



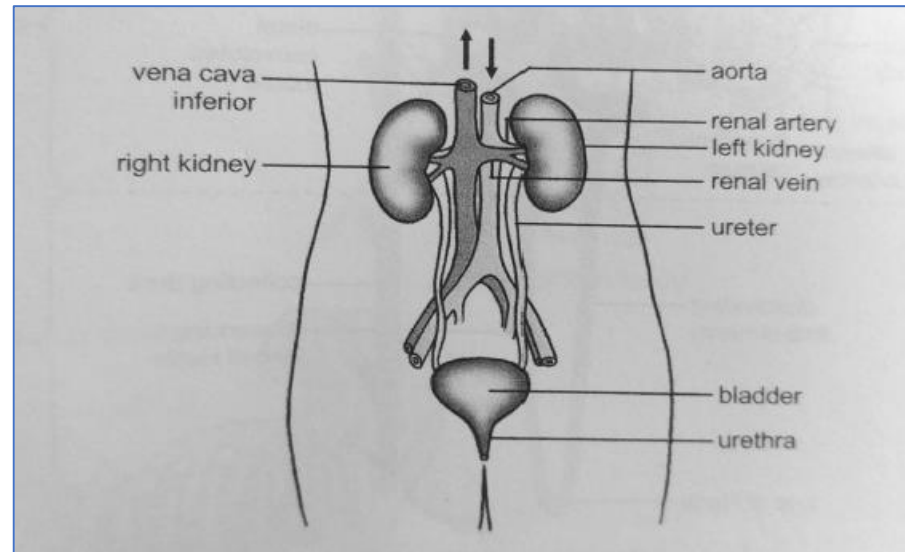
SUBJECT and GRADE	Life Sciences Grade 11
TERM 3	Week 5
TOPIC	Excretion in humans – Urinary system- position of organs, structure and functioning of kidneys, structure and functioning of a nephron
AIMS OF LESSON	<p>At the end of this lesson you should be able to:</p> <ul style="list-style-type: none"><li>• Know the structure of the urinary system including the position of the kidneys, ureters, bladder and urethra</li><li>• Know the structure and functioning of the kidney i.e. removal of excess water and salts, re-absorption of glucose and some salts</li><li>• Know the structure and functioning of the nephron i.e. ultra-filtration, re-absorption, tubular excretion, pH control and formation of urine</li></ul>
RESOURCES	<b><i>Paper based resources</i></b>
	<p>Refer to your textbook section on:</p> <ul style="list-style-type: none"><li>• The structure and function of the urinary system</li></ul>
INTRODUCTION	<p>Refer to the following sections for background information:</p> <ul style="list-style-type: none"><li>• the excretory system in Grade 9</li><li>• excretion in various organs in Grade 11</li></ul>
CONCEPTS AND SKILLS	<p><b>Below are definitions of some of the terms that you will study under this section. Use your textbook and underline all the new terms/words that you encounter while studying through this section. Use the glossary in your textbook to define these new terms/words</b> (Note: At least 2 marks are awarded if you can define a term correctly in a test or examination)</p> <p><b>Renal capsule</b> – The connective tissue membrane which surrounds and protects the kidney</p> <p><b>Nephrons</b> – The structural and functional units of the kidney</p> <p><b>Malpighian body</b> – The structure that consists of the glomerulus and Bowman’s capsule</p> <p><b>Afferent arteriole</b> – The blood vessel that transports blood to the glomerulus</p> <p><b>Glomerulus</b> – The network of capillary blood vessels in the capsule of Bowman.</p> <p><b>Renal artery</b> – The blood vessel that transports oxygenated blood rich in metabolic waste to the kidney</p> <p><b>Glomerular filtration</b> – The process in the functioning of the kidney that occurs in the Malpighian body</p> <ul style="list-style-type: none"><li>•</li></ul>

**Study the following content:**

**Structure of the urinary system:**

- The urinary system consists of 2 kidneys, 2 ureters, the bladder and the urethra.

**The human urinary system**



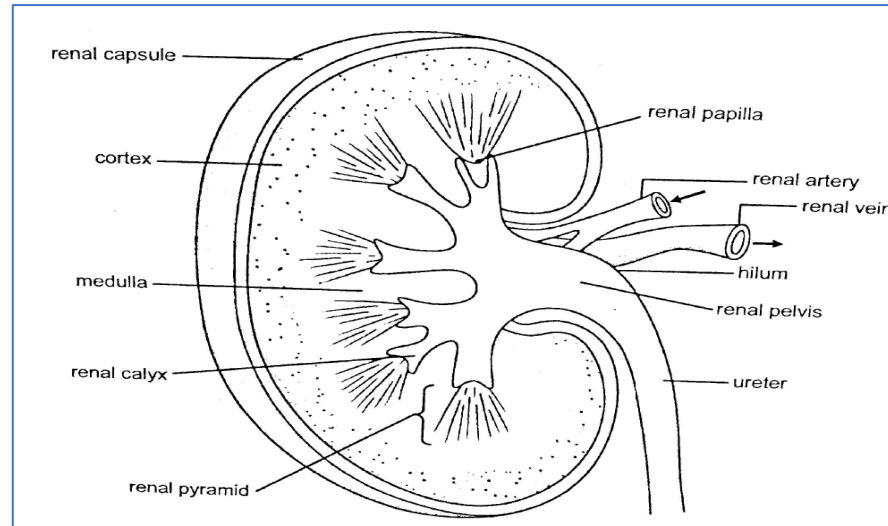
- The kidneys are located in the abdominal cavity on either side of the vertebral column just below the diaphragm.
- The **renal arteries** transport oxygenated blood, rich in metabolic waste to the kidneys
- The **renal veins** transport deoxygenated blood, purified of metabolic waste away from the kidneys.
- The two **ureters** transport urine from the kidneys to the bladder.
- The **bladder** is a thin-walled muscular sac that stores urine temporarily.
- The **urethra** transports the urine from the bladder to the outside

**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**.

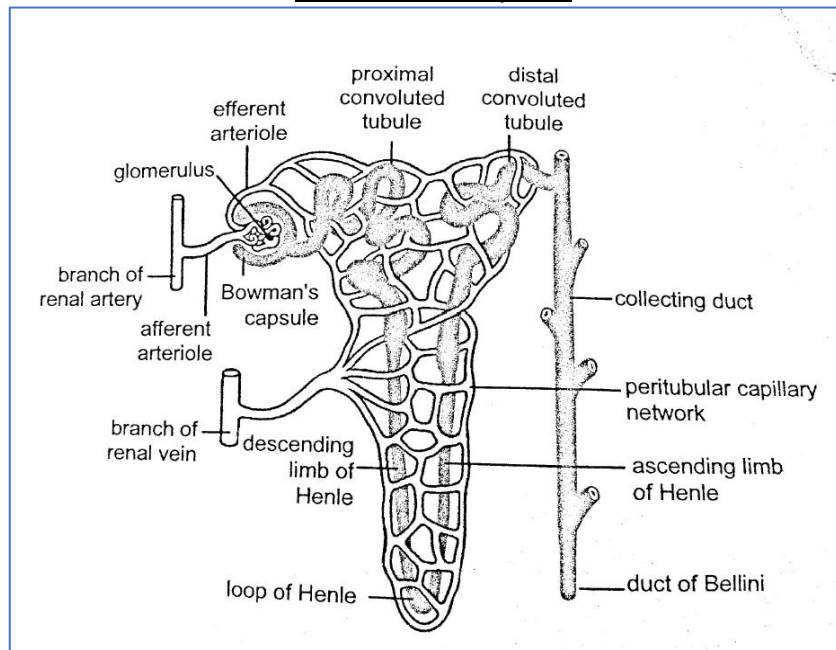
Longitudinal section of a kidney



**Nephrons:**

- Each kidney is made up of about one million microscopic structures called **nephrons**.
- The nephrons are the structural and functional units of the kidney.

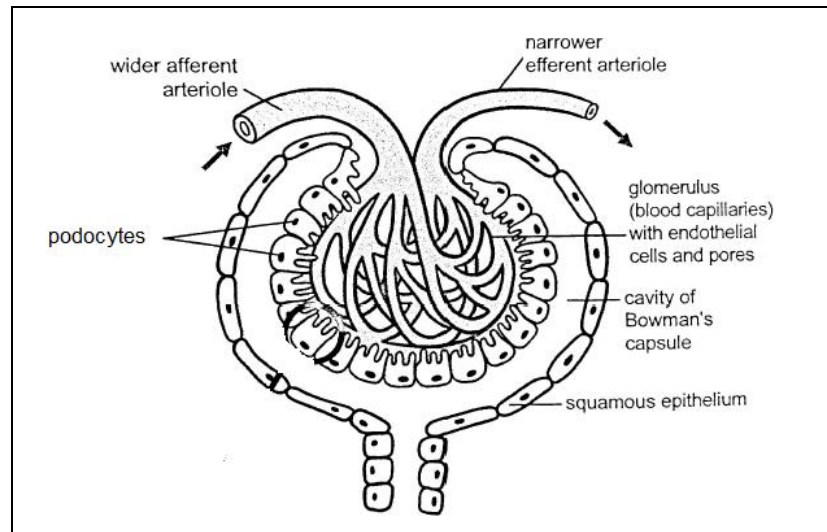
### Structure of a nephron



Each nephron consists of the

- **Malpighian body** and
- **renal tubule**

### 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.

### Renal tubule:

- 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.

**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.

**Functions of the kidney:**

- Excretion of nitrogenous waste
- Regulation of the water content in the blood (osmoregulation)
- Regulation of the salt content in the blood
- Regulation of the pH in the blood.

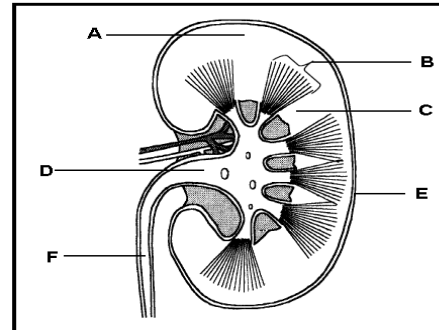
**Know the meaning of instructional verbs in test and examination questions e.g.**

Instructional verb	Meaning
Name	Give the name of something
Differentiate	Use differences to qualify between two or more categories
Tabulate	Draw a table and indicate the answers as direct pairs.
Describe	State in sentences the main points of a process
Explain	Give your answer in a cause-effect or statement and reason sequence

**Answer the following questions:**

**Question 1**

1. Study the diagram below and answer the questions that follow. (DBE Exemplar Paper P1 2013)



1.1 *Name* the organ represented in the diagram.

1.2 *Identify* region **A** and parts **B** and **D**.

1.3 *Give* the function of each of the following parts:

(a) E

(b) F

1.4 *Give* THREE functions of the organ named in QUESTION 1.1.

1.5 *State* why region **A** is darker in colour than region **C** in an actual kidney.

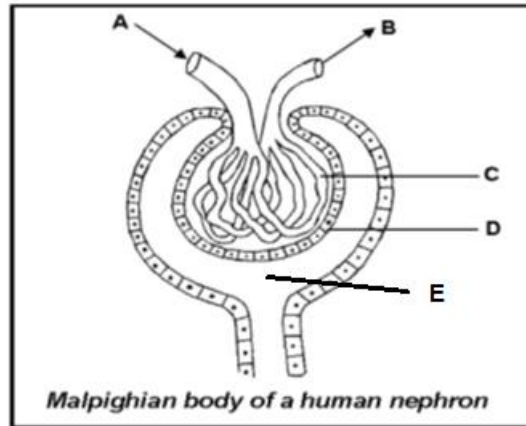
1.6 *State* the role of the fatty tissue surrounding the kidney.

1.7 *Describe* how the functioning of the kidney will be affected if part **F** is blocked by a large kidney stone.

**Question 2:**

2. Study the diagram below and answer the questions that follow. (DBE Exemplar Paper P1 2013)

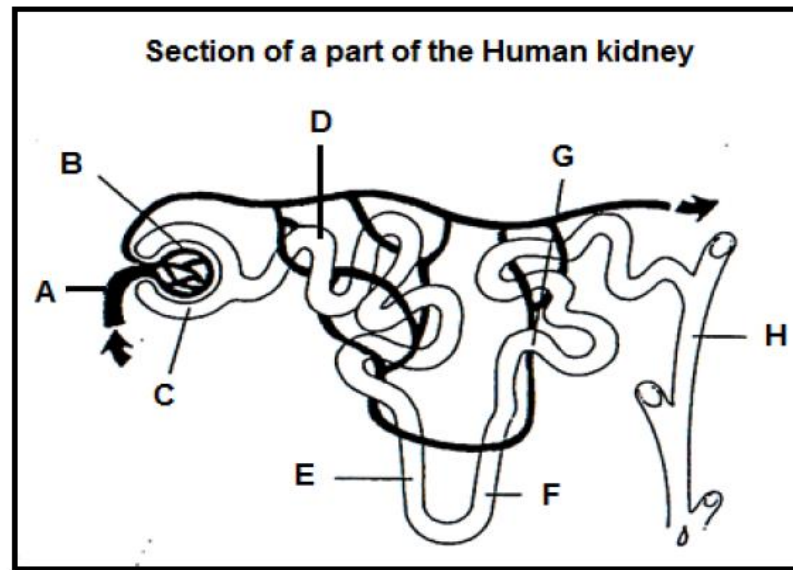




- 2.1 *State* the region of the kidney where you would find this structure?
- 2.2 *Name* the process in urine formation that occurs in this structure.
- 2.3 *Identify* part **C**.
- 2.4 *Describe* TWO structural adaptations of part **C** for the process in QUESTION 2.2 above.
- 2.5 *Give* ONE advantage of the difference in diameter between the structures labelled A and B.
- 2.6 *Name* the liquids present in parts **C** and **E** respectively.
- 2.7 Which blood vessel (**A or B**) contains more urea?
- 2.8 *Explain* why heart failure can sometimes lead to kidney failure.

**Question 3:**

3. Study the following diagram and answer the questions. (Free State Nov 2016 P1)



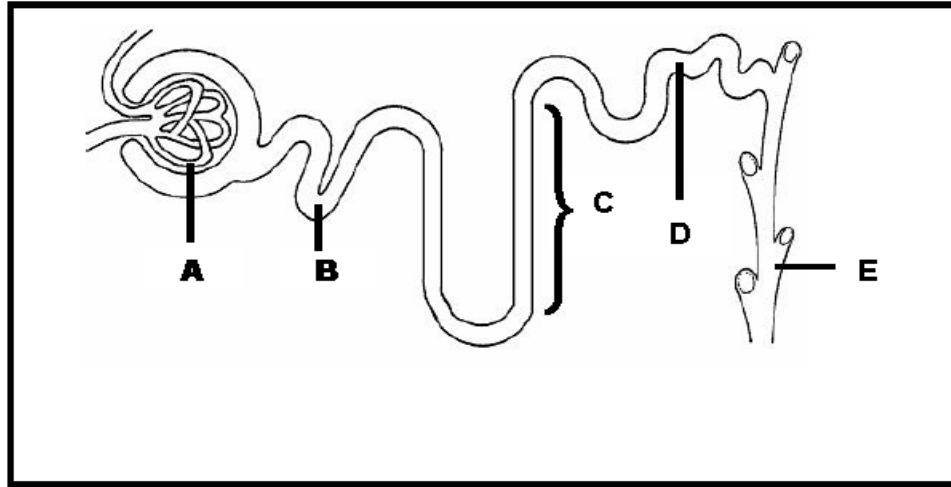
3.1 Identify parts **A** and **H**.

3.2 *Tabulate* THREE differences between the fluids in **A** and in **H** respectively.

3.3 Name TWO structural adaptations of region **D** for its function.

**Question 4:**

4. Study the following diagram and table and answer the questions that follow. (Biology NSC P2 2005)



*Table showing some substances moving through different parts of the structure in the diagram above*

Substance	Amount moving through part A daily	Amount moving through part E daily	Amount reabsorbed daily
Water	180 litres	?	178,5 litres
Glucose	180g	?	180g
Urea	60g	35g	?

4.1 Give the biological name of the structure represented by the diagram.

4.2 Identify parts C, D, and E.

4.3 Name the physical process that takes place at B.

4.4 Explain THREE ways in which the cells in part B are structurally suited for the process named in QUESTION 4.3.

4.5 Calculate how much water is lost in the urine. Show ALL calculations.

4.6 Calculate how much urea (in grams) will be re-absorbed in a normal healthy person.

4.7 Explain the following:

(a) The presence of proteins in D

(b) The absence of glucose in C.

	<b>Common errors made by learners in examinations:</b> <ul style="list-style-type: none"> <li>• Do not understand instructional verb/s in a question e.g. the difference between <i>describe</i> and <i>explain</i>.</li> <li>• Not able to provide labels to parts of diagrams</li> <li>• Not able to describe or explain the structural adaptations of different parts of the urinary system</li> </ul>
ACTIVITIES/ASSESSMENT	<ul style="list-style-type: none"> <li>• Complete the activities/questions on excretory organs in your textbook.</li> </ul>
CONSOLIDATION	<ul style="list-style-type: none"> <li>• Define all the terminology relevant to the topic/s covered in this lesson</li> </ul> <p><b>Note:</b> The knowledge and skills gained in this section will help you to have a better understanding of the following section that you still need to deal with</p> <ul style="list-style-type: none"> <li>• Homeostatic control of water and salts</li> </ul>
VALUES	<ul style="list-style-type: none"> <li>• By studying and learning about the excretion in humans you will understand the importance of maintaining a healthy lifestyle.</li> <li>• You will also develop a level of academic and scientific literacy that will enable you to read, talk about, write and think about biological processes, concepts and investigations.</li> </ul>