

Respiratory Gaseous Exchange and Elimination of Body Wastes

We can live without food for several days but we cannot live without breathing even for a short while. Breathing provides oxygen to the cells of our body for oxidation of food in order to generate energy for various activities. Breathing along with utilization of oxygen in the cells and release of carbon dioxide is included in the process of respiration.

Another vital function of life is excretion. Excretion is the process of eliminating certain body waste, which if retained in the body would act like a poison and make us ill or even kill us.

In this lesson, you shall learn how oxygen reaches all the cells and how carbon dioxide and other wastes are removed from our body. Plants too need to respire as well as need to remove wastes from their body. You will also learn about respiration in plants in this lesson.

OBJECTIVES

After completing this lesson, you will be able to:

- distinguish between breathing and respiration;
 - explain the need for respiratory gaseous exchange;
 - explain the structure of stomata and their role in respiratory gaseous exchange in plants;
 - sketch the human respiratory organs;
 - explain the mechanism of breathing in the human body;
 - explain briefly the exchange of gases at the level of tissues;
 - name few respiratory disorders;
 - define the term excretion;
 - give a brief account of excretion in plants;
 - list the different parts of human excretory system and draw them;
 - explain briefly the mechanism of waste formation and its elimination;
 - suggest a treatment for kidney failure.
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27.1 NEED FOR RESPIRATORY GASEOUS EXCHANGE

Every cell of our body needs to produce energy for its activities. This energy is produced by oxidising the food (glucose), which the cell receives as product of digestion. Oxygen is required for oxidation of glucose in the cell. The intake of oxygen for the release of energy by its action on glucose is termed as respiration.

27.2 BREATHING AND RESPIRATION

The mechanism by which organisms obtain oxygen from the environment and release carbon dioxide into it is termed **breathing**.

Respiration in ordinary sense is a wider term, it includes breathing as well as

- (i) exchange of oxygen and carbondioxide in the tissues, and
- (ii) action of oxygen on glucose inside the cell to release energy (oxidation).

27.3 RESPIRATION IN PLANTS

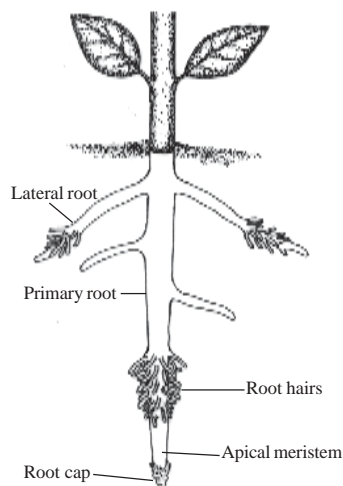


Fig. 27.1 Root hairs

Plants do not have any special respiratory organs. Roots take up oxygen by means of root hair (Fig. 27.1). Root hair are embedded in the soil. Oxygen in the air surrounding them diffuses into the root hair and from there into the roots. The carbon dioxide given out, similarly, diffuses out through roots. You may check the mechanism of diffusion in the lesson 26 on transportation.

Tiny apertures called **stomata** (Fig. 27.2) are found on the surface of the leaf. They have a mechanism for opening and closing. They open to let in oxygen and release carbon dioxide.

In the older parts of roots or bark of woody plants, tiny openings called lenticels are present. It is through these lenticels that oxygen reaches the inner living tissues and carbon dioxide moves out.

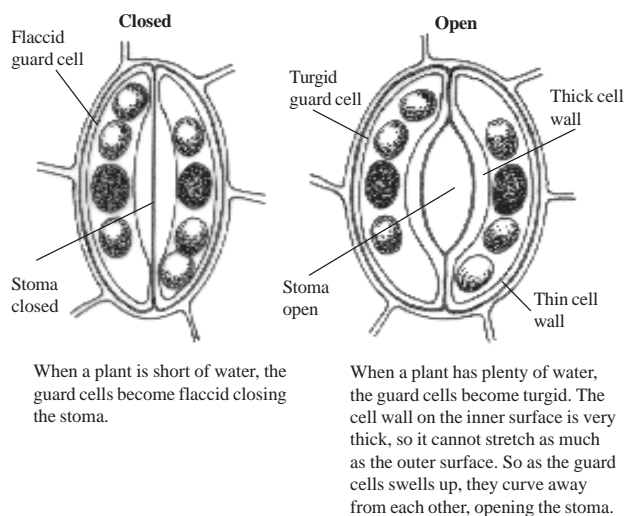


Fig.27.2 Opening and closing of stomata

CHECK YOUR PROGRESS

27.1

1. Roots are present below the soil. Do they pick up oxygen from air surrounding the root hair or from the water surrounding them?
2. Name the apertures found on the green stems and leaves that let in oxygen.

3. The bark of woody plants is dead but the inner layers inside the bark are living. How do they get oxygen and release carbon dioxide?
4. Differentiate between breathing and respiration.
5. How does respiration help in the release of energy?

27.4 RESPIRATION IN ANIMALS

Animals have special organs for respiration. Most aquatic animals have gills (e.g. fish, prawn). The major organs for respiration in land animals are the lungs.

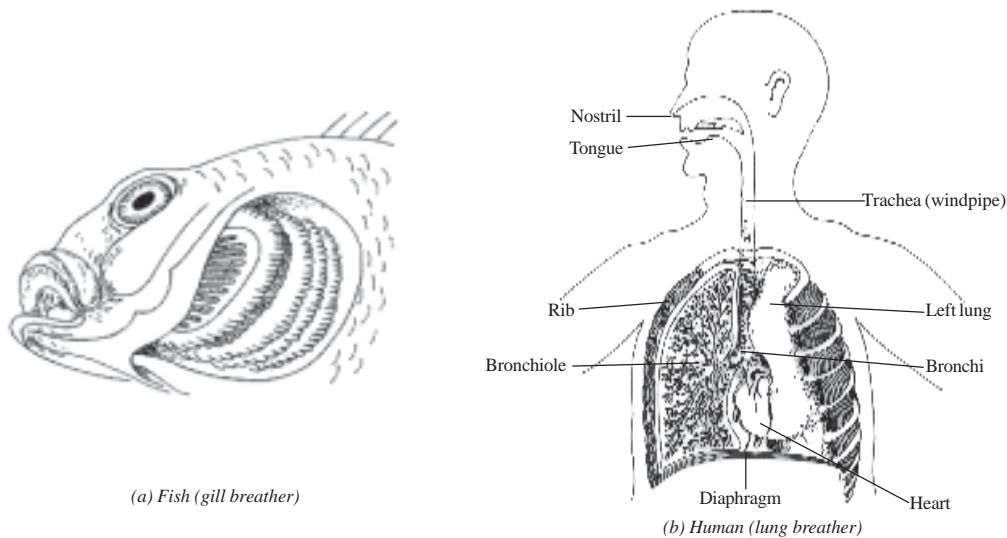


Fig. 27.3 Gill and lung breather

27.4.1 Respiration in human beings

Like other land animals, human beings take in oxygen from the surrounding air and release carbon dioxide into it.

27.4.1a Respiratory system

Respiratory system of human beings has the following parts (Fig. 27.4).

- External nares or nostrils
- Nasal cavities inside the nose
- Internal nostrils opening into pharynx
- Pharynx that leads into the wind pipe or trachea
- Trachea divides into two bronchi (*sing* bronchus) which lead into the two lungs

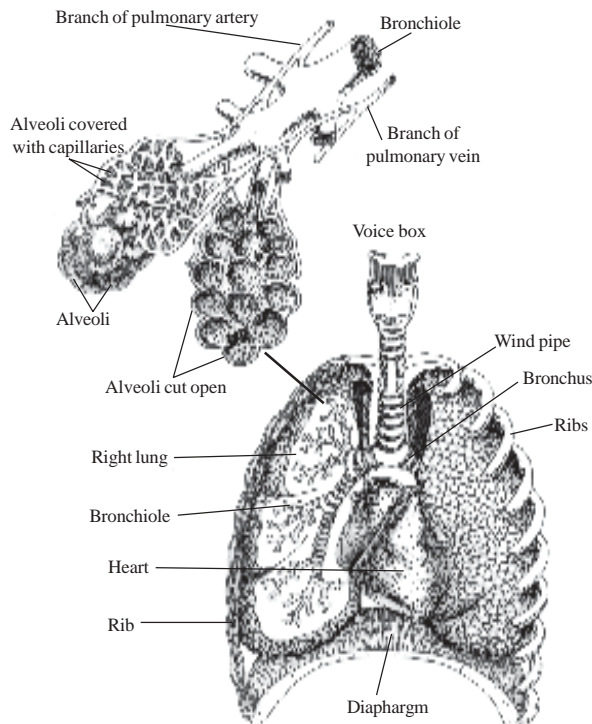


Fig. 27.4 Respiratory system in human beings

The opening of the pharynx into the trachea is called **glottis**. Trachea is thin walled but its walls do not collapse even when there is negligible amount of air in it as it is supported by rings of cartilage.

Lungs enclose within them branches of bronchi called **bronchioles** which branch further and end in very thin walled sac-like structures called **air sacs** or **alveoli** (*sing.* alveolus).

27.4.1b Mechanism of breathing or Ventilation of lungs

Lungs are located in the chest cavity or the thoracic cavity. Below the chest cavity is the abdominal cavity. These two cavities are separated from each other by a dome-shaped (upwardly arched) muscular sheet called diaphragm (see figure). The movements of this diaphragm help in breathing. Breathing, also called ventilation of the lungs involves two processes

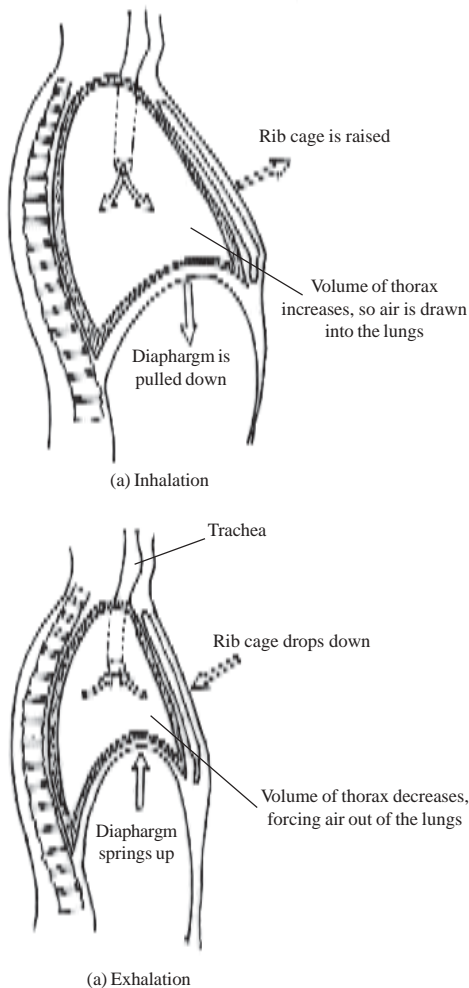


Fig. 27.5 How the thorax changes shape during breathing

- **inhalation** (taking the air inside)

- **exhalation** (forcing the air out)

(i) **Inhalation** (drawing the air inwards) (Fig. 27.5a) is the result of increase in the volume of the thoracic cavity. This increase is caused by the changes that take place in the position of diaphragm and ribs.

- Diaphragm straightens out
- Ribs are raised upward and outward and volume of chest cavity increases.
- The air drawn in brings in oxygen which diffuses into the alveolar air.

(ii) **Exhalation** (Fig. 27.5b) is the result of decrease in the volume of the thoracic cavity. This decrease in the volume is caused due to the following:

- Diaphragm relaxes and resumes its dome-shape arching upwards.
- Ribs are lowered downward and inward.

The thoracic cavity is compressed and the pressure inside the lungs is increased. Air is pushed out through the trachea and nose. The alveolar carbon dioxide diffuses out. This breathing out of carbon dioxide laden air is called exhalation.

You can breathe heavily and feel your chest go up and down.

Breathing rate

When at rest, an adult human breathes about 16 to 18 times per minute. Breathing rate increases during physical exercise, disease, fever, pain and under stress.

Exchange of gases between blood and tissues

Inhalation fills in the alveoli of lungs with oxygenated air. This oxygen has to reach the various tissues of the body. Thus as the first step, blood capillaries on alveoli (Fig 27.6) pick up oxygen from alveoli and carbon dioxide brought by the capillaries from the tissues is exchanged for oxygen and diffuses into alveoli.

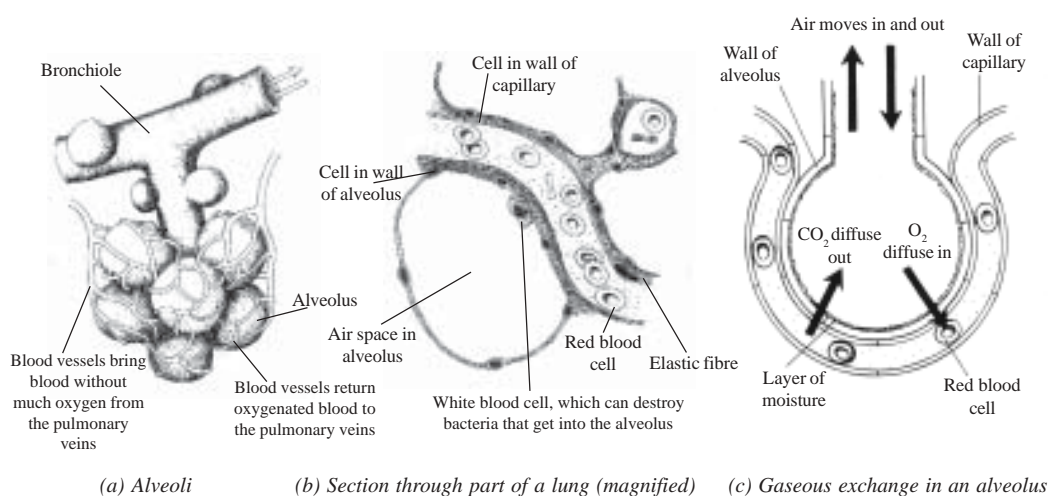


Fig. 27.6 Exchange of gases between blood and alveoli

In the tissues, oxygen gets used up and carbon dioxide is accumulated which is now exchanged for oxygen. The carbon dioxide picked up by blood from tissues is carried to the heart through veins.

27.4.1c Cellular respiration

Once inside the tissues, oxygen acts upon the digested food (glucose) which has reached the cells of the tissues. As a result energy and carbon dioxide are released. This occurs in the mitochondria of the cells and is called cellular respiration.

Respiration suffers at high altitudes and great depths. Do you know why mountaineers and sea divers carry oxygen cylinders and wear oxygen masks?

As we climb higher and higher altitudes, the air pressure becomes lower and lower. Reduced oxygen supply causes breathing troubles and oxygen masks facilitate breathing. People living in hilly areas have evolved adaptation such as increased number of red blood corpuscles and large thoracic cavity.

Divers carry oxygen masks because we derive our respiratory oxygen from air and not water.

27.4.1d Artificial respiration

A victim of an accident like drowning, electric shock or inhalation of poisonous gas suffers from “asphyxia” or the condition of lack of oxygen. The symptoms are blueing of lips, fingernails, tongues and stoppage of breathing. In such cases mouth-to-mouth respiration is given.

You must have realised how important respiration is for survival. Medical technology has introduced certain gadgets like the “oxygen mask” and “ventilators” which aid in respiration when a patient develops breathing problems. Often these help the patient to overcome respiratory problems.

27.4.2 Respiratory disorders

Two common diseases of the respiratory system are bronchitis and pneumonia.

27.4.2a Bronchitis

In bronchitis, the bronchi and bronchioles get inflamed and their cavities become narrow so that air cannot pass in and out of lungs easily. The pathway gets constricted either due to accumulation of mucus on the walls of the bronchi or bronchioles. This happens due to excessive smoking. Also infection of the accumulated mucus leads to inflammation of walls of the lungs and bronchi, which narrow the airways and cause difficulty in breathing.

27.4.2b Pneumonia

Pneumonia is caused by pneumococci bacteria. These bacteria attack the trachea and bronchi and spread to the terminal bronchi. Symptoms of pneumonia are shivering, vomiting and continuous fever. Antibiotics have to be administered to cure bronchitis and pneumonia.

CHECK YOUR PROGRESS 27.2

1. Why does the trachea not deflate (collapse) when the air is pushed out?
2. Name the parts of the human respiratory system in a sequence starting from the nose.
3. State the events which occur during inhalation.
4. In which organelle of the cell does cellular respiration occur?
5. Why are the alveoli supplied with capillaries?

27.5 EXCRETION

Many chemical reactions take place inside the body cells. Some products of these chemical reactions are not needed by the body. They may even be harmful. Most of these waste products contain nitrogen and therefore they are termed nitrogenous waste products. Their removal from the body is called excretion. We shall now learn about the excretory organs and mechanism of excretion.

27.5.1 Excretion in plants

In plants, breakdown of substances is much slower than in animals. Hence accumulation of waste is much slower and there are no special organs of excretion

in plants. Carbon dioxide released during respiration gets utilized during photosynthesis.

However, a number of chemical substances which are formed as byproducts during certain activities of plants, are known to be thrown out of the plant and deposited on the bark, old wood, old leaves etc. These substances may be nitrogenous such as alkaloids, or non-nitrogenous such as oils, resins and crystals of silica.

The alkaloids include Quinine, which deposits in the bark of the cinchona tree and is a medicine for malaria; Morphine in poppy fruits was used as an anaesthetic. Caffeine, which yields the beverage coffee is deposited in coffee leaves.

The non-nitrogenous substance exuded by plants include: tannins found in tea leaves, essential oils such as are deposited in leaves of tulsi and lemon and Eucalyptus, resins thrown out are deposited on the bark of pine trees. We use resins in varnish and polish. In certain grasses crystals of silica are deposited by the plant.

27.5.2 Human excretory system

In human beings, excretion is carried out by an organ system known as the urinary system or the excretory system. See the figure (Fig.27.7) and locate the following parts:

- Two bean shaped **kidneys**, located below the diaphragm in the abdomen and towards the back.
- Two excretory tubes or **ureters**, (one from each kidney).
- One **urinary bladder**, ureters open into it.
- A muscular tube called **urethra** arises from the bladder. The urinary opening is at the end of urethra.

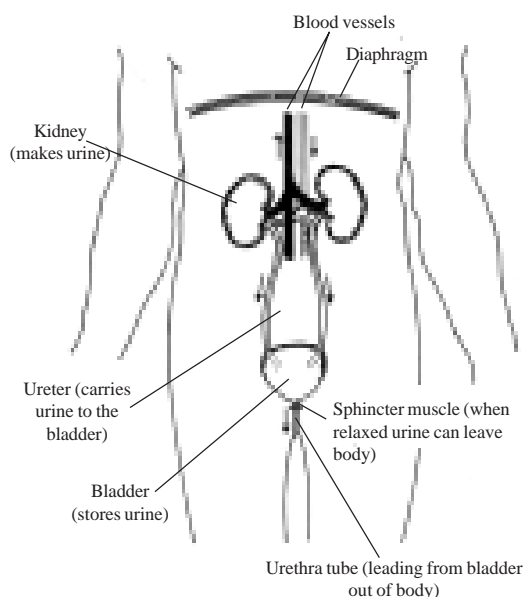


Fig.27.7 Human excretory system

27.5.2a Structural and functional unit of the kidney — Nephron

Each kidney is made of tube like structures called **nephrons** (renal tubules). A nephron is the structural and functional unit of the kidney. The cup-shaped upper end called **Bowman's capsule**, has a network of capillaries within it called glomerulus. **Glomerulus** is a knot of capillaries formed from the artery which brings blood containing wastes and excess of water to the kidney. Bowman's capsule leads into a tubular structure.

The tubular part of the nephron or renal tubule has three sub-parts, the **proximal convoluted tubule (PCT)**, a thinner tube called **loop of Henle** and the

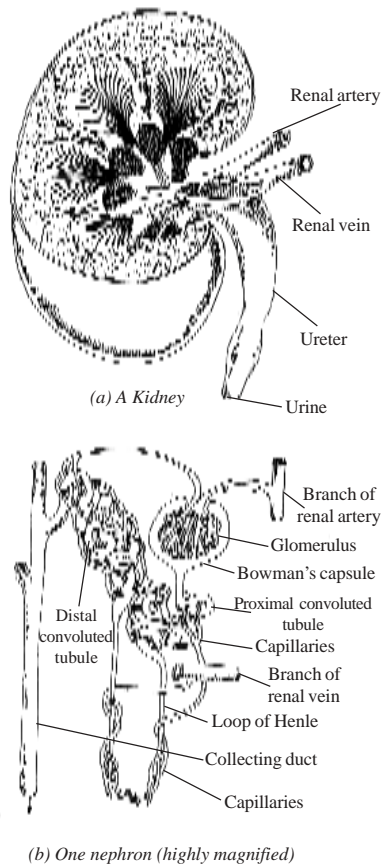


Fig. 27.8 Structural and functional unit of the kidney — Nephron

distal convoluted tubule (DCT) (Fig. 27.8). Blood capillaries surround these tubules.

27.5.2b Mechanism of excretion

Blood leading into the glomerulus gets filtered in the Bowman's capsule and is called the nephric filtrate. The red blood corpuscles and proteins do not filter out.

The filtrate which now comes into the renal tubule not only contains waste but also useful substances. The useful substances get reabsorbed from the tubule into the blood capillaries surrounding the tubule. Excess water and salts like sodium and chloride also get reabsorbed into the blood from the renal tubule. Thus, the waste alone which is primarily in the form of urea enters into collecting tubules from various renal tubules. It is the urine.

From the kidneys, the urine enters the ureters to reach the urinary bladder where it is stored temporarily. The urine is thrown out periodically through the urinary opening.

27.5.2c Functions of the kidneys

- Excretion of nitrogenous wastes,
- Regulating the water content of the body (osmoregulation), and
- Keeping the normal mineral balance in the blood. When this balance is upset, a person can fall sick.

27.5.3 Other organs that remove waste from our body

Apart from kidneys, some other organs of the body also remove waste from the body. These organs are as follows (Fig. 27.9)

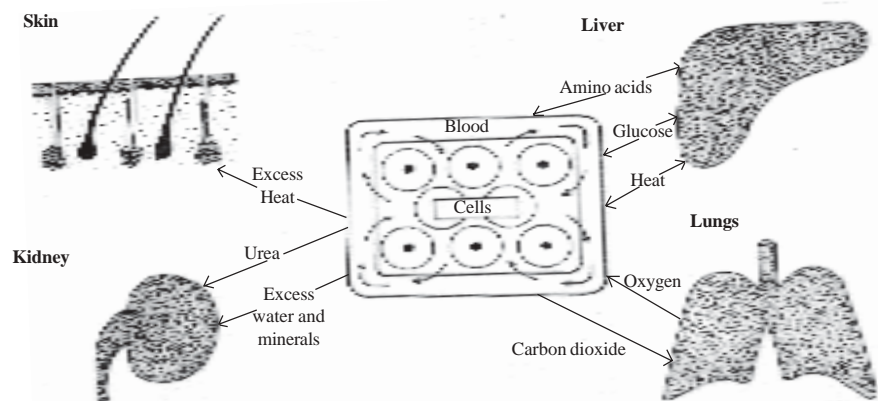


Fig. 27.9 Some organs of our body that remove waste

- Sweat glands in the skin remove excess salts when we perspire.
- Lungs remove carbon dioxide.
- Rectum (large intestine) removes undigested food.

27.5.4 Maintenance of the internal environment

A person gets sick if the balance of substances such as mineral ions, water or even hormones inside the body is upset. Maintenance of the correct amount of water and mineral ions in the blood is termed osmoregulation. Osmoregulation is a function of the kidney.

Homeostasis means maintaining a steady state inside the body. It requires the regulation of all substances inside the body in the correct amount and proportion. Kidneys and liver play an important role in maintenance of homeostasis.

27.5.5 Kidney failure, dialysis and kidney transplant

Certain diseases or sometimes an accident may lead to kidney failure. Since the number of nephrons is as large as almost one million in each kidney, a person can survive even with one kidney. However, in case both the kidneys are damaged, it is difficult to remain alive.

Modern technology can now save such patients with the helps of new techniques like dialysis and kidney transplant. As shown in the figure (Fig. 27.10) an artificial kidney is employed. A tube is inserted in an artery in the patient's arm or leg. The tube is connected to the kidney machine. This plastic tube has two membranes so as to form one tube within the other. In the inner tube flows blood from patient's artery. This blood is surrounded by fluid (dialysis fluid) in the outer tube, separated from it by the membrane of the inner tube. Wastes move out of blood into the fluid. The blood cleaned of its waste goes back from the kidney machine into the vein in the arm or leg and back into the body. The kidney dialysis fluid carrying waste is removed from the machine. This technique is termed dialysis.

Nowadays, surgeon sometimes remove a non-functioning kidney from a patient and replace it with a kidney donated by another person. Care, however, has to be taken so that a foreign kidney gets accepted by the body.

CHECK YOUR PROGRESS

27.3

1. Define excretion.
2. Name the organ of the excretory system, which stores urine before its removal from the body.

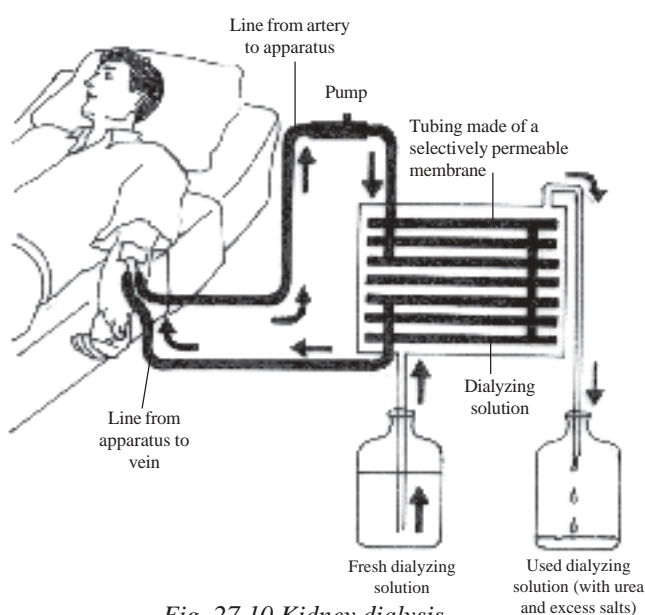


Fig. 27.10 Kidney dialysis

3. In which part of the nephron does filtration occur?
4. What happens to the useful substances that get filtered into the renal tubule?
5. What is osmoregulation?

TERMINAL EXERCISES

A. Multiple choice type questions.

Select the most appropriate answer of the following.

1. Which of the following is NOT a step in the process of respiration?
 - (a) Breathing
 - (b) Diffusion of oxygen from blood to tissues
 - (c) Diffusion of oxygen from tissues to blood
 - (d) Production of energy
2. From which part of the respiratory system is oxygen picked up by the blood?
 - (a) Trachea
 - (b) Bronchus
 - (c) Alveolus
 - (d) Nostrils
3. Which one of the following is not a part of nephron?
 - (a) Loop of Henle
 - (b) Proximal Convoluted tubule (PCT)
 - (c) Distal Convoluted Tubule (DCT)
 - (d) Seminiferous tubules.
4. Identify the process involved in the functioning of the artificial kidney.
 - (a) Renal transport
 - (b) Dialysis
 - (c) Renal failure
 - (d) Catalysis
5. Which is the correct sequence of the following parts of the urinary system?
 - (A) Kidney
 - (B) Ureter
 - (C) Urethra
 - (D) Urinary bladder
 - (a) B A C D
 - (b) D C B A
 - (c) A B C D
 - (d) A B D C

B. Fill in the blanks.

1. Excretion is a process of removal of _____ waste.
2. Nephrons are the functional units of _____
3. The main excretory nitrogenous product in human beings is _____
4. The openings in plant leaves through which gaseous exchange takes place are called _____

C. Descriptive type questions.

1. State one point of difference between each of the following:
 - (i) Breathing and respiration
 - (ii) Inhalation and exhalation
 - (iii) Ureter and urethra
 - (iv) Homeostasis and osmoregulation
 - (v) Bowman's capsule and glomerulus
 - (vi) Bronchi and bronchioles
 2. Which step occurs earlier than the other - breathing or cellular exchange of gases?
 3. What happens to the size of thoracic cavity when we breathe in air?
 4. Describe the mechanism of breathing in human beings.
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5. How are respiratory gases exchanged between blood and tissues?
6. Draw the urinary system in the human body and label its parts.
7. What is glottis? Mention its function.
8. Explain the mechanism of excretion.
9. Write notes on the following:
 - (i) artificial kidney
 - (ii) glomerular filtrate
 - (iii) organs of excretion in human beings

ANSWERS TO CHECK YOUR PROGRESS

27.1

1. Air
2. Stomata
3. Through lenticels
4. Breathing is the mechanism for obtaining oxygen from the environment and release carbon dioxide into it / respiration is the intake of oxygen as also its utilization by cells for release of energy.
5. Energy is released through oxidation of food (glucose) during respiration in cells.

27.2

1. The cartilaginous rings around the trachea prevent its collapse.
2. External nostrils, nasal cavity, internal nostrils, pharynx, trachea, bronchi, lungs.
3. The diaphragm contracts, thoracic cavity increases in volume, air from outside rushes into lungs.
4. Mitochondria
5. They pick up oxygen from alveoli and carbon dioxide carried by them diffuses into alveoli.

27.3

1. Excretion is the process of removal of nitrogenous waste products.
2. Urinary bladder
3. Glomerulus
4. They are reabsorbed into blood
5. Maintaining the normal amount of water and mineral ions in blood is termed Osmoregulation

GLOSSARY

Bowman's capsule: Thin walled cup-shaped part of the nephron with the glomerulus lying within the cup. Bowman's capsule leads into the renal tubule.

Breathing: The mechanism in which oxygen from the environment is taken into the lungs and carbon dioxide present in the lungs removed.

Bronchitis: A respiratory disease in which the air passages in lungs become inflamed.

Cellular respiration: The oxidation of glucose in the mitochondria of the cell.

Dialysis: The mechanism of cleansing the blood of its waste outside the body by using a 'kidney machine'.

Diaphragm: A muscular partition between the thoracic cavity and abdominal cavity of mammals which participates in breathing.

Excretion: The process of elimination of nitrogenous waste products from the body.

Exhalation: Removal of carbon dioxide from the lungs during breathing.

Glomerulus: A network of capillaries, which is a part of nephron.

Inhalation: Intake of oxygen-laden air into the lungs during breathing.

Lenticels: Tiny openings in older parts of roots and bark of woody plants for exchange of gases.

Nephron: The structural and functional unit of the kidney. It is made of glomerulus and renal tubule.

Pneumonia: The inflammation of lungs due to fluid accumulation in the alveoli caused by bacterial infection.

Stomata: Openings in leaves which open and close for exchange of gases.

Respiration: The intake and utilization of oxygen for oxidation of glucose in the cells for the liberation of energy.

Renal tubule: The tubular part of the nephron.
