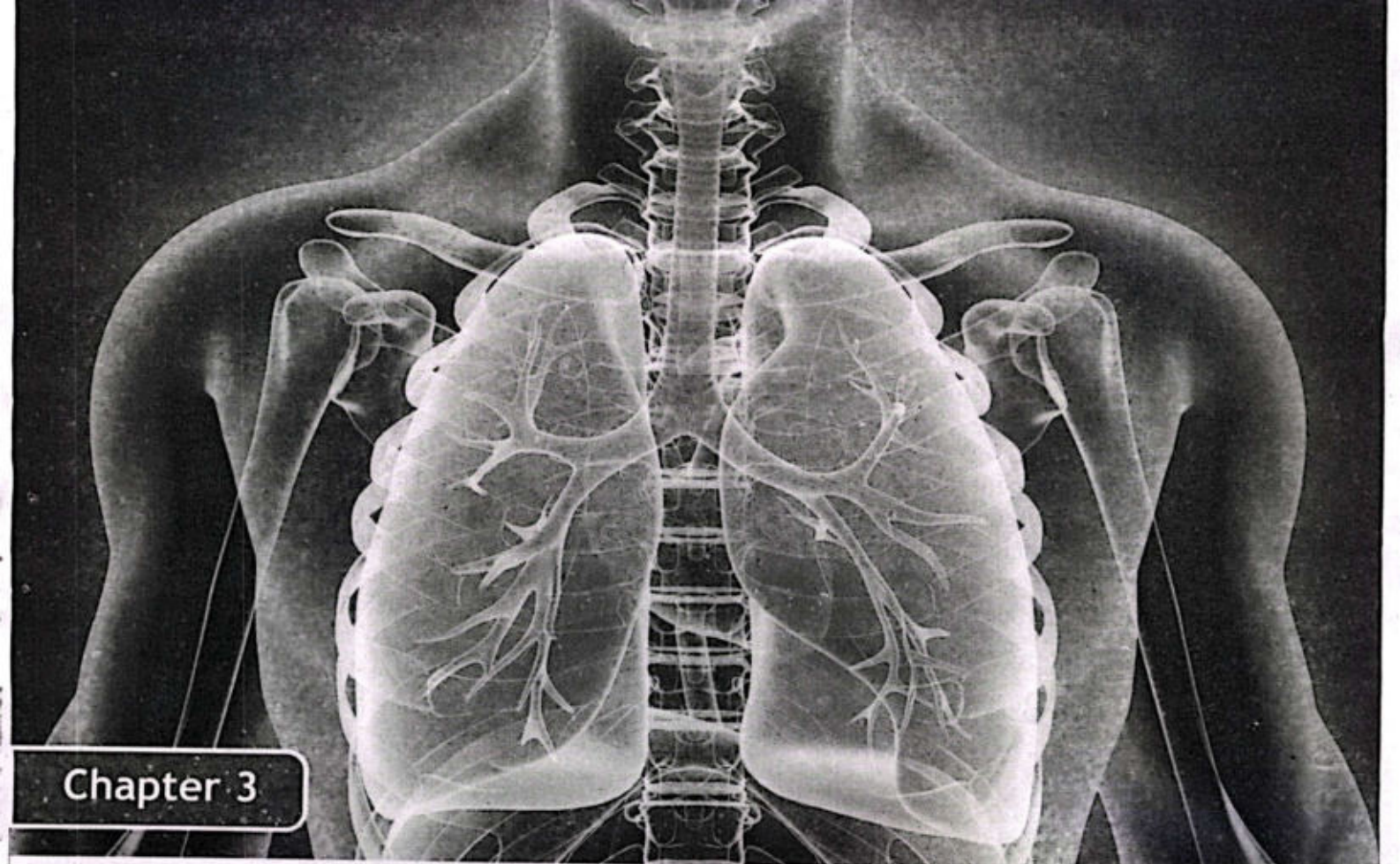




Chapter 3

RESPIRATORY SYSTEM

SLOs: After completing this lesson, the student will be able to:

1. [B-10-R-24] Describe the roles of the parts of the air passageway and lungs.
2. [B-10-R-25] Describe the mechanism of breathing in terms of movements of ribs and muscles.
3. [B-10-R-26] Differentiate between composition of inspired and expired air.
4. [B-10-R-27] Discuss briefly diseases related to respiratory system like bronchitis, emphysema, pneumonia, asthma and lung cancer.

What happens when we burn anything? Oxygen is used up and carbon dioxide is produced. The flame gives off light and heat. The same sort of thing happens in our body. The food we take has glucose. Oxygen is needed to break the glucose down and release the energy. **Respiration** is the process by which cells obtain energy from glucose. Oxygen is needed for the process of respiration so it is called **aerobic respiration**. The process, in which oxygen and glucose undergo a series of chemical reactions inside the cell, is called **cellular respiration**. Respiration is different from breathing. The movement of air into and out of the lungs is called **breathing**. Respiration is the chemical reaction inside the cell. As a result of respiration the cells release energy, that is needed for growth and other cell processes. The **respiratory system** moves oxygen from outside the environment into the body. It also removes carbon dioxide from the body.

3.1 AIR PASSAGE WAY

Man faces the same general problems of obtaining oxygen and getting rid of carbon dioxide, as do all other large and complex animals. He must have moist and thin respiratory surface across which gaseous exchange with the environment can occur. In addition, he must have some means of transporting oxygen and carbon dioxide to and from the cells. We breathe in air to get oxygen and breathe out carbon dioxide. This is called gas exchange.

3.1.1 Air Passageway and Lungs

The organs responsible for gas exchange in man are the two lungs and the air passages which lead to the lungs.

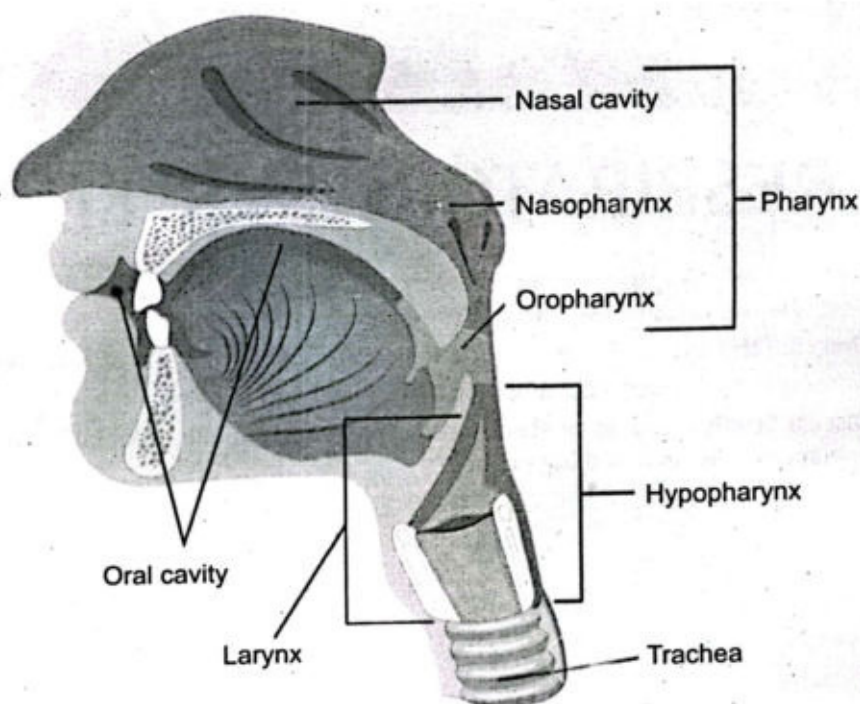


Fig. 3.1: Nasal passage

The air passageway consists of nose, pharynx, larynx, trachea, bronchi, and bronchioles.

Nose: The nose is an elevated structure. It is divided into two parts. The external openings of the nose are nostrils having hairs. The nostrils lead into a nasal cavity. The top of the nasal cavity has *lining of nerve cells, which are responsible for sense of smell*. The walls and the base of the nasal passage are lined with cilia. Between the ciliated epithelial cells are goblet cells, which produce sticky fluid, called mucus.

The nasal cavity performs important functions. The air entering the respiratory system must be warmed, moistened and filtered to keep the lung tissue healthy. The hairs lining the entrance to the nasal cavity trap large dust particles. The thin layer of mucus moistens the air and also traps particles of dust or smoke. The cilia sweep the trapped particles and mucus towards the pharynx. These are either swallowed or spit out. By the time air

the lungs it is relatively dust free, germ free, warm and moist. These protective measures keep the lungs clean, so that the lungs can perform the important work of gas exchange.

Pharynx: Air is drawn out of the nasal passages into a channel called **pharynx**, at the back of the mouth. There are several openings in the pharynx. The air is channelized from the pharynx into the larynx. **Larynx** or voice box is a cartilaginous structure. It surrounds the upper end of the trachea. The cavity of the larynx is called **glottis**. **Epiglottis** is a cartilaginous structure.

Trachea: The trachea is a tube running from the pharynx to the lungs. It is held permanently open by C shaped rings of cartilage in its walls. The cartilage rings also keep the trachea open when it develops a low internal air pressure during every intake of breath.

Do You Know?

All the cilia in the respiratory system beat toward the back of the throat, up from the lungs and down from the nose. Cilia may beat 1,000 times a minute.

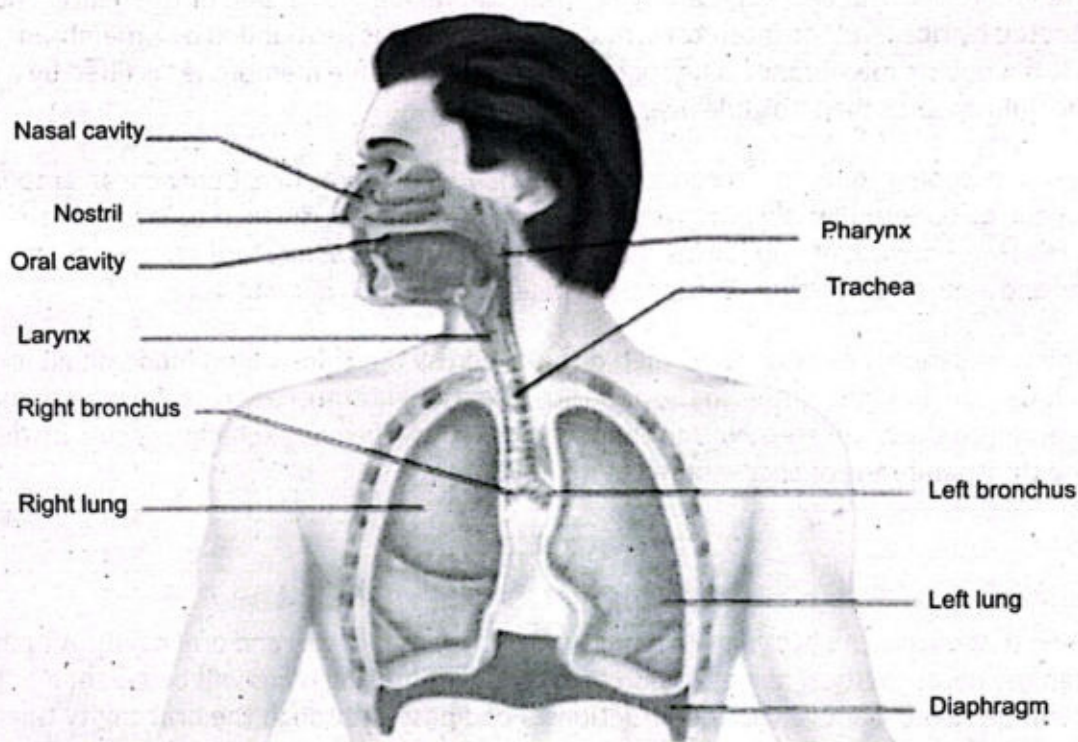


Fig. 3.2: Human respiratory system

The trachea divides into two **bronchus**, (Plural: bronchi) the one leading to each lung. Inside the lungs each bronchus divides again and again to form a mass of very fine branches called **bronchioles**. Bronchi have irregularly shaped plates of cartilage, which keep the tubes permanently open.

The bronchioles branch into many short tubes of equal diameter called **alveolar ducts**, which end in tiny hollow bags called **air sacs**. The air sacs have many bubble-like pockets in their walls called **alveoli**. The alveoli are the respiratory surface of a mammal.

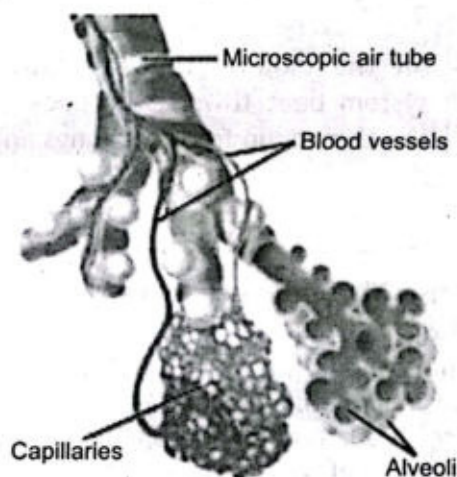


Fig. 3.3: Bronchioles and alveoli

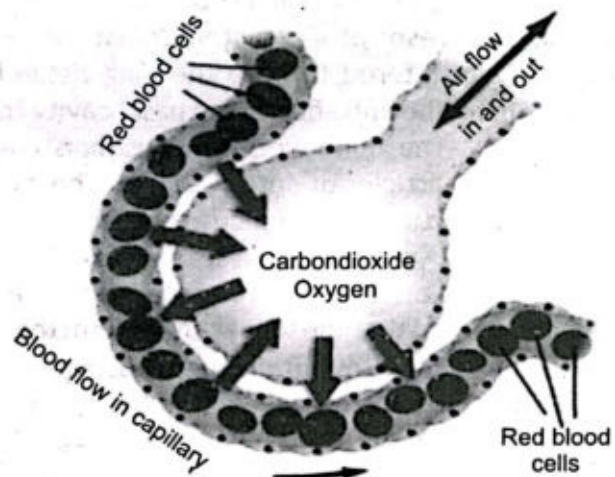


Fig. 3.4: Section through alveolus showing gas exchange

Lungs

There are two lungs. The two lungs are lying in the thorax on either side of the heart. The lungs are protected by ribs, and the intercostal muscles. Each lung is surrounded by a membrane called pleura. It is a double membrane. The space between the double membranes is filled by a film of fluid. The fluid enables them to glide over one another.

The lungs are spongy due to presence of alveoli. Alveoli look like bunches of grapes. The arrangement of bubble-like alveoli gives the lungs a far greater surface area. Each alveolus is surrounded by a network of capillaries. Here the real work of respiratory system takes place as the blood and air are side by side. The inner surface of the alveoli has moisture.

Oxygen dissolves in this moisture and then diffuses across the thin-walled blood capillaries into the blood. Carbon dioxide diffuses in the opposite direction. It diffuses across the membrane of an alveolus and into the air present within the alveolus. Thus, the gas exchange occurs by diffusion across the thin membrane of an alveolus and a capillary.

Science Titbits

Importance of Keeping Nasal and Oral Cavity Clean

Anything that enters the body has to pass through the nasal cavity and oral cavity. Air passes through the nasal cavity, if the cavity is clean then air entering lungs will be clean, and thus lungs will be saved from germs and infections. Food passes through the oral cavity to enter the gut. If the oral cavity is not clean germs along with food enter the gut and will cause disorders of gut. You will breathe out bad odour. Your teeth will start decaying.

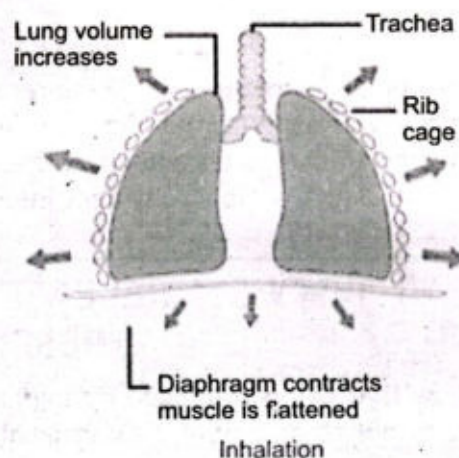
3.2 MECHANISM OF BREATHING

Breathing is a mechanical process. It is the movement of air into and out of the lungs. The force that drives air into the lungs comes from ordinary air pressure.

The lungs themselves neither draw in air nor push it out. The expansion and contraction of the lungs is accomplished by the diaphragm, and by intercostal muscles. The mechanism of breathing consists of two phases: 1. Inspiration or inhalation 2. Expiration or exhalation.

When you breathe in or inhale these changes happen:

1. The muscles in diaphragm contract. This pulls the diaphragm downwards.
2. The intercostal muscles contract. This pull the ribs upwards and outwards
3. The lungs expand. When the volume increases, the pressure decreases in the lungs.
4. Air moves into the lungs from nose/mouth.



When you breathe out or exhale these changes occur

1. The diaphragm muscles relax. This allow the diaphragm to become normal, domed shape
2. The intercostal muscles relax. This allow the ribs to move downwards and inwards
3. The lungs are compressed. When the volume decreases, the pressure increases in the lungs
4. Air is forced out from the lungs to the surrounding air

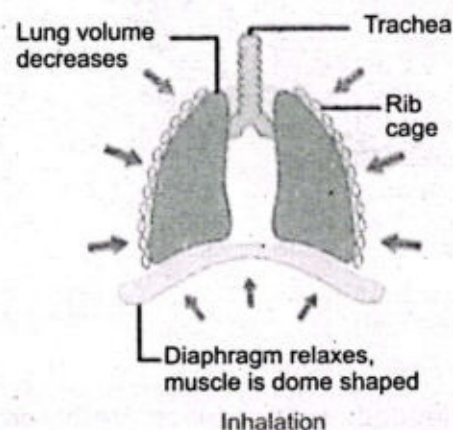


Fig. 3.5: Mechanism of breathing

3.3 COMPOSITION OF INSPIRED AND EXPIRED AIR

We will see the composition of inspired and expired air in the given table

Table 10.1: Composition of Inspired and Expired Air			
	Gas	Inspired Air	Expired Air
1	Oxygen	21%	16%
2	Carbon dioxide	0.04%	4%
3	Nitrogen	79%	79%
4	Water vapour	Variable	Saturated
5	Temperature	Variable	About body temperature
6	Dust particles	Variable	Little, if any

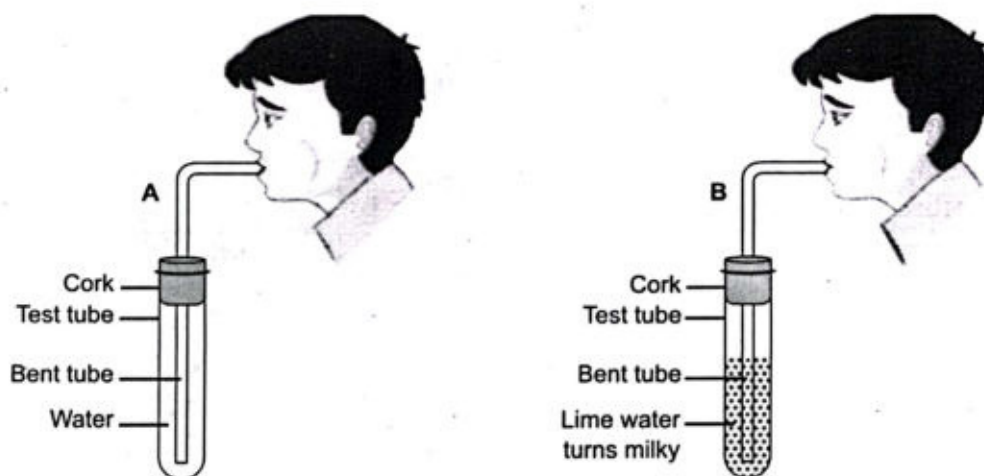
Do you know?

Importance of breathing in fresh air

Oxygen is needed for respiration. Respiration is needed for energy, thus the net result of breathing in fresh air is to get more energy. Fresh air is free of pollutants i.e., carbon monoxide, smoke, chemicals and other disease-causing agents. Thus, breathing in fresh air is the best way of prevention from many infections and diseases.

STEAM ACTIVITY 3.1 RELEASE OF CARBON DIOXIDE THROUGH RESPIRATION

Aim: To show that CO_2 is produced during respiration. The composition of CO_2 in the air we breathe out is more than that of the normal air.



Materials needed: Two test tubes, Freshly prepared lime water, Water, Bent glass tube

Procedure:

1. Pour water in test tube labelled A.
2. Pour the freshly prepared lime water into test tube labelled B.
3. With the help of a bent glass tube, blow air in the test tube labelled A and B.

Observation: The lime water in test tube B turns milky showing that we exhale CO_2 . In test tube A, there is no change of colour in water.

Inference: Lime water turns milky when CO_2 is mixed with it. Air blown from the mouth contains CO_2 , approximately 4%. The composition of CO_2 in atmosphere is 0.04%. This proves that the percentage of CO_2 in the air during exhalation is higher than the CO_2 in the atmosphere.

Questions:

1. Which process is being tested in the activity?
2. What is the result of the activity? Give reasons.

Answer:

1. Exhalation process during respiration
2. The lime water in test tube 'B' turns milky but water in tube A remains unchanged. Because CO_2 is present in the exhaled air, it mixes with lime water in 'B' and turns it milky.

3.4 DISEASES RELATED TO RESPIRATORY SYSTEM

The common respiratory disorders are Bronchitis, Emphysema, Pneumonia, Asthma and Lung cancer.

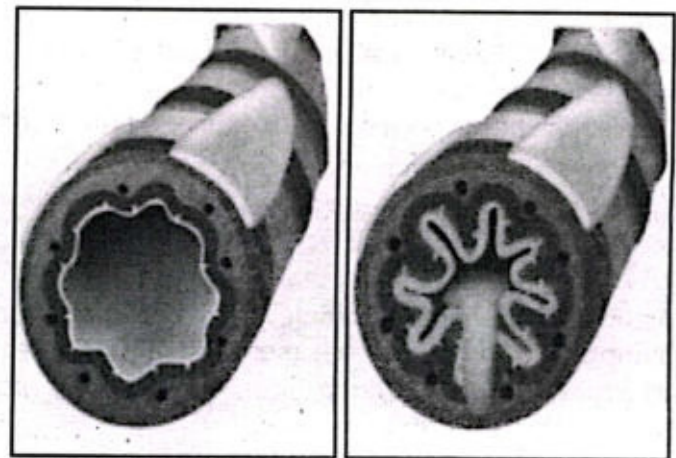
3.4.1 Bronchitis

Bronchitis is the inflammation of lining of the air passages like trachea, bronchi and bronchioles.

Symptoms: One of the symptoms is secretion of excess mucus from the goblet cells in response to the irritation. The main symptom is cough, which occurs repeatedly. Coughing and breathlessness increases as the disease progress. Bronchitis can be acute or chronic.

Cause: Acute bronchitis usually lasts a few days only and is a side effect of viral infections like flu. Chronic bronchitis is most commonly caused by smoking and to a lesser extent by air pollution. It may last for months. The sensation of breathlessness occurs, due to the reduced gases exchange.

Treatment: The infection will generally go away on its own within one week. One should take the following steps for some relief: (a) Do not smoke. (b) Drink plenty of fluids. (c) Take rest. (d) An inhaler may be taken. (e) If your doctor thinks that you have a secondary bacterial infection, antibiotics may be prescribed.



Normal bronchi

Acute bronchitis

Fig. 3.6: Bronchi

Acute bronchitis: Short term bronchitis inflammation of the bronchi of the lungs.

Chronic bronchitis: It is the long term inflammation and irritation of the bronchi.

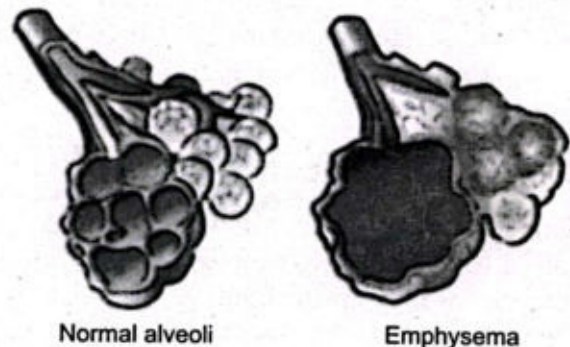
3.4.2 Emphysema

Emphysema is a respiratory disease where there is over-inflammation of the alveoli in the lungs, causing a decrease in lung function.

Symptoms: The main sign of emphysema is increasing breathlessness. In advance case the patient finds it difficult to walk. The lungs lose elasticity, so that it becomes more difficult to exhale air. Inflammation and narrowing of the finer bronchioles also occur.

Cause: It is due to gradual breakdown of the thin walls of alveoli and the total surface area for gaseous exchange decreases. The main cause is the long-term irritation of the lungs, most commonly by cigarette smoke, air pollution or industrial dust.

Treatment: Treatment methods for emphysema do not cure or reverse the damage to the lungs. The best way to prevent emphysema is to avoid smoking. A variety of medications may be used in the treatment of emphysema.



Normal alveoli

Emphysema

Fig. 3.7: Alveoli

3.4.3 Pneumonia

Pneumonia is defined as an inflammation of alveoli of lungs caused by acute infection. Double pneumonia is a lung infection that affects both lungs.

Symptoms: Fever, shaking chills, chest pain, cough, headache, sore throat, nausea, diarrhoea etc.

Cause: The most common cause of pneumonia is bacteria

Streptococcus pneumoniae.

Treatment: Antibiotics are prescribed for bacterial pneumonia.

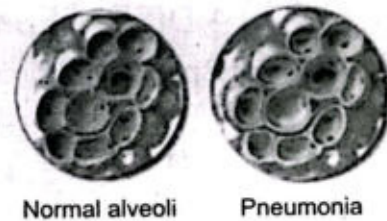


Fig. 3.8: Alveoli

3.4.4 Asthma

Asthma is the common chronic inflammatory disease of the airways.

Symptoms: The person has more difficulty in breathing out than breathing in. A characteristic whistling sound is caused by breathing. There is secretion of excess of mucus and swelling of the lining of the respiratory pathway.

Cause: It is due to an allergic response to substances like pollen, household dust, a particular food or feathers from pillow, cold air, exercise, and smoking etc., emotional disturbance may also provoke an attack.

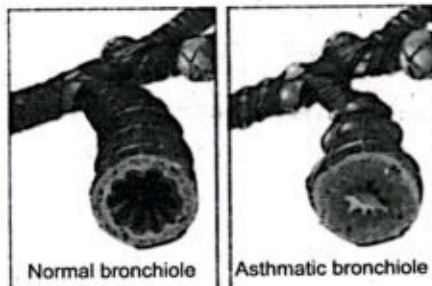


Fig. 3.9: Bronchiole



Fig. 3.10: Inhalers help asthma patient to breathe

Treatment: Mild attack of asthma is controlled with bronchodilators that dilate the airway. Different devices called **inhalers** help asthma patient to breathe. Asthma is a long-term disease that has no cure. Asthma is treated with two types of medicines: long-term control and quick-relief medicines.

3.4.5 Lung cancer

Cancer is caused by cells dividing repeatedly out of control and form unspecialised masses of cells called **tumours**. Lung cancer usually starts in the epithelium of the bronchioles. It then usually spreads throughout the lungs.

Symptoms: The first event appears to be thickening and callusing of the cells lining the bronchi. Then there is a loss of cilia, so that it is impossible to prevent dust and dirt from setting in the lungs. After that a tumour consisting of cancerous cells with a typical nucleus appears at one location. Due to metastasis the cancer spreads. The tumour may grow until the bronchus is blocked, cutting off the supply of air to that lung.

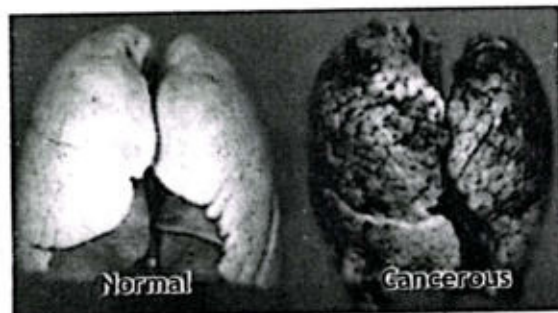


Fig. 3.11: Lungs

Cause: Tobacco smoke is the main cause of cancer. Air pollution also increases the risk of lung cancer specially car exhaust, asbestos and arsenic.

Treatment: The only treatment is pneumonectomy i.e., to remove a lobe or the lung completely or destroying it through radiation.

Do you know?

Bad effects of smoking

It causes cancer, chronic bronchitis, emphysema, early morning cough. Smokers are likely to get pneumonia. Smoking can make it hard to breathe. Smoking can also worsen asthma and allergies.

STEAM ACTIVITY 3.2 Construction of lung model

An experiment to demonstrate how the diaphragm works during breathing

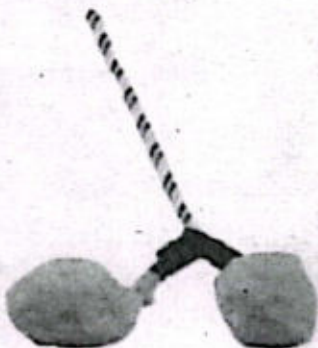
Materials needed: 2 litre plastic bottle, Straws, Scissors, Quality tape, 3 large balloons, Plasticine/Blu-Tac, Elastic bands

Procedure

1. Cut the bottom off the two litre bottle, make the cut a smooth as possible.



3. Add a balloon to each end of the Y-shaped connector. Secure in place with tape or elastic bands.



2. Create a Y shaped connector.

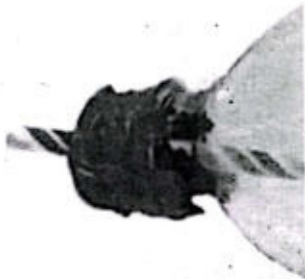
Cut one straw open (1cm from the end) and fold it out to create two small legs to make a Y. Cut 8 cm off the 2nd straw, gently fold in half and cut out a 2 cm diamond shape (fold is in the middle). Place Y of straw 1 over the diamond shaped hole in straw 2 and tape it in place. Make the seal airtight.



4. Place the balloon and straw connector structure inside the plastic bottle. Carefully thread the long straw portion through the neck of the bottle.



5. Create an airtight seal around the straw and bottle using tape. Alternatively, drill a hole in bottle top to thread straw through and seal with plasticine/Blu Tac.



6. Tie a knot at the end of remaining balloon, cut balloon in half across largest part. Stretch the balloon, with knot on outside, across bottom of bottle opening. Tape in place.



Working mechanism

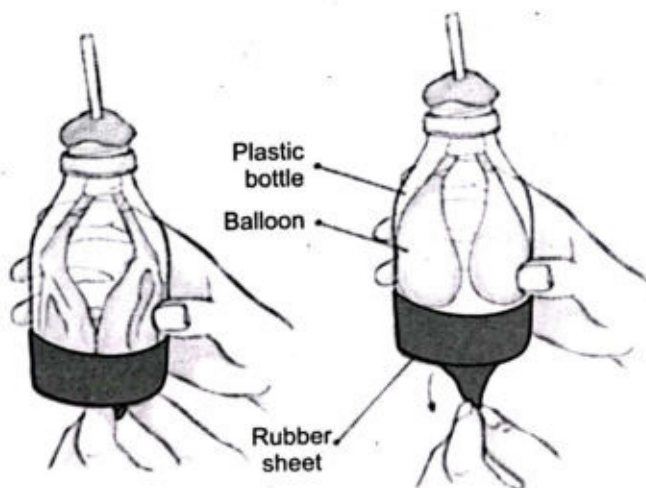
- To understand the working mechanism of lungs hold the large, bottom balloon and pull it downwards slowly.
- Now push the rubber/plastic sheet up and observe the balloons.

Observation

From this model we can conclude that when we pull down the balloons inflate and deflate, due to pressure inside the bottle similar to the lungs.

Inference

On comparing this model with our respiratory system we can infer that the balloons represent the lungs, the bottle represents the thorax and the rubber sheet represents the diaphragm.



EXHALATION

INHALATION

Structure of the system

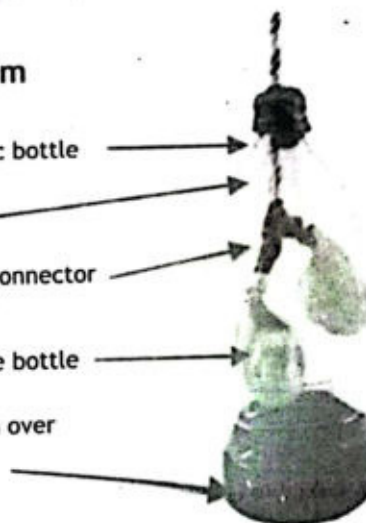
Chest cavity = plastic bottle

Windpipe = straw

Bronchi = Y shaped connector

Lung = balloon inside bottle

Diaphragm = balloon over bottom of bottle



SUMMARY

1. Respiration is the exchange of oxygen and carbon dioxide between cells and the environment.
2. Respiration is the process by which cells obtain energy from the glucose.
3. The air passage consists of nose, pharynx, larynx, trachea, bronchi and bronchioles.
4. Nose provides air for respiration, conditions the air by filtering, warming, and moistening it, and cleans itself of foreign debris extracted from inhalations.
5. Air is drawn out of the nasal passage into pharynx.
6. The tube running from the pharynx to the lungs is called trachea which divides into two bronchi.
7. Inside the lungs each bronchus divides to form bronchioles.
8. The bronchioles divide into alveolar ducts which end into air sacs. The air sacs have alveoli.
9. The lungs are the pair of spongy, pinkish-grey organs where exchange of gases takes place.
10. Breathing is the movement of air into and out of the lungs.
11. Inhalation is the process by which other gases or air enters the lungs.
12. During exhalation, the diaphragm relaxes and moves upward, causing compression of the lungs and an outward flow of air.
13. The common respiratory disorders are bronchitis, emphysema, asthma, pneumonia, and lung cancer.

EXERCISE

Section I: Multiple Choice Questions

Select the correct answer:

1. One reason for emphysema is:
A) smoking B) exercise C) food D) iron deficiency
2. In humans during expiration:
A) diaphragm is lowered and ribs are raised B) both diaphragm and ribs are raised
C) diaphragm is raised and ribs are lowered D) both diaphragm and ribs are lowered
3. The inner most chamber of the respiratory system into which air can be drawn:
A) bronchiole B) bronchus C) bronchial tube D) alveoli
4. What is the percentage of oxygen in expired air when a person is resting?
A) 8 % B) 12 % C) 16 % D) 20 %
5. Which process does not use energy released by respiration?
A) active transport to the glucose into the villi
B) diffusion of oxygen across the alveolar surface
C) maintenance of constant body temperature
D) passage of nerve impulses
6. Which path does a molecule of oxygen take as it enters the body?

A)	bronchiole	bronchus	larynx	trachea
B)	bronchiole	bronchus	trachea	larynx
C)	trachea	bronchiole	bronchus	alveolus
D)	trachea	bronchus	bronchiole	alveolus

7. When you inhale, the diaphragm:
- A) relaxes and moves upward B) relaxes and moves downward
C) contracts and moves upward D) contracts and moves downward
8. Respiration in living organisms always involves:
- A) carbon dioxide production B) energy release
C) gaseous exchange D) oxygen consumption
9. The gas exchange portion of the human respiratory system is the:
- A) trachea B) bronchi C) larynx D) alveoli
10. The disease involving breakdown of air sacs of the lungs is:
- A) pneumonia B) bronchitis C) emphysema D) asthma
11. Which blood vessel surrounds the alveoli?
- A) capillary B) vein C) venule D) artery
12. In asthma, shortness of breath occurs due to:
- A) constriction of bronchi. B) rupturing of alveolar walls.
C) rupturing of bronchial walls. D) accumulation of pus in alveoli.
13. The percentage of oxygen gas in inspired is 21% and in expired air it is 16%. This difference in the amount of oxygen gas is due to the:
- A) storage of oxygen gas in lung tissues.
B) non-reactivity of oxygen gas with the blood.
C) liberation of oxygen gas as a metabolic waste.
D) utilisation of oxygen gas in energy production.
14. Which one of the following row best describes the action of different structures associated with the process of inhalation?

	Diaphragm	Rib muscles	Ribs
A)	contract	relax	remain unchanged
B)	relax	relax	raised
C)	contract	contract	raised
D)	relax	contract	remain unchanged

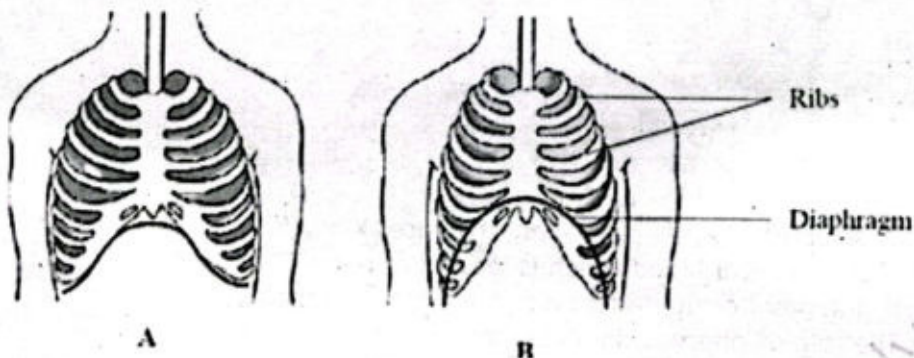
15. Which row correctly describe the functions of the diaphragm, cilia and mucous in human gaseous exchange system?

	Diaphragm	Cilia	Mucous
A)	Contracts to cause breathing out	Trap bacteria from air	Absorb CO ₂ coming from alveoli
B)	Contracts to cause breathing in	Carry mucous to the throat	Trap dust and bacteria from air
C)	Relaxes to cause breathing in	Filter dust from air	help in sound production
D)	Relaxes to cause breathing out	Produce mucous	Decrease acidity

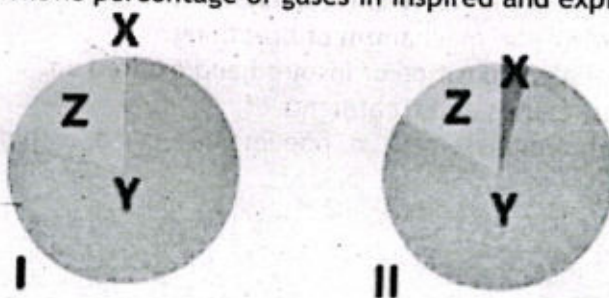
Section II: Short Answer Questions

- How exchange of gases takes place in alveoli?
- What is the effect of exercise on the rate of breathing?
- Compare inspired air and expired air.
- How viral infections like Covid-19 affect bronchi?
- What is the importance of breathing in fresh air?
- What is the importance of keeping nasal and oral cavity clear?
- Differentiate between:

a. Respiration and Breathing	i. Bronchi and bronchioles
b. Respiration and Photosynthesis	j. Air sacs and alveoli
c. Inhalation and Exhalation	k. Oxyhaemoglobin and carboxyhaemoglobin
d. Smoker and Passive smoker	
e. Bronchitis and Pneumonia	
f. Aerobic and Anaerobic respiration	
g. Pharynx and Larynx	
h. Glottis and Epiglottis	
- Breathing through nose is healthier than breathing by mouth. Why?
- What are the conditions necessary for efficient gaseous exchange between organism and environment?
- The two steps of breathing are shown in the given diagrams.
Which of the given diagrams, A or B, shows the process of exhalation? Support your answer with a reason.

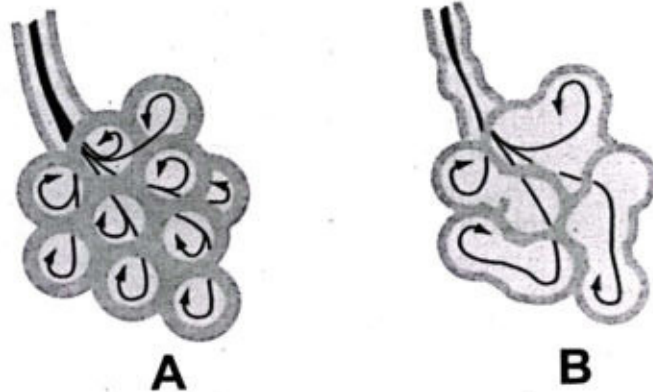


- Describe the effects of cigarette smoking on the inner walls of trachea of human beings.
- The diagram shows percentage of gases in inspired and expired air.

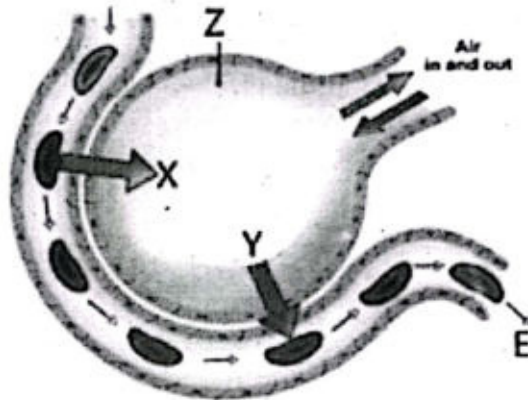


- Identify I, II, X, Y and Z.
- Why gas X is almost negligible in figure I?
- How the percentage of X is increased in figure II?

13. The figure shows a healthy lung and a diseased lung
- Identify the disease and affected part of the lung.
 - How the part B show structural variation from part A.
 - Write any two symptoms of the disease.



14. The diagram shows structural and functional unit of lungs.



- Identify structure Z.
 - Name the gases X and Y.
 - What is the name of blood which is leaving at point E?
15. How nose and nasal cavity function in filtering incoming air?
16. What is the role of 'pharynx' in human respiration?

Section III: Extensive Answer Questions

- Describe the structure of human respiratory system.
- Define breathing. Write the mechanism of breathing.
- Differentiate between composition of inspired and expired air.
- State the symptoms, causes and treatments of:
 - bronchitis
 - emphysema
 - pneumonia
 - asthma
 - lung cancer.