

Biology Notes

Topic: Excretion

Objectives:

At the end of this topic, the students should be able to:

- 1. Define the term excretion.*
- 2. State the importance of excretion.*
- 3. Describe the external and internal structure of the kidneys.*
- 4. Describe the structure and function of the kidney tubule (nephron).*
- 5. Describe the role of the bladder and the urethra.*
- 6. Describe dialysis and its applications in kidney machines.*

What is excretion and why is it important?

Excretion is the elimination from the body of the waste products of metabolism.

(The sum total of all chemical reactions going on in cells is known as metabolism).

Many of the waste products of metabolism are toxic and if allowed to accumulate in the body they could damage and kill body cells. They therefore need to be removed as they are produced by the body.

NOTE: Faeces is not an excretory product.

Excretory organs and excretory products

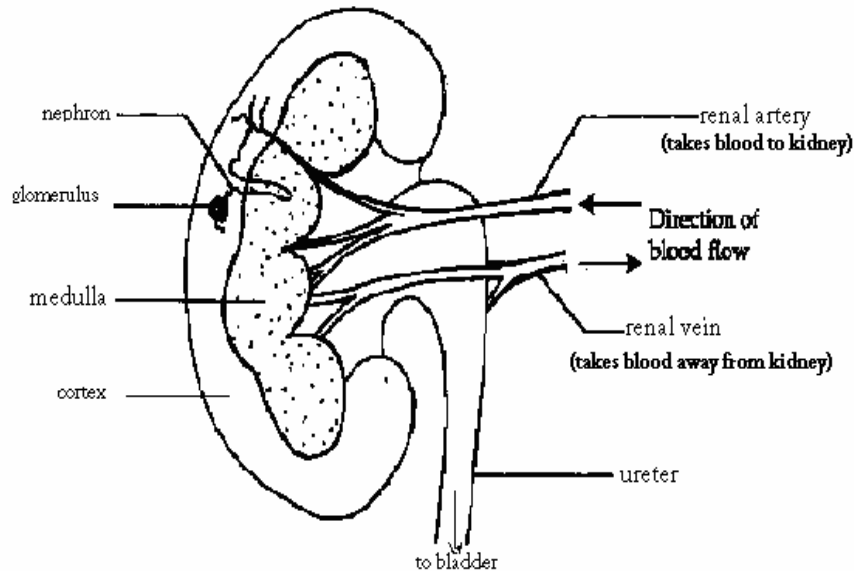
lungs – carbon dioxide

skin – salt and water

kidneys – urea

It is important to excrete these waste products because if they accumulate in the body they may poison the cells and cause ill health or even death.

Structure of the kidney



Description of the structure of the kidney

They are reddish-brown bean-shaped organs situated towards the back of the abdominal cavity just above the waist.

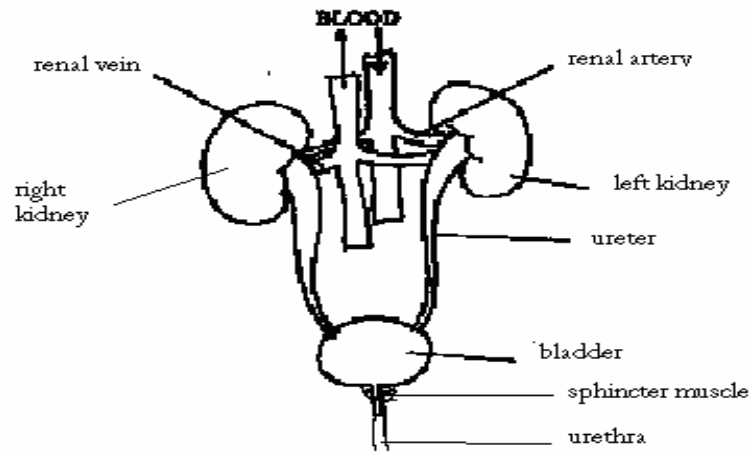
Inside the kidney, it is divided into a light outer area called the **cortex**, a darker inner layer called the **medulla** and an inner cavity called the pelvis. The pelvis narrows to form the ureter.

The kidneys have two main functions:

- Excretion** – elimination of urea (nitrogenous waste)
- Osmoregulation** – control of the relative concentrations of salt and water in the blood.

The urinary system

Diagram



renal artery – transports blood to the kidneys

renal vein – transports blood away from the kidneys

ureter – transports urine to the bladder

urethra – transports urine to the exterior of the body

sphincter muscle – guards the opening of the bladder

bladder – stores urine

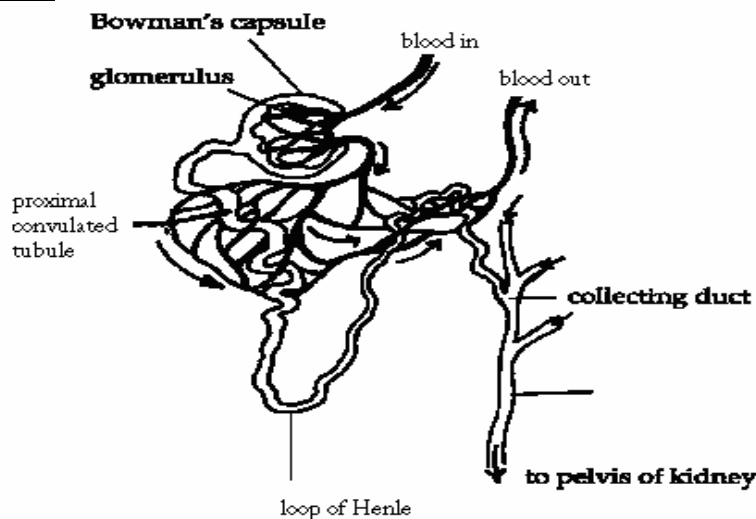
The kidney tubule (nephron)

The functional unit of the kidney is the kidney tubule. It is also called the nephron. Each kidney contains approximately one million (1,000,000) nephron. The blind end of the nephron lies in the cortex and is expanded into the cup shaped Bowman's capsule, which encloses a small knot of capillaries called the glomerulus.

After leaving the the Bowman's capsule, the tubule **coils**, loops into the medulla to form the loop of Henle, returns to the cortex and coils again before joining the collecting duct which leads to the center of the kidney (pelvis). The coils help to provide large surface area for reabsorption to take place.

The tubule is **selectively permeable** i.e. it only allow some materials to pass through. The pore size of the membrane of the tubing prevents the movement of larger molecules such as blood cells and blood proteins. Smaller molecules such as food nutrients, urea, water and salts are able to pass through however.

The structure of the nephron



How the nephron works to produce urine

Blood under high pressure from the renal artery enters the **glomerulus** where it is filtered into the **Bowman's capsule**. This is called **ultra filtration**. (*Materials move from the blood in the glomerulus into the Bowmans capsule*). The fluid filtered into the Bowman's capsule is called the **glomerular filtrate** and it contains **urea, glucose, amino acids, vitamins, minerals, water and salt**. Blood cells and blood proteins are not filtered because they are too large to go through.

The filtrate trickles along the tubule and as it does so some of the substances that were filtered are selectively **reabsorbed** i.e. move back into the blood stream. They move back because they are needed by the body. All the glucose (except persons with diabetes mellitus), amino acids, vitamins, minerals, most of the water and some of the salts are reabsorbed. Reabsorption begins in the proximal convoluted tubule and most reabsorption takes place here. Water is reabsorbed automatically in the loope of Henle and, according to the needs of the body, in the distal convoluted tubule. **The amount of salt and water reabsorbed depends on the body's need at the time.**

By the time the filtrate gets to the end of the tubule, what is left is a concentrated solution of urea called urine. This enters the **collecting duct** and is transported by the ureter to the bladder where it is stored. The urethra transports the urine from the bladder to the exterior.

Description of urine

Urine is pale yellow fluid produced by the kidneys and which carries metabolic wastes out of the body. The amount passed depends on fluid intake and other factors. Urine is 95% water, in which are dissolved urea, uric acid, creatinine, and other waste products. Normal urine also contains small amounts of substances ordinarily utilized by the body, such as sodium, potassium, and calcium; these substances are excreted by the kidneys when excessive amounts are present in the bloodstream. The pH of normal urine can vary from 4.5 to 8.0 but the normal value is about 6.0

Dialysis and its application in kidney machines

Dialysis is the physical process by which molecules of different sizes are separated by passing through a partially permeable membrane into a salt solution. The small pore size of the membrane prevents the movement of larger molecules such as blood cells and the blood proteins.

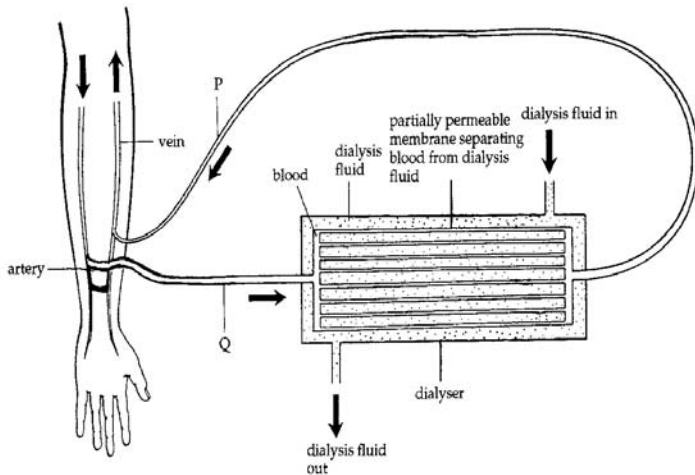
This process is used in the artificial kidney or kidney machine for people whose kidneys have failed as a result of damage or infection

Blood from the patient flows over the surface of the partially permeable dialyzing membrane on the other side of which is a watery (dilute) solution. Urea and other unwanted substances pass from the blood where they are at a higher concentration, to the dilute solution, where their concentration is very low. In other words, they are moving with their concentration gradient. The dilute solution is constantly removed and replaced to ensure that the concentration gradient is maintained. Meanwhile, the "cleaned" blood returns to the patient via a vein.

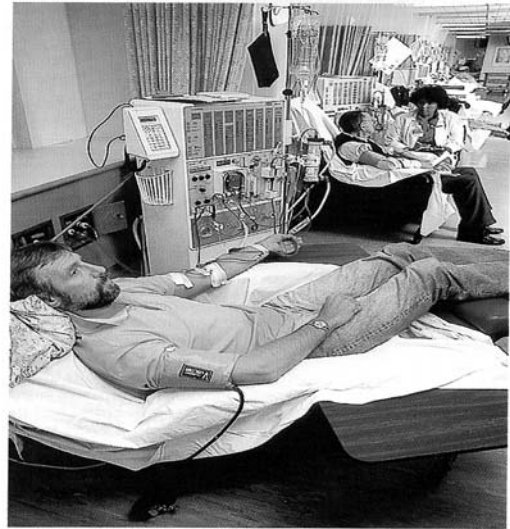
The patient must spend 8-10 hours, three times a week on this machine. During this time the blood passes over the dialyzing membrane several times until all metabolic wastes are removed from the blood.

Kidney machines are life-saving inventions but patients may suffer medical problems such as anemia and infections. In addition, large amounts of time must be spent on the dialysis machine and the treatment is very expensive. Patients are required to follow a strict diet and in particular not to eat foods producing large amounts of urea i.e protein foods.

Diagram of a kidney machine attached to a patient



Patients in a dialysis unit at a hospital



The machine is connected to an artery in the patient's arm and the blood flows out and passes over the dialyzing membrane which is highly coiled just like the kidney tubule. The movement over the membrane is very slow so as to provide sufficient time for unwanted materials to diffuse out. Clean blood returns to the patient via a vein in the patient's arm.

Osmoregulation

The second important function of the kidneys is osmoregulation. This means that they regulate the concentration of body fluids. The amounts of water and salts found in the body determine its concentration. This concentration is never constant and may change due to activities such as sweating and eating. The kidneys regulate the concentration of the blood by controlling the amount of water and salts that are reabsorbed into the bloodstream during selective reabsorption.

Assignment questions (Answer in complete sentences)

- 1.(a) Name TWO waste substances that would normally be found in the glomerulus. (2)
 - (b) (i) Why do substances move from the glomerulus into the Bowman's capsule? (1)
 - (ii) Where is the first place that substances are reabsorbed into the blood after leaving the glomerulus? (1)
 - (c) How would the contents of the collecting duct of a person with diabetes differ from the contents of a person with a healthy pancreas? (2)
 - (d) Explain the role of the collecting duct on
 - (i) a very hot day (1)
 - (ii) a day when excessive amounts of water have been drunk.(1)
2. Refer to the diagram of the kidney machine given above to answer the following questions.
 - (a) What are TWO differences between the contents of the blood in P and Q after the blood has passed through the machine for a few hours? (2)
 - (b) How, and why, would the concentration of the blood's contents be affected if the dialysis fluid were more concentrated than the blood? (2)
 - (c) What are TWO structural similarities between the tubes in the kidney machine and the tubules in the human kidney? (2)
 - (d) State the food groups that a person with a diseased kidney should eat in limited amounts. Explain your answer. (2)