The Respiratory System

THE NEED FOR RESPIRATION

Respiration is the chemical process of releasing energy by breaking down glucose for carrying out life processes.

ANIMALS NEED MORE ENERGY

The need for production of energy is greater in animals than in plants. This is because animals consume more energy in doing physical work.

Birds and mammals need still more energy.

The birds and mammals including ourselves have also to produce a lot of heat for keeping the body warm. This heat comes through respiration in the cells. The amount of heat to keep the body warm is quite large.

Shivering and clattering of teeth is an emergency activity of the muscle cells to produce extra heat to keep body warm.

GLUCOSE HAS NO ALTERNATIVE FOR RESPIRATION

If the simple carbohydrate is not available directly, the cells may break down the proteins or fats to produce glucose for respiratory needs. Think for a while about the wild animals which are totally flesh-eaters. The main constituent of their diet is protein with very little carbohydrates.

TWO KINDS OF RESPIRATION AEROBIC AND ANAEROBIC

In animals there is normally aerobic respiration using oxygen. Anaerobic respiration is only exceptional in some cases as in the tapeworms living inside the human intestines.

Anaerobic respiration may occur even in our own body in the fast-working skeletal muscles temporarily. Accumulation of lactic acid e gives the feeling of fatigue. This is a condition which may be called oxygen-debt.

CHEMICAL STEPS IN RESPIRATION

Aerobic respiration in animals

The chemical changes taking place in aerobic respiration in animals are the same as in the aerobic respiration in plants.

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + 38\ ATP + 420\ kcal$

Anaerobic respiration in animals

In animal cells, particularly in the skeletal muscle cells, anaerobic respiration may occur when they have to work very fast with insufficient oxygen.

$C_6H_{12}O_6 \rightarrow$ lactic acid + 2 ATP + heat energy

Special points to note in the above chemical reaction in anaerobic respiration in animals, are as follows:

1. It is a slow process.

2. The reaction cannot continue for long time. The product lactic acid has a toxic effect on cells, which causes muscle fatigue and aches.

3. No CO_2 is produced.

4. Total energy released per mole of glucose is much less compared to aerobic respiration.

PARTS OF RESPIRATION

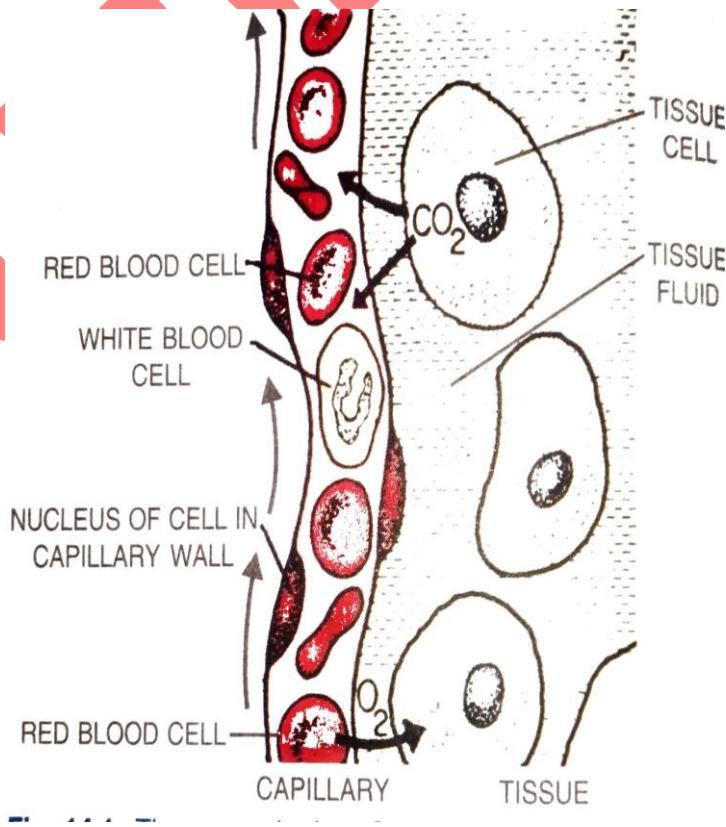
In humans there are four major parts of respiration :

1. Breathing: **This is a physical process in which the atmospheric air is taken in and forced out of the oxygen-absorbing organs, the lungs.**

2. Gaseous transport: **The oxygen absorbed by the blood in the lungs is carried by the RBCs as oxyhaemoglobin throughout the body by means of arteries.**

3. Tissue respiration: **The terminal blood vessels, i.e., the capillaries deliver the oxygen to the body cells or tissues where oxygen diffuses through their thin walls.**

4. Cellular respiration : **The complex chemical changes which occur inside the cell to release energy from glucose.**



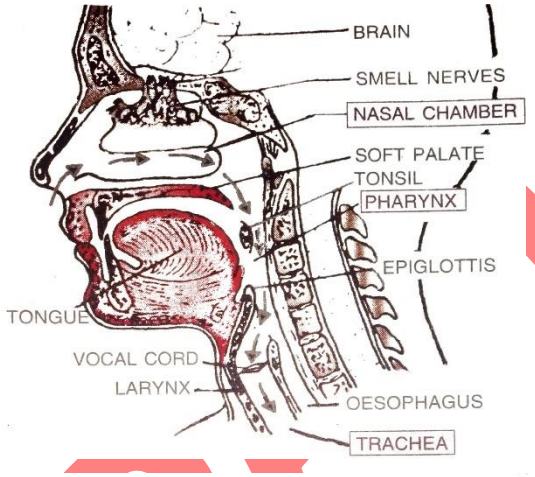
RESPIRATORY ORGANS (BREATHING)

The respiratory system in humans consists of air passages and the lungs.

The Nose: **The external part of the nose bears two nostrils separated by a cartilaginous septum. The hairs present in the nostrils prevent large particles from entering the system.**

The Pharynx: **The nasal chambers open at the back into a wide cavity, the pharynx, situated at the back of the mouth. It is a common passage for air and food.**

The Larynx: **The larynx or the voice-box is a hollow cartilaginous structure located at the start of the windpipe. You can feel it with your fingers in the front part of your neck.**



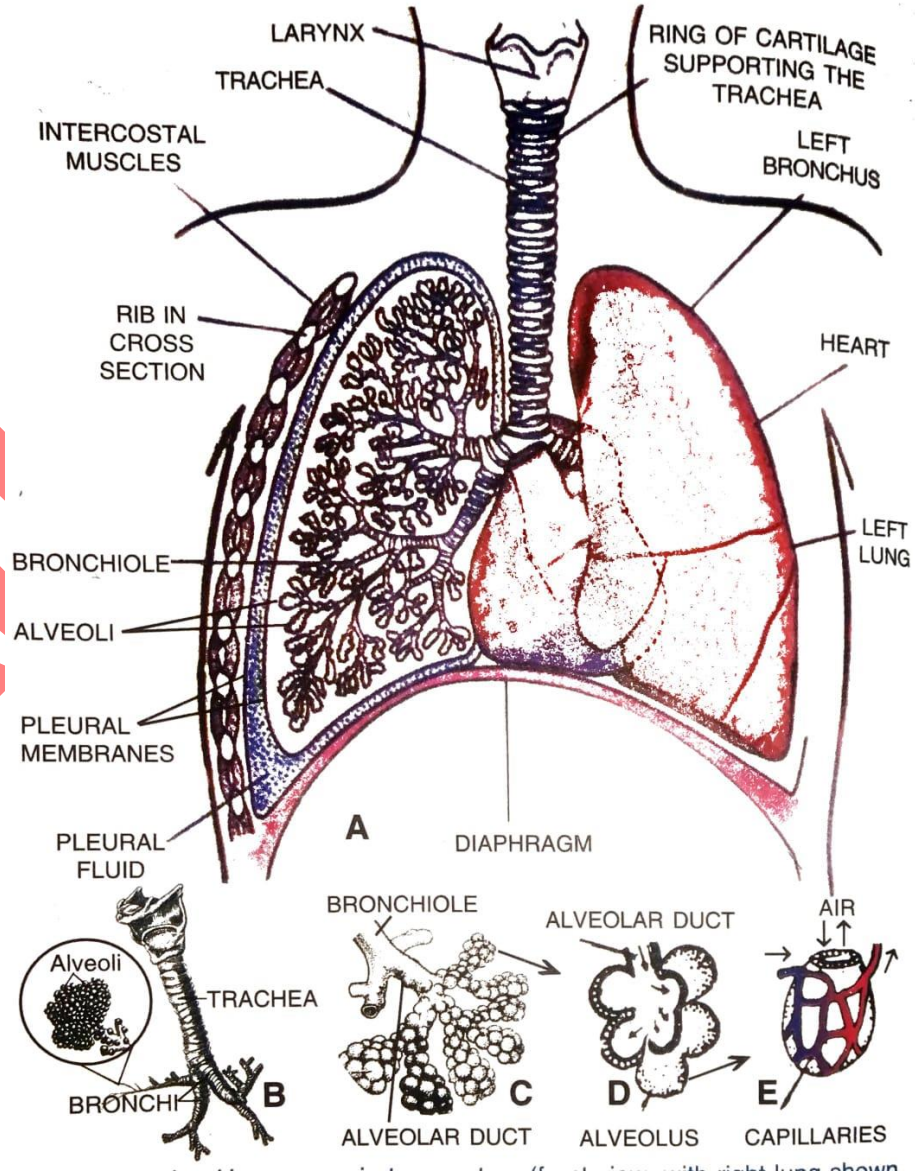
The Trachea: **The trachea or the windpipe emerges from the larynx down below in the neck where it is partly covered by the thyroid gland.**

The Bronchi: **Close to the lungs, the trachea divides into two tubes, called the bronchi, which enter the respective lungs.**

Protective inner lining of respiratory passage. The entire inner lining of the larynx, trachea, bronchi and bronchioles is formed of ciliated epithelium.

The Lungs are a pair of spongy and elastic organs formed by the air sacs, their connecting bronchioles, blood vessels, etc.

Membranous coverings of the lungs. Each lung is covered by two membranes the inner (visceral) pleura and outer (parietal) pleura with a watery fluid (pleural fluid) in the pleural cavity found between the two membranes.



Blood supply to the lungs

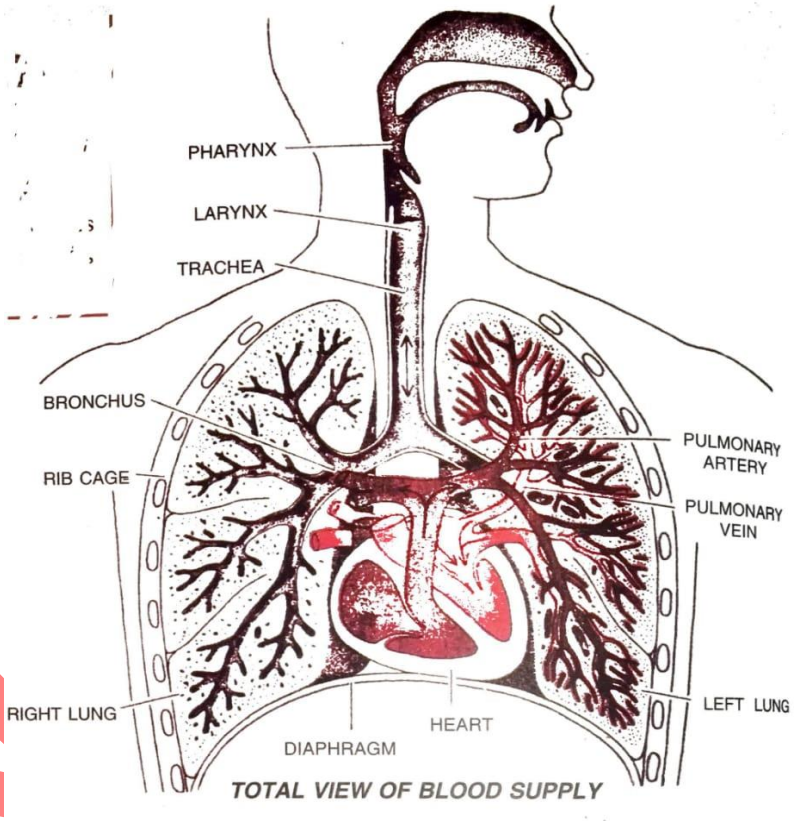
The right auricle pumps all the deoxygenated blood received in it from the body into the right ventricle, which in turn, pumps it into the lungs through the main pulmonary artery. The pulmonary artery, soon after its emergence,

divides into two branches entering their respective lungs. Inside the lungs, they divide and redivide several times to ultimately form capillaries around the air sacs.

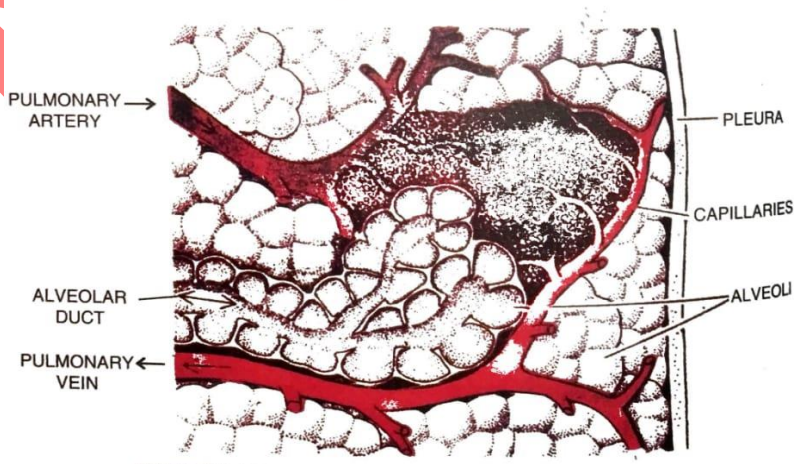
BREATHING - RESPIRATORY CYCLE

Respiration vs. Breathing

Respiration is a broader term which includes intake of air/oxygen and its utilization in the body cells to produce energy But, breathing is simply a mechanical process of inhaling and exhaling the air, in other words it is a muscular process.



TOTAL VIEW OF BLOOD SUPPLY



ALVEOLI AND CAPILLARIES, HIGHLY MAGNIFIED

1. Inspiration (or inhalation) is the result of increase in the size of thoracic cavity and this increase is due to the combined action of the ribs and the diaphragm.

The ribs are moved upward and outward due to the contraction of the external intercostal muscles stretched between them, thus enlarging the chest cavity all around.

The diaphragm, a sheet of muscular tissue, which normally remains arched upward like a dome, towards the base of the lungs, contracts and flattens from the dome-shaped outline to an almost horizontal plane and thus contributes to the enlargement of the chest cavity lengthwise.

2. Expiration (or exhalation) is the result of reverse movements of the ribs and diaphragm. The external intercostal muscles relax and the ribs move in automatically. The diaphragm is relaxed and move upwards to its dome-like outline.

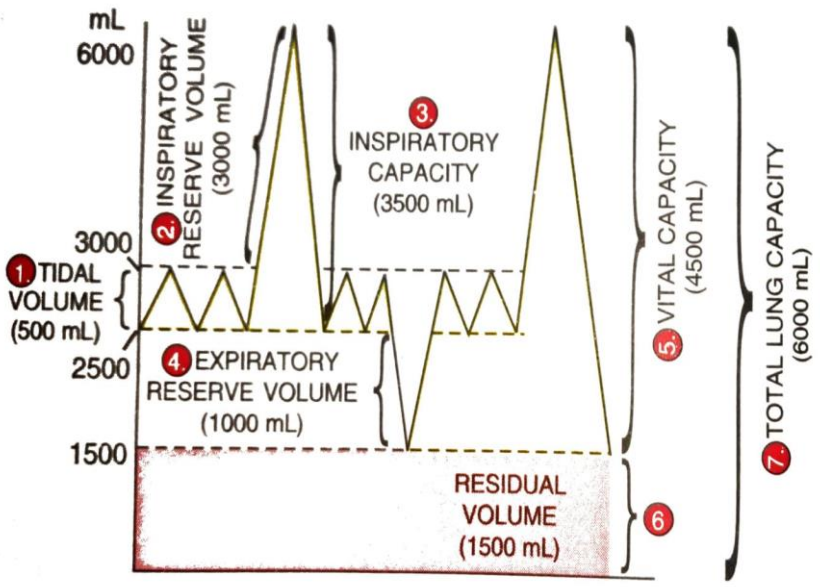
CONTROL OF BREATHING MOVEMENTS

The breathing movements are largely controlled by a respiratory centre located in the medulla oblongata of the brain. This centre is stimulated by the carbon dioxide content of the blood.

CAPACITIES OF THE LUNGS

Capacities of the lungs or the Respiratory volumes in a normal human adult are approximately as follows:

1. Tidal volume. **Air breathed in and out in a normal quiet (unforced) breathing =500mL**



Dead air space. Some tidal air is left in respiratory passages such as trachea and bronchi where no diffusion of gases can occur =150 mL

2. Inspiratory reserve volume. **Air that can be drawn in forcibly over and above the tidal air (also called complemental air) =3000 mL**

3. Inspiratory capacity. **Total volume of air a person can breathe in after a normal expiration =3500 mL**

4. Expiratory reserve volume. **Air that can be forcibly expelled out after normal expiration (also called supplemental air) =1000 mL**

5. Vital capacity. **The volume of air that can be taken in and expelled out by maximum inspiration and expiration =4500 mL**

6. Residual volume. **Some air is always left in the lungs even after forcibly breathing out. This is the leftover (residual) air =1500 mL**

7. Total lung capacity. **Maximum air which can at any time be held in the two lungs =6000 mL**

INSPIRED AIR vs. EXPIRED AIR

The air inside the lungs is never replaced completely. It is always a mixture of the air left inside and the air inspired.

Quality wise, the expired air differs from inspired air in the following respects:

1. It contains less oxygen.

2. It contains more carbon dioxide.

3. It contains more water vapour.

4. It is warmer (or at the same temperature as that of the body).

5. It may contain some bacteria.

EFFECT OF ALTITUDE ON BREATHING

As we go higher up, the air we breathe in decreases in pressure accompanied by a gradual decrease in oxygen content.

HYPOXIA AND ASPHYXIATION

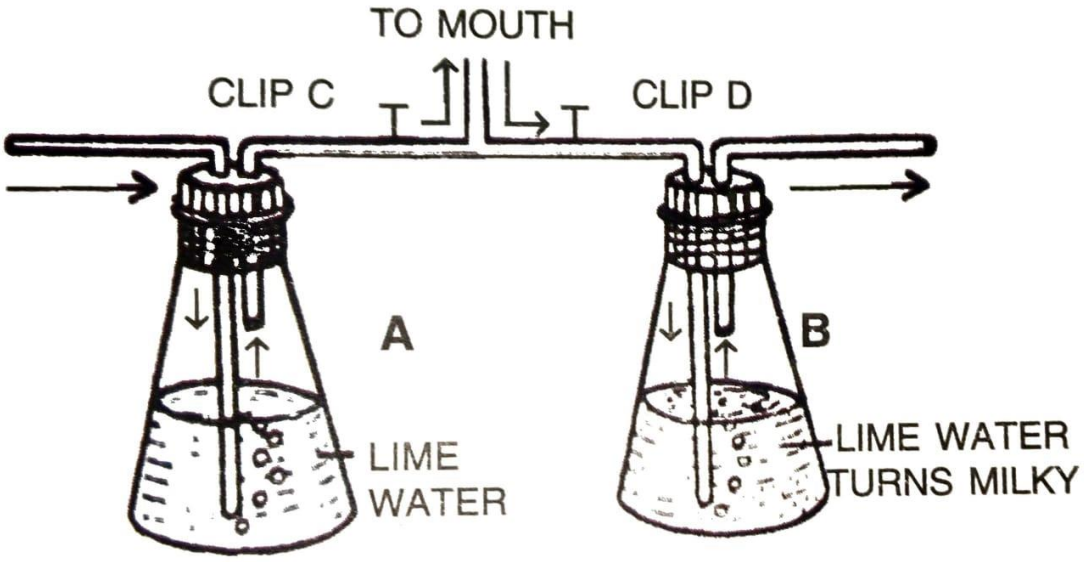
HYPOXIA is the deficiency of oxygen reaching the tissues. It may result due to sitting for long hours in a crowded room with poor ventilation.

ASPHYXIATION is a condition in which the blood becomes more venous by accumulation of more carbon dioxide and the oxygen supply is diminished.

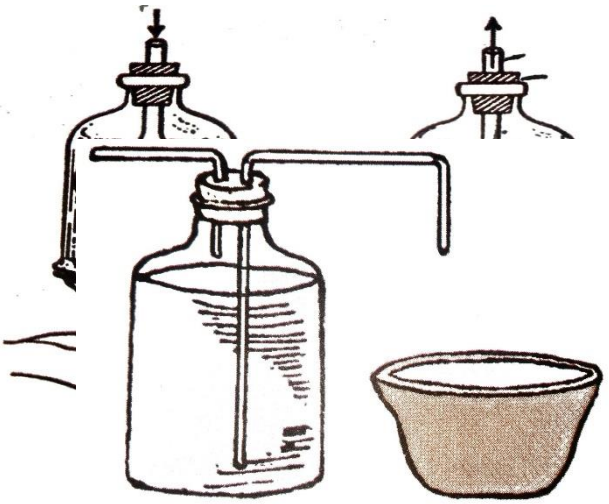
SOME EXPERIMENTS ON BREATHING AND RESPIRATION

1. To demonstrate that water is lost during breathing: Gently breathe upon a cold surface such as a piece of glass or slate; the water droplets appearing on the surface prove the presence of moisture in expired air.

2. To demonstrate that CO_2 is given out in breathing: Clip (C) is opened and clip (D) is closed. Air is sucked in by the mouth, through the tube at the centre. Atmospheric air rushes in flask (A) bubbling through the lime water. Next, clip (C) is closed and clip (D) is opened and the exhaling air is blown through the same central tube. This time the air is forced into flask (B) bubbling through its lime water. The process is repeated about ten times. The lime water in flask (B) turns milky much faster than in flask (A).



3. To demonstrate the action of the diaphragm during breathing: **The rubber sheet tied around the bottom edge of the Bell jar represents the diaphragm. When the sheet is pulled downward, volume is increased, pressure inside the bell jar lowered and the rubber balloons are expanded by the air rushing in through the tube at the top.**



4. To measure the volume of expired air: **Fill your chest with air to the maximum, and then blow out through the short tube expelling as much air as you can. The water expelled from the other tube when measured gives the volume of the air exhaled.**

5. To show that oxygen is taken in by animals during respiration: **Use a small animal such as a cockroach or snail in this experiment. Take two conical flasks A and B. Place a live cockroach in one flask (A) and a dead cockroach that has been soaked in formalin to prevent decay in the other flask (B). This flask with the dead cockroach acts as a control.**