EXCRETION IN HUMANS 31 JULY 2013

Lesson Description

In this lesson we:

- Discuss organs of excretion
- Look at the structure of the urinary system
- Look at the structure and functioning of the kidney
- Discuss the structure and function of the nephron
- Consider Homeostasis of water and salts
- Discuss diseases of the kidneys

Key Concepts

Excretion

Is the removal of waste products from the body formed during metabolic reactions e.g. water, carbon dioxide and nitrogenous waste.

Excretory Organs

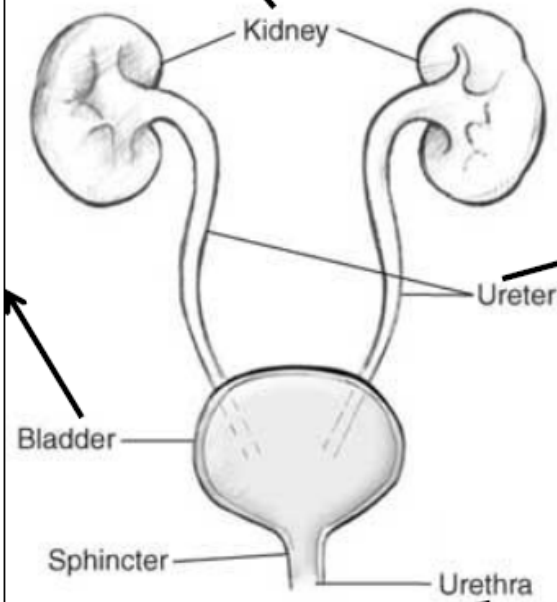
Organ	Waste product
Lungs	Carbon dioxide form cellular respiration
Skin	Water, salts released in the form of sweat
Alimentary canal	Bile pigments and cholesterol are excreted as bile pigments in the faeces
Liver (not an excretory organ)	Nitrogenous waste • Urea – deamination of excess amino acids • Uric acid – breakdown of nucleic acids Non –nitrogenous wastes • Creatinine – from the muscles • Toxins and drugs • alcohol
Kidneys	Nitrogenous waste from the liver. Non-nitrogenous waste, carbon dioxide, water, ions, hormones, poisons, drugs

The Structure of the Urinary System

The urinary system consists of two kidneys, two ureters, a urinary bladder and a urethra. The urine is made in the kidneys, travels to the bladder via the ureters and leaves the body via the urethra.

The kidneys are the primary organs of the urinary system. The kidneys are the **organs that filter the blood, remove the wastes, and excrete the wastes in the urine** (Campbell, 2008).

The urinary bladder is a **temporary storage reservoir for urine**. The size and shape of the urinary bladder varies with the amount of urine it contains and with pressure it receives from surrounding organs. The muscle in the bladder wall is called the detrusor muscle which relaxes to allow the bladder to fill and contracts during urination (Fox, 2009)

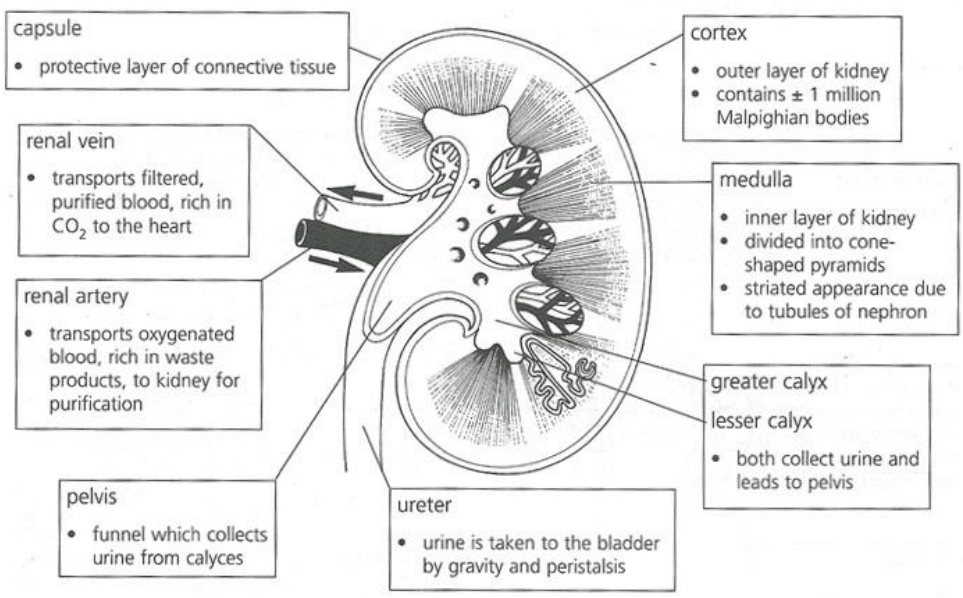


Each **ureter** is a narrow tube, about 25 cm long that **carries urine from each kidney to the urinary bladder**. It extends from the renal pelvis (an area where urine is collected in the kidney), and enters the urinary bladder.

The final passageway for the flow of urine is the urethra, a thin-walled tube that conveys urine from the floor of the urinary bladder to the outside.

In females, the urethra is short, only 3 to 4 cm long and opens to the outside just anterior to the opening for the vagina. In males, the urethra is much longer, about 20 cm in length, and transports both urine and semen. The external urethral opening opens to the outside at the tip of the penis (Campbell, 2008).

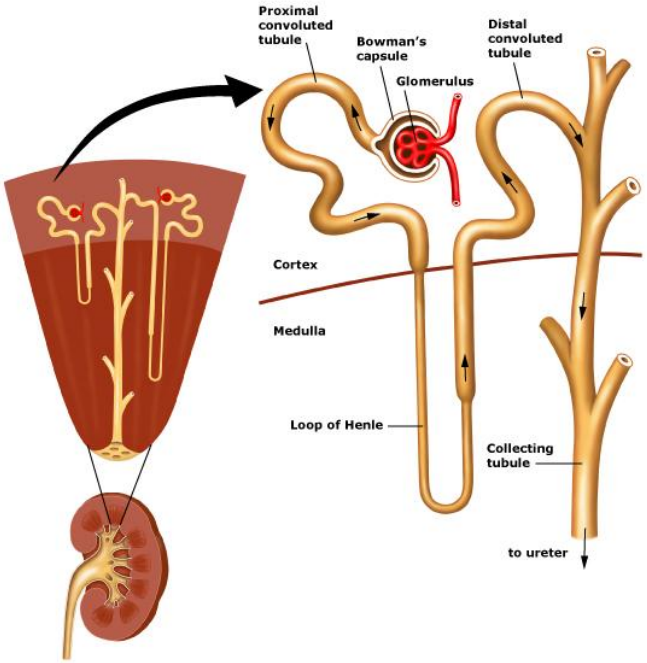
The Kidneys – Macroscopic Structure



Internal (macroscopic) structure of the kidney

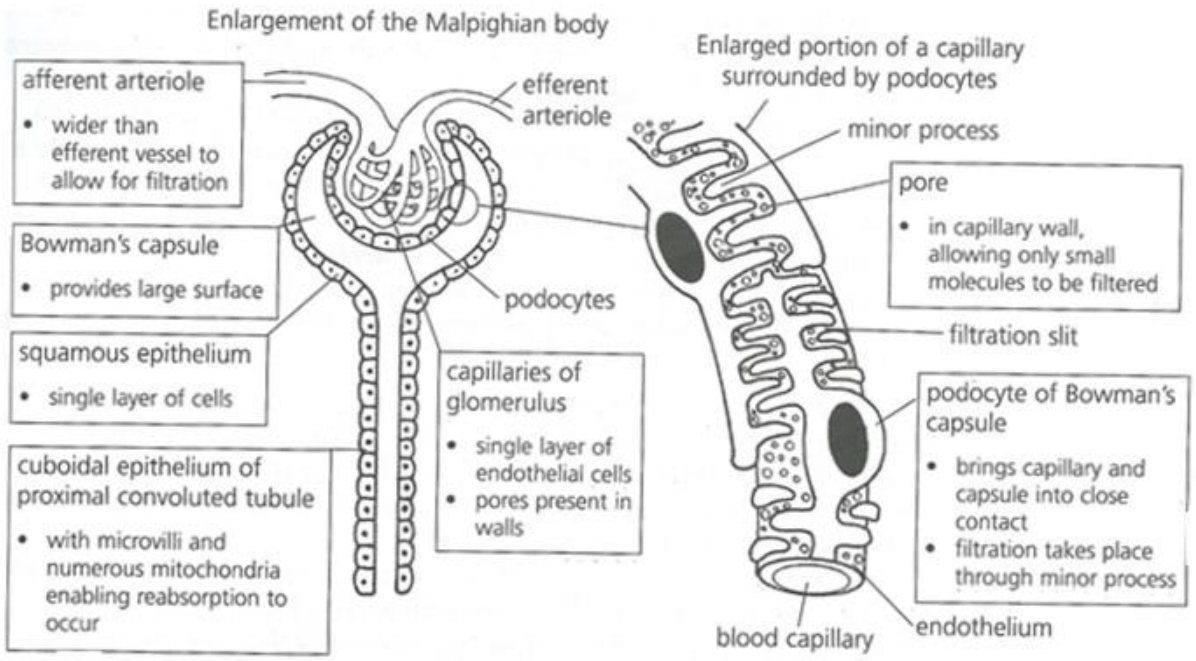
The Nephron – Microscopic Structure of the Kidney

- Each kidney is made up of about one million small tubes known as **nephrons**
- The nephrons are the structural and functional units of the kidney
- Each nephron consists of two main parts:
  - **Malpighian body/Renal corpuscle**
  - **Renal tubule**



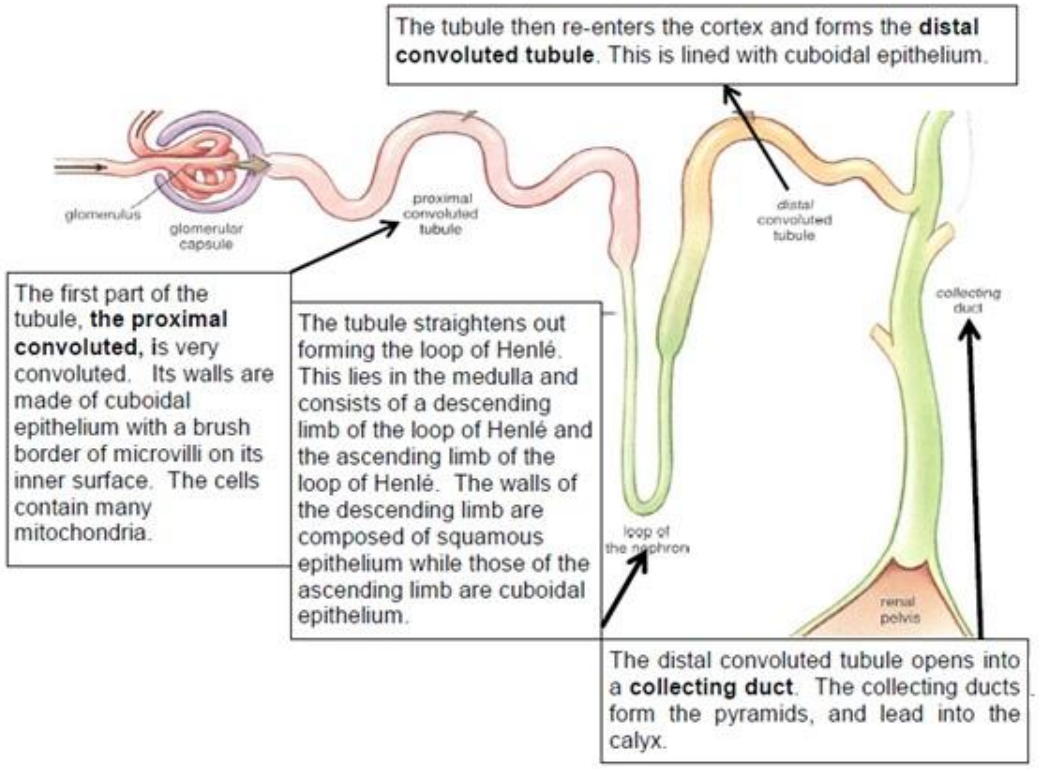
The Malpighian Body

- It consists of a double walled cup surrounding a network of capillaries.
- The cup is known as the **Bowman's capsule** while the capillary network is the **glomerulus**.
- A small arteriole - the **afferent arteriole** (ultimately a branch of the renal artery), leads into the glomerulus and divides into many capillaries. These unite to form the **efferent arteriole** leaving the glomerulus.
- The bore (diameter of the lumen) of the afferent arteriole is greater than that of the efferent arteriole.
- The walls of the capillaries are composed of squamous endothelium resting on basement membrane (towards the outside of the capillary).
- There are many tiny pores - called **micropores** - between the cells and also in the cells of the capillary wall
- The wall lining the hollow Bowman's capsule is composed of squamous epithelium.
- The cells of this epithelium rest on the basement membrane and are modified to form specialised cells known as podocytes



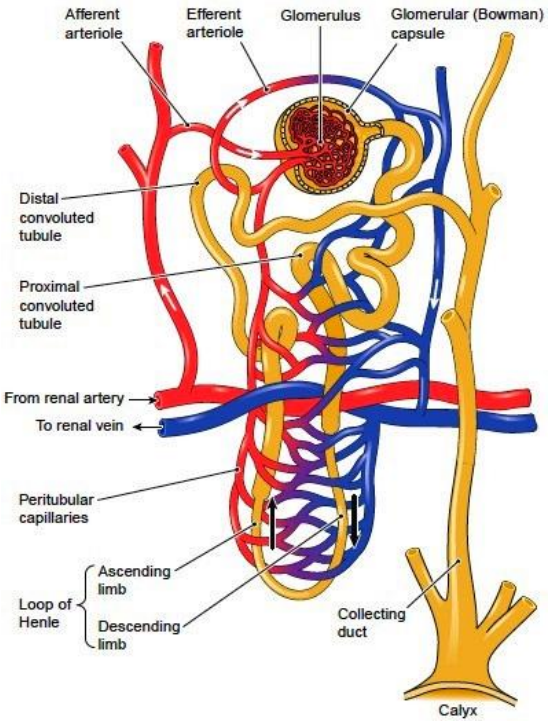
The Renal Tubules

- This is a tube that extends from the Malpighian body, and it consists of the following parts



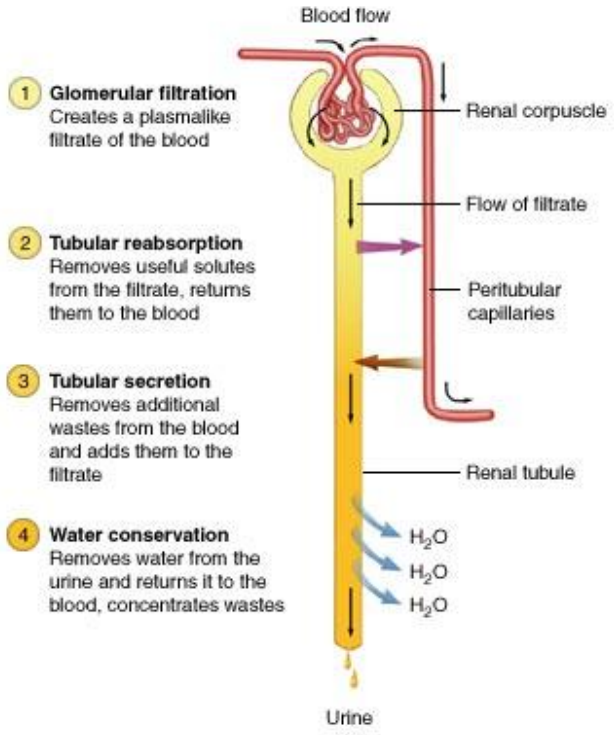
The Blood Supply to the Kidney

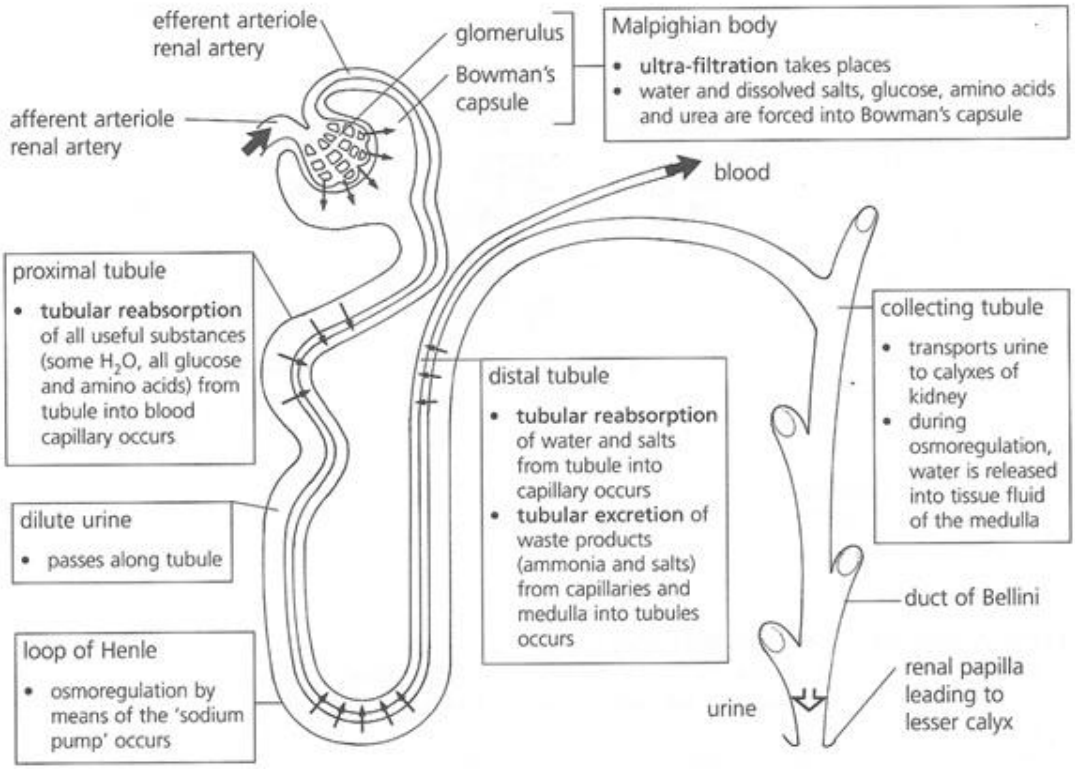
- Branches of the **renal artery** divide into tiny **arterioles**.
- An **afferent arteriole** enters the Malpighian body
- It sub-divides in the Bowman's capsule to form a network of capillaries – the **glomerulus**.
- The capillaries reunite to form an **efferent arteriole** leaving the glomerulus. This has a narrower bore than the afferent arteriole has.
- The efferent arteriole sub-divides to form a network of capillaries that surround the loop of Henle and the convoluted tubules. This is known as the **peritubular capillary network**.
- These capillaries reunite to form a small venule which drains into the renal vein.



The Functioning of the Kidney

- The functioning of the kidney can be divided into three main processes:
  - **Glomerular filtration**
  - **Tubular reabsorbtion**
  - **Tubular excretion/secretion**





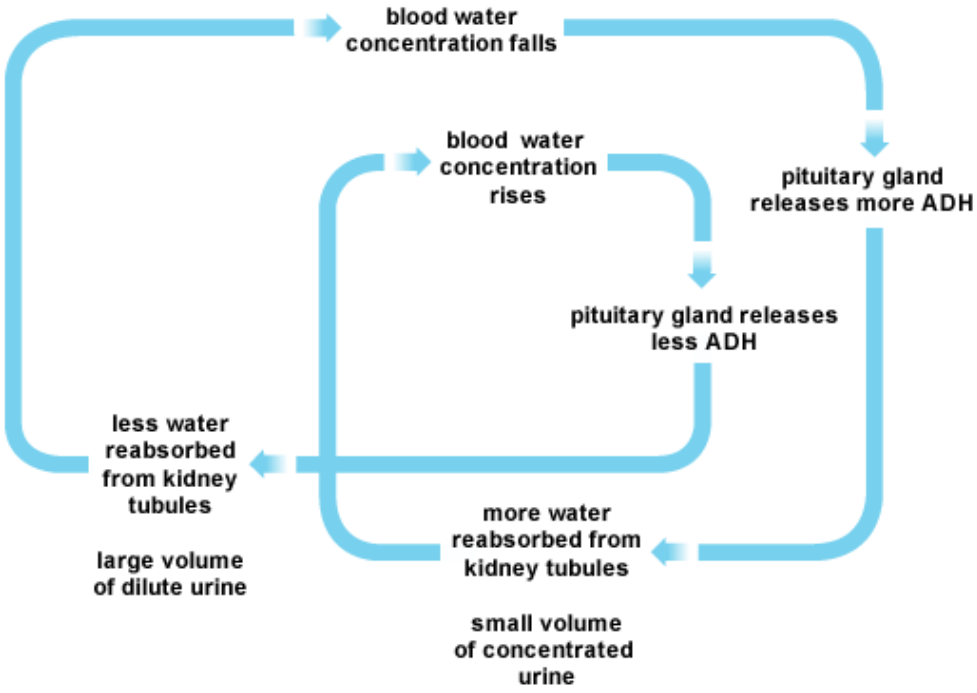
Homeostasis and Osmoregulation

Osmoregulation in the Kidneys

The Loop of Henle and the collecting ducts are concerned with regulating the amount of water in the blood through modifying the concentration of the urine. If the body is dehydrated, mechanisms come into play to reabsorb water from the urine to add to the blood. In this case, the body would produce small volumes of concentrated urine. If the body is well hydrated, less water will be reabsorbed from the urine and the body will produce larger volumes of dilute urine. Two essential hormones drive this process

1. **Aldosterone**: secreted by the adrenal gland helps maintain the sodium (Na+) and potassium (K+) ion balance in the blood by causing the reabsorption of Na+ and the secretion of K+ (Fox, 2009). This ultimately leads to an increase of water reabsorption.

2. **Anti-diuretic hormone (ADH):** secreted from the posterior pituitary gland, increases the permeability of the collecting ducts to water so more water is drawn out of the urine before the urine leaves the nephron. The water is drawn out of the collecting duct as a result of the actions of aldosterone. The water moves out by osmosis into the medulla of the kidney and into the blood to regulate the water potential. The more dehydrated the body, more ADH secreted and therefore the more water reabsorbed into the blood.



The kidney acts as an organ of homeostasis as it serves to maintain constant internal conditions in the body. Osmoregulation is very important: body tissues do not lose or gain water by osmosis because the concentrations of water and salts are the same inside and outside the cells. The osmotic strength of the blood obviously depends upon how much glucose and mineral salts it contains as well as how much water is present

Kidney Diseases

Disease	Cause
Kidney stones – salt crystals in the renal calculi	• Too much calcium • To little water intake • Abnormally high alkaline or acidic urine
Renal failure	• Bacterial infections • Parasites e.g. bilharzias • Overuse of pain killers • Age

The solution to long term kidney failure is either dialysis or a kidney transplant.

Dialysis	Transplant
Dialysis is a form of treatment that removes the body's waste directly from the blood of a person who has lost their kidney functions. It replaces some of the functions that the kidney can no longer perform There are 2 types of dialysis: haemodialysis, which occurs in a dialysis centre, and peritoneal dialysis, which is done at home through an access point in the abdominal cavity. Usually one dialysis session takes about 4 hours to complete and patient requires dialysis 3 times a week	A kidney transplant is an alternative treatment for kidney failure. In transplantation, a kidney from either a living related or a dead person is removed and surgically placed into the kidney failure patient. The patient's own kidneys do not have to be removed. Living related donors would have to undergo extensive investigations before donation to assess their suitability and transplanted kidneys sometimes function for more than 30 years
Advantages: Staff performs treatment in the dialysis center • Three treatments per week in the dialysis center • Permanent internal access required • Regular contact with people in the center	**Advantages:** Absence of need for frequent dialysis treatment • Better quality of life • Better health • Reduced medical cost after first year • No diet and fluid intake restriction
Disadvantages: Requires travel to a dialysis centre • Fixed treatment schedule • Two needle sticks for each treatment; tied onto a machine and cannot move about during treatment • Diet and fluid intake restriction • Can result in excessive medical bills	**Disadvantages:** Need for frequent physician visits • Pain, discomfort of surgery • Risk of transplant rejection • Prone to infections • On lifelong medications • Increased chance of contracting cancer of the lymphatic system as a result of excessive use of anti-rejection drugs

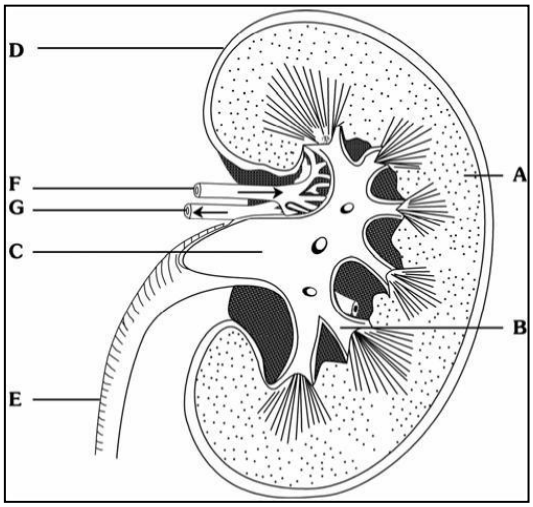
Important Terms

Osmoregulation
Homeostasis
Macroscopic
Microscopic
Excretion
Nitrogenous waste
Nephron
Malpighian body
Renal tubules
Glomerulus
Afferent arteriole
Efferent arteriole
Podocytes
Glomerular filtration
Tubular reabsorbtion
Tubular excretion
Dialysis

Questions

Question 1

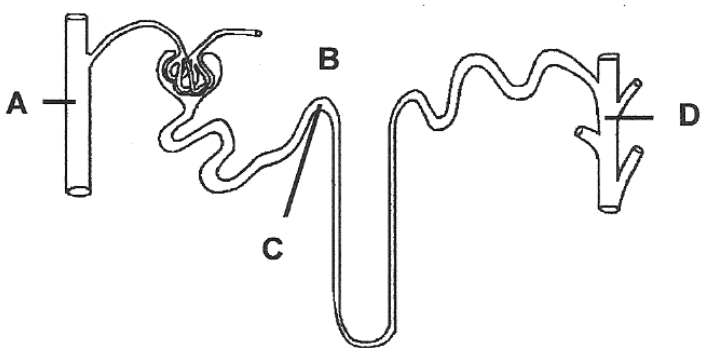
Study the drawing of the internal structure of the kidney below and answer the questions that follow.



Provide Labels for the parts marked A to G.

Question 2

Study the diagram and table below, which shows the various amounts of substances present in the blood plasma, filtered and reabsorbed in the human kidney over a period of 24 hours, and answer the questions that follow.



A nephron and its associated structures

SUBSTANCE	Amount in plasma	Amount filtered	Amount reabsorbed	Amount in urine
Water (ml)	180 000	180 000	178 000	?
Urea (g)	53	53	28	25
Sodium (g)	540	540	537	3
Creatine (g)	1,4	1,4	0	1,4
Glucose (g)	180	180	180	0

a.) Calculate (show your working) the amount of water that is excreted from the kidney, i.e. is present in the urine, in 24 hours.

b.) On the drawing of the nephron above, label each of the following: B, C and D

c.) Draw a line on the diagram, to indicate the separation of the cortex and the medulla.

d.) Use an X on the drawing, to label the place where you will find only blood cells and blood proteins

e.) Explain why:

i. Glucose appears in the filtrate.

ii. No glucose appears in the urine.

Links

- www.youtube.com/watch?v=IPnEN8t1Rjk
- https://ugdsbsecondarytechcoach.wikispaces.com/.../**Kidney**+**Dissection**