



Western Cape
Government

Western Cape Education Department
Directorate: Curriculum FET

LIFE SCIENCES

TERM 3

REVISION BOOKLET

Grade 11

The revision program covers the following topics:

- Gaseous exchange (32 marks in Paper 1 in Final Examination)
- Excretion in humans (32 marks in Paper 1 in Final Examination)
- Population ecology (37 marks in Paper 2 in Final Examination)
- Human impact on the environment (37 marks in Paper 2 in Final Examination)

TERM 3 CONTENT

Study the core content below on the topics gaseous exchange, excretion and population ecology.

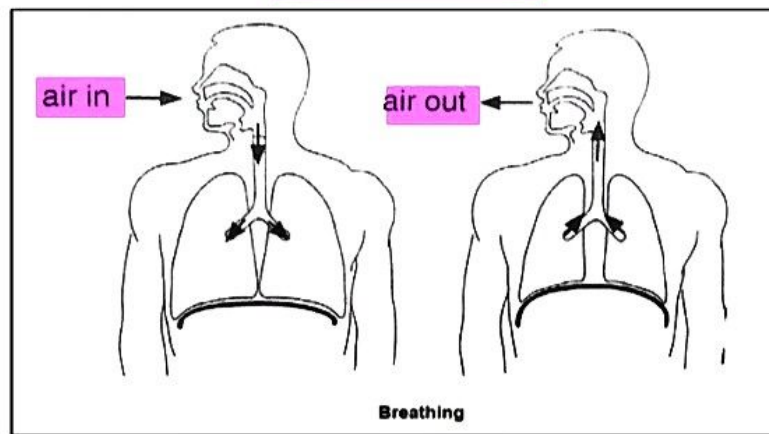
2. GASEOUS EXCHANGE

Revise cellular respiration from term 2 in Grade 11.

2.1 DIFFERENCE BETWEEN CELLULAR RESPIRATION, BREATHING AND GAS EXCHANGE

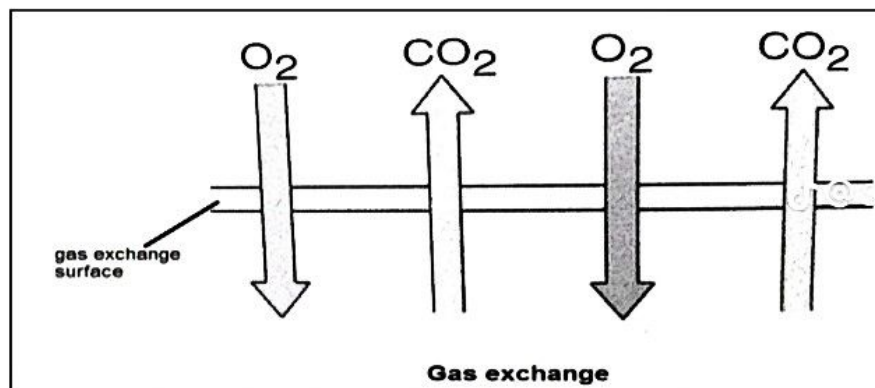
- **Breathing** – the physical process whereby air moves in and out of the lungs

Figure 1: Breathing



- **Gas exchange** – The exchange of oxygen (O_2) and carbon dioxide (CO_2) across a gaseous exchange surface.

Figure 2: Gaseous exchange



- **Cellular respiration** – a chemical process occurring inside cells in which food molecules such as glucose are broken down to release energy

2.2 REQUIREMENTS OF EFFICIENT GAS EXCHANGE ORGANS

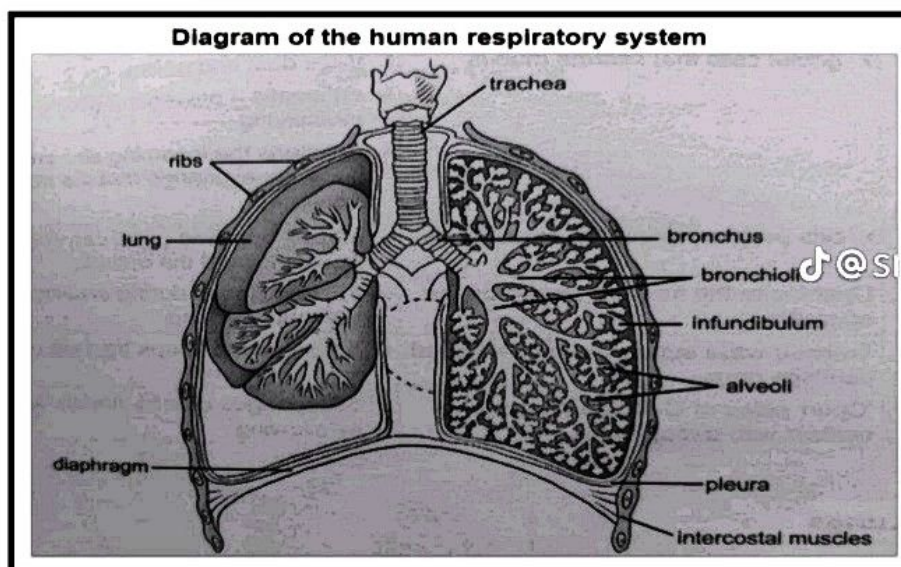
- The gas exchange surface must be **large** – to provide sufficient oxygen and to get rid of sufficient carbon dioxide
- The gas exchange surface must be **thin** – to ensure rapid diffusion of gases
- The gas exchange surface should be **moist** – to prevent cells from drying out and to ensure that gases (oxygen and carbon dioxide) can diffuse in a dissolved state.
- The gas exchange organs must be **well-ventilated** – to ensure fresh supplies of air containing oxygen from the external environment and to remove air containing carbon dioxide.
- The gas exchange surface must be **well protected** – to prevent drying out and damage
- The gas exchange surface must have a **transport system** – for efficient transport of gases between gas exchange organs and body cells

2.3 HUMAN GAS EXCHANGE- STRUCTURE, LOCATION, FUNCTIONS AND ADAPTATIONS OF THE VENTILATION SYSTEM

The ventilation/breathing system of humans consist of the:

- Nasal cavities
- Trachea
- Two bronchi
- Many bronchioles
- Two lungs
- Respiratory muscles

Figure 3: Human respiratory system



Nasal cavities

- The two external **nostrils** lead to two nasal cavities that are separated by a **septum**
- Small **hairs** in the nasal cavities filter large particles from the inhaled air
- Each nasal cavity is divided into three passages by three curved **turbinate bones**.
- The nasal cavities are lined with a mucous membrane that consists of **ciliated columnar epithelial cells**
- The epithelial cells are richly supplied with **blood capillaries** that warms the incoming air
- **Goblet cells** in the epithelium secrete **mucus** that moistens the incoming air, traps dust and germs and is antiseptic.
- **Cilia** on the epithelial cells perform sweeping movements in a direction away from the lungs to expel dust – carrying mucus to the outside.

Pharynx

- The nasal cavities open into the pharynx.
- The pharynx leads to two openings i.e. the opening known as the **glottis** which leads to the **trachea** and the opening that leads to the **oesophagus**

Trachea

- The trachea is a long, tubular structure located at the front of the oesophagus
- The **larynx** (voice box) with the vocal chords is located at the top of the trachea
- The **epiglottis** is at the top of the larynx and consists of cartilage
- The **epiglottis** closes the glottis during the swallowing process and prevents food from entering the trachea
- The walls of the trachea are supported and kept open by **C-shaped cartilage rings**.
- The trachea is lined with ciliated columnar epithelium with goblet cells that secrete mucus.
- The mucus moistens the incoming air and trap dust particles
- Mucus with trapped foreign particles are moved to the pharynx through the sweeping actions of the cilia

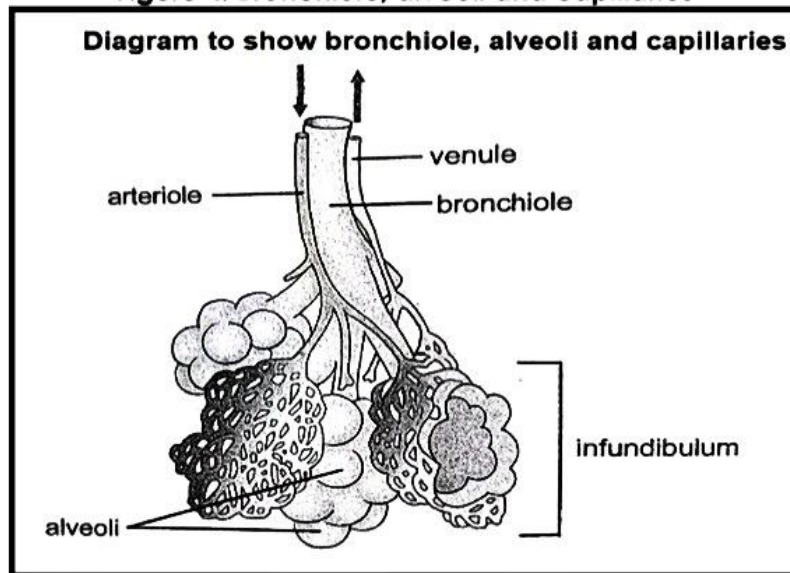
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Bronchi, bronchioles and alveoli

- The trachea branches into two **bronchi** that enters the right and left lung
- The bronchi are also lined with a mucous membrane and are held open by **O-shaped cartilage rings**
- The bronchi divide into smaller branches inside the lungs and form the **bronchioles**
- The bronchioles do not have cartilage rings and their walls consist of smooth muscle that can contract and relax to alter air flow.

- Each bronchiole ends in an **infundibulum** which consists of groups of **alveoli**.
- The millions of alveoli increase the gaseous exchange surface
- The walls of the alveoli are thin and consists of a single layer of squamous epithelium. These thin walls allow for efficient gaseous exchange
- A thin layer of tissue fluid lines the inside surface of the alveoli and keep the surface of the alveoli moist, preventing the cells from drying out.
- The alveoli are surrounded by a network of capillaries.
- Capillaries transport oxygen to the tissues and carbon dioxide to the lungs
- The walls of the capillaries are thin and consist of a single layer of squamous epithelium to allow for efficient gaseous exchange.

Figure 4: Bronchiole, alveoli and capillaries



Lungs

- The two lungs are located in the chest and are protected by 12 pairs of ribs.
- The lungs are spongy and elastic and can expand and contract during breathing
- The right lung has three lobes and the left lung has two lobes
- Each lung is surrounded by a double membrane, the **pleura**
- The fluid between the pleura prevents friction when the lung expands or shrinks

Respiratory muscles and the ribs

Diaphragm

- The diaphragm is a dome-shaped muscle plate which separates the chest and the abdomen
- The diaphragm contracts and flattens altering the volume of the chest cavity and is important in breathing.

Intercostal muscles

- The intercostal muscles are located between consecutive ribs and consists of the external and internal intercostal muscles.
- The intercostal muscles contract and relax during inhalation and exhalation altering the volume of air in the chest (thoracic cavity)

Ribs

- The ribs are on either side of the sternum, **protect** the lungs from injury

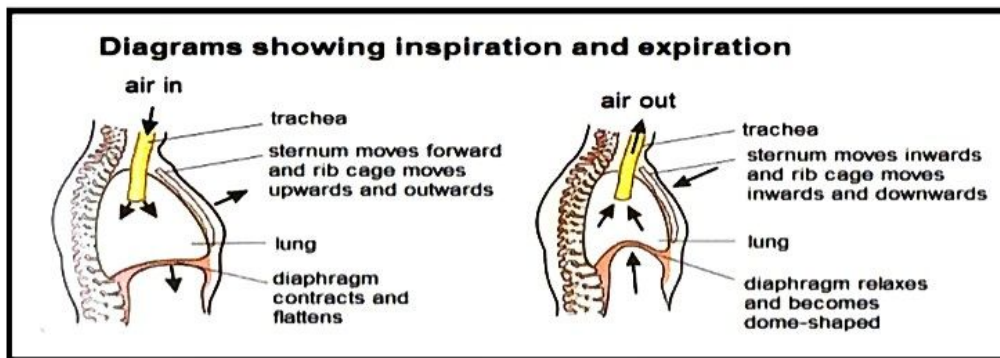
2.4 VENTILATION OF THE LUNGS

Ventilation of the lungs takes place in two phases i.e.

- **Inhalation/Inspiration** – movement of air from the atmosphere into the lungs
- **Exhalation/Expiration** – movement of air from the lungs to the atmosphere

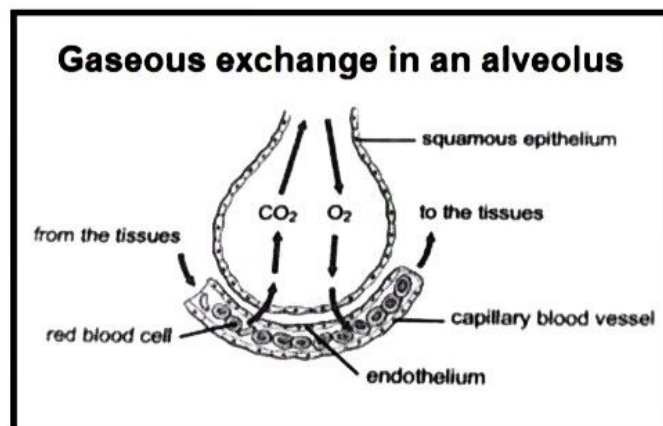
Table 2: Inhalation and exhalation

Inhalation/ Inspiration	Exhalation/ Expiration
• This is the active phase of breathing • The external intercostal muscles contract • Causing the ribs to move upward and outwards • The diaphragm contracts and becomes flatter • The volume of the thoracic cavity increases • The abdominal muscles relax so that the abdominal cavity can accommodate all the internal organs • The pressure in the thoracic cavity and lungs decrease • The elastic lungs expand • Atmospheric pressure is higher than the pressure of air in the lungs • Air rich with oxygen(O_2) flows into the lungs	• This is the passive phase of breathing • The external intercostal muscles relax • Causing the ribs to move downwards and inwards • The diaphragm relaxes and become dome-shaped • The volume of the thoracic cavity is decreased • The abdominal muscles contract and force the abdominal content upwards against the diaphragm • The pressure in the thoracic cavity and lungs increase • The elastic lungs are compressed • Air pressure in the lungs is higher than in the atmosphere • Air rich with carbon dioxide (CO_2) flows out of the lungs

Figure 5: Inspiration and expiration

2.5 GASEOUS EXCHANGE AT THE ALVEOLI SURFACE

- The inhaled air in the alveoli has a higher oxygen concentration than the blood in the surrounding blood capillaries
- The oxygen dissolves in the thin layer of moisture that lines the alveoli and diffuses through the thin walls of the squamous epithelium of the alveoli and endothelial walls of the capillaries into the blood.
- The blood that reaches the alveoli from the tissues has a higher concentration of carbon dioxide than the air in the alveoli
- Carbon dioxide diffuses from the blood in the capillaries through the endothelial walls of the capillaries and the thin squamous epithelial walls of the alveoli into the air in the alveoli.

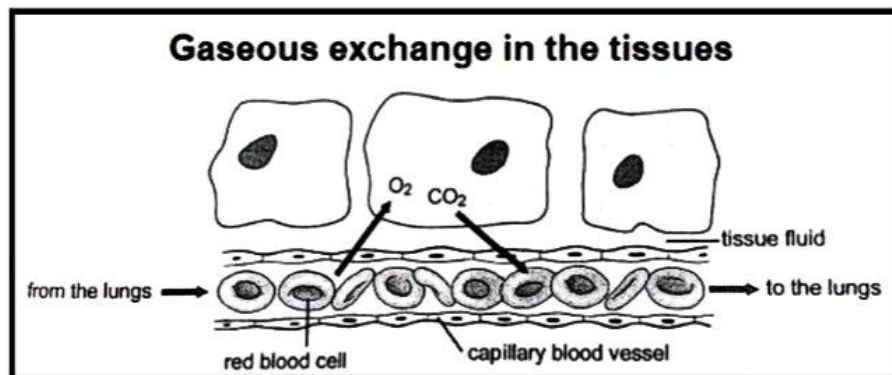
Figure 6: Gaseous exchange in alveolus

2.6 GASEOUS EXCHANGE BETWEEN THE BLOOD AND TISSUES

- Oxygenated blood reaches the tissues
- The blood in the capillaries has a higher oxygen concentration than the cells of the tissues
- Oxygen diffuses through the endothelial walls of the capillaries into the tissue fluid that surrounds the cells and then into the cells

- The cells have a higher carbon dioxide concentration than the blood in the capillaries
- Carbon dioxide diffuses from the cells into the tissue fluid and then diffuses into the blood in the capillaries.

Figure 7: Gaseous exchange in the tissues



2.7 TRANSPORT OF GASES IN THE BLOOD

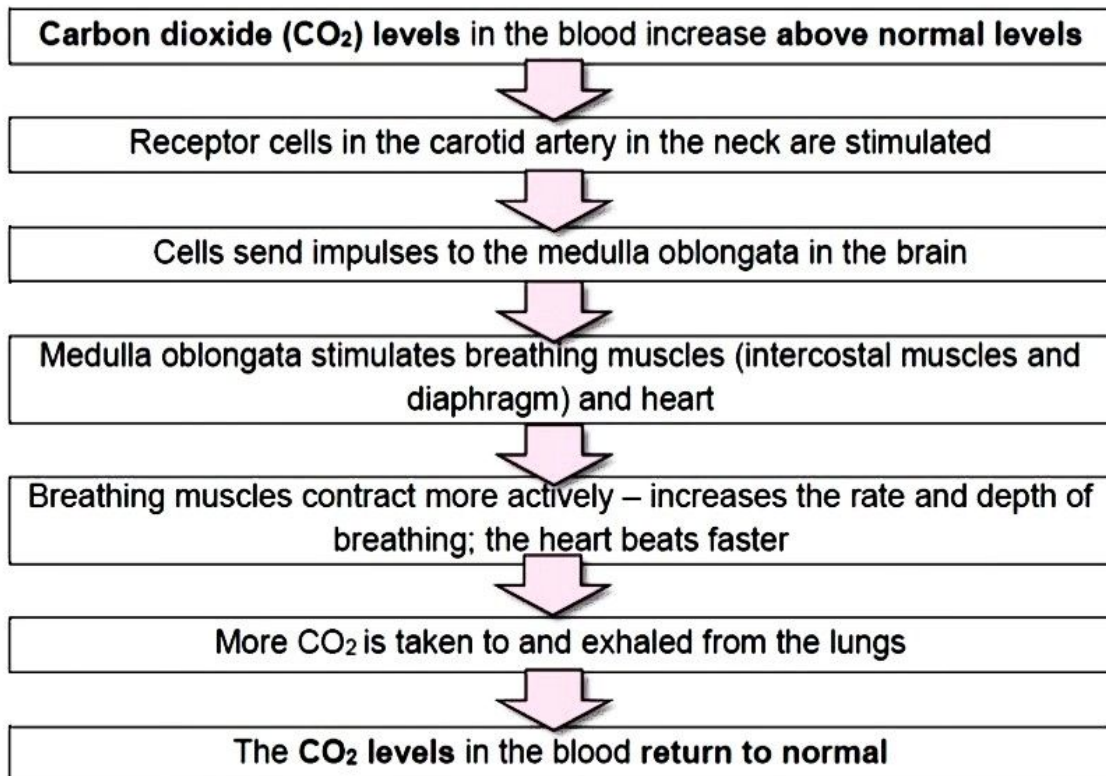
Transport of oxygen:

- Most of the oxygen that diffuses from the air in the alveoli to the blood in the capillaries combines with **haemoglobin** in the red blood cells (erythrocytes) to form **oxyhaemoglobin**.
- A small portion of oxygen dissolves in the **blood plasma** and is transported in solution.

Transport of carbon dioxide:

- Most of the carbon dioxide that diffuses from the cells into the blood in the capillaries is transported as **bicarbonate ions**. Carbon dioxide combines with water to form carbonic acid. The carbonic acid dissociates and forms bicarbonate ions.
- Some of the carbon dioxide combines with haemoglobin to form **carbaminohaemoglobin**. The carbon dioxide is then transported in this form by the erythrocytes to the lungs.
- The smallest portion of carbon dioxide dissolves in the **blood plasma** and is transported in solution.

2.8. HOMEOSTATIC CONTROL OF BREATHING



3. EXCRETION IN HUMANS

3.1 EXCRETORY ORGANS AND THEIR EXCRETED PRODUCT

Table 3: Excretory organs and excretions

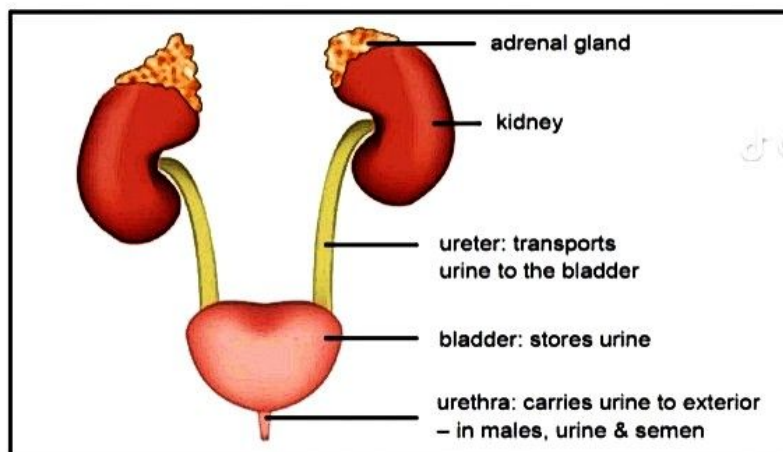
Excretory organ	Substances that they excrete	Origin of these substances
Lungs	Carbon dioxide and water vapour are excreted in exhaled air during breathing	- Carbon dioxide is formed as a product of cellular respiration - Excess water is formed as a product of cellular respiration as well as from the intake of fluids and food

Kidneys and bladder	Urine. Urine consists of excess water, mineral salts and nitrogenous waste e.g. urea and uric acid . The bladder temporarily stores the urine that was formed by the kidneys. Urine passes out of the body when we urinate.	- Excess water is formed as a product of cellular respiration as well as from the intake of fluids and food - Urea is formed in the liver from deamination of excess amino acids. The urea is transported by the blood to the kidneys. - Uric acid is the end product of metabolism of nucleic acids
Liver	Bile pigments and urea	- Bile pigments are formed in the liver during breakdown of haemoglobin - Urea is formed in the liver from deamination of excess amino acids. The urea is transported by the blood to the kidneys.
Alimentary canal	Bile pigments	Bile pigments are formed in the liver during breakdown of haemoglobin. The bile pigments from the liver enters the alimentary canal and are excreted as bile salts in the faeces.
Skin	Sweat. Sweat consists of excess water, salts and a small amount of urea . Sweat is excreted through sweat glands in the skin.	Excess water is formed as a product of cellular respiration as well as from the intake of fluids and food

3.2 THE URINARY SYSTEM

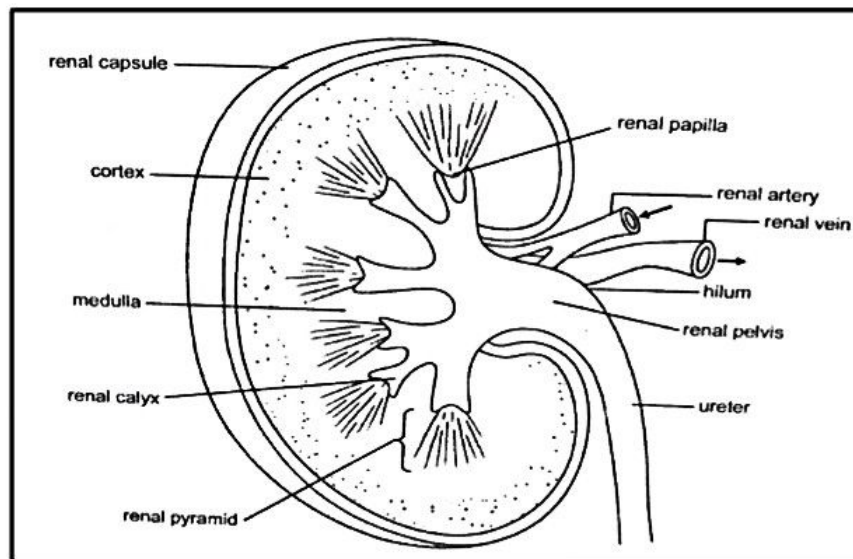
- The two kidneys, two ureters, bladder and urethra form the urinary system

Figure 8: The urinary system



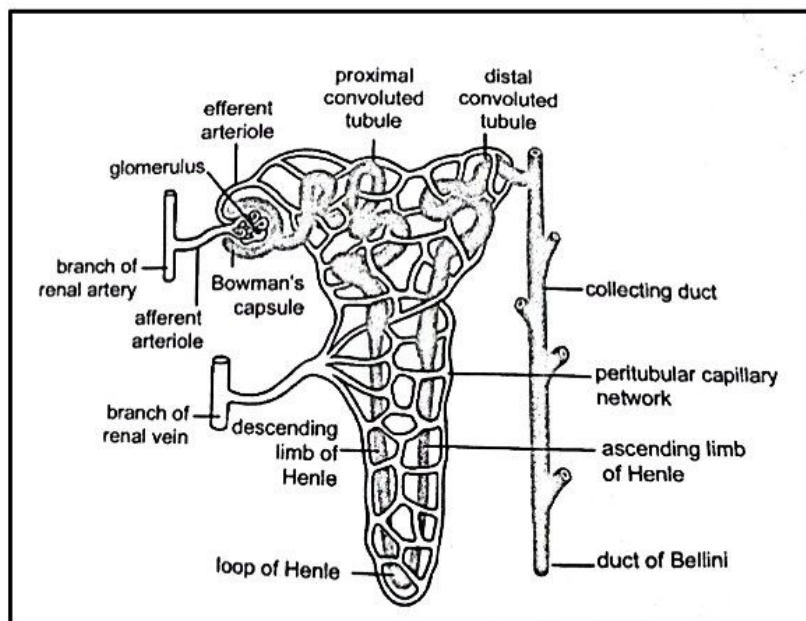
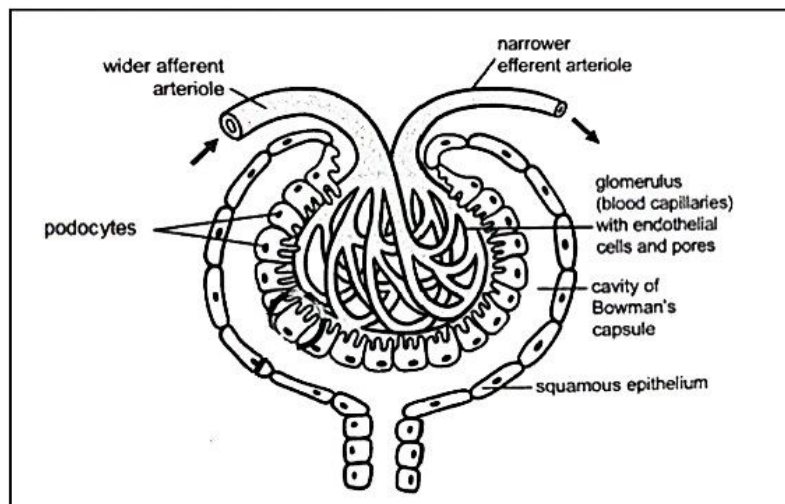
3.2.1 STRUCTURE OF THE KIDNEY

Figure 9: Structure of the kidney



- The kidneys are dark-red bean shaped organs.
- In the middle of the concave side is an indentation, the **hilum** where the renal artery enters, and the renal vein and ureter leave the kidney.
- The kidneys are protected against mechanical injuries by a layer of fat that surrounds the kidneys.
- Each kidney is surrounded by a connective tissue membrane, the **renal capsule** which protects the kidney.
- A reddish-brown region, called the **cortex**, can be found just under the renal capsule.
- The **medulla** is the inner region of the kidney and is lighter in colour and contains groups of tubes.
- Each group of tubes forms a **pyramid** which project into the **renal pelvis**.
- Each kidney is made up of about one million microscopic structures called **nephrons**.
- The nephrons are the structural and functional units of the kidney.
- The main functions of the nephron are to filter the blood, regulate the waste, water and other important substances the body needs.
- Each nephron can be divided into 2 separate sections i.e. the **Malpighian body** and the **renal tubule**.

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Figure 10: Structure of a nephron**Figure 11: The Malpighian body**

- The Malpighian body consists of a cup-shape structure called the **Bowman capsule** and a network of blood capillary vessels called the **glomerulus**.
- The blood capillary vessels of the glomerulus are lined with a single layer of squamous epithelial cells with pores between the cells.
- The **wider blood vessel** that transports blood to the glomerulus is called the **afferent arteriole**.
- The **narrower blood vessel** that transports blood away from the glomerulus is called the **efferent arteriole**.
- The **renal artery** that enters the kidney branches into smaller arteries. These smaller arteries eventually form the afferent arteriole.

- The efferent arteriole branches and forms the network of capillaries, the **peritubular capillary network**, which surrounds the renal tubule.
- The peritubular capillaries combine to form venules which eventually form the **renal vein** which transports deoxygenated blood to the heart.
- The inner wall of the Bowman's capsule consists of specialized cells called **podocytes**.
- The podocytes are cells with projections between which small openings, called the **filtration slits** occur.
- The renal tubule is a long-convoluted tubule that consists of the **proximal convoluted tubule**, the **loop of Henle** and the **distal convoluted tubule**.
- The renal tubule is lined with a single layer of cuboidal epithelium.
- The distal convoluted tubules open into a **collecting duct**.
- A few collecting ducts converge and form the **ducts of Bellini**.
- The ducts of Bellini form the **pyramids** that open into the renal pelvis.

3.2.2 **FUNCTIONING OF THE KIDNEY: (GLOMERULAR FILTRATION, TUBULAR REABSORPTION, TUBULAR EXCRETION)**

Refer to the diagrams of the nephron and Malpighian body above when studying the content below.

GLOMERULAR FILTRATION

- Glomerular filtration occurs in the Malpighian body.
- The blood in the glomerulus is under high pressure because of the wider afferent arteriole and the narrower efferent arteriole.
- The thin endothelium with pores which lines the blood capillaries of the glomerulus and the podocytes with filtration slits form an ultrafine filter through which the filterable substances in the blood are forced.
- Blood cells and plasma proteins are too large to filter and they remain in the blood of the capillaries.
- The part of the blood that filters into the Bowman's capsule is known as the **glomerular filtrate**.
- The glomerular filtrate contains useful substances e.g. water, amino acids, glucose, vitamins, mineral salts and waste products e.g. urea, uric acid and creatinine.

Try to answer the following question:

Explain how the Malpighian body is adapted for its function of filtration.

TUBULAR REABSORPTION:

- Useful substances that pass through the glomerular membrane during filtration must now be reabsorbed and returned to the bloodstream.
- The filtrate leaves the Bowman's capsule and enters the proximal convoluted tubule.

- As the filtrate moves through the proximal convoluted tubule all the glucose, amino acids and water-soluble vitamins are actively reabsorbed into the peritubular capillary blood vessels
- Mineral salts e.g. sodium ions and fat-soluble vitamins are also actively reabsorbed as they are needed by the body.
- Most of the water is passively reabsorbed through osmosis into the peritubular capillaries.
- The filtrate enters the loop of Henle.
- An increased sodium concentration in the medulla of the kidney creates a water potential gradient which lead to the passive osmosis of water. The descending loop of Henle is permeable to water and water is passively reabsorbed by osmosis.
- Sodium ions are actively pumped out of the ascending loop of Henle into the tissue fluid of the medulla (sodium pump) and chloride ions follow passively. The ascending loop of Henle is impermeable to water.
- As the filtrate moves through the distal convoluted tubule further reabsorption of useful substances takes place.
- From the distal convoluted tubule, the filtrate moves to the collecting duct

TUBULAR EXCRETION

- Substances are secreted from the blood in the surrounding peritubular capillaries through the epithelium of the renal tubule and added to the filtrate.
- This process occurs in the proximal and distal convoluted tubules.
- Hydrogen ions, potassium ions, creatinine, urea, drugs and other foreign substances are actively added to the filtrate.
- The secretion of hydrogen ions from the blood into the tubules occurs when the pH of the blood becomes too low. The excess hydrogen ions are therefore removed from the blood and the pH of the blood increases.
- When the pH of the blood increases, fewer hydrogen ions are secreted from the blood into the tubules but more bicarbonate ions are secreted from the tubules into the blood. Bicarbonate ions increase the pH of the blood.
- The filtrate now moves into the collecting ducts and is called urine.

3.2.3 HOMEOSTATIC CONTROL OF WATER AND SALTS; ROLE OF ADH AND ALDOSTERONE

3.2.3.1 REGULATION OF THE WATER CONTENT OF THE BLOOD

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- The part of the brain that controls the water balance in the body is called the **hypothalamus**.
- The hypothalamus controls the release of a hormone called **ADH** (anti-diuretic hormone)
- The hormone ADH is secreted by the **hypophysis (pituitary gland)**, which is an **endocrine gland** at the base of the brain
- ADH affects the water permeability of the walls of the distal convoluted tubule and collecting duct of the nephron

- If the walls are permeable then more water passes out of the distal convoluted tubule into the blood and water is conserved in the body.
- If the walls are impermeable then very few water is retained in the body and it passes out of the kidneys in the form of urine.

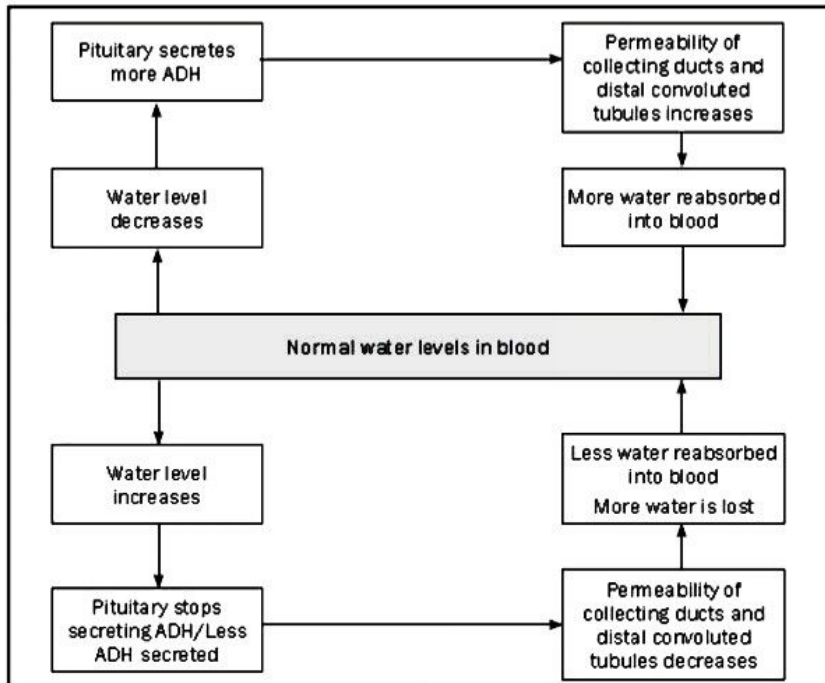


Table 4: Regulation of the water content of the blood

When the blood has more water than normal e.g. on a cold day when a person does not sweat a lot or takes in a lot of fluids	When the blood has less water than normal e.g. on a warm day when a person sweats a lot or takes in very little fluid
• The hypothalamus is stimulated • and sends impulses to the hypophysis to secrete less or stop secreting the hormone ADH • Less ADH/no ADH is transported in the blood to the kidneys • The collecting ducts and distal convoluted tubules of the kidney become less permeable to water • Less water is re-absorbed and passed to the surrounding blood vessels • More water is excreted in the urine • The urine is less concentrated (more diluted) • The water content in the blood decreases and returns to normal	• The hypothalamus is stimulated • and sends impulses to the hypophysis to secrete more of the hormone ADH • ADH is transported in the blood to the kidneys • The collecting ducts and distal convoluted tubules of the kidney become more permeable to water • More water is re-absorbed and passed to the surrounding blood vessels • Less water is excreted in the urine • The urine is more concentrated • The water content in the blood increases and returns to normal

3.2.3.2 REGULATION OF THE SALT CONCENTRATION

- The hormone **aldosterone** that is secreted by the **adrenal glands** regulates the salt (e.g. sodium ions) concentration in the blood.
- The adrenal glands are **endocrine glands** that occur on top of the kidneys

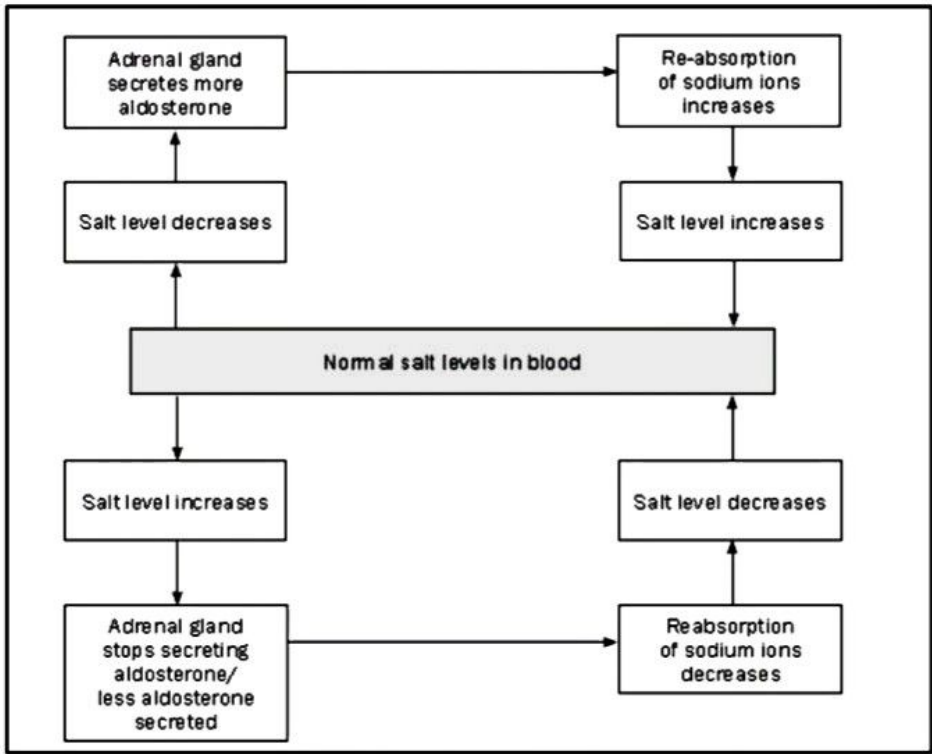


Table 5: Regulation of the salt concentration

When the salt level in the blood increases	When the salt level in the blood decreases
• Receptor cells in the afferent and efferent arterioles of the kidney detects the high salt/sodium ion level • The adrenal gland is stimulated • to stop secreting aldosterone/to secrete less aldosterone • The re-absorption of sodium ions from the renal tubules in the kidney into the blood vessels decreases • The sodium ion concentration in the blood decreases and returns to normal	• Receptor cells in the afferent and efferent arterioles of the kidney detects the low salt/sodium ion level • The adrenal gland is stimulated • to secrete more aldosterone • The re-absorption of sodium ions from the renal tubules in the kidney into the blood vessels increases • The sodium ion concentration in the blood increases and returns to normal