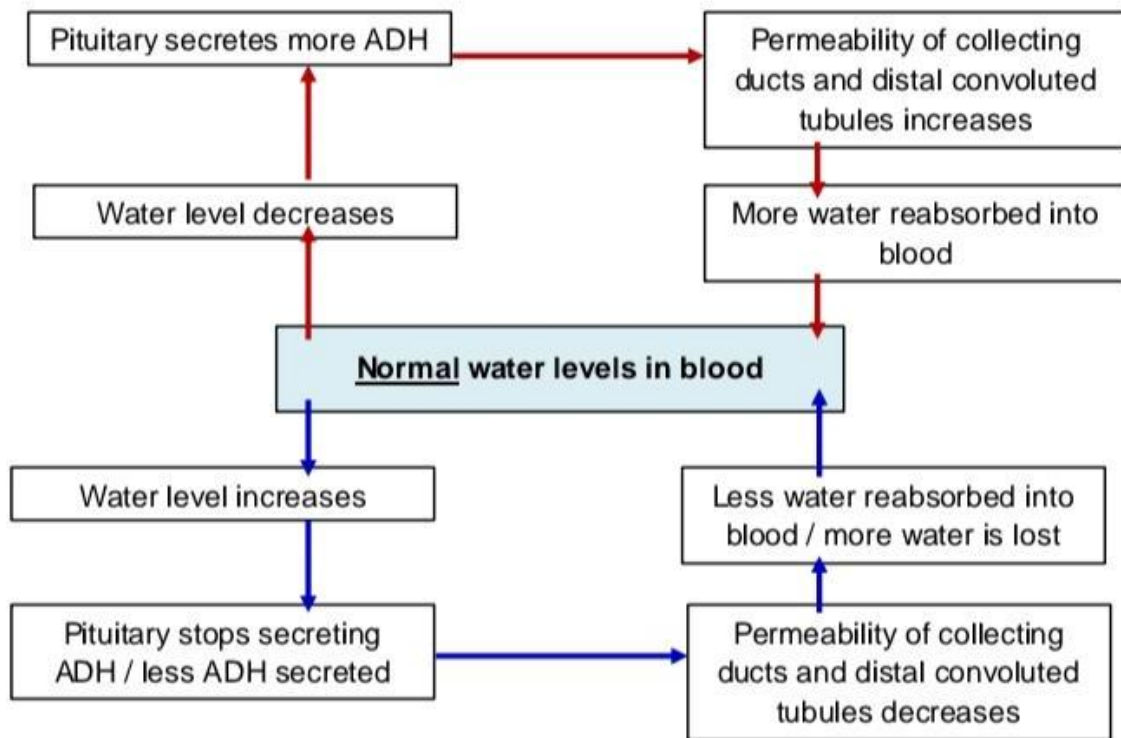


Figure 10: Homeostatic control of water in the body fluids

The regulation of salt levels in the blood

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.

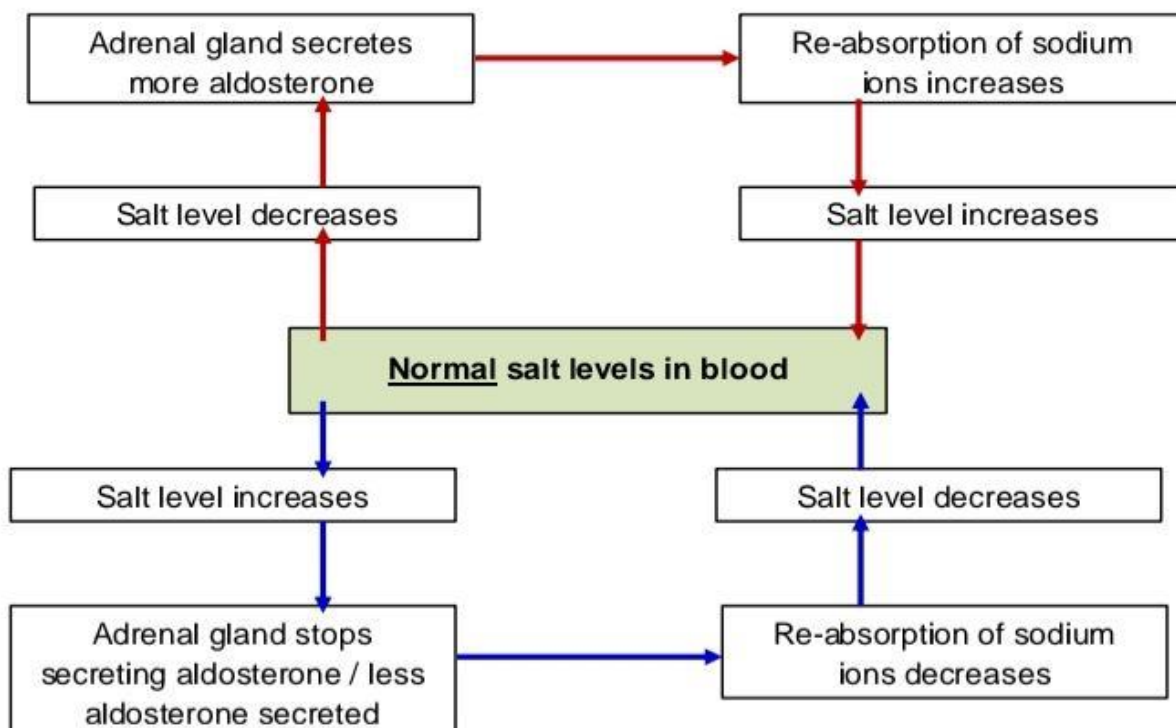


Figure 11: Homeostatic control of salt concentrations

Kidney diseases

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, <i>Schistosoma</i>, 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.

Kidney failure:

Ineffective kidney function results in an **imbalance of salts, water and pH** in the blood which may reach toxic levels. Severe cases of kidney failure require **dialysis** or even a **kidney Transplant**.

