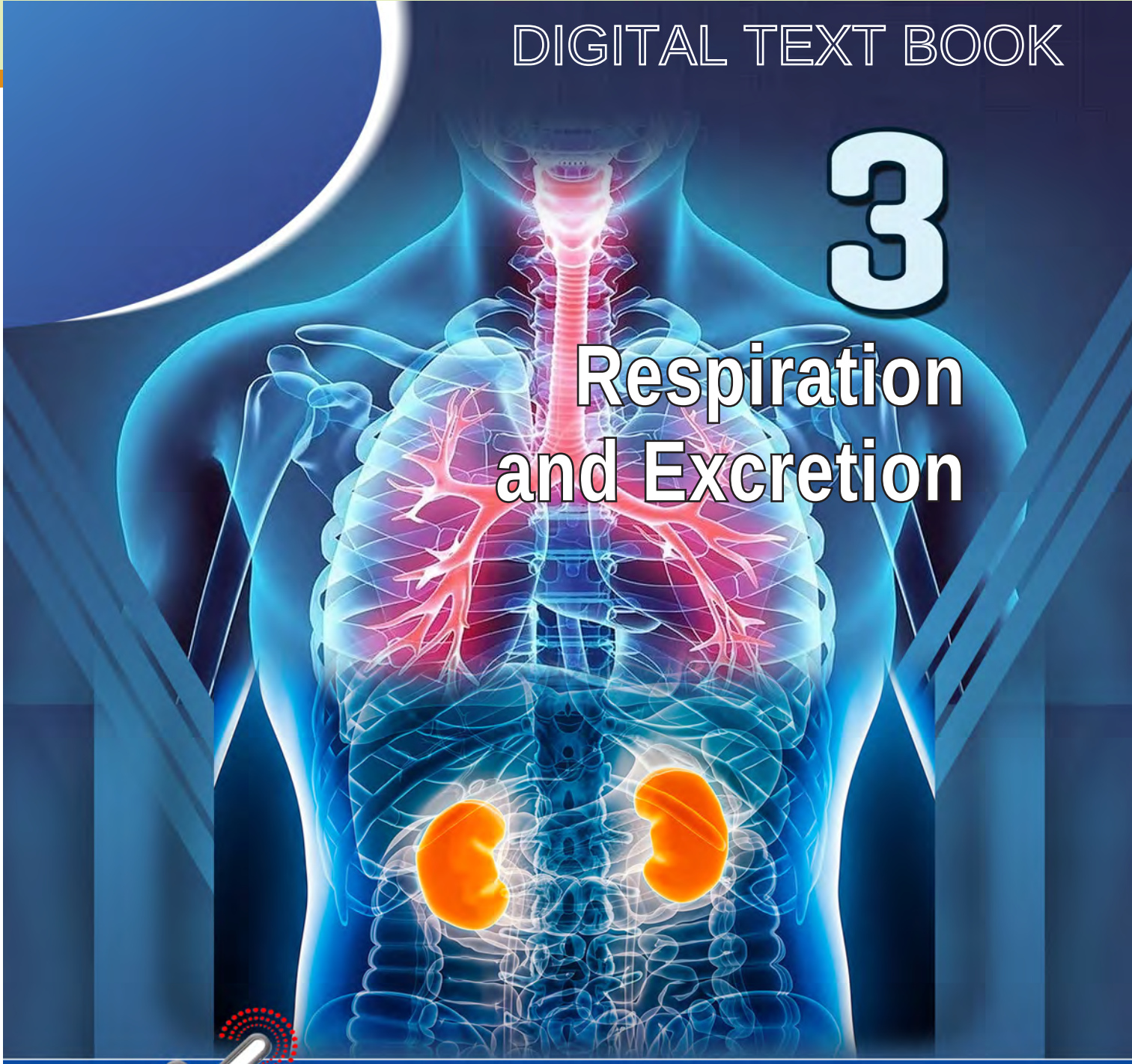
DIGITAL TEXT BOOK

3

Respiration and Excretion



- Human respiratory system
- Gaseous exchange
- Cellular respiration
- Respiration in other organisms
- Synthesis of urea
- Formation of urine
- Excretion in plants
- Hemodialysis
- Kidney transplantation
- Homeostasis

DIGITALIZED BY: SEBIN THOMAS C, GBHS, WADAKANCHERY

What is respiration?

Antoine Lavoisier (1743-1794) was an eighteenth century scientist who successfully explained the process of respiration in organisms. He inferred that the process which takes place during burning of objects and during respiration in organisms are the same. In order to prove this he placed a guinea pig in a small bucket. Then he immersed it in another bucket filled with ice and covered the guinea pig with a net. In order to prevent the melting of ice due to external heat insulation precautions were taken. But the ice melted. Lavoisier proved that the ice melted due to the heat from the guinea pig's body. He calculated that 80 kilo calories of energy was used for this from the guinea pig's body. This energy was received through respiration. When a piece of wood is burned oxygen is used and carbon dioxide and heat energy are formed. The same happens during respiration, when oxygen breaks down glucose.

You have read the description of an interesting experiment conducted by Lavoisier during the eighteenth century. Analyse and improve your idea on respiration based on the indicators.

- Role of oxygen in respiration and burning
- Products of respiration and burning

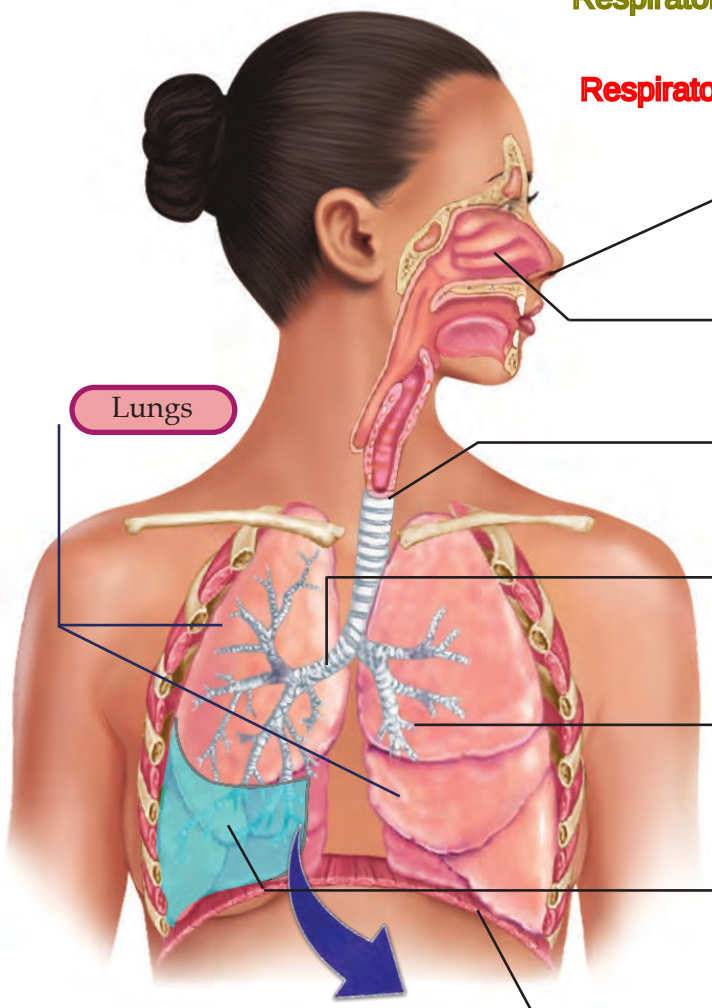
Now you have understood that oxygen is used and carbon dioxide is formed during respiration. A suitable respiratory surface and related systems are required for the exchange of these gases.

A large respiratory surface is required in human beings to get sufficient oxygen to cells for the production of energy. Which is the respiratory surface in human beings? How is it arranged in our body?

Complete the illustration 3.1, analyse the description and prepare a short note on respiratory surface in human beings .

Respiratory system - 3D View Click here

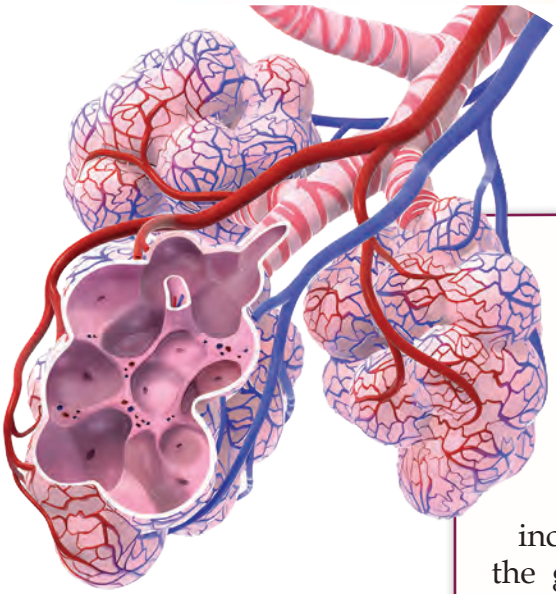
Respiratory system - Video Click here



Bronchiole
The branches of bronchus which open to the alveoli.

Pleura
The membrane which covers the lungs

Diaphragm
The muscular wall which separates the thoracic and abdominal cavities.



Alveolus

These are delicate air sacs which are elastic in nature and are seen at the tip of bronchioles. A network of numerous blood capillaries are found on their surface. There are approximately 70 crores alveoli in both lungs together. The surface area of alveoli is approximately 70 m^2. It increase the area of the respiratory surface and make the gaseous exchange efficient.

Illustration 3.1: Human Respiratory system

Now you have understood the parts of the human respiratory system. Prepare a flowchart to illustrate the path of atmospheric air, entering the nostrils till it reaches alveoli.

Don't you involve in sports and physical exercises? Is there any change in the rate of ventilation (breathing) during such activities? Do the activity given below.

- Form a group of two children each.
- Take rest for 5 minutes. Both of them record the number of inspirations that happen within a minute during this time.
- Record the time using a stop watch.
- In an interval of one minute, record the number of inspirations two more times.
- Then record the number of inspirations of the two children after running for three minutes as mentioned above.
- Continue to record the number of inspirations in every minute till they reach the normal condition.
- Complete the table given below using the recorded results, draw a line graph and compare the rate of ventilation of both the children.

Hint	Number of inspirations in resting state			Number of inspirations after exercise		
Time in minutes	1	3	5	9	11	13
Child 1						
Child 2						

Table 3.1: Rate of ventilation

Inference

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Since muscular activities increase during exercise more energy is required. As more energy is required, the requirement of oxygen also increases. Besides more carbon dioxide has to be eliminated from the body. This is the reason for the rate of increase of breathing, which is the first step of respiration.

Ventilation

Movement of air from the atmosphere to lungs and back is called as ventilation.

Which are the stages of ventilation?

- Inspiration (Inhalation) : The process by which atmospheric air enters the lungs.
- Expiration (Exhalation) : .....
  .....

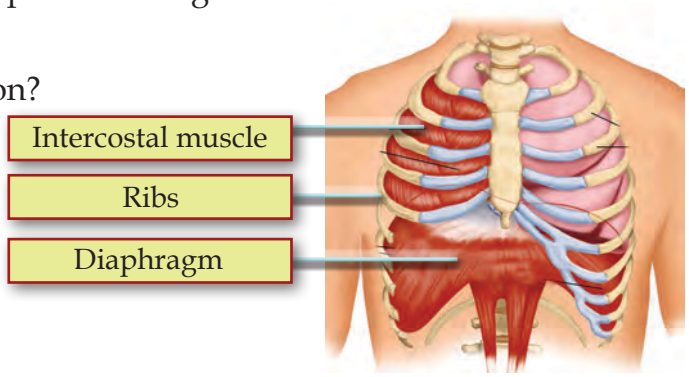


Figure 3.1

How do these happen?

Analyse the figure 3.1 and illustration 3.2 and complete the table 3.2.

Inspiration

Click to see the Video

Expiration

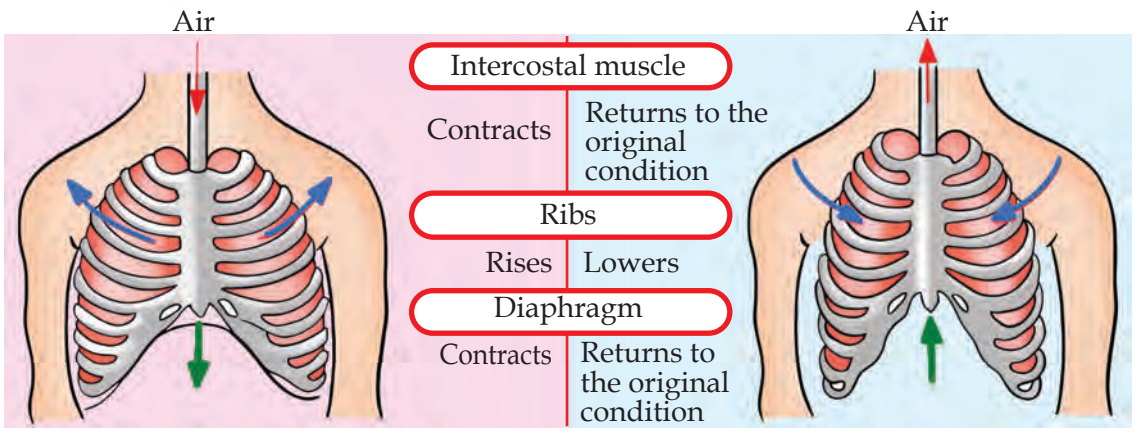


Illustration 3.2: Ventilation

Indicators	Inspiration	Expiration
Action of intercostal muscles		
Movement of ribs		
Change that occurs to the diaphragm		
Volume of thoracic cavity	Increases	Decreases
Pressure of air in the lungs		
Movement of air		

Table 3.2 : Ventilation

Now you have understood the first stage of respiratory process. The next stage of respiration is the exchange of oxygen from the air which has entered the alveolus, into the blood and exchange of carbon dioxide into the alveolus from the blood. This is called alveolar exchange of gases.

Alveolar exchange of gases

Exchange of gases occur between alveoli and the blood in the capillaries which covers them. How does this process take place? Analyse the illustration 3.3 as per the indicators. Form inferences based on the discussions and prepare short notes.

Click to see the Video

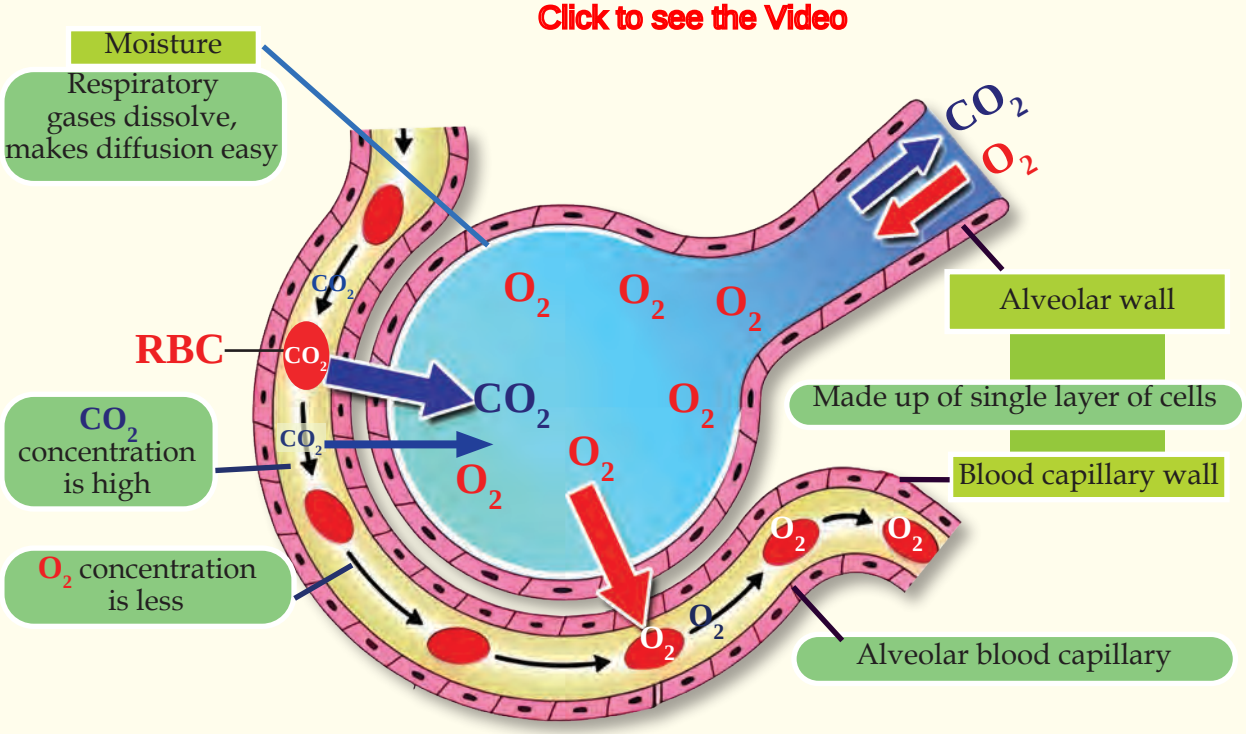


Illustration 3.3 : Alveolar exchange of gases

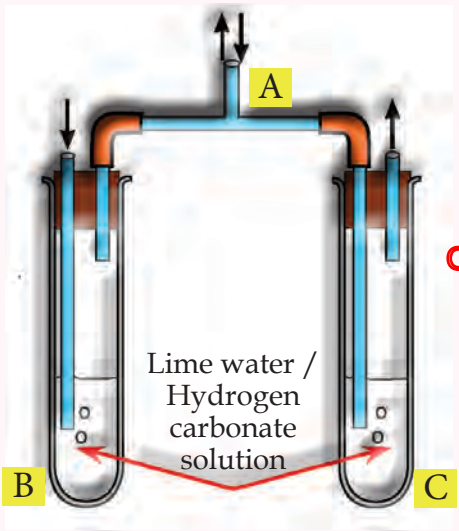
- Characteristic features of the walls of the alveolus and blood capillaries.
- Importance of moisture in the wall of the alveolus.
- Concentration of O_2 and CO_2 in the alveolus and in blood capillaries.
- The exchange of O_2 and CO_2 between alveolus and blood capillaries.

The distance between the air in the alveolus and the blood in the alveolar capillary is less than one by thousand of a millimetre.

Surfactant Click to see the Video

The substances inside the alveoli which help them to expand freely when air enters and contract slowly when air is released is called as surfactant. If the level of surfactant is too low, breathing becomes difficult. This condition is generally seen in premature babies. Such new born babies are prone to death.

Let's understand the presence of carbon dioxide in the inhaled and exhaled air



Click to see the Video

Figure 3.2

- Arrange equipments as shown in the figure.
- Breathe slowly using mouth through tube A.
- Observe the colour change in the indicator solution in test tubes B and C.

(Hint: *If lime water is used as indicator, it turns milky when carbon dioxide passes through it. If hydrogen carbonate indicator solution is used, its colour changes from red to yellow.)*

Observation and inference

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Now you have understood the alveolar exchange of gases. Analyse the illustration 3.4 which includes other stages of respiration. Based on the indicators complete the table 3.3.

Alveolar exchange of gases

As the concentration of carbon dioxide is high in plasma, carbon dioxide diffuses into the alveolus.

O_2 diffuses into the blood in the alveolar blood capillaries as the concentration of O_2 is high in the alveolus.

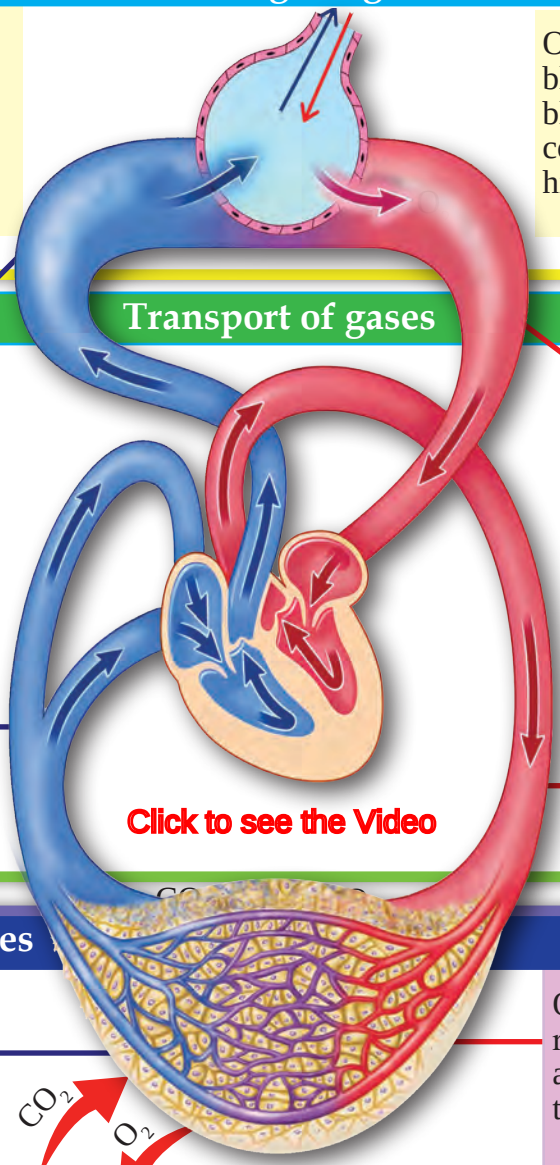
Transport of gases

In the alveolar blood capillaries carbamino haemoglobin and bicarbonate dissociate and CO_2 reaches plasma.

7% CO_2 dissolves in plasma. 23% combines with haemoglobin to form carbaminohaemoglobin. 70% combines with the water in the RBC to form bicarbonate.

In the lungs a small portion of the O_2 dissolves in plasma. The remaining O_2 combines with haemoglobin to form oxyhaemoglobin.

Adjacent to the cell oxyhaemoglobin dissociates and oxygen becomes free.



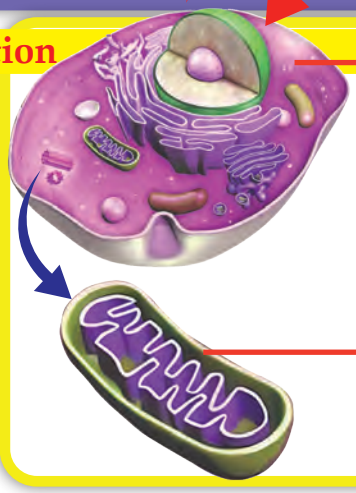
Systemic exchange of gases

CO_2 passes from cells to tissue fluid and from there to blood.

Oxygen from the blood reaches the tissue fluid and from there enters the cells.

Cellular respiration

The process of breaking down of glucose using oxygen and releasing energy, which occurs in cells.



Glycolysis

First phase of cellular respiration. Takes place in the cytoplasm. Oxygen is not required. Glucose is converted into pyruvic acid. 2ATP molecules are formed.

Click to see the Video

Krebs cycle

Second phase of cellular respiration. Takes place in mitochondria. Oxygen is required. Pyruvic acid is converted to carbon dioxide and water. 28 ATP molecules are formed.

Illustration 3.4 Respiratory process

- Transport of oxygen
- Entry of oxgyen from the blood to tissues
- Cellular respiration
- Entry of carbon dioxide from the tissues to blood
- Transport of carbon dioxide
- Elimination of carbon dioxide
- Phases of respiration

Indicators	Glycolysis	Krebs cycle
Site of activity		
Substances that take part in the chemical process		
Products		
Requirement of oxygen		

Table 3.3 : Cellular respiration

ATP molecules formed as a result of respiration is the source of energy for body activities. The byproducts, carbon dioxide and to some extent, water, are eliminated immediately through exhaled air. The process of transport of respiratory gases and the breaking down of glucose in cells using oxygen to release energy, together constitute respiration.

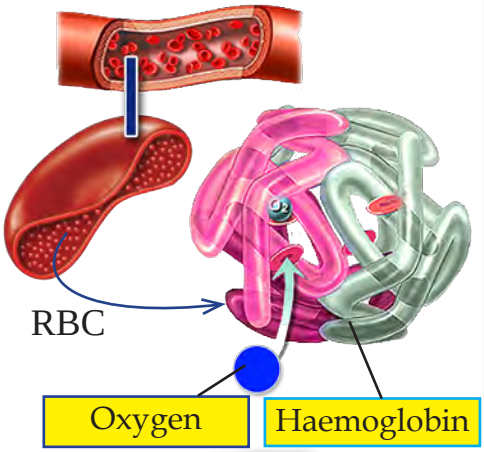
Complete the chemical process illustrated below by including the missing reactants required for cellular respiration and the products formed.

Glucose + ... $\xrightarrow{\text{Enzymes}}$ ..... + ... + 30 ATP

Photosynthesis and respiration are metabolic processes that take place in the living world. Compare these two processes and revise the table 3.3 replacing glycolysis and Krebs cycle with photosynthesis and respiration respectively. **Click to see the revised table**

Hans Adolf Krebs (1900-1981) is the German biochemist who discovered the chemical processes in the second phase of cellular respiration. So this phase is called Krebs cycle. He shared the Nobel prize for medicine with Fritz Lipmann for this discovery in 1953.

Haemoglobin



- Pigment in RBC
- Protein having iron as the main component.
- 270 million haemoglobin molecules are present in each RBC.
- One haemoglobin molecule transports either four oxygen molecules or four carbon dioxide molecules.
- The level of haemoglobin in females is 12-16 gm/dL of blood and in males it is 14-18 gm/dL of blood.
- Decrease in levels leads to anaemia.

Illustration 3.5 : Haemoglobin

Click to see the Video

What are the conditions that lead to the decrease in the level of haemoglobin? What are the different types of anaemia? Find out.

What are the healthy habits that can be followed to prevent anaemia? Discuss.

Now you have understood the process of respiration in human beings.

Discuss how respiration takes place in other animals and plants.

Respiration in other organisms

The respiratory process in organisms which use oxygen for respiration is similar to that of human beings. However, there are differences in gaseous exchange and transportation. Respiratory surfaces are different in various organisms. Discuss and present your findings regarding different respiratory surfaces and gaseous exchanges after observing the illustration 3.6 and gathering information.

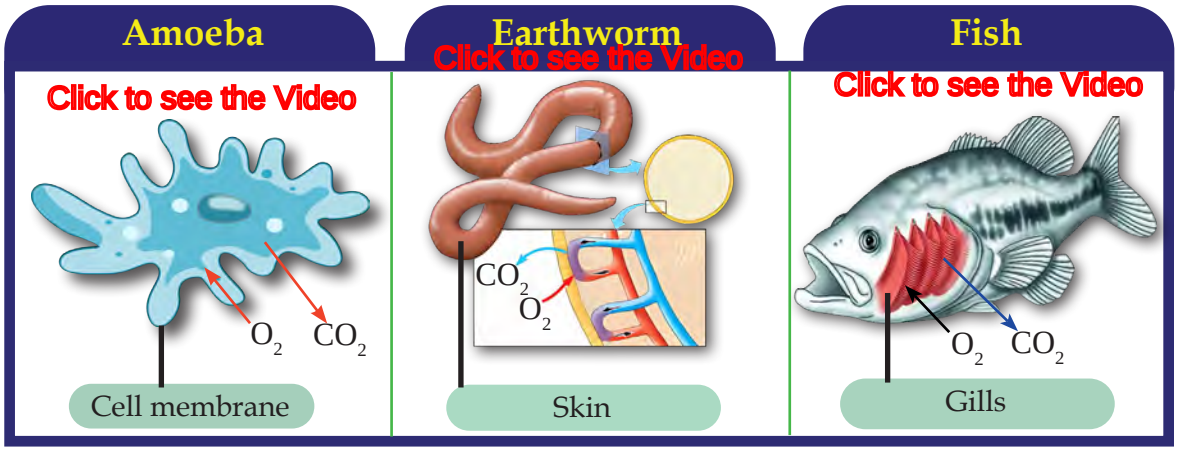


Illustration 3.6 : Respiration in other organisms

Now you have understood that the cellular respiration in plants is similar to that of human beings. They do not have respiratory system or separate organs for transport of gases. But they have special features in leaf, stem and root for the exchange of gases. Analyse the illustration 3.7 and description. Now prepare a short note on respiration in plants.

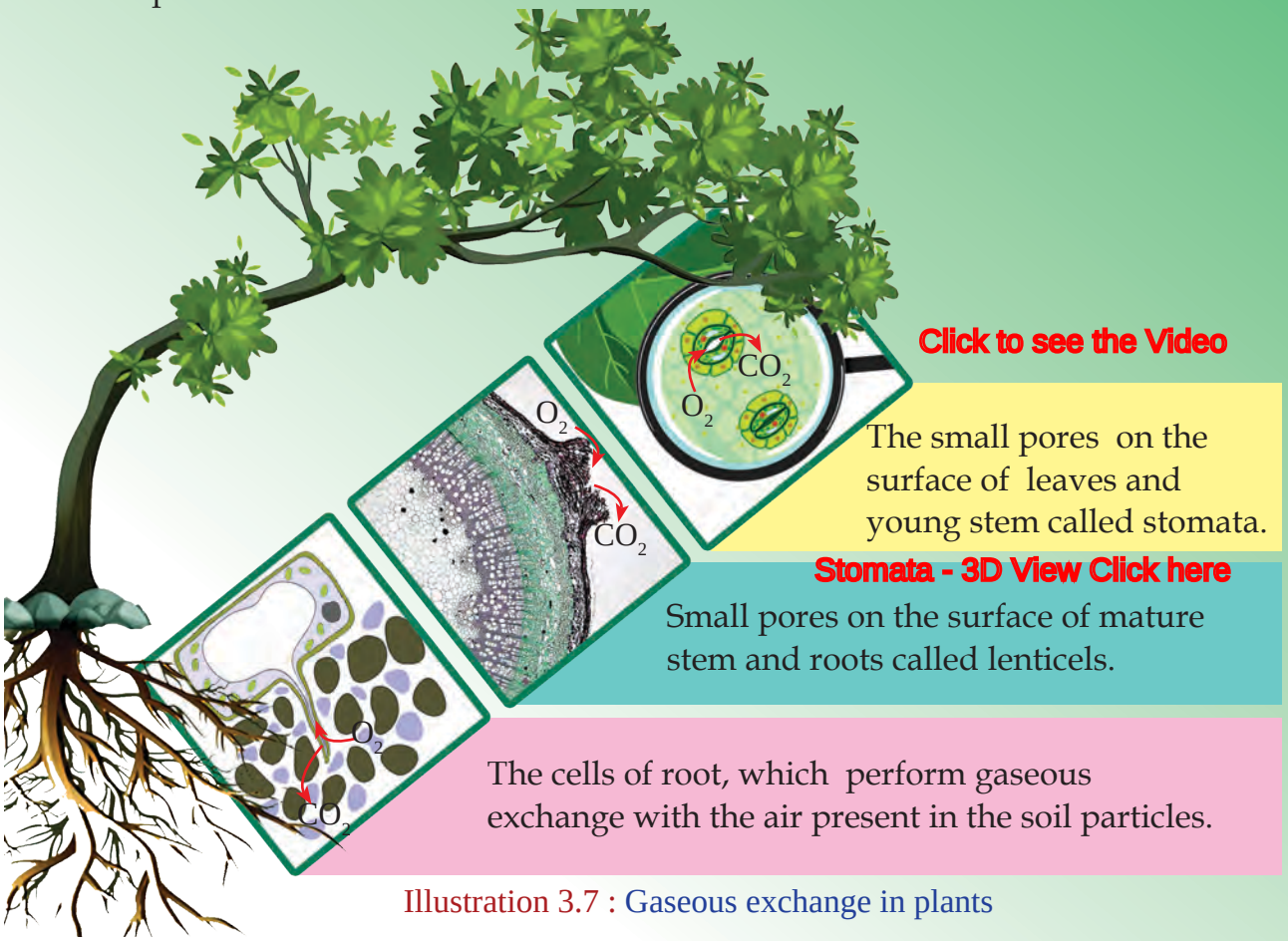


Illustration 3.7 : Gaseous exchange in plants

Stomata remain open in the day time and close at night. During the day photosynthesis and respiration take place simultaneously in the mesophyll cells of leaves. Since the rate of photosynthesis is high during the day, oxygen formed is used for respiration and the excess oxygen is expelled. CO_2 formed as a result of respiration is utilised for photosynthesis and the insufficient CO_2 is received from the atmosphere. During night when stomata close, exchange of respiratory gases takes place through diffusion.

Observe the illustration 3.8, compare the cellular respiration of lactobacillus bacteria and yeast with the aforementioned organisms. Make discussions based on the indicators and form inference.

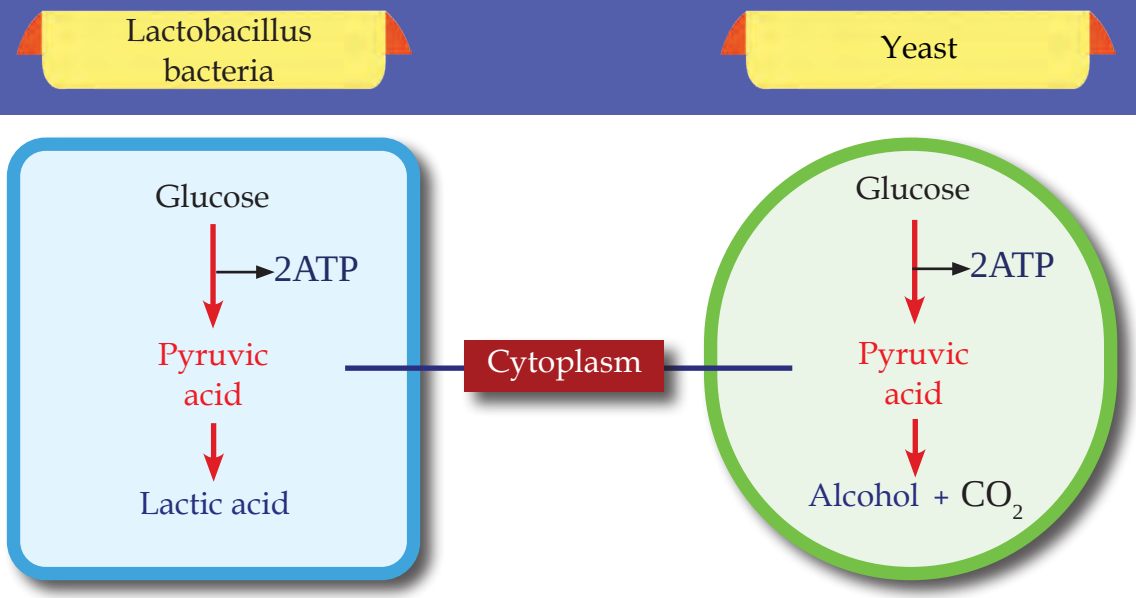


Illustration 3.8 : Anaerobic respiration

- Requirement of oxygen.
- Similarities and differences in the phases of respiration.
- Number of ATP.
- Difference in the cellular respiratory processes in bacteria and yeast.

Does anaerobic respiration take place in human beings? Find out.

All animals including human beings and plants use oxygen for cellular respiration. Such type of respiration is called aerobic respiration. But in some bacteria and yeast respiration takes place without using oxygen. Such type of respiration is called anaerobic respiration.

Some situations in daily life are given below. Discuss how anaerobic respiration is beneficial in such situations and prepare short notes on the same.

- Yeast is added to leaven the dough.
- Curd is added to milk to prepare curd.

Now you have understood how energy is produced from glucose. As a result of such metabolic activities several byproducts are formed in the cells. If they become harmful to homeostasis, they are turned into waste. The process of removal of such waste materials from the body is called excretion.

If CO_2 is not elimited in time, how does it adversely affect the body? Find out.

Which are the major excretory substances in our body? List out those which are familiar to you.

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You have understood how carbon dioxide formed as a result of cellular respiration is eliminated in time from the body. However carbon dioxide is utilised in various life processes. The process which converts the toxic substance ammonia formed as a result of the metabolism of protein into less toxic urea, is an important one among these. How does this process occur?

Analyse illustration 3.9 based on the indicators and prepare short note on synthesis of urea.

Urea synthesis

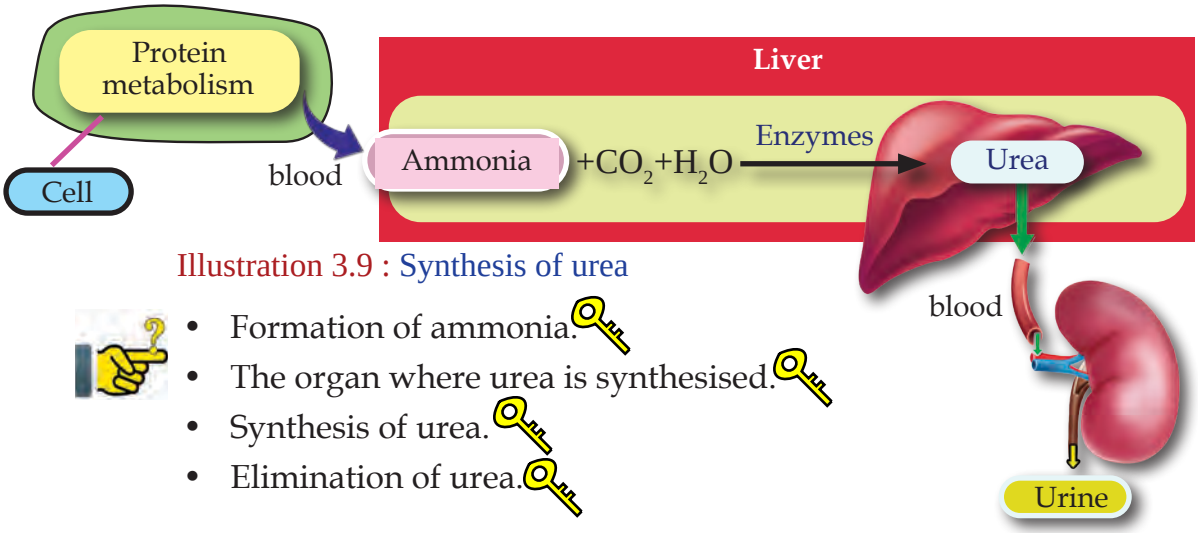


Illustration 3.9 : Synthesis of urea

- Formation of ammonia.
- The organ where urea is synthesised.
- Synthesis of urea.
- Elimination of urea.

Kidneys play a major role in the excretion of urine which contains waste materials including urea. Which are the excretory organs in our body?

- Kidney - Excretes water and salts through urine.
- Liver - Synthesises urea.
- Skin.....
- Lungs.....

Excretory system - 3D View Click here

Kidney - 3D View Click here

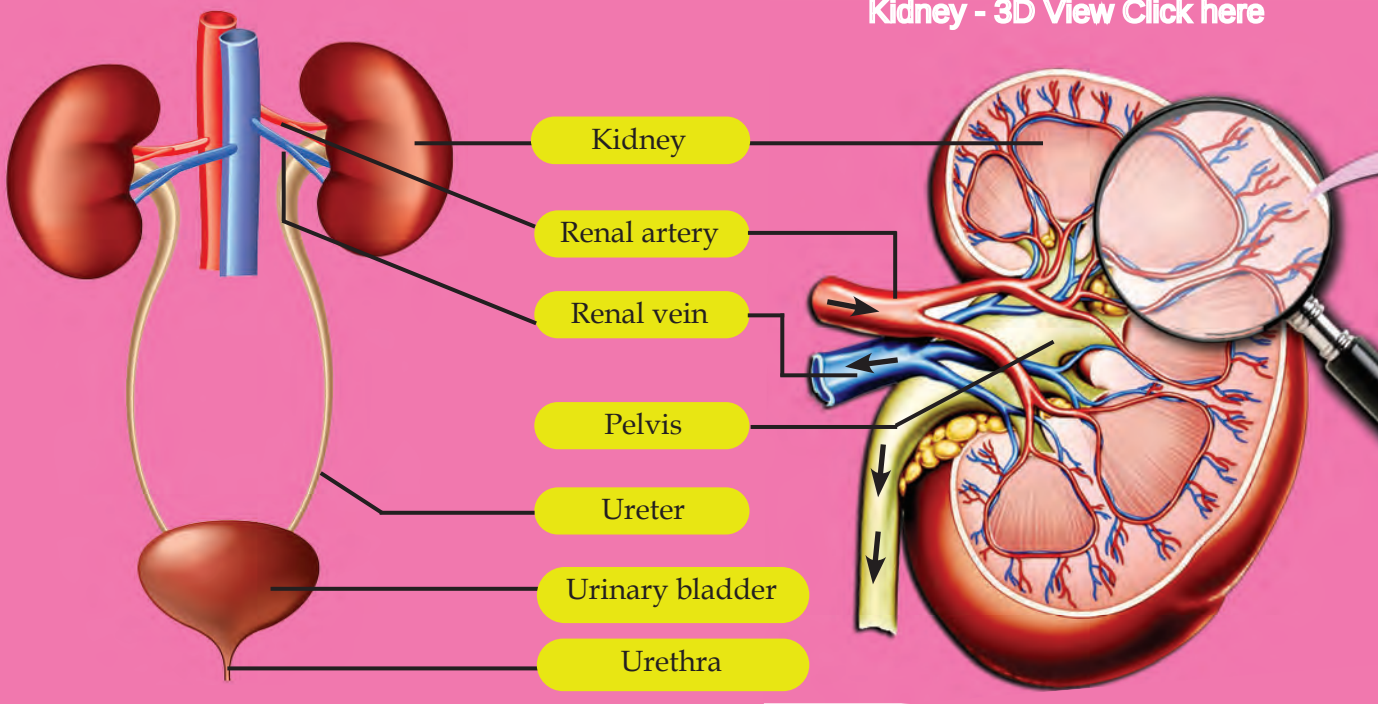


Illustration 3.10 : Kidney and related parts

Nephron - 3D View Click here

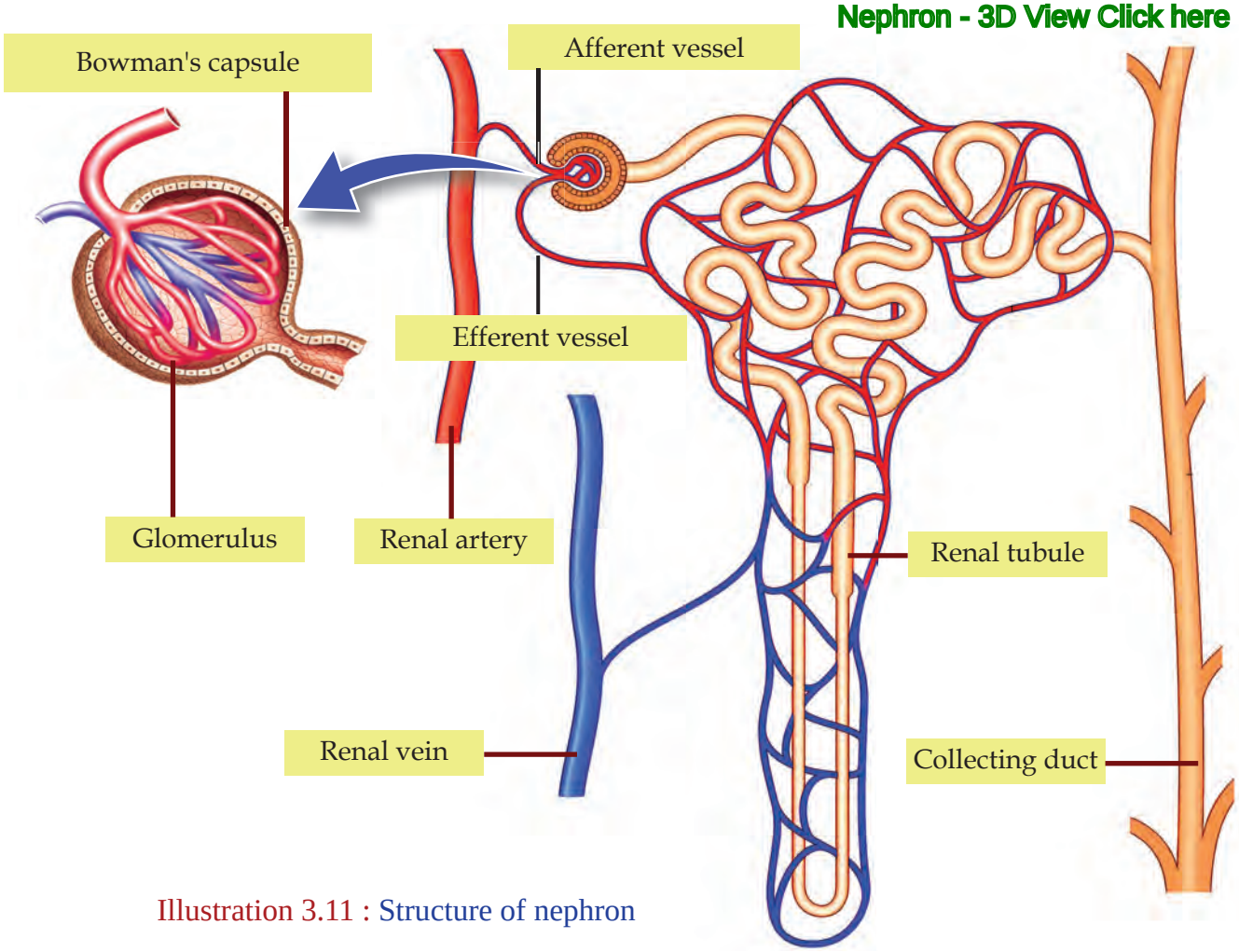
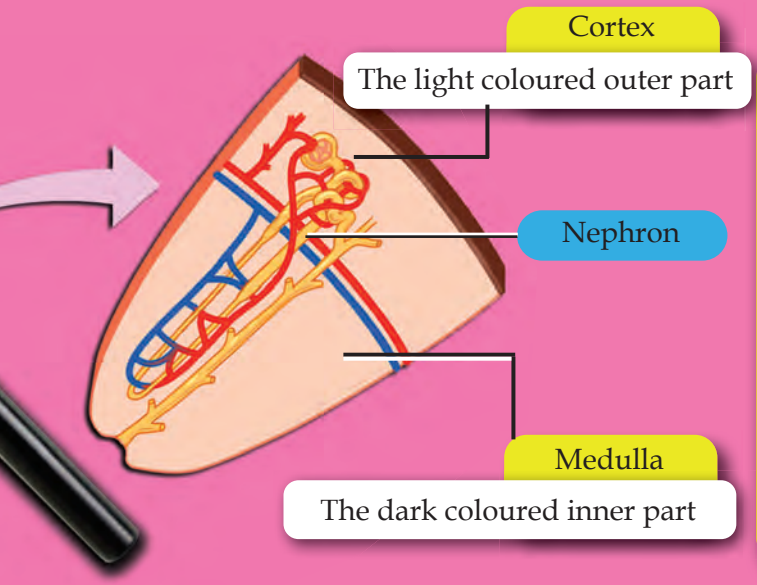


Illustration 3.11 : Structure of nephron

Click to see the Video



Kidney and related parts

Human beings have a pair of kidneys. They are bean-shaped and are located in the abdominal cavity on either sides of the vertebral column. Kidneys contain ultra filters which filter waste from the blood. They are called nephrons. Nephrons are the basic structural and functional units of kidneys. Around 12 lakh nephrons are present in each kidney.

Analyse illustration 3.10, 3.11 based on the hints and find out how the structure of kidney and nephrons are suitable to remove waste materials and complete the table 3.4.

Hints	Parts
Blood vessel which carries blood to the kidneys	
Blood vessel which carries blood away from the kidneys	
Ultra filters present in the kidneys	
The double walled cup-shaped structure present at one end of the nephron	
Network of minute capillaries present in the Bowman's capsule	
Blood vessel which carries blood to the capillary network	
Blood vessel which carries blood away from the capillary network	
The long tubule which connects the Bowman's capsule and the collecting duct	
The part where renal tubules enter, collects urine and carries it to the pelvis.	
The initial part of ureter	
Part that carry urine to urinary bladder.	

Table 3.4 : Kidney and related parts

Urine formation

Now you have understood the parts and functions of ultra filters in kidneys. How do these filters filter blood and eliminate the waste materials? Analyse illustration 3.11 and complete the worksheet 3.1 using the hints.

1 Ultrafiltration

When blood flows through the glomerulus, ultrafiltration takes place through its small pores. As a result of this a fluid called glomerular filtrate is formed. The high pressure developed in the glomerulus, due to the difference in the diameters of afferent vessel and efferent vessel helps in this process.

Components of Glomerular filtrate

Water, glucose, amino acids, sodium, potassium, calcium ions, vitamins, urea, uric acid, creatinine etc.

2 Reabsorption

When glomerular filtrate flows through renal tubules to the collecting duct, the essential components are reabsorbed from it into the blood.

3 Secretion

The excess components that are retained in blood are secreted into the renal tubules.

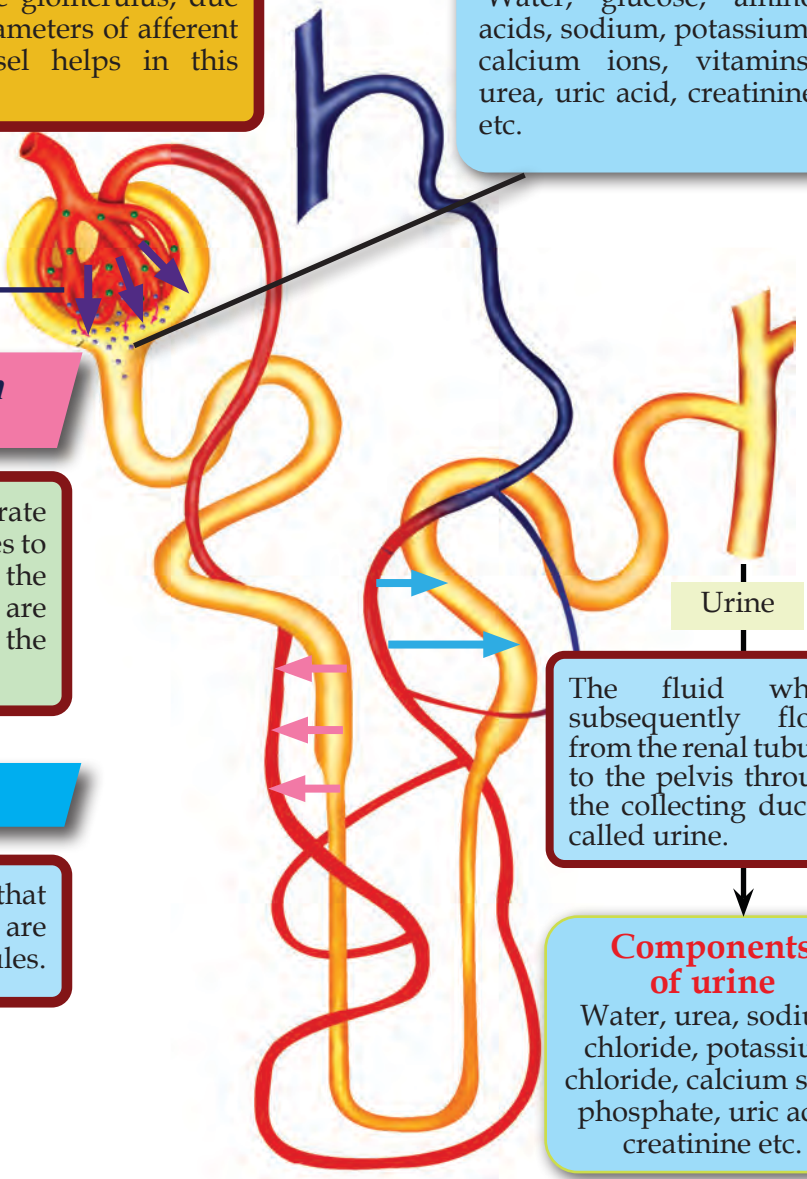
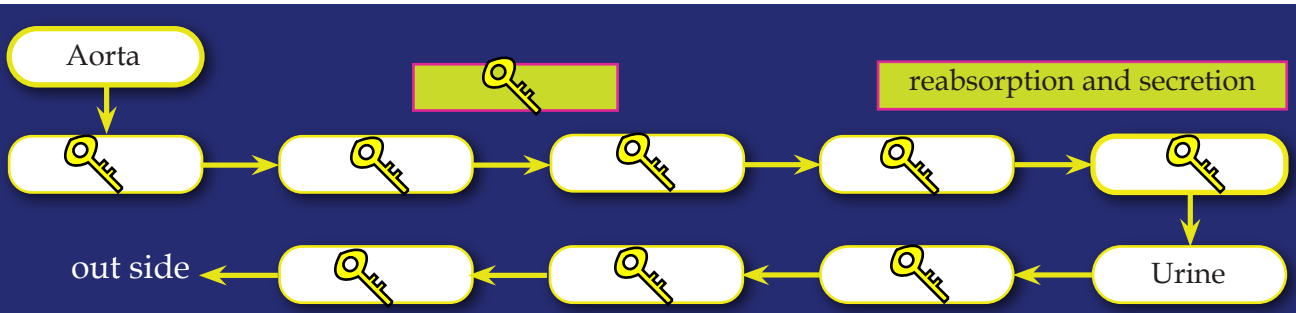


Illustration 3.12 : Formation of Urine



Hint ultrafiltration, glomerular filtrate, ureter, renal tubule, collecting duct, urinary bladder, pelvis, glomerulus, renal artery.

Work sheet 3.1 : Formation of urine

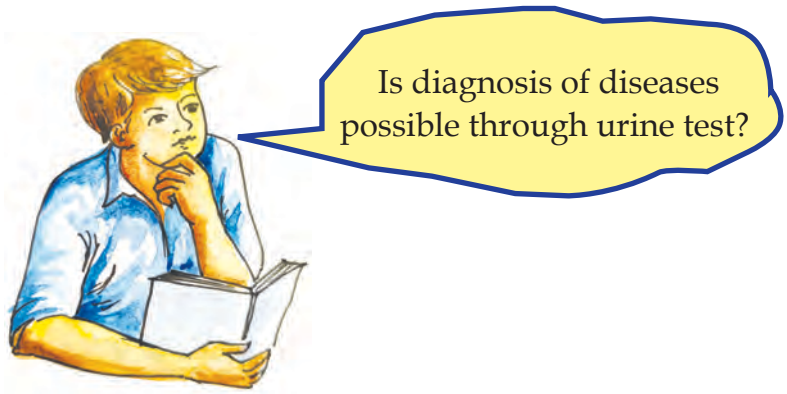
Why all components in the glomerular filtrate are not present in urine? Find out the components which are reabsorbed and the components which are secreted.

Urine from the nephrons reaches the pelvis through the collecting duct. From there it reaches the urinary bladder through the ureter and then it gets excreted through urethra.

Health of kidneys

Several factors are to be considered for the health of kidneys. The washing out of disease causing germs from the urinary tract takes place during the process of micturition. Avoiding urination for a long time prevents the expulsion of bacteria that may be present in the urinary tract. This may cause infection in the inner membrane of the urinary bladder and may lead to serious kidney diseases. Drinking sufficient quantity of water and timely urination are necessary to avoid urinary tract infection.

Click to see the Video



Haven't you noticed the doubt raised by the child?

Analyse the table 3.5 and generate more ideas regarding this.

Components	Possible diseases
Glucose	Diabetes
Albumin	Kidney diseases
Blood	Kidney diseases
Bilirubin	Jaundice
Calcium oxalate crystals	Kidney stone
Pus cells	Urinary tract infections

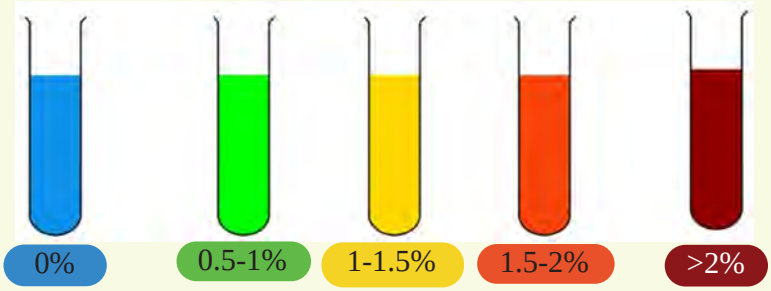
Table 3.5 : Abnormal components in urine

Detection of the presence of glucose in urine

Take two clean and dry test tubes. Take 2 ml urine sample in one of them. In the second test tube take 2 ml of glucose solution. Add 2 ml Benedict reagent in both the test tubes using a dropper. Heat for 2 minutes. Observe the colour change in both the samples.

Hint : *The colour of the sample changes from blue to green, then to yellow, orange and red depending up on the amount of glucose.*

Click to see the Video



Observation : **To See the Experiment report click here** .....

Inference : .....

Now did you understand that certain diseases can be diagnosed by testing the abnormal constituents found in urine?

Visit the medical lab in your area and collect information regarding urine test. Then prepare a table which includes the normal level of urine constituents and exhibit in the class.

Kidney stone, nephritis, uraemia etc. are some of the diseases which affect kidney. Prepare a presentation including the causes, symptoms etc of these diseases and present it in the class. **Click here to see the table of diseases affecting kidney**

Hemodialysis

The process of removal of waste materials from the blood will get interrupted if both the kidneys stop functioning. Therefore excretory materials may remain in blood without being filtered. This inturn disrupts homeostasis. Haemodialysis is done in such situations to save life. Analyse the illustration 3.13 and prepare a short note on how hemodialysis is done.

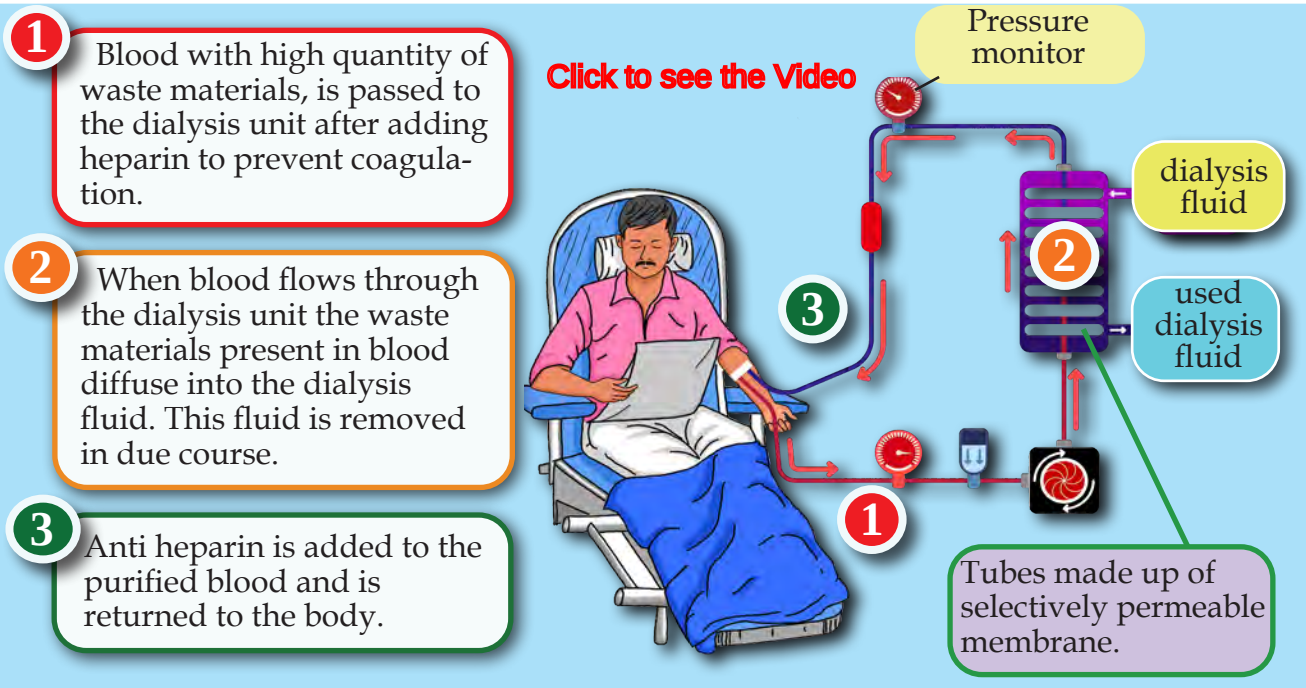


Illustration 3.13 : Hemodialysis.

Collect information regarding different types of dialysis and present it in the class. Prepare a short animation video on hemodialysis process and present it in the class.

Why is the dialysis fluid removed from the dialysis unit in due course of time?

Kidney transplantation

When is kidney transplantation required?

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Analyse illustration 3.14 and prepare a note on kidney donation.

Click to see the Video

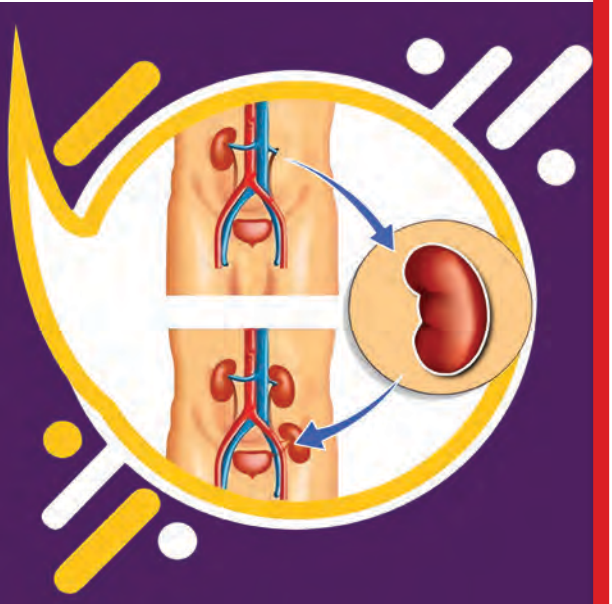


Illustration 3.14 : Kidney Transplant

Donor

A healthy person or a healthy person who died in accident or by other means.

Preparation

Blood group matching, tissue matching, cross matching.

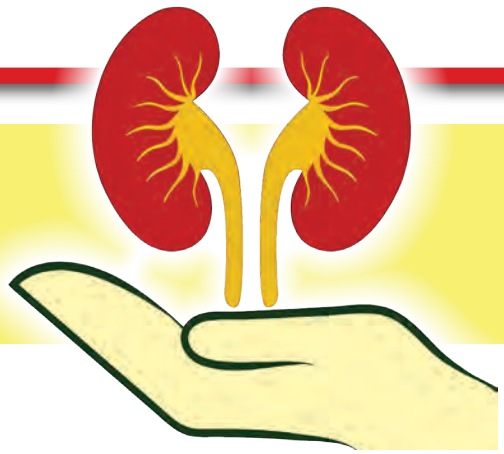
Surgery

The blood vessels and ureter of the kidney taken from the donor is connected with the recipient's.

Post surgery

Medicines which suppress immunity are to be used. Follow up examinations need to be done.

Collect more information on the importance of kidney donation, prepare a digital poster using a suitable software and display it to the class.



Excretion in other organisms

Doesn't the excretory material differ in each organism depending on its life processes? Is kidney the main excretory organ in all organisms like human beings? Complete the given table 3.6 collecting information about the main excretory products and excretory organs of the organisms.

Organism	Main excretory product	Main excretory organ/ mechanism
Amoeba	ammonia	Contractile vacuole
Earthworm		
Insects		
Fish		
Frog		
Reptiles		
Birds		

Table 3.6 : Excretion in other organisms

Animals have extensive systems for excretion. But plants do not have special excretory system like animals. Analyse the illustration 3.15 and prepare a short note on excretion in plants.

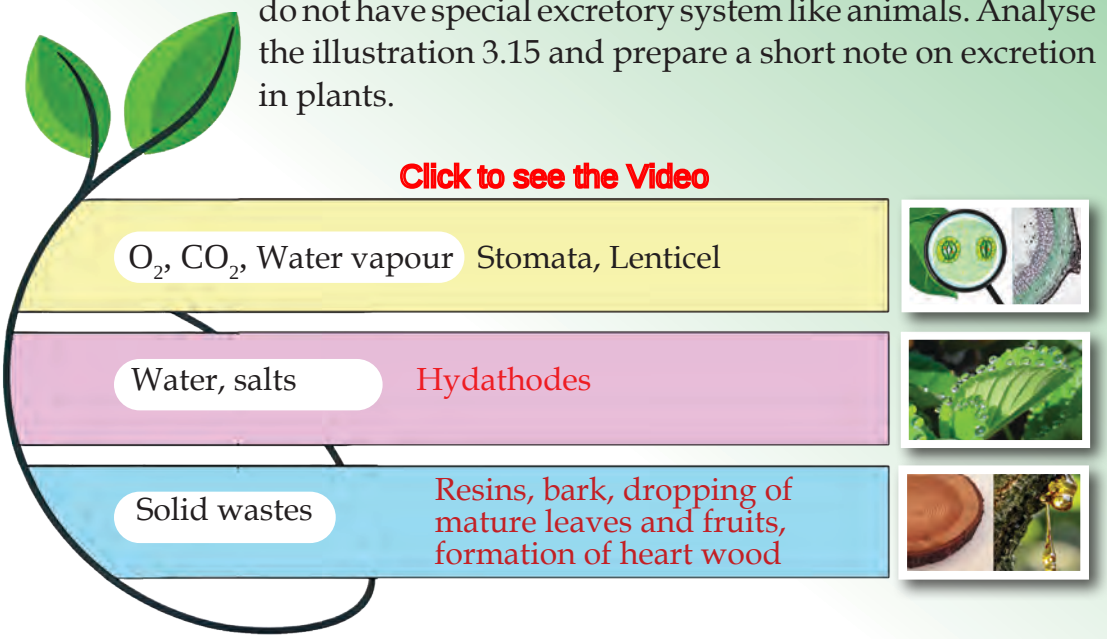


Illustration 3.15 : Excretion in plants

Maintenance of homeostasis

Maintenance of homeostasis is the sign of life. Now you have understood how liver, kidney, lungs and skin take part in the process of excretion. This is also a means to maintain homeostasis. How do these organs help in maintaining homeostasis?

Analyse the illustration 3.16 and prepare a short note.

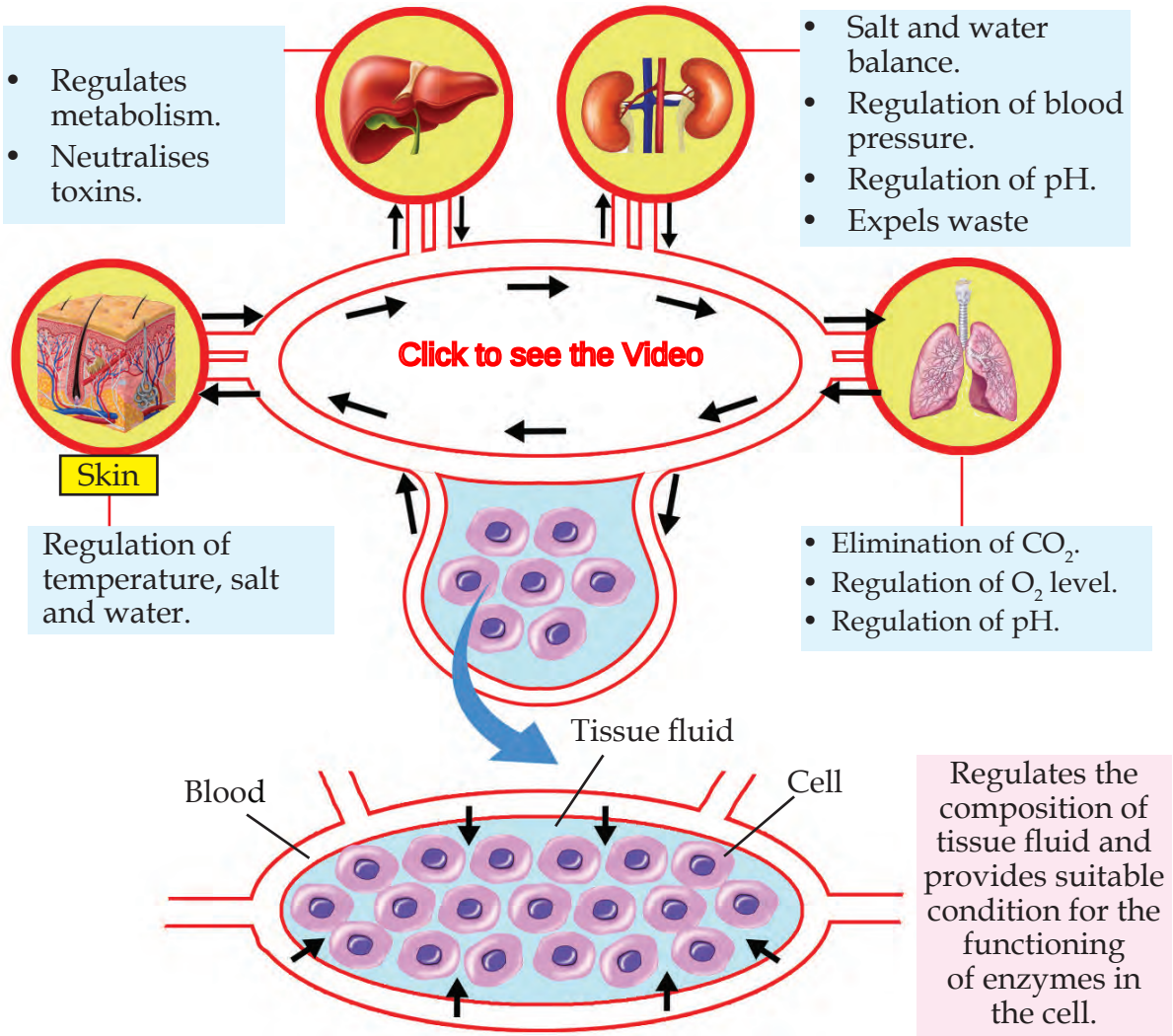


Illustration 3.16 : Maintenance of homeostasis

Any change in the internal environment disrupts homeostasis. Our improper life styles play a major role in this. Hints related to factors which affect homeostasis are given below. Collect information and conduct a seminar in the class.

Click to see Sample seminar report

Sub themes

- Wrong food habits, over nutrition, under nutrition.
- Lack of exercise, mental stress.
- Alcoholism, smoking, use of additive drugs.
- Pollution, lack of hygiene, abundance of pathogens.
- Improper use of medicines, contact with toxic substances.

External environment is also important as internal environment. Observe the figure 3.3. If such situation prevails in your area, find out how these would affect the external environment and prepare a report on the same.

Click to see Sample report

Figure 3.3 : Environment and pollution

Conduct a panel discussion on the steps to be taken to avoid such harmful changes in the external environment.

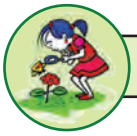
Sub themes

- Individuals
- Society
- Local self government bodies
- *Haritha karma sena*
- Attitude
- Laws

Perform a role play on the topic
'Waste Free New Kerala' based on the ideas generated from the discussion.

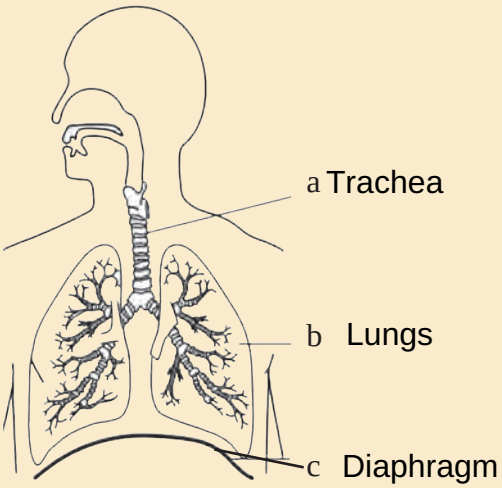
External environment should be kept waste free for the wellbeing of living organisms. Every individual should develop the right attitude towards this. Prepare a master plan for making the school and its surroundings waste free on behalf of the health club and implement it as part of the school master plan.

Wellbeing of both external and internal environments is required for a healthy life. It is our responsibility to keep the external environment waste free and follow the life style that does not disrupt the balance of the internal environment. So let us follow a life style which is required to preserve good health.

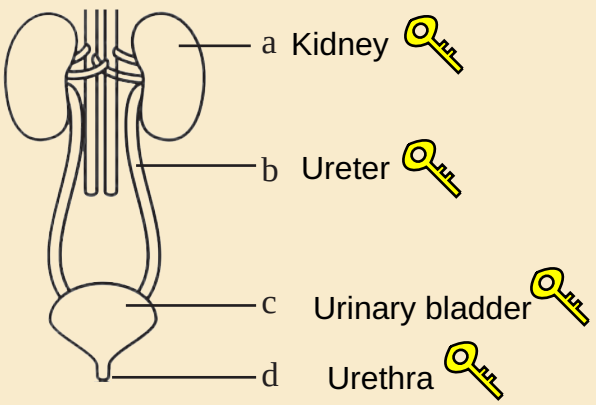


Let us Assess

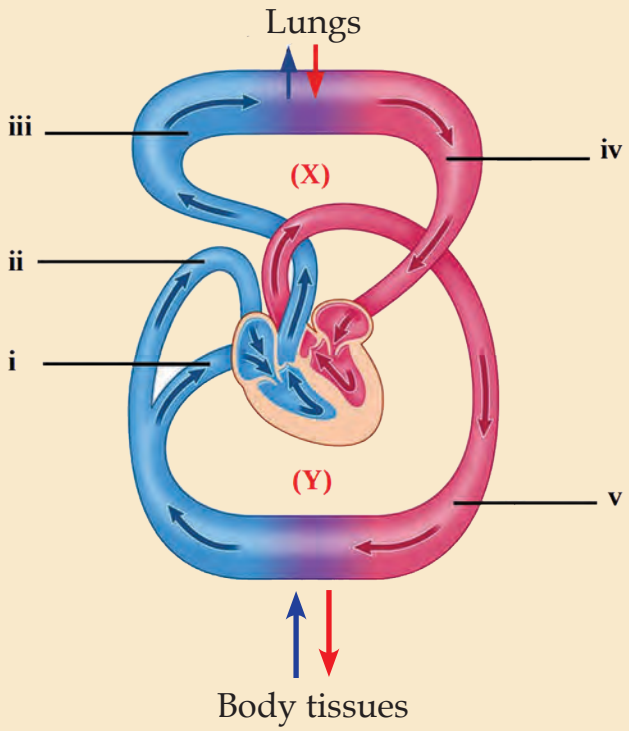
1. Which among the following given below is not the characteristic feature of an efficient gaseous exchange surface?
   a) Thick cell wall
   b) Proximity to blood capillaries
   c) Moist membrane
   d) Large surface area
2. Redraw the diagram and label the parts.



3. Write the role of each of the following in the exchange of gases.
   a) Plasma
   b) RBC
   c) haemoglobin
   d) Tissue fluid
4. Redraw the digram, label the parts and write their functions.



5. Analyse the figure and answer the questions.



a) Write the names of the circulations X and Y.

b) Write the names of the blood vessels i, ii, iii, iv, v.

c) What is the role of these circulations in the exchange and transport of gases

d) Explain the role of these circulations in the process of excretion.

Extended activities

1. Visit a primary health centre and conduct an interview with a doctor on diseases affecting lungs and kidney.
2. Construct models of respiratory system, kidney and related parts and display them in the class.
3. Organise an awareness class on organ donation.
4. Organise and implement programs to make your home and school waste free.