HUMAN PHYSIOLOGY
(BREATHING & EXCHANGE OF GASES)

Oxidation of nutrients releases their chemical bond energy for utilisation in the body. Such oxidations take place in steps. The released energy is temporarily stored as ATP. The high energy bonds of ATP are subsequently broken to use the energy for various activities.

In some lower organisms such as anaerobic bacteria and yeasts, nutrients are oxidised without using molecular oxygen. Such a process is called **anaerobic metabolism** or **fermentation.** For example, yeast derives energy by the anaerobic fermentation of glucose to ethanol; lactic acid bacteria ferment glucose and lactose to lactic acid. Anaerobic metabolism occurs even in some multicellular animals such as intestinal parasites and liver flukes living in environments with less oxygen.

In most animals, however, tissue oxidations are carried out by **aerobic respiration.** Cells utilise molecular oxygen for oxidising nutrients aerobically; carbon dioxide is produced as a result of such oxidation. An exchange of oxygen and carbon dioxide occurs between the organism and the surrounding medium. But even in aerobically respiring animals, anaerobic metabolism takes place in certain tissues like skeletal muscles which do not immediatly get as much oxygen as is necessary for their work. This is why fast muscles produce lactic acid anaerobically from glucose during vigorous movements. There are also some cells like mammalian erythorcytes which lack mitochondria for aerobic respiration; they can only carry out anaerobic metabolism. The lactic acid produced anaerobically in some tissues is subsequently collected from blood and at least a part of it is oxidised aerobically by other tissues such as liver and cardiac muscle.

Aerobic respiration is carried out in two phases. One is **external respiration.** This consists of uptake of oxygen from the surrounding gaseous or liquid medium and elimination of carbon dioxide into that surrounding medium. This takes place by diffusion across the body surface. This other phase is **internal respiration.** This is involves three activities: (i) oxygen uptake by tissue cells, (ii) tissue oxidation by oxidising enzymes, and (iii) carbon dioxide elimination from tissue cells. Thus, aerobic respiration involves the exchange of respiratory gases at two places in multicellular animals– one between the body surface and surrounding medium, the other between the individual cells and the extracellular fluid around them.

Aerobic respiration can also be classified into the following two types:

(a) **Direct respiration: It involves the exchange of** environmental oxygen and carbon dioxide of the body cells. There is no blood (for the transport of gases) and special respiratory organs. It is based on the principle of diffusion. It occurs in aerobic bacteria, protists, sponges, cnidarians, flatworms, round worms and insects.

(b) **Indirect respiration:** There is no direct contact between the environmental oxygen and body tissue cells .It involves special respiratory organs such as gills,skin, buccopharyngeal mucosa, lungs as wells as the blood.It occurs in larger and complex animals like crustsceans,molluscs, larvae of insects, fishes, amphibians, reptiles, birds and mammals.

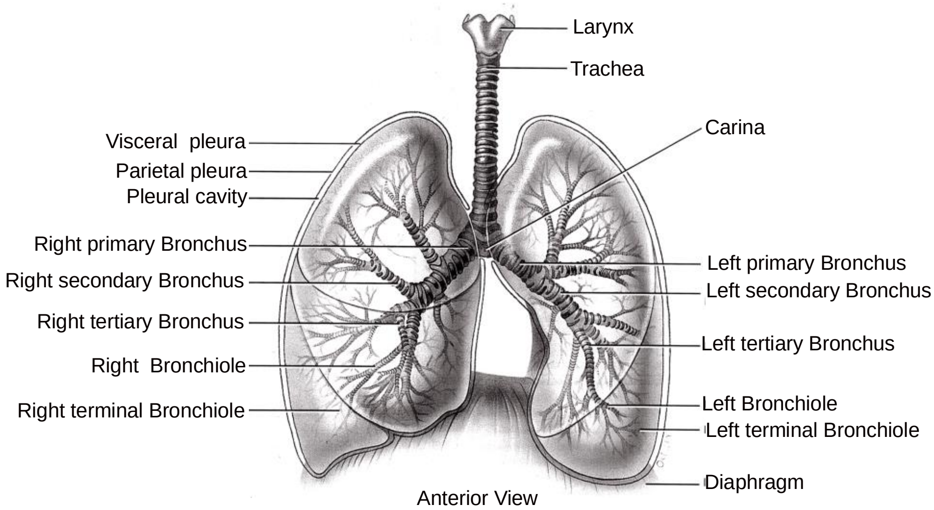
Respiratory organs in different animals

	Animal	Respiratory organ/System	Examples
1.	Lower invertebrates	No well-developed respiratory organ is present. Exchange of gases by simple diffusion.	Sponges, coelenterates, flatworms
		Moist, thin and vascular cuticle.	Earthworm
		Tracheal system (network of tubes)	Insects like cockroach.
		Gills- plate-like or filamentous and vascularised structures.	Aquatic arthropods like cray fish, prawn and mollusks like unio.
		Book lungs	Arachnids
	Vertebrates		
2.	Fishes	Gills	Cartilaginous and bony fishes
	Amphibians	Gills	Tadpole larva of frog.
		Moist skin, Lungs, Buccal cavity	Frogs, toads etc
	Reptiles	Lungs	Snakes, lizards etc
	Birds	Lungs	Pigeon, sparrow etc
	Mammals	Lungs	Humans

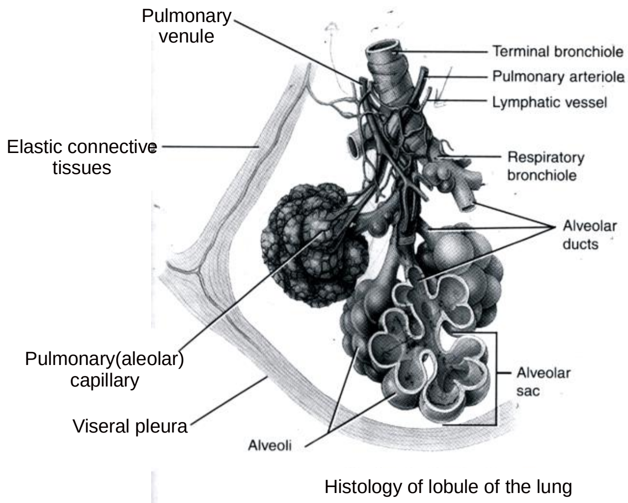
Human Respiratory system

The human respiratory system consists of the nasal cavity, nasopharynx, larynx, trachea, bronchi, bronchioles and lungs. It communicates with the exterior through the nasal openings. These lead to the cavity, opening in the posterior part of pharynx called the nasopharynx, which communicates through a cartilaginous structure called **larynx** with a long, wide cartilaginous tube called **trachea**. The trachea runs through the neck in front of the oesophagus, enters the thorax and divides into the right and left **bronchi**.These two tubes enter into two elastic and conical lungs and divide repeatedly into small bronchi within the lungs. The lungs are enclosed in double-walled sacs called **pleura**. The bronchi branch repeatedly into smaller tubes called **bronchioles.** The smallest bronchioles open into many thin-walled sacs called **alveoli.** Each alveolus is lined by a thin, highly permaeble membranous wall surrounded by many blood capillaries. The lumen of each alveolus is filled with air breathed in though nostrils. Branches of pulmonary artery supply blood to alveolar capillarires. This blood is poor in oxygen and rich in carbon dioxide. Respiratory gases are exchanged between the blood and the alveolar air by diffusion through the alveolar wall. The oxygenated blood is then returned from alveolar capillaries to pulmonary veins.

Alveoli are far more permeable and vascular than the skin. The total alveolar surface, available for gas exchanges, far exceeds the general body surface. In adult man, the surface area of skin is around 1.6 m^2 only, but the total alveolar surface area is nearly $100m^2$. So, lungs replace the skin very effectively in mammals as respiratory organs. Respiration by the lungs is termed **pulmonary respiration.**



Bronchial tree in relation to the lungs
(The bronchial tree begins at the trachea and ends at the terminal bronchioles)



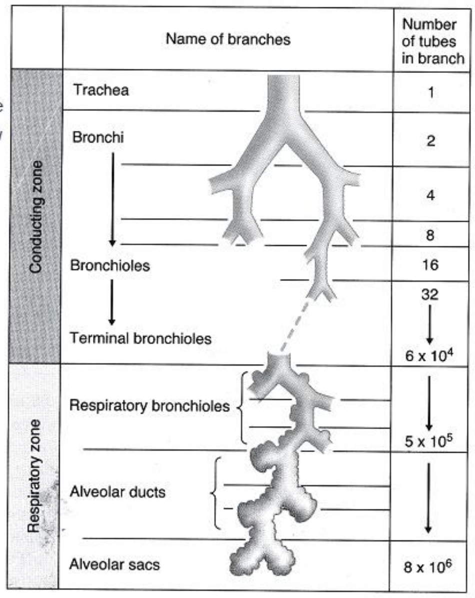
Histology of lobule of the lung

Bronchial tree

Trachea
↓
Primary bronchi < Right bronchus – short & wide; Left bronchus – long & narrow
↓
Secondary / Lobar bronchi < Right – 3; Left – 2
↓
Tertiary / Segmental bronchi < Right – 10; Left – 9
↓
Intrapulmonary bronchioles
↓
Terminal bronchioles
↓

Respiratory tree

Respiratory bronchioles
↓
Alveolar ducts
↓
Alveolar sacs
↓
Alveoli



Two parts of human respiratory system are

Conducting Part	Exchange or Respiratory part
This part consists of external nostrils, nasal chamber, internal nares, nasopharynx, larynx, trachea, bronchi and brochioles (upto terminal bronchioles)	It include alveoli and their ducts.
Functions	**Functions**
❖ Conducts air from external nostrils upto bronchioles. ❖ Clears the incoming air by trapping dust particles present in. ❖ Makes the incoming air humid by providing moisture produced by epithelium of nasal cavities. ❖ It brings the temperature of air upto the body temperature	It is the main site of human respiratory system where diffusion of gases O_2 and CO_2 occurs

Steps involves in respiration: Respiration is a complex process which occurs in number of steps. These are:

1. **Breathing:** It is simply the inhalation of atmospheric air and exhalation of CO_2 rich alveolar air. It is also known as pulmonary ventilation.

2. **Diffusion of gases between alveoli and blood:** Diffusion of gases O_2 and CO_2 takes place across the alveolar membrane to the blood capillaries surrounding it. The membrane is very thin and richly supplied with blood capillaries.

3. **Transport of gases:** Blood is the medium for transport of gases O_2 and CO_2, which transports O_2 to the body cells from alveoli and CO_2 from the body cells to alveoli.

4. **Diffusion of gases between blood and tissues:** O_2 is diffused from blood to tissues and CO_2 is diffused from tissues to blood.

5. **Utilisation of O_2:** O_2 is used by the body cells for the releases of energy. Breakdown of glucose occurs in presence of O_2 which produces CO_2, water and energy. This is also known as cellular respiration as it occurs inside the cells. It is a biochemical reaction. The CO_2 produced is eliminated out of the body. Reaction involved is

$$\underset{\substack{\text{Glucose}\\\text{(present inside}\\\text{the cells)}}}{C_6H_{12}O_6} + \underset{\text{Oxygen}}{6O_2} \longrightarrow \underset{\substack{\text{Eliminated}\\\text{out of the}\\\text{body}}}{6CO_2} + \underset{\text{Water}}{6H_2O} + \underset{\substack{\text{Utilised to}\\\text{perform bodily}\\\text{activities}}}{\text{Energy}}$$

Test your Resonance with concept

1. During hibernation frog performs
(1) Pulmonary respiration (2) Cutaneous respiration
(3) Bucco-pharyngeal respiration (4) Both cutaneous and pulmonary respiration

2. Skin is an accesory organ of respiration in
(1) Humans (2) Frog (3) Rabbit (4) Lizard

3. Diffusion of oxygen in tissues of Cockroach occurs through
(1) Blood (2) Integument (3) Tracheae (4) Tracheoles

4. Arytenoid cartilage occurs in
(1) Larynx (2) Nose (3) Hyoid (4) Sternum

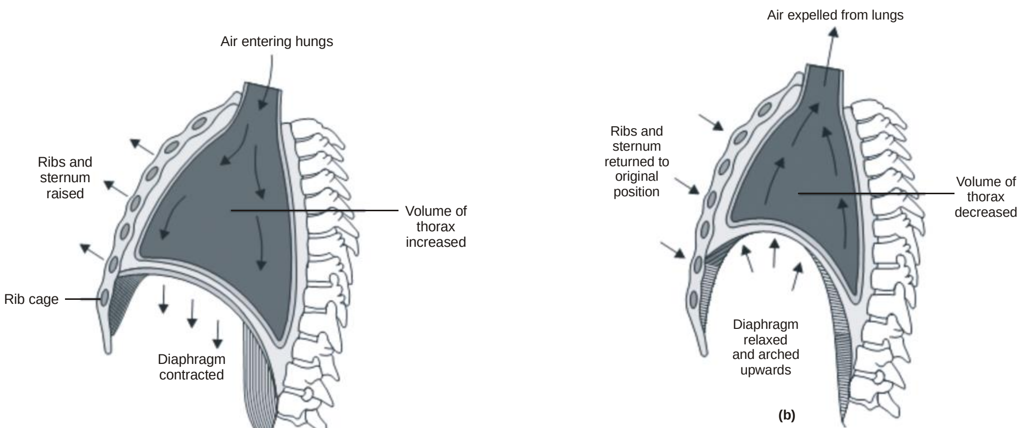
5. Covering of the lungs is called:
(1) Perichondrium (2) Pleural membrane (3) Pericardium (4) Peritoneum

Answers

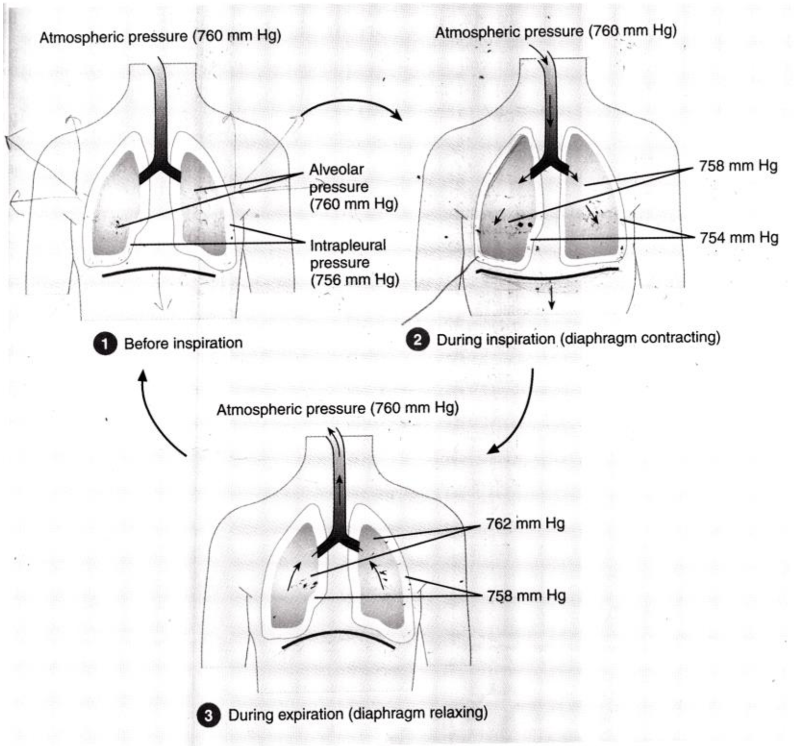
1. (2) **2.** (2) **3.** (4) **4.** (1) **5.** (2)

MECHANICS OF PULMONARY RESPIRATION

Respiration involves (i) letting in O_2 from air into the lungs and CO_2 out of the lungs by means of breathing movements (ventilation or breathing), (ii) exchange of gases on the alveolar surface, and (iii) transport and exchange of gases in the tissues. Lungs are located in the cavity of thorax. Lateral walls of thorax are mainly made of ribs and intercostal muscles attached to ribs. A muscular partition called the DIAPHRAGM separates the thoracic cavity from the abdominal cavity below. During **inspiration** (breathing in), the diaphragm and some intercostal muscles contract, due to which the diaphragm moves down towards the abdomen while the intercostal muscles move the lateral thoracic walls outward and upward. The volume of thorax increases. Because the thorax is a closed cavity, the pressure of air in it falls with the rise in its volume. Lungs being situated in the thorax, the fall of pressure in the latter lowers the pressure inside lungs a few mm of Hg below the atmospheric pressure. Air from outside rushes into the lungs through nostrils, trachea and **bronchi.** Inspiration is thus brought about by contractions of the diaphragm and some intercostal muscles; these muscles are, therefore, called **inspiratory muscles.** But **expiration** (breathing out) is ordinarily carried out passively by relaxation of diaphragm and intercostal muscles. As they relax, the diaphragm moves up towards the thorax while intercostals move the lateral thoracic walls inward and downward. The volume of thorax decreases and the pressure inside thorax and lungs is increased. This causes some air to be expelled from lungs to the atmosphere. This process of renewal of lung air by such muscular movements is called the mechanics of respiration.



Mechanism of breathing showing : (a) inspiration (b) expiration



Pulmonary Ventilation: pressure changes

Each breath consists of one inspiration and one expiration alternating with each other. The rate of respiration averages 12-16 breaths per minute in a normal adult man, at rest. Alternate inspirations and expirations are due to the rhythmic arrival and interruption of nerve impulses to inspiratory muscles.

In **forceful expiration** requiring effort, a different group of intercostal muscles and some abdominal muscles contract to reduce the volume of thorax more than that in ordinary expiration. The consequent rise of pressure in the lungs exceeds than that in ordinary expiration.So, a larger volume of air is breathed out. Such muscles are called **expiratory muscles.**

Test your Resonance with concept

1. The process of cellular respiration is concerned with
(1) Intake of O_2 (2) Liberation of O_2
(3) Liberation of CO_2 (4) Liberation of energy

2. During inspiration, the diaphragm:
(1) relaxes to become dome-shaped (2) contracts and flattens
(3) expands (4) shows no change

3. Rate of breathing in an adult human is:
(1) 10-12/min (2) 12-16/min (3) 20-25/min (4) 25-30/min

4. The structure which does not contribute to the breathing movements in mammals is:
(1) Larynx (2) Ribs (3) Diaphragm (4) Intercostal muscles

5. In expiration, diaphragm becomes
(1) Flattened (2) Relaxed (3) Straightened (4) Contracted

Answers

1. (4) **2.** (2) **3.** (2) **4.** (1) **5.** (2)

PULMONARY VOLUMES AND CAPACITIES

Measurement of pulmonary volumes is done the help of Spirometer.

(1) Tidal Volume (TV): Volume of air which is inspired or expired in normal breathing. It is 500 ml.

(2) Inspiratory reserve volume [IRV]: Volume of air which inspired forceful beyond Tidal volume. This averages 2500 mL to 3000 mL.

(3) Expiratory reserve volume [ERV]: Volume of air which expired forcefully beyond Tidal volume. This averages 1000 mL to 1100 mL.

(4) Residual volume [RV]: Volume of air which always remain in lungs after forceful expiration. It can not expired in any condition. This averages 1100 mL to 1200 mL.

(5) Vital capacity of lungs [VC]: Volume of air which expired forcefully after forceful inspiration.

Vital capacity = IRV + ERV + TV
= 2500 - 3000 + 1000 - 1100 + 500
= 4100 - 4600 ml

(6) Inspiratory Capacity [IC]: IRV + TV
= 2500 - 3000 + 500 = 3000 - 3500 ml

(7) Functional Residual Capacity (FRC): Volume of air that will remain in the lungs after a normal expiration. This includes ERV + RV
1000 - 1100 + 1100 - 1200 = 2100 - 2300 ml

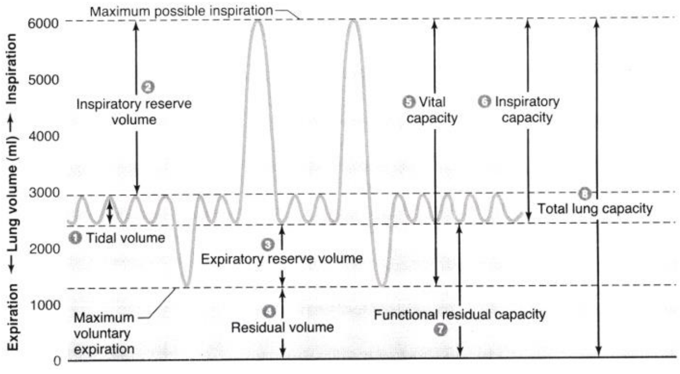
(8) Total capacity of lungs:
Volume of air which can be filled in lungs.
Total capacity = Vital capacity + RV
= 4000 - 4600 + 1100 - 1200 = 5100 - 5800 ml

(9) Dead Space Volume: Complete volume of fresh air do not take part in gaseous exchange, while a part of this air retain in respiratory tract from external nostrils to terminal bronchiole called **dead space volume. It is 150ml.**

(10) Minute respiratory volume:
Volume of air which is inspired or expired per minute in normal breathing.
It is 500 x 12 - 16 = 6000 - 8000 ml.

(11) Alveolar ventilation:
Volume of fresh air which take part in gaseous exchange per minute.
It is 350 x 12 - 16 = 4200 - 5600 ml.

(12) Expiratory Capacity (EC):
Total volume of air a person can expire after a normal inspiration. This includes tidal volume and expiratory reserve volume (TV + ERV) = 500 + 1000 - 1100 = 1500 - 1600 ml.



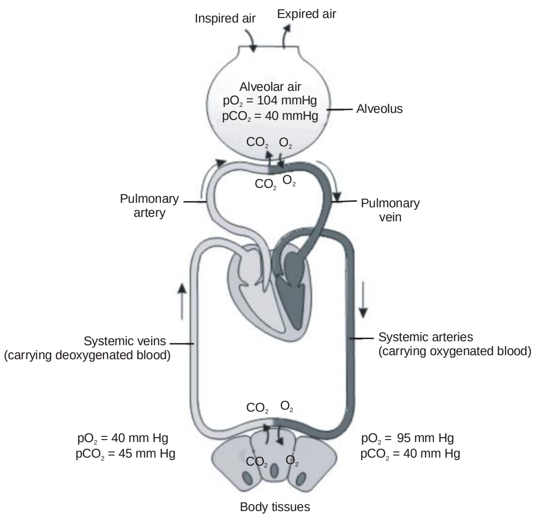
PULMONARY EXCHANGE OF GASES

In man, external respiration takes place between the blood in alveolar capillaries and the alveolar air drawn from the atmospheric air. The atmospheric air contains about 21 per cent oxygen. 0.04 percent carbon dioxide, 78.6 percent nitrogen and small amounts of other gases and aqueous vapour. In the atmospheric air and consequently in the inspired air, partial pressures of oxygen (pO_2) and of carbon dioxide (pCO_2) normally amount to 158 and 0.3 mm Hg, respectively, at the sea level. The lungs, into which the inspired air collects, contain some gases even at the end of expiration. But this air contains less oxygen and more carbon dioxide than that of the inspired air. Because the inspired air mixes with this air in alveoli, the alveolar air comes to contain less oxygen and more carbon dioxide than that of the inspired air. When inspired air mixes with the already present alveolar air, the oxygen content and the pO_2 of the alveolar air increase to about 13.6 per cent and 104 mm Hg, respectively, while the carbon dioxide content and the pCO_2 of the alveolar air decrease to about 5.3 per cent and 40 mm Hg, respectively.

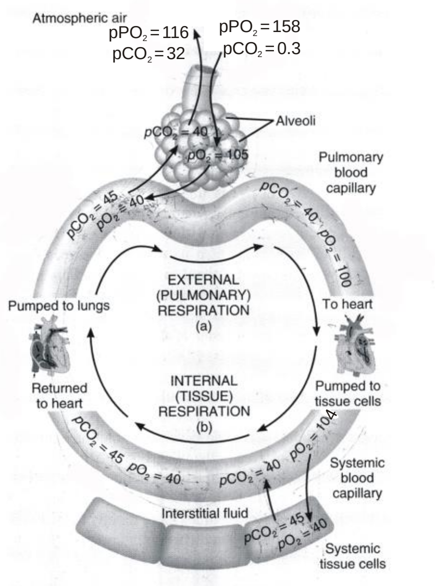
The pulmonary artery contains venous (deoxygenated) blood which it brings to the alveolar capillaries supplying the alveoli. This blood has a pO_2 which is much lower than the alveolar pO_2. So, oxygen diffuses from the alveolar air to the capillary blood. This oxygenated blood is collected from alveoli of the lungs by pulmonary veins. It has a pO_2 of about 95 mm Hg. At this pO_2, arterial blood contains 19.8 per cent oxygen.

PARTIAL PRESSURES (mm Hg) OF RESPIRATORY GASES						
Gas	**Inspired air**	**Alveolar air**	**Venous blood**	**Arterial blood**	**Tissues**	**Expired air**
Oxygen	158	104	40	95	40	116
Carbon dioxide	0.3	40	45	40	45	32

The venous (deoxygenated) blood, reaching the alveolar capillaries, has a pCO_2 of 45 mm Hg which is higher than the alveolar pCO_2 of 40 mm Hg. So, carbon dioxide diffuses from the alveolar capillary blood to the alveolar air until the blood pCO_2 falls to 40 mm Hg. This lowers the carbon dioxide content of the blood from 52.7 per cent in the venous blood to 49 per cent in the arterial blood. Thus the alveolar air gives up the oxygen received from the inspired air to the blood in pulmonary vein and picks up CO_2 from the blood of pulmonary artery.



Diagrammatic representation of exchange of gases at the alveolus and the body tissues with blood and transport of oxygen and carbon dioxide



Changes in partial pressures (in mm Hg) during external and internal respiration

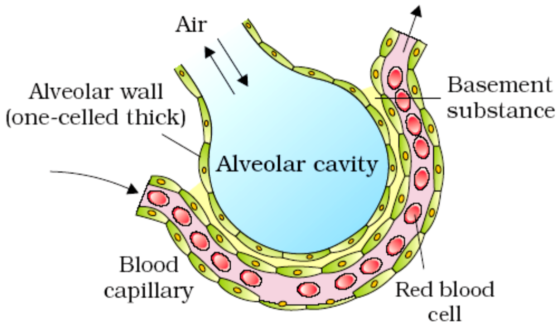


Figure - A diagram of a section of an alveolus with a pulmonary capillary.

Factors that affect the rate of diffusion

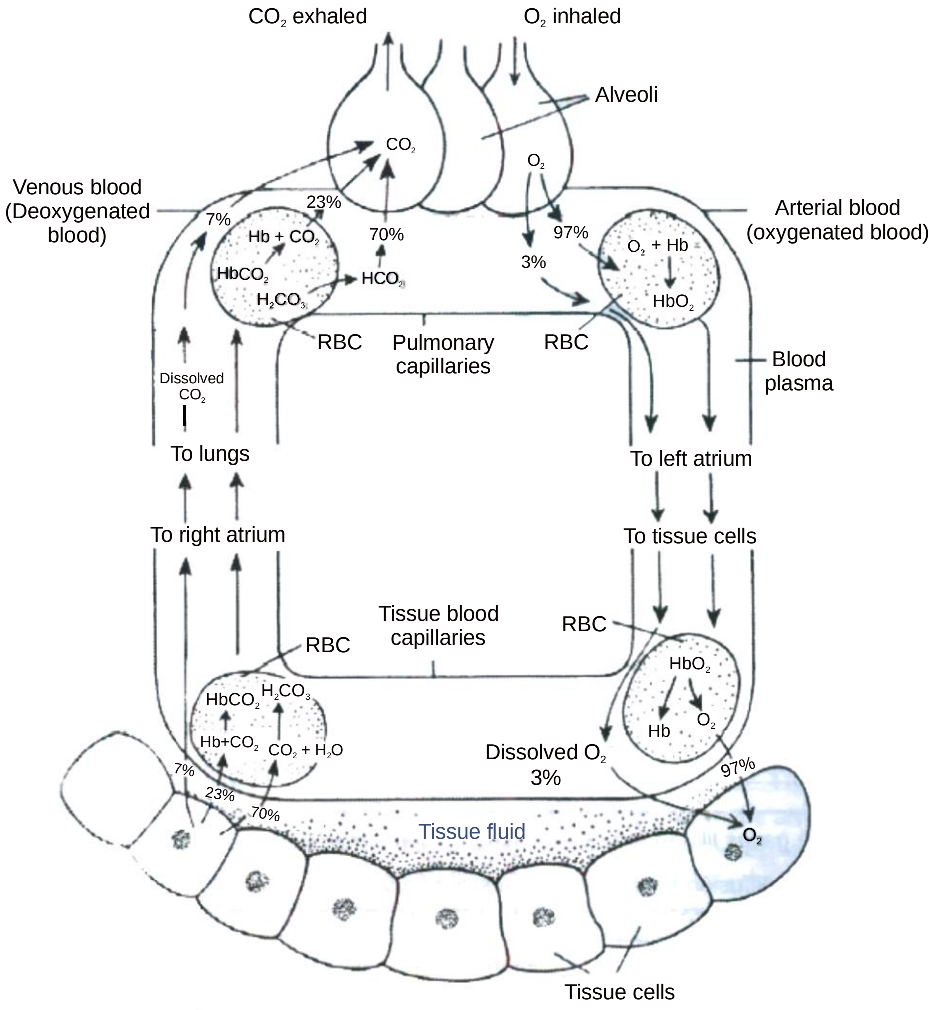
1. **Solubility of gases:** Solubility of partial pressure of Gas. A gas having high solubility, diffused at faster rate than the gas having low solubility. For example, solubility of CO_2 is 20-25 times higher than that of O_2, the amount of CO_2 that diffuses across diffusion membrane is much higher than that of O_2. [Henery's law]
2. **Partial pressure:** As we know that gases are diffused according to their partial pressure. For example O_2 is diffused from atmospheric air having partial pressure 159 mm Hg to the alveoli where pO_2 is less i.e., 104 mm Hg. [Dalton's law] $p = pN_2 + pO_2 + p$ other gases.
3. **Thickness of membrane:** More the thickness of membrane, less will be the rate of diffusion. More the membrane thin, more will be the rate of diffusion. For efficient diffusion to occur, membrane should be very thin.
4. Molecular weight of gases - Molecular weight of CO_2 is 1.6 x more than O_2.

GAS TRANSPORT IN BLOOD

Oxygen Transport: Very little of oxygen or carbon dioxide gets dissolved in the plasma to be carried in solution. Most of them is carried in chemical combinations in the erythrocytes (RBC) or in the plasma.

Of about 4.6 ml of oxygen entering each decilitre of blood in the lungs, only 0.17 ml remains in solution in the plasma. Oxygen diffuses into erythrocytes and combines loosely with the Fe^{2+} ions of haemoglobin to form oxyhaemoglobin. Each of the four Fe^{2+} ions in the haemoglobin molecule can bind with one molecule of oxygen; so, oxyhaemoglobin carries 1-4 molecules of oxygen according to its degree of saturation with oxygen. In the arterial blood haemoglobin is normally 97 per cent saturated with oxygen. The oxygenation of haemoglobin in the lungs depends on the arterial pO_2 and so, on the alveolar pO_2. Moreover, the oxygen affinity of haemoglobin is enhanced with the fall in the blood pCO_2, resulting from the elimination of carbon dioxide from the blood in the lungs. In the pulmonary alveoli, haemoglobin is exposed to high pO_2 and a low pCO_2. The combined effects of these two factors enable haemoglobin to take up large volumes of oxygen in the lungs.

Oxyhaemoglobin does not dissociate before blood reaches tissue capillaries. So blood carries its full load of oxygen until it enters the capillaries in the tissue. The more active the tissue, the lower is its pO_2 and the higher is its pCO_2. Both these factors combine to affect a dissociation of oxyhaemoglobin to deoxyhaemoglobin and molecular oxygen.The pO_2 is much lower and the pCO_2 is much higher in an active tissue than in a less active one. So, far more oxygen is released from oxyhaemoglobin in a more active tissue than in a less active one. Each decilitre of blood releases up to 4.6 ml. of oxygen in the tissues, 4.4 ml from oxyhaemoglobin and 0.17 ml from the dissolved oxygen in the plasma.



Transport of oxygen and carbon dioxide

Carbon Dioxide Transport: Most of the carbon dioxide produced in a tissue enters the red blood cells by diffusion. More carbon dioxide enters the blood from a more active tissue than from a less active one. Each decilitre (100 ml) of blood receives an average 3.7 ml of carbon dioxide from tissues. Some carbon dioxide gets dissolved in the plasma and is carried in solution and the rest enters the erythrocytes by diffusion. About 70 per cent of the carbon dioxide entering into the erythrocytes, reacts with water to from **carbonic acid.**

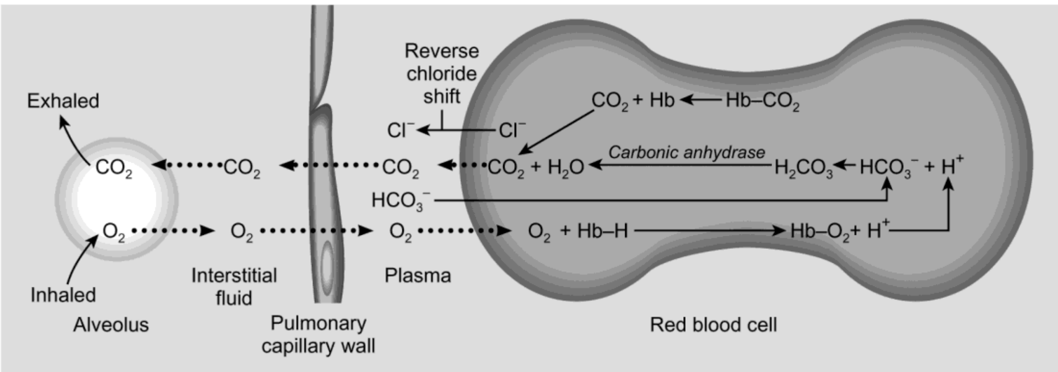
$$CO_2 + H_2O \xrightleftharpoons{C.A.} H_2CO_3$$

This reaction is catalysed by a zinc containing enzyme, called **carbonic anhydrase.** In erythrocytes, carbonic acid forms bicarbonate:

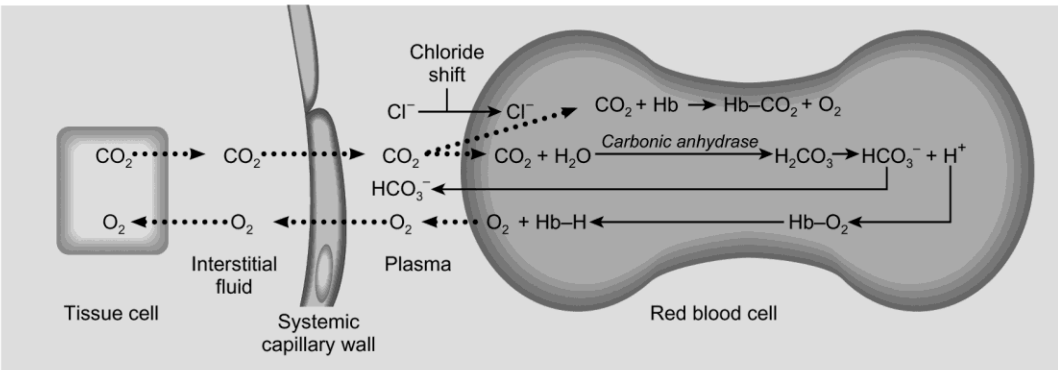
$$H_2CO_3 \xrightleftharpoons{C.A.} H^+ + HCO_3^-$$

Some of the bicarbonate $\left(HCO_3^-\right)$ is carried in erythrocytes while most of its comes out in the plasma to be carried by it. About 22-23 per cent of carbon dioxide, entering the erythorcytes, combines with the globin part of deoxyhaemoglobin to form carbaminohaemoglobin. Carbon dioxide is thus carried in the blood in three major forms: bicarbonates in plasma and erythrocytes, carbaminohaemoglobin in erythrocytes, and small amounts of dissolved carbon dioxide in plasma. The entry of carbon dioxide into the blood from tissues, increases the pCO_2 of the blood. Compared to the arterial pCO_2 of 40 mm Hg, the venous blood has a pCO_2 of 45 mm Hg.

On reaching the lungs, blood is oxygenated. Oxyhaemoglobin is a stronger acid than deoxyhaemoglobin. So it donates H+ which joins bicarbonate (HCO_3^-) to form carbonic acid. The latter is cleaved to water and carbon dioxide by carbonic anhydrase. Thus, carbon dioxide is released from bicarbonate. Oxygenation of haemoglobin simultaneously releases carbon dioxide from carbaminohaemoglobin also, because oxyhaemoglobin cannot hold as much carbon dioxide as deoxyhaemoglobin. In this way, every decilitre of blood releases, about 3.7 ml of carbon dioxide in the lungs. This CO_2 is removed from the lungs during expiration.



(a) Exchange of O_2 and CO_2 in pulmonary capillaries (external respiration)



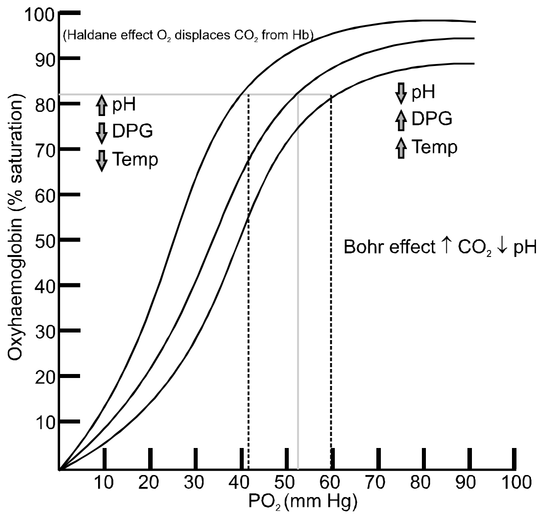
(b) Exchange of O_2 and CO_2 in systemic capillaries (internal respiration)

Gas Exchange in Tissues

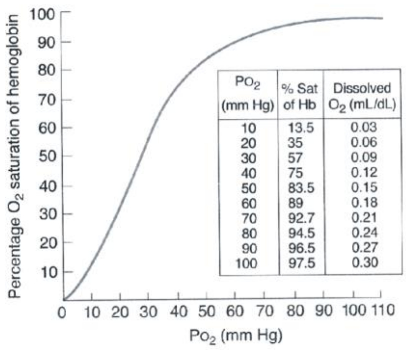
As in the lungs, so also in the tissues, gases are exchanged by diffusion. Tissue cells use up oxygen during their activities. So, in the tissue fluid around the cells, pO_2 falls below the arterial pO_2.Consequently, oxygen is released from oxyhaemoglobin and diffuses from the capillary blood to the tissue fluid and then, to the cells of the tissue. Carbon dioxide diffuses from the cells to the tissue fluid to raise is pCO_2 above the arterial pCO_2. This enables carbon dioxide to diffuse from the tissue fluid to the capillary blood. Unlike the blood, tissue fluids do not carry these gases in chemical combinations such as oxyhaemoglobin, carbaminohaemoglobin or bicarbonate. Only small amounts of the gases are held in solution in the tissue fluid while most of them diffuse as such through it.

Oxygen haemoglobin dissociation curve

The relationship between oxyhaemoglobin saturation and oxygen tension is called **oxygen dissociation curve**. It is sigmoid. For myoglobin of muscles, the oxygen dissociation curve is **hyperbolic**. Oxygen haemoglobin dissociation curve shifts to **right** by **increase** in H+ concentration, CO_2CO_2 tension, 2, 3-diphosphoglycerate in RBCs (DPG formed in RBCs during glycolysis), temperature and fall in pH which lowers the affinity of haemoglobin for oxygen.

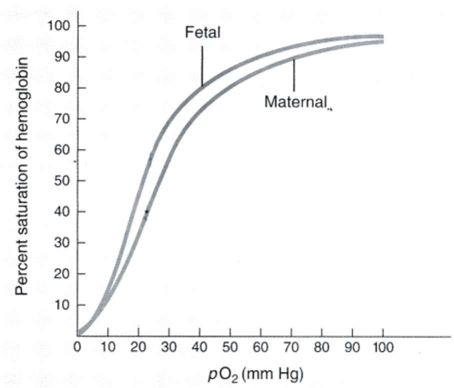


Oxygen hemoglobin dissociation Curve



Po_2 (mm Hg)	% Sat of Hb	Dissolved O_2 (mL/dL)
10	13.5	0.03
20	35	0.06
30	57	0.09
40	75	0.12
50	83.5	0.15
60	89	0.18
70	92.7	0.21
80	94.5	0.24
90	96.5	0.27
100	97.5	0.30

Oxygen hemoglobin dissociation curve at normal body temperature showing the relationship between hemoglobin saturation and Po_2



Oxygen hemoglobin dissociation curves comparing fetal and maternal hemoglobin

Test your Resonance with concept

1. Oxygen is transported in vertebrates as
(1) Dissolved in plasma (2) Complex with haemoglobin
(3) Dissolved in cytoplasm of erythrocytes (4) Absorbed over the RBC.

2. Bicarbonate ion is produced inside
(1) Lymphocytes (2) Erythrocytes (3) Neutrophils (4) Basophils

3. Blood cells possess CO2 in the form
(1) $NaHCO_3$ (2) H_2CO_3 (3) Hb-CO_2 (4) Hb-CO_2 and Hb-CO

4. Exchange of O_2 and CO_2 at the respiratory surface occurs through
(1) Facilitated transport (2) Active transport
(3) Osmosis (4) Diffusion.

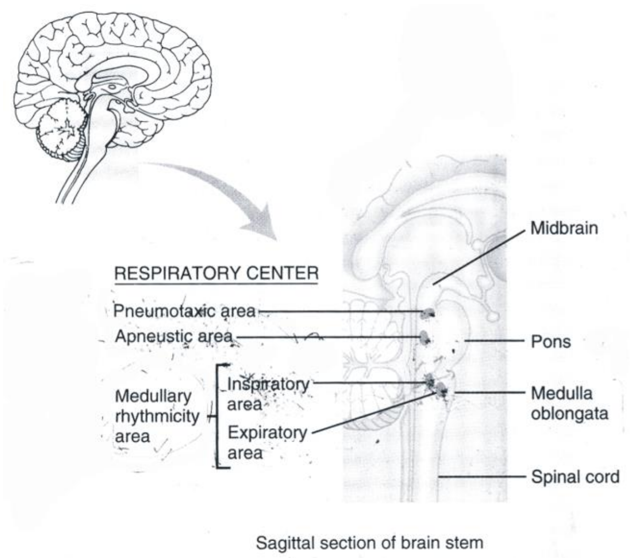
5. Dissociation curve is connected with
(1) Carbonic anhydrase (2) Carbon dioxide
(3) Oxygen (4) Oxyhaemoglobin

Answers

1. (2) **2.** (2) **3.** (3) **4.** (4) **5.** (4)

REGULATION OF RESPIRATION

Human beings have a significant ability to maintain and moderate the respiratory rhythm to suit the demands of the body tissues. This is done by the neural system. A specialised centre present in the medulla oblongata of the brain called respiratory rhythm centre is primarily responsible for this regulation. Another centre present in the pons varolii of the brain called pneumotaxic centre can moderate the functions of the respiratory rhythm centre. Neural signal from this centre can reduce the duration of inspiration and thereby alter the respiratory rate. A chemosensitive area is situated adjacent to the rhythm centre which is highly sensitive to CO_2 and hydrgeon ions. Increase in these substances can activate this centre, which in turn can signal the rhythm centre to make necessary adjustments in the respiratory process by which these substances can be eliminated. Receptors associated with aortic arch and carotid artery also can recognise changes in CO_2 and H^+ concentration and send necessary signals to the rhythm centre for remedial actions. The role of oxygen in the regulation of respiratory rhythm is quite insignificant.



Location of areas of the respiratory center

Functions of areas in the respiratory centre:

1. The medullary rhythmicity area contains two regions–The inspiratory area and expiratory area.
2. Nerve impulses arising in the inspiratory area establish the basic rhythm of respiration.
3. Neurons in the expiratory area are inactive during quiet respiration but cause contraction of the internal intercostal and abdominal muscles during forceful expiration.
4. The pneumotaxic area sends inhibitory impulses to the inspiratory area to limit inspiration and brings about expiration.
5. The apneustic area sends stimulatroy impulses to the inspiratory area to prolong inspiration when the pneumotaxic area is inactive.

Respiratory Disorders

1. **Tuberculosis:** Bacterial disese caused by *Mycobacterium tuberculosis*. Infection of several parts but common of lungs. Vaccination with B.C.G (Bacillus-Calmette-Guerin).
2. **Bronchial Asthma:** Due to narrowing of bronchi and spasms in bronchial muscles. The disorder is generally due to hypersensivity of bronchioles to a foreign substances. There is intense coughing and difficulty in exhalation.
   Mucous glands become overactive producing a lot of mucus that clogs bronchioles and bronchi. Exposure to allergens should be avoided. In case the sensitivity is to one or two allergens, hyposensitisation by giving very small doses of allergens is used as a preventive measure. Bronchodilators, inhalers and antibiotics are given for relief and protection against infection.

3. **Bronchitis:** Inflammation of bronchi and bronchioles due to hypertrophy and hyperplasia of seromucous glands and goblet cells. There is a regular coughing with thick greenish yellow sputum indicating infection and excessive secretion of mucus. It is commonly caused by viral infection of nasal tract followed by bacterial infection. The disorder is common in smokers and persons exposed to CO- rich polluted air. Persons suffering from bronchitis should avoid smoke, irritating chemicals and pollutants. Bronchodilators provide symptomatic relief. Antibiotics are used to cure infection.
4. **Emphysema:** Cigarette-smoking leads to the disease emphysema. Many alveoli collapse together to form large chambers due to destruction of their walls. This change of smaller alveoli to large chambers reduces the area of alveolar surface across which respiratory gases are exchanged. All these changes seriously reduce both oxygen uptake and carbon dioxide elimination. Years of smoking may aggravate the condition acutely to suffocate the patient of death.
5. **Occupational Lung Disease:** Irritating gases, fumes and dusts present in the work place result in lung disorders. In **pneumoconiosis** there is permanent deposition of particulate matter in the lungs. Tissue reaction to the irritating substances causes proliferation of fibrous connective tissue called **fibrosis**. It is common in flour mill workers, iron mill workers, coal miners, stone grinders (silicosis), asbestos industry workers (asbestosis), cotton mill workers, plastic industry, etc. The disease takes a long time to express its symptoms, sometimes 10–15 years. By this time the lungs come to suffer permanent damage. Therefore, occupational lung disease is largely incurable. However, bronchodilators provide some relief while antibiotics cure secondary infections. It is always advisable to undertake preventive measures in work places involving pollution risks by (i) Reducing emission of harmful dust and chemicals. (ii) Using protective gears and clothing. (iii) Short duties. (iv) Informing workers about the risks and preventive measures. (v) Regular health check up.

Test your Resonance with concept

1. Asphyxia occurs due to the combination of

(1) hypoxia and hypercapnea (2) hypoxia and hypocapnea
(3) hyperoxamia and hypocapnea (4) hyperoxamia and hypercapnea

2. Reduction in respiratory surface of the lungs due to the break down of partition in the alveoli is known as

(1) Asphyxia (2) Bronchitis (3) Asthma (4) Emphysema

3. Match the columns I and II.

Column-I	**Column-II**
(a) Asthma	(i) Inflammation of the nasal tract
(b) Bronchitis	(ii) Constriction of bronchi
(c) Rhinitis	(iii) Abnormal distension of alveoli
(d) Emphysema	(iv) Inflammation of bronchi
	(v) Cough with blood stained sputum

(1) a - iv , b - ii, c - v, d - i (2) a - v , b - iii, c - ii, d - i
(3) a - iii , b - i, c - v, d - iv (4) a - ii , b - iv, c - i, d - iii

4. Infiammation of the covering of the lungs causing severe chest pain is termed as

(1) Emphysema (2) Pleurisy (3) Asphyxia (4) Hypoxia

5. Apnoea refers to the

(1) Decreased ventilation (2) Absence of breathing
(3) Laboured breathing (4) Increased ventillation

Answers

1. (1) **2.** (4) **3.** (4) **4.** (2) **5.** (2)

ADDITIONAL INFORMATION

Haldane effect: Proposed by JS Haldane, it states that binding of oxygen with haemoglobin tends to displace carbon dioxide from blood. It is quantitatively far more important in promoting CO_2 transport than the Bohr Effect in promoting O_2 transport.Haldane effect encourage CO_2 exchange in both the tissue and the lungs.

Bohr Effect: The **Bohr Effect** is a physiological phenomenon first described in 1904 by the Danish physiologist Christian sBohr, stating that *haemoglobin*'s oxygen binding affinity is inversely related both to acidity and to the concentration of carbon dioxide.

MOUNTAIN SICKNESS

When a person living on plains ascends and stays on a mountain above 8000 ft from sea level, he develops certain symptoms in 8-24 hours. These symptoms include breathlessness, headache, dizziness, irritability, nasusea, vomiting, mental fatigue and a bluish tinge on the skin, nails and lips. This is known as mountain sickness.

You know that the barometric pressure falls progressively with the rise in altitude. Simultaneously, pO_2, falls proportionately in the atmospheric air. This lowers the alveolar pO_2 and consequently reduces the diffusion of oxygen from the alveolar air to the blood. So, oxygenation of blood is decreases progressively with the rise in altitude. The fall in oxygenation of blood produces the symptoms of mountain sickness.

All tissues are not equally affected by the shortage of oxygen. The more active a tissue, the more it is affected. So, skeletal muscles, heart and brain are much more affected than skin, intestine and bones.

CARBON MONOXIDE POISONING

If a person sleeps in a closed room with a lamp burning, the absence of sufficient amount of oxygen causes an incomplete combustion of carbon and produces carbon monoxide in the room. As the person Inhales carbon monoxides, it diffuses from the alveolar air to the blood and binds to haemoglobin forming carboxyhaemoglobin. The latter is a relatively stable compound and cannot bind any oxygen. So, the amount of haemoglobin available for oxygen transport is reduced. The resulting deficiency of oxygen causes headache, dizziness, nausea and even death.

DECOMPRESSION SICKNESS

The pressure of water rises progressively with the depth in the sea. When a diver descends to great depths, his body is subjected to high pressure by the surrounding sea water. This tends to collapse his lungs unless he breathes compressed air under high pressure. But breathing of air at high pressure increases the partial pressures of gases in alveolil, As nitrogen forms about 79 per cent of the air, the rise in alveolar nitrogen tension affects the body most. While at the depth, much nitrogen diffuses and dissolves in the blood and body fats. This makes the diver lose his strength and work capacity, and feels drowsy. But more severe symptoms develop if he is lifted rapidly to sea surface (decompression sickness). With the rapid fall in pressure, nitrogen is evolved from his body fluids and forms gas bubbles in the blood and tissues. Nitrogen bubbles may block pulmonary vessels producing serous shortness of breath. Itchings and local pain result from bubbles in peripheral nerves. Dizziness, paralysis and mental dearrangement may be caused by bubbles in the vessels of brain and spinal cord. To avoid decompression sickness, the diver should be lifted very slowly to the sea surface, nitrogen will then be evolved very slowly and will be effectively removed without forming bubbles.