EXCRETION

@PETER L OKION 778001502/ 758795415

Excretion

is the removal of waste products such as ***carbon dioxide***, ***urea*** produced as a result of metabolic processes in an organism

Secretion: is the active or passive flow of substances from living cells. Such substances as enzymes, hormones, mucus etc.

Note

Egestion should not be confused with excretion because most of the contents of the faeces, apart from the bile pigments, have not taken part in reactions in the cells of the body.

SIGNIFICANCE OF EXCRETION

- ➢ Eliminates waste products formed during body metabolism
- ➢ Removal of waste products which would be toxic to body cells
- ➢ It allows for the removal of unwanted materials taken into the body along with useful nutrients
- ➢ It involves the removal of materials synthesized in excess of the current body demands
- ➢ Continuous removal of waste products allows for maintenance of a constant internal environment of the body.

NOTE:

Excretory products arise in a number of ways and these include, from:-

- Unwanted substances absorbed with food
- Absorption of excess nutrients
- Osmoregulatory processes
- Breakdown of protoplasmic constituents
- From body metabolism

Excretion in Animals

Animals like human beings have specialized organs such as the ***kidneys***, ***lungs***, ***liver*** and ***skin*** for excretion.

Waste products include ***carbon dioxide***, ***water***, ***mineral salts*** and ***nitrogenous wastes***.

These excretory organs ensure that ions, water and temperature are regulated in the body.

Excretory organs and their waste products

Excretory organ	Excretory product
Skin	Urea, lactic acid, excess salts and excess water in form of sweat.
Kidney	Excess salts, excess water and nitrogenous wastes in form of urine.
Lungs	Carbon dioxide and excess water in form of water vapour
Liver	Bile pigments
	Nitrogenous compounds such as ammonia, urea, uric acid and trimethylamine oxide.

ROLE OF LUNGS IN EXCRETION

Removal of carbon dioxide

Carbon dioxide produced during metabolism diffuses along its concentration gradient from the blood to the alveolar air at the lungs, this is expelled out of the body during exhalation.

NOTE:

Carbon dioxide is a by-product of respiration.

If it accumulates in the cell it changes the pH of the cell.

It then interferes with the functioning of certain enzymes.

If this situation is not corrected, the affected cells eventually die.

Getting rid of excessive heat

When cold air from the atmosphere enters the respiratory system it is warmed as it absorbs heat from the blood in blood vessels by **conduction**, the warm air is then exhaled, resulting in a significant source of **heat loss**.

Removal of water

In coming dry air from the environment dissolves in the mucus, this is warmed until it forms water vapor and also water vapor formed during **metabolism** diffuses into alveolar sac and expelled during **exhalation**.

The skin

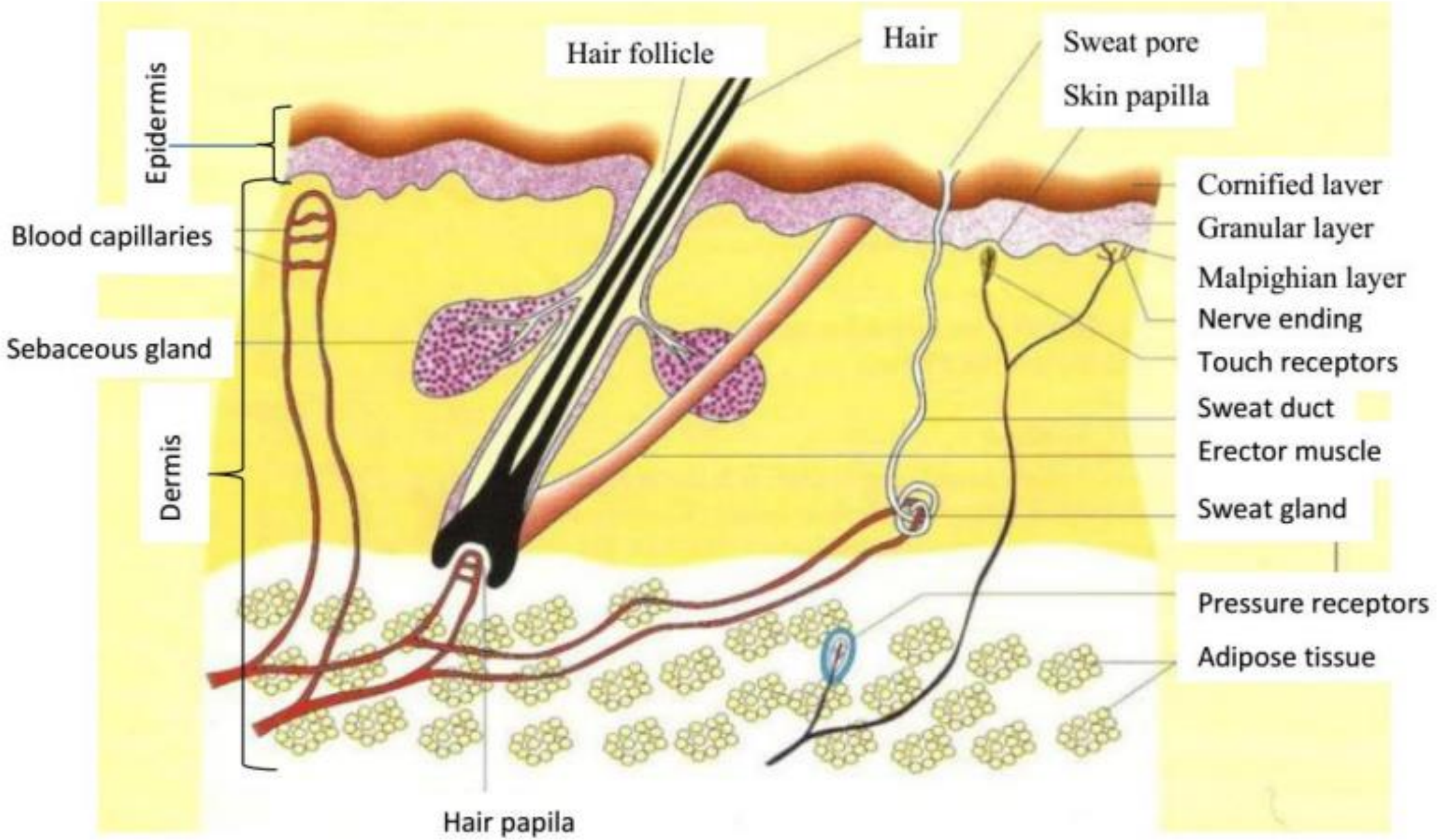
The skin is a continuous protective layer over the body. **It is the largest organ of the body**

Functions of the skin

- Protection of the body from physical damage.
- Protection against entry of microorganisms such as bacterial and viral infections.
- Prevents loss of water from the body.
- It acts as a **sense organ** sensitive to pain, **touch** and **heat**. This helps the organism to be aware of its environment.
- Regulates body temperature.
- It synthesizes **vitamin D** in presence of sunlight.
- It excretes salts, excess water, lactic acid, carbon dioxide and traces of urea.
- Stores fats in the adipose tissue.
- Melanin pigment blocks ultraviolet rays from penetrating into the body tissues

ASSIGNMENT

1. *Make a well labeled **drawing** of the skin*
2. ***Describe** each part of the skin*
3. *Give the **function** of each part of the skin.*


Epidermis
Hair follicle
Hair
Sweat pore
Skin papilla
Blood capillaries
Cornified layer
Granular layer
Malpighian layer
Nerve ending
Sebaceous gland
Touch receptors
Sweat duct
Dermis
Erector muscle
Sweat gland
Pressure receptors
Adipose tissue
Hair papila

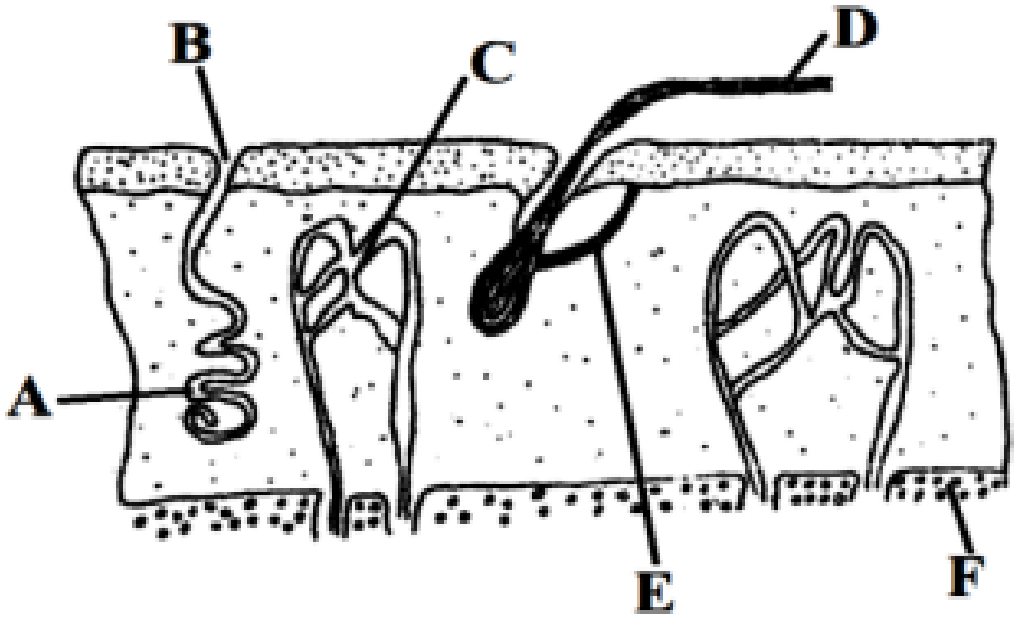
Sample question

The figure below shows a longitudinal section of a human skin.

a) Name the parts labelled **A** to **F**. *(03 marks)*

b) State the function of each of the parts labelled A, B, D and F. *(04 marks)*

c) Suggest the type of temperature conditions to which the skin is responding. State two observable features as reasons for your answer. *(03 marks)*



THE KIDNEY AND THE EXCRETORY SYSTEM

Structure of urinary system

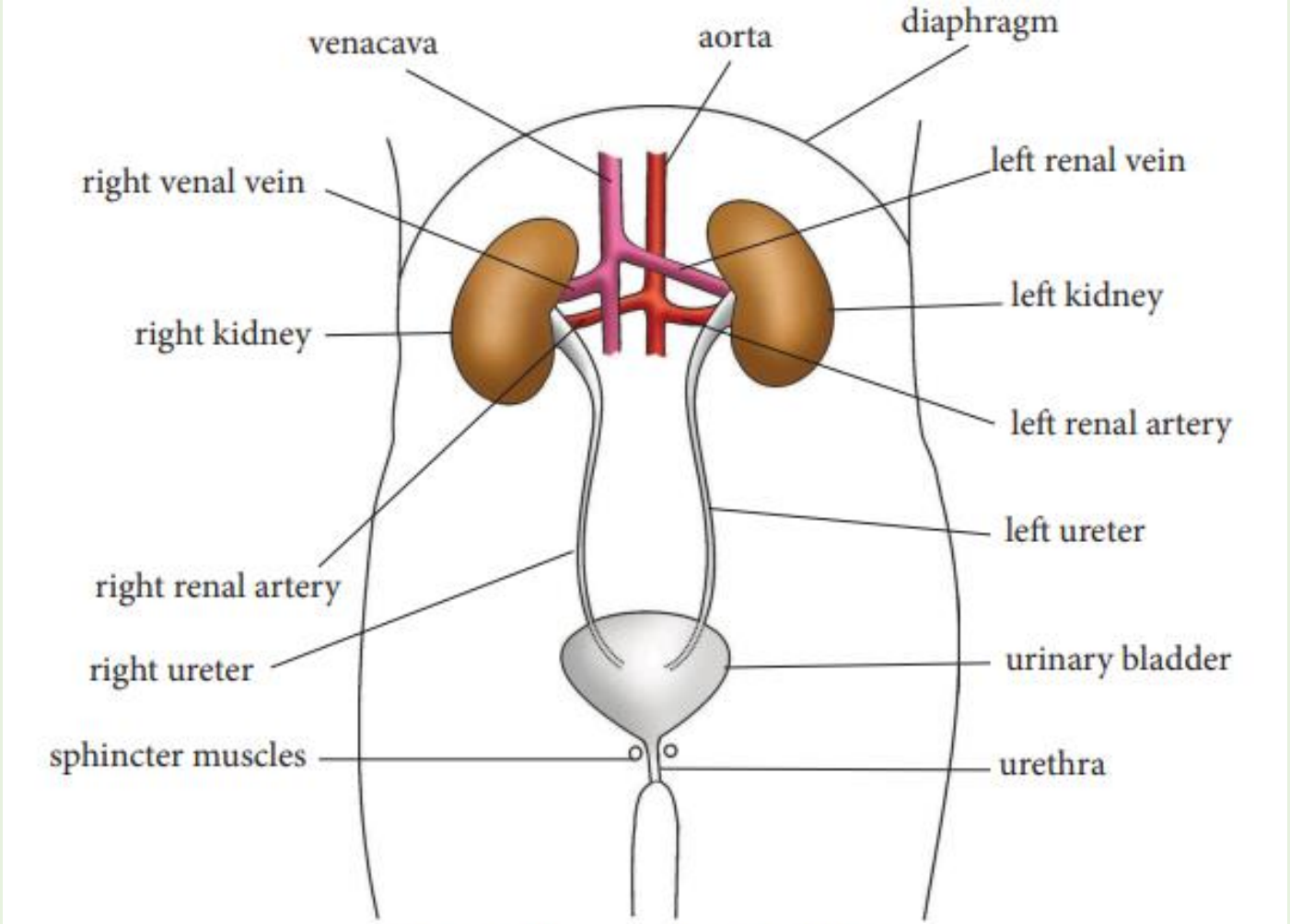


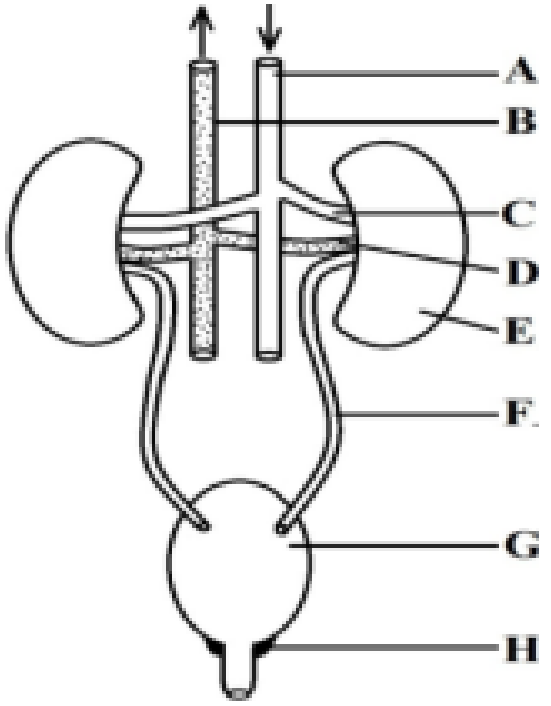
Fig 10.3 Human urinary system

Parts and functions of the urinary system

1) **Aorta:** It carries **oxygenated** blood with all food nutrients to the kidney.
2) ***Renal artery:*** This arises from dorsal aorta. It brings blood containing **excretory products** to the kidney.
3) ***Renal vein:*** It carries **filtered blood** from the kidney to the posterior vena cava.
4) ***Ureter:*** These are two narrow tubes arising from **hilum** of each kidney. They connect the kidneys to the urinary bladder. They transport **urine** to the urinary bladder.
5) ***Urinary bladder:*** It is a thick walled elastic sac-like structure which **stores urine**.
6) ***Sphincter muscle:*** These muscles are **elastic** thus can contract and relax to **control urine flow.**
7) ***Urethra:*** It is a **passage** for urine to the outside of the body

Sample question

The figure below shows the urinary system of a mammal. Study it carefully and answer the questions that follow.



a) Name the parts labelled **A** to **H** *(04 marks)*

b) State the function of the part labelled *(02 marks)*

i. **E** _____

ii. **F** _____

iii. **G** _____

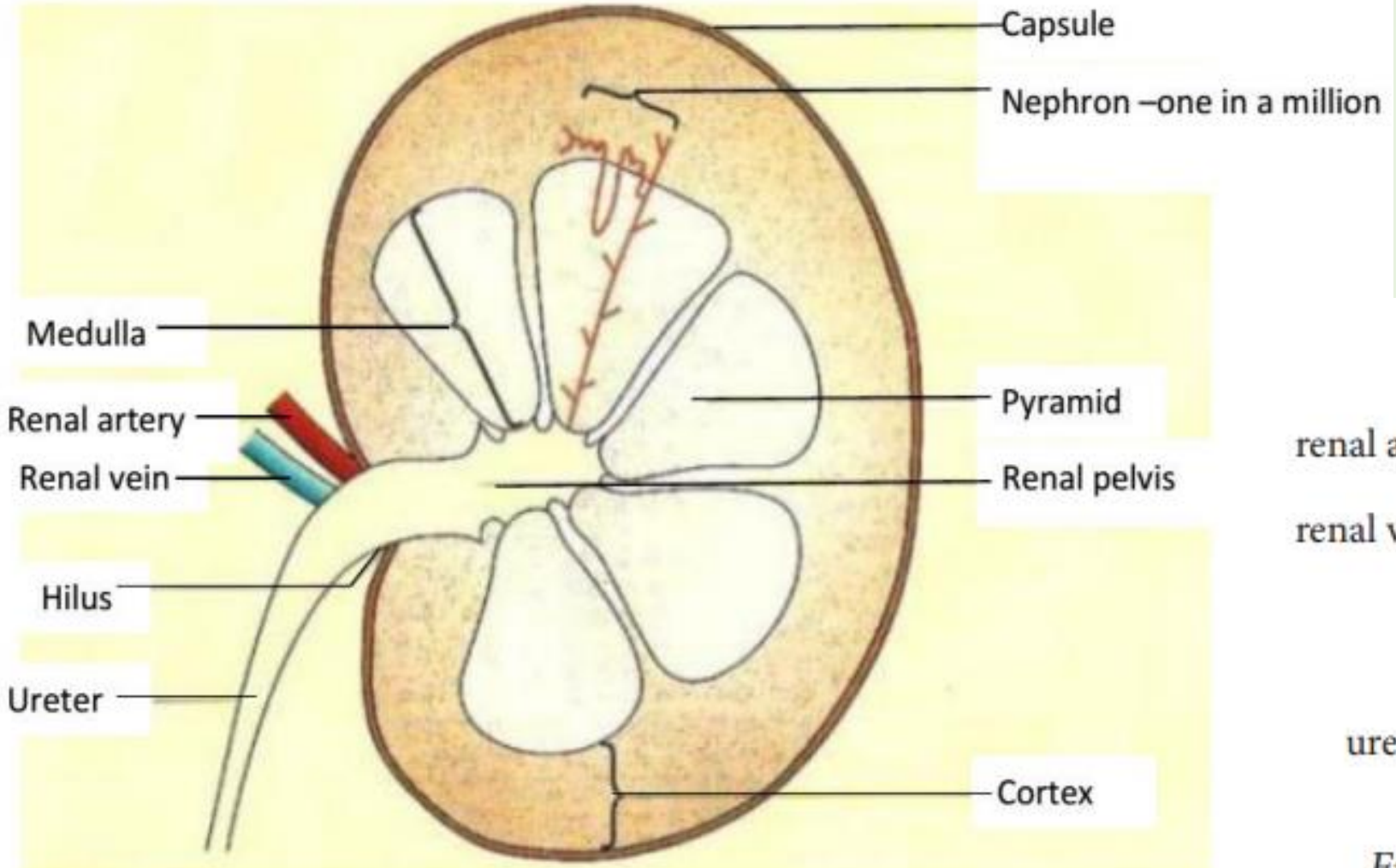
iv. **H** _____

c) State two differences in the composition of blood flowing in **C** and **D** *(02 marks)*

d) Briefly explain why the concentration of urea in **D** is less than that in **C**. *(02 marks)*

The Kidney

Structure of the kidney



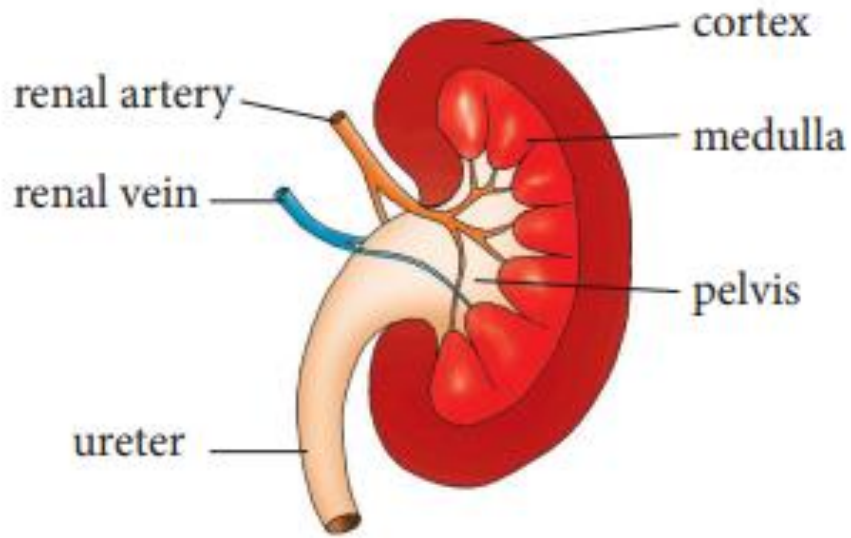


Fig. 10.4: Cross-section of kidney

The kidneys are **solid bean-shaped** structures and they occur in **pairs** in mammals.

They are **reddish-brown** in color enclosed in a transparent membrane and attached to the back of the abdominal cavity.

The kidney tissue consists of many capillaries and renal tubules connected together by connective tissue.

The kidney has **two** major parts.

1. **The cortex** which is a dark outer part. It consists of the **Bowman's capsule** which is responsible for **ultra-filtration** of blood passing across it.

2. **The medulla,** which is a lighter inner, part. It is made up of many cone-shaped portions called **pyramids**. The **pelvis** is the area where the ureter leaves the kidney.

The kidney performs three major functions in the body i.e.

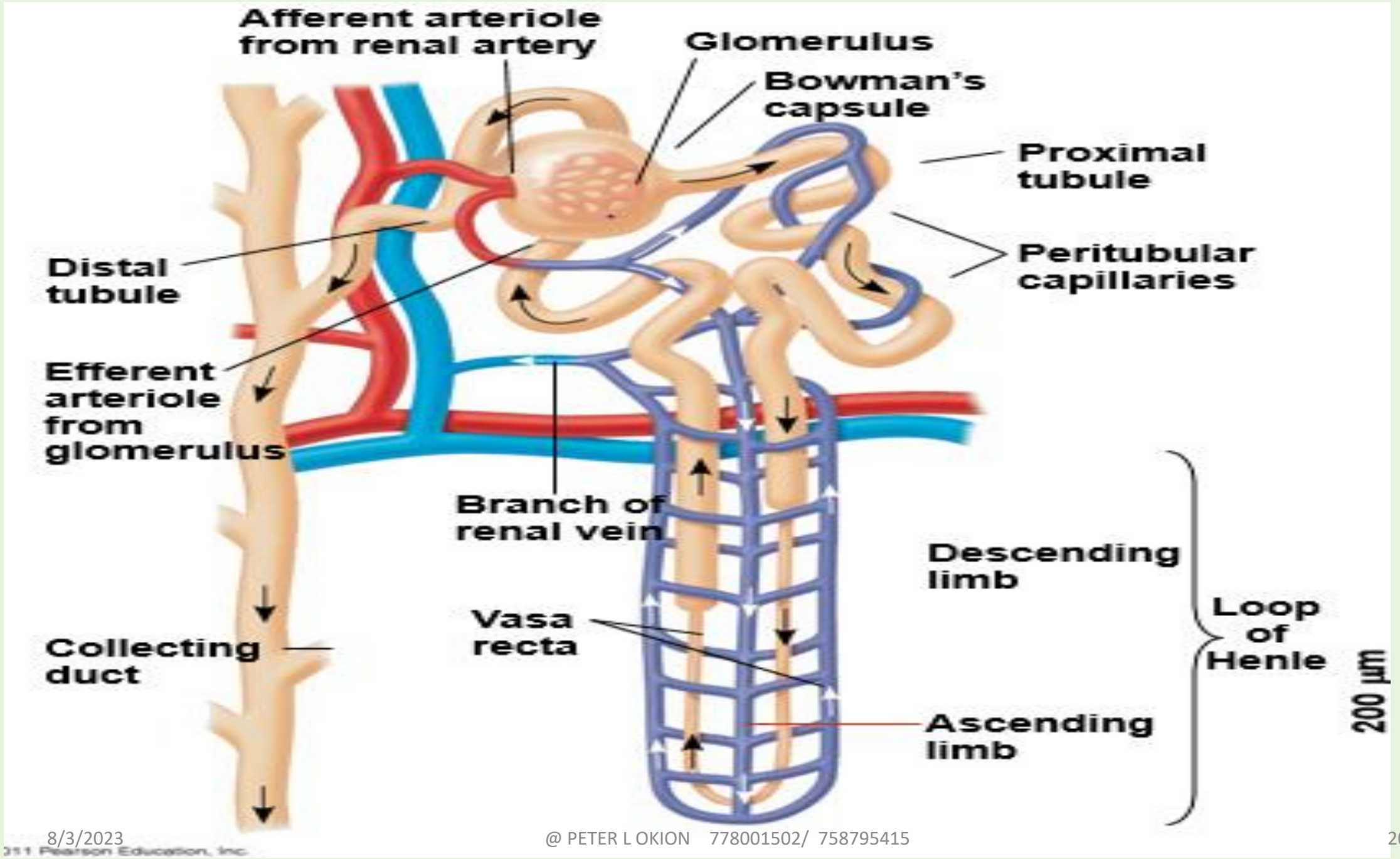
1. It carries out **excretion**.
2. It carries out the function of **osmoregulation**.
3. It contains endocrine glands, which **secrete hormones** such as erythropoietin, renin and calcitriol

The kidney is made up of several microscopic structures (functional units) called **nephrons** where the actual excretion and osmoregulation takes place.

The Nephron

This is the **functional unit** in the kidney.

It carries out the function of excretion and osmoregulation in the kidney.



Sample question

The diagram represents part of the mammalian excretory organ.

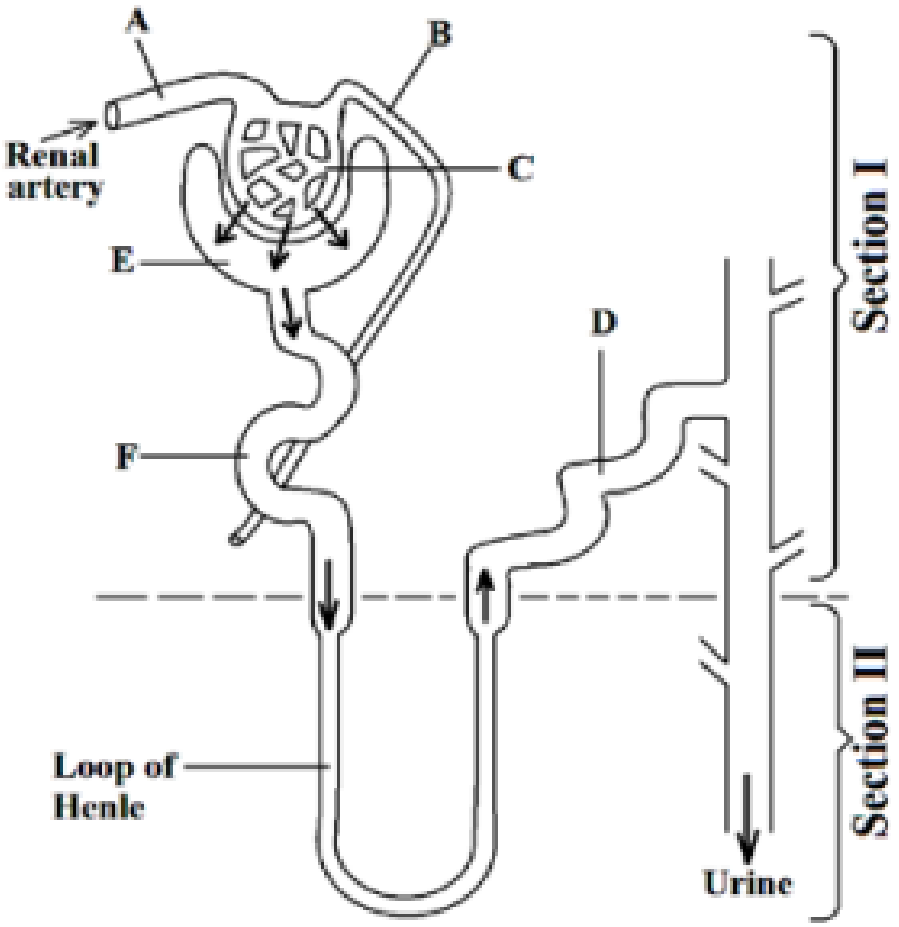
a) Name the parts labelled **A** to **D** *(02)*

b) State the name of the major process, which occurs in region E, and F. *(02 marks)*

c) Explain how the process in region **E** occurs. *(02 marks)*

d) From the diagram, describe how section I is adapted to its function during excretion. *(03 marks)*

e) Suggest why some desert mammals may have very long loops of Henle? *(01 mark)*



Parts of the Nephron

1. Bowman's capsule:

is a **cup-shaped structure**, It contains a dense-network of highly coiled capillaries that form a **knot** called **glomerulus**.

The glomerulus is formed from the wider arteriole of renal artery called afferent arteriole.

It is located in the **cortex**.

Functions:

contains glomerular capillaries involved in **ultra-filtration**.

Filters small molecules in blood such as **urea, glucose, amino acids**, and **mineral ions** through its basement membrane.

Adaptations of the Bowman's capsule to collect the filtrate

- Large cup-shaped structure to provide more space for collecting more filtrate.
- Is cup shaped to provide surface area to enclose glomerular capillaries which carry out ultra-filtration
- Porous basement membrane to allow filtration of materials.

2. Glomeruli;

these are numerous capillaries found in the Bowman's capsule formed due to branching of the afferent arteriole

Adaptations of the glomerulus to ultra-filtration

- Afferent arteriole **wider** than the efferent arteriole creating **a high blood pressure** that forces **small molecules** out of the glomerulus.
- Many blood capillaries to provide a large surface area for ultra-filtration.
- Porous membrane to can allow small sized molecules to pass through.

3. Proximal convoluted tubule:

is a **highly coiled** structure leading from the Bowman's capsule.

Function:

It is a site where **re-absorption** of useful materials such as **glucose** and some **small amino acids** and **water** from glomerular filtrate back to blood takes place.

Adaptations of proximal convoluted tubule to its function

- **Long** providing a large surface area over which absorption of materials can occur
- Tubule **one cell thick** to reduce the diffusion distance for faster diffusion of materials
- Cells in the walls have **microvilli** to increase the surface area over which absorption can occur
- Surrounded by **numerous blood capillaries** for rapid transportation of absorbed materials
- Cells in the walls contain large **quantities of mitochondria** to produce a large quantity of ATP for rapid active transport of materials.

4. Loop of Henle:

is a **U shaped tubule,** made up of a **descending** (going down) limb and an **ascending** (going up) limb.

Function:

- ➢ Re-absorption of water.
- ➢ Re-absorption of mineral ions.

5. Distal convoluted tubule:

this is the **second** coiled tube found after the ascending limb of loop of Henle.

Function:

For re-absorption of ions like chloride ions, sodium ions together with water.

6. Collecting duct:

a tubule with several branches where distal convoluted tubule extends from.

Functions:

➢ Carries urine from the distal tubule to the pelvis of kidney.

➢ Allows reabsorption of water thus conserving it.

Urine formation

The process of urine formation takes place in the **nephron**.

It occurs in **two** phases.

1. Ultra-filtration:

which is filtration of small molecules through tiny pores at high pressures.

2. Selective re-absorption:

is the process of taking back into blood of some of the essential substances still required by the body from the glomerular filtrate.

Ultra filtration

✓ Much blood comes from the afferent arteriole into the glomerulus than that which leaves through efferent arteriole because the afferent arteriole has a **wider** lumen than the efferent arteriole.

✓ High pressure is generated in the blood capillaries of the glomerulus forcing **small molecules** such as **glucose, urea, water, salts and vitamins** to filter out of the blood capillaries to form the glomerular filtrate.

✓ **Proteins** and **blood cells** do not filter out because they have **bigger** molecules, which cannot pass through the tiny pores in the walls of the glomerulus.

✓ The filtrate formed moves from the Bowman's capsule through the capsular space and pores in basement membrane to proximal convoluted tubule where **selective reabsorption** starts to occur.

The pressure required for ultra-filtration is derive from; pressure due to **pumping action of heart**, pressure developed due to **difference in size of afferent arteriole and efferent arteriole**, **hydrostatic pressure of blood.**

NOTE:

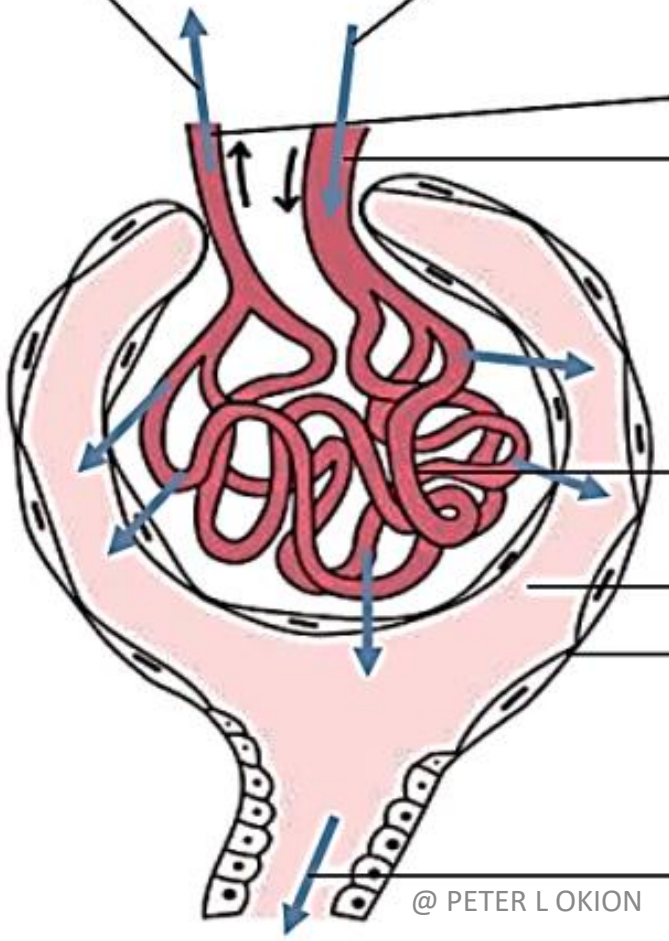
Ultrafiltration is a **passive, mechanical process**.

- Selection of substances passing through from the blood into the filtrate within the nephron is achieved purely on the **basis of size.**

Diagrammatic illustration of ultrafiltration

Blood leaving the glomerulus contains proteins and blood cells because they have bigger molecules, which cannot pass through the walls of the glomerulus.

Blood entering through the afferent vessel contains proteins, red blood cells, white blood cells, urea, water, salts, amino acids and vitamins.



Efferent arteriole

Afferent arteriole

Glomerulus

Capsular space

Bowman's capsule

Glomerular filtrate flowing to proximal convoluted tubule

Selective Reabsorption

In the proximal convoluted tubule:

✓ Most of the **food materi**als are re-absorbed into the blood capillaries first by **diffusion** like **sodium ions, chloride ions** and then by **active transport** e.g. all the **glucose, amino acids, vitamins, and some mineral ions**, some **water** is re absorbed by **osmosis**

In the loop of Henle:

✓ As the filtrate flows down the descending limb, **water** is re absorbed back into the capillaries by **osmosis** leading to increased concentration of the filtrate down the descending limb.

Highest concentration of the filtrate is at tip of the loop.

✓ As the filtrate ascends, first in the thin section, sodium ions and chloride ions are reabsorbed by diffusion and in the thick section of the ascending limb of loop of Henle, salts like Na+ and K+ are reabsorbed by active transport.

This leads to a decrease in concentration of the glomerular filtrate in the ascending limb.

In the distal convoluted tubule:

✓ Selective re-absorption of salts by diffusion occurs.

✓ Substances such as Urea are actively transported (secreted) from blood into the filtrate.

✓ Water is reabsorbed only due to stimulation by **Anti diuretic hormone (ADH)**

In the collecting duct:

✓ Water is lost to the highly concentrated medulla tissues by osmosis from which later the remaining filtrate is urine which goes via the ureter and temporarily stored in the urinary bladder.

✓ Water is reabsorbed only due to stimulation by Anti diuretic hormone (ADH)

Summary of the steps involved in formation of urine in the kidneys

Region of nephron	Function
Bowman's capsule	Ultra filtration of the blood in glomerulus; high hydrostatic pressure produces an ultra-filtrate free of plasma proteins and red blood cells
Proximal convoluted tubules	• Reabsorption of useful substances such as Na^+, K^+, Cl^-, HCO_3^-, amino acids and glucose by a mixture of diffusion and active transport • Reabsorption of water by osmosis • Reabsorption of urea by diffusion
Loop of Henle	Reabsorption of water from the collecting duct
Distal convoluted tubule	• Reabsorption of Na^+ • Reabsorption of water under the control of ADH • Secretion of H^+, NH_4^+ and reabsorption of HCO_3^- to control blood pH • Secretion of some drugs
Collecting duct	Reabsorption of water under control of ADH

Comparison of substances in blood and urine

Nitrogenous waste	In blood	In urine
Urea	0.03	2.0
Proteins	7-9	0
Glucose	0.1	0
Chloride ions	0.37	0.6
Sodium ions	0.32	0.35
Water	93	95

✓ There are **proteins in blood and there is none in urine** because proteins are not filtered out of the blood vessels into the glomerulus due to the **large size** of their molecules.

✓ **Urea is more in urine** than in blood because it is filtered out of blood and it is **not reabsorbed** back in the blood.

✓ **Water is more in urine** than in blood because it is **used to dissolve urea**.

✓ However the relative amounts of water in urine and in blood varies depending on the amount of water in the body, amount of solutes in the body, temperature and body activity.

✓ There is **glucose in blood and no glucose in urine** because **glucose is reabsorbed** from the glomerular filtrate back into the blood.

✓ **Salts like chlorides and sodium ions are more in urine** than in blood. This is because they are **in excess and they are not reabsorbed back** into the blood. Because of this they tend to concentrate in urine.

Kidney failure (renal failure)

A condition in which kidneys **lose the ability to remove waste and balance fluids**

Causes

Diabetes and high blood pressure

Liver failure

Blood pressure medications

Infections

Use of aspirin, ibuprofen or related drugs

Blood or fluid loss

Heart attack

Signs and Symptoms

Fatigue

Nausea and vomiting

Swelling (edema), particularly around your hands or ankles

Changes in how often you go to the bathroom and brain fog

Treatment

Dialysis or a kidney transplant

Need for proper disposal of human wastes e.g. urine

- ✓To avoid polluting water sources
- ✓Minimize the chances of spreading diseases
- ✓Maximize the rate of decomposition
- ✓Avoid the negative implications of someone else finding it

QUIZ

Brainstorm on the need for tests to determine the presence of **Glucose and Protein** in urine and explain the significance of the tests

END

BIOLOGY IS LIFE

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