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RESPIRATORY SYSTEM

INTRODUCTION:

The aerobic life, characteristics of most animals, needs a steady flow of oxygen into the cell of the body and also a ready elimination or removal of the carbon dioxide. This is required to derive energy for various metabolic processes.

Respiration is the complex of processes by which an organism meets its requirements of oxygen and eliminates carbon dioxide. In man and the higher animals it comprises the following processes:-

1. Exchange of the air between the external environment and the pulmonary alveoli (external respiration).
2. Exchange of gases between the alveolar air and the blood flowing along the pulmonary capillaries (diffusion of gases in the lungs).
3. Transport of gases by the blood.
4. Exchange of gases between blood and tissues through the tissue capillaries (diffusion of gases in the tissues).
5. Consumption of oxygen by cells and the elimination of carbon dioxide (cell or internal respiration).

ORGANS IN RESPIRATORY SYSTEM:

1. **Nasal cavity** – It is a large, air filled space in the skull above and behind the nose in the middle of the face. As inhaled air flows through the nasal cavity it is warmed and humidified. Hairs in the nose help trap larger foreign particles in the air before they go deeper into the respiratory tract. Also helps in sense of smell.

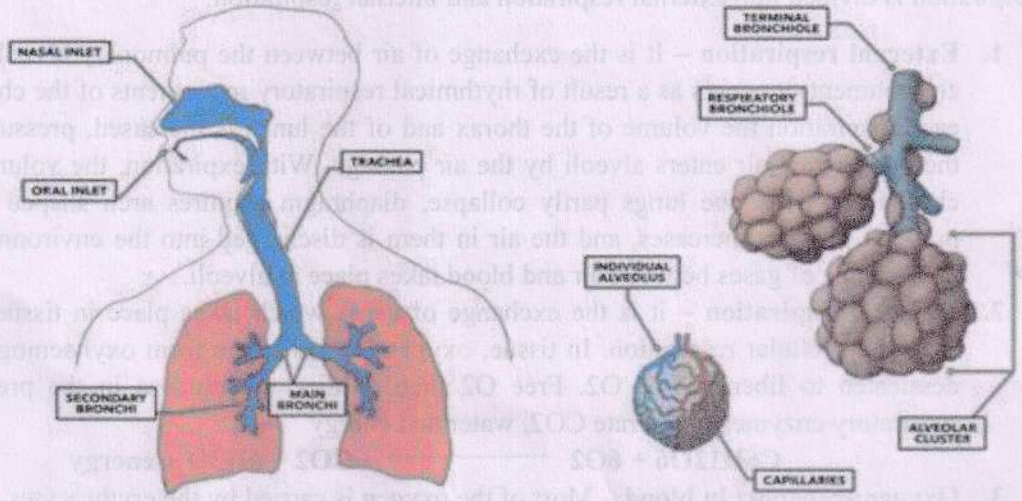
2. **Pharynx** – It is a tube like structure that connects the nasal cavity and the back of the mouth to other structures lower in the throat, including the larynx. It has dual functions: both air and food pass through it, so it is part of both the respiratory and digestive systems.

3. **Larynx** – The larynx connects the pharynx and trachea and helps to conduct air through the respiratory tract. The larynx is also called as voice box because it contains vocal cord. It also helps in protecting the trachea from aspirated food. When swallowing occurs, the backward motion of the tongue forces a flap called the epiglottis to close over the entrance to the larynx to keep food and liquid out of our airways.

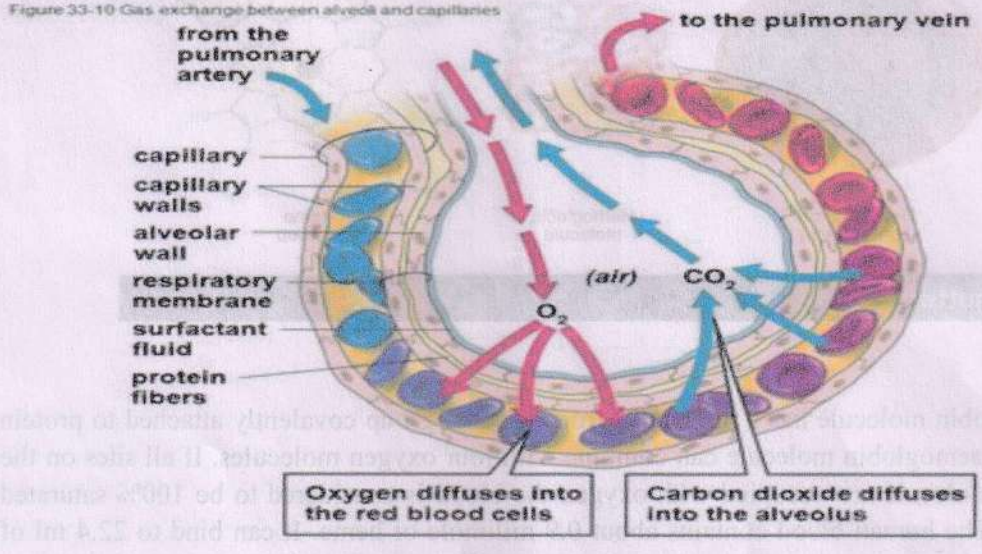
4. **Trachea** – it is the widest passageway in the respiratory tract. The trachea connects the larynx to the lungs for the passage of air through the respiratory tract. It branches at bottom to form two branchial tubes.

5. **Bronchi and bronchioles** – there are two main bronchial tubes called the right and left bronchi. The bronchi carry air between the trachea and lungs. Each bronchus branches and divides into secondary bronchi, tertiary bronchi and smallest bronchioles. The bronchioles terminates in clusters of air sacs called as alveoli in the lungs.

6. **Lungs** – The lungs are placed in thoracic cavity and invested by a double layer of coelomic epithelium called *pleura.* Each of the two lungs is divided into sections which are called as lobes and they are separated from each other by connective tissue. The right lung is larger and contains three lobes. The left lung is smaller and contains only two lobes. In lungs there are tiny air sacs called alveoli which are functional units of lungs where gas exchange takes place.



MECHANISM OF RESPIRATION:-

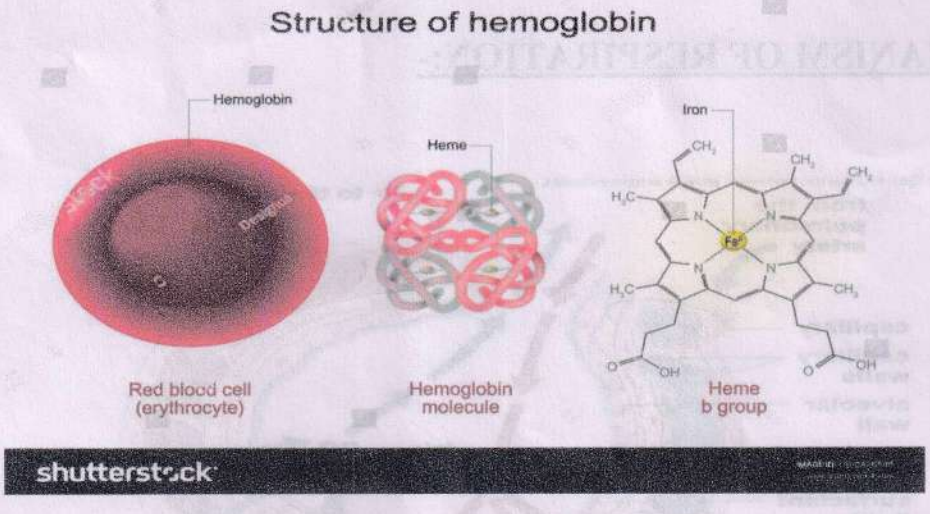


Respiration is divided into external respiration and internal respiration.

1. **External respiration** – It is the exchange of air between the pulmonary alveoli and the environment. It occurs as a result of rhythmical respiratory movements of the chest. With each inspiration the volume of the thorax and of the lungs is increased, pressure within them falls, and air enters alveoli by the air passage. With expiration, the volume of the chest is reduced, the lungs partly collapse, diaphragm acquires arch shaped position, pressure in them increases, and the air in them is discharged into the environment. The interchange of gases between air and blood takes place in alveoli.
2. **Internal respiration** – it is the exchange of gases which takes place in tissue, so also known as cellular respiration. In tissue, oxygen carried in the form oxyhaemoglobin get dessicated to liberate free O2. Free O2 then oxidize the glucose in the presence of respiratory enzymes to liberate CO2, water and energy

   $C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$ + energy
3. **Oxygen transport in blood** – Most of the oxygen is carried by the erythrocytes. Only 0.3 volume percent of the total 19 volume percent of oxygen extracted from arterial blood is dissolved in the plasma; the remainder is contained in the erythrocytes in the form of an oxyhaemoglobin (HbO_2).

   $Hb + O_2 \longleftrightarrow HbO_2$

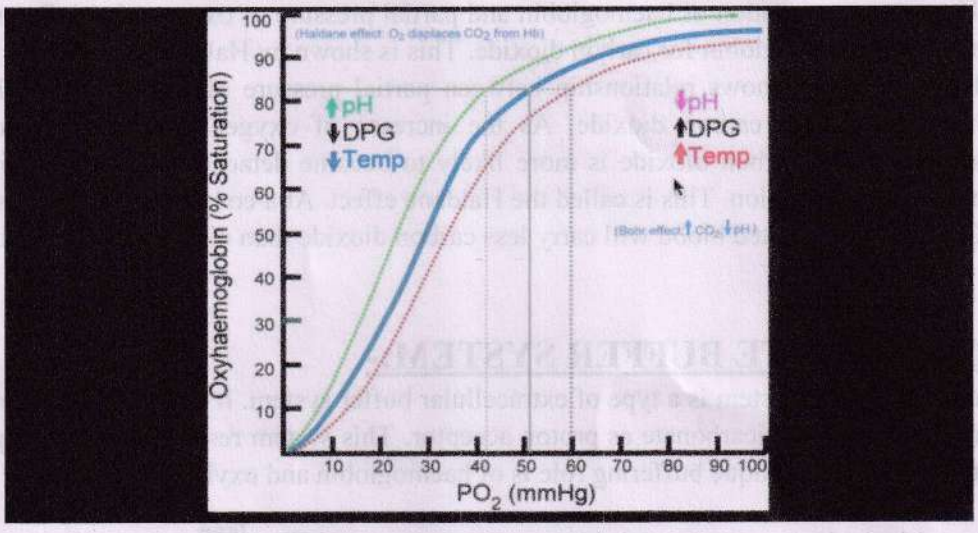


Each haemoglobin molecule has a prosthetic group – heme group covalently attached to protein globin. Each haemoglobin molecule can combine with four oxygen molecules. If all sites on the haemoglobin molecule are occupied with oxygen the blood is considered to be 100% saturated with oxygen. The human blood contains about 0.9 milimole of heme. It can bind to 22.4 ml of oxygen. Therefore the oxygen carrying capacity is 0.9 x 22.4 = 20.2% (v/v).

Oxygen diffuses across the alveoli, it enters the bloodstream, and is transported to the tissues where it is unloaded. Partial pressure is the fraction contributed by a gas. The pO2 and pCO2 of alveoli

is 100 mm Hg and 36mm Hg respectively. The pO2 and pCO2 of venous blood is approximately 40 and 46 mm Hg respectively. The difference in pressure allows passage of oxygen from pulmonary alveoli to venous blood which is thus oxygenated.

The relationship between present saturation of the respiratory pigment haemoglobin with oxygen and the partial pressure of oxygen is given by **oxygen dissociation curve or Oxyhaemoglobin-dissociation curve.** The resulting graph is sigmoidal or S shaped. As the partial pressure of oxygen increases, the haemoglobin becomes increasingly saturated with oxygen. When pO2 is zero, oxyhaemoglobin loses all its oxygen.



Factors that affect oxygen binding:-

1. pO2
2. pCO2
3. Blood pH –
   The **Bohr effect** is a phenomenon that arises from the relationship between pH and oxygen's affinity for haemoglobin. Increase in CO2 concentration in blood causes reduction in pH (more acidic pH). A lower pH cause reduction in oxygen affinity of haemoglobin so promotes oxygen dissociation and higher pH inhibits oxygen dissociation from haemoglobin. A fall in pH of blood shift the oxygen haemoglobin dissociation curve to the right. This is called as Bohr effect.
4. Body temperature –
   Higher temperature promotes dissociation while lower temperature inhibits dissociation.
5. Electrolytes
6. Certain hormones that stimulate production of BPG (2,3-bisphosphoglycerate) – BPG promotes dissociation of oxygen from haemoglobin.

3. Carbon dioxide transport –

- CO2 is transported in bloodstream from tissue to lungs by three mechanisms:-
  as carbonic acid (7%),
  as bicarbonate ions in the plasma (70%),
  as carbaminohaemoglobin (23%).

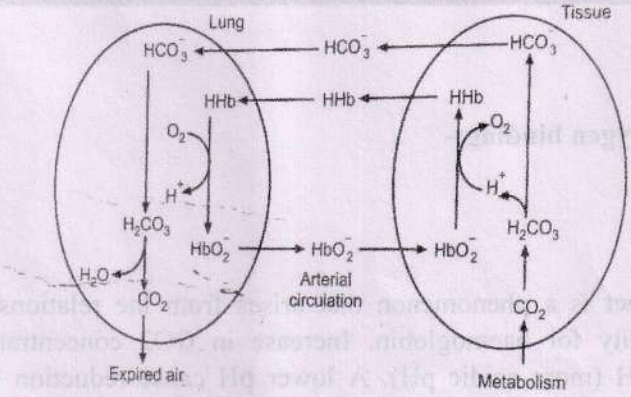
Carbon dioxide diffuses out of the blood and into the alveoli to be expelled from the body. Difference of pressure of CO2 between venous blood and alveoli (10 mm Hg) allows the diffusion of CO2 from venous blood to alveoli.

The oxygen saturation of haemoglobin and partial pressure of oxygen also influences the affinity of haemoglobin for carbon dioxide. This is shown by Haldane effect.

Haldane effect shows relationship between partial pressure of oxygen and affinity of haemoglobin for carbon dioxide. As the increase of oxygen increases haemoglobin saturation, the carbon dioxide is more likely to become detached and diffused into the alveoli for exhalation. This is called the Haldane effect. At a consistent partial pressure of CO2, the oxygenated blood will carry less carbon dioxide than deoxygenated blood.

- **BICARBONATE BUFFER SYSTEM:-**

Bicarbonate buffer system is a type of extracellular buffer system. It consists of carbonic acid as proton donor and bicarbonate as proton acceptor. This system resists any pH change. The most important and unique buffering role is of haemoglobin and oxyhaemoglobin.



Chloride shift :- When blood gets loaded with CO2 at the level of tissues, CO2 enters in red blood cells and H_2CO_3 is formed in presence of carbonic anhydrase. The dissociation of H_2CO_3 leads to the formation of H^+ and HCO_3^-. The excess of HCO_3^- ions diffuse out of the red blood cells into the plasma and in exchange Cl^- ions enter into the red blood cells in order to maintain electrical neutrality. This exchange of HCO_3^- and Cl^- ions is called ***the Chloride shift or Hamburger's phenomenon.***

- **Terminologies –**

1. **Tidal volume:-**

The volume of air inspired and expired during normal breathing is called tidal volume and is about 500 ml in human beings . Tidal volume depends on the depth of breathing and it increases during exercise.

2. **Vital capacity :-**

The maximum volume of air which can be ventilated during forced breathing is called the vital capacity of the lungs. It mainly depends on the body build. This is normally between 3 to 4 litres, but in atheletes it may be as high as 3 to 6 litres.

3. **Total lung capacity :-**

The total lung capacity of the human lungs is about 5 to 6 litres depending upon the Body build.

4. **Dead space :-**

Although 500 ml of fresh air is breathed during each inspiration, but only part of this air reaches the alveoli (where actual gaseous exchange occurs), while the rest fills the nasal cavity, trachea, bronchioles, etc. (where no gaseous exchange occurs). The air contained in these tubes, which is about 150 ml, is called dead space. Thus, the volume of air which is actually used for gaseous exchange in the alveoli will only be 350 ml (Tidal volume-Dead space)

- **Regulation of respiration:-**

The respiratory process needs to be regulated so as to provide proper supply of the oxygen and the elimination of carbon dioxide through the blood. A number of regulatory processes remain at work for this purpose.

1. **Chemical regulation** – according to J.B.S. Halden, the oxygen content of the blood influences the respiratory process particularly in mammals. When the tissues do not receive the sufficient amount of oxygen, the condition is referred to as *hypoxia* and when the tissues are completely deprived of the oxygen, the condition is referred to as *anoxia.*

   Chemical regulation includes Role of Carbon dioxide and Role of Oxygen.
2. **Neural regulation** – the movement of voluntary muscles involved in breathing is under the control of respiratory centre in the brain stem or medulla. It detects the level of oxygen and carbon dioxide in the blood and sends the required signals by the respiratory muscles. Respiratory centre consist of two parts : Inspiratory centre

and Expiratory centre. As is obvious from their names inspiratory centre is concerned with inspiration, while expiratory centre is concerned with expiration. Both these centres are not active together, that is, when inspiratory centre is active, expiratory centre is inactive and visa versa. This makes the respiration a rhythmic or periodic process.

3. **Role of blood acidity** – An increase in acidity of the blood enhances the ventilation process, although Ph may not change significantly. The acidity of the blood increases with increase in CO2 tension in the blood. Likewise, lowering of CO2 tension in the blood depresses the rate of ventilation.

• IMPORTANCE OF REPIRATORY SYSTEM :-

Besides operating sufficient quantity of oxygen and elimination of carbon dioxide formed in the body, the respiration is also important for :

1. Keeping the functions of blood normal by adjusting changes in the Ph of the blood.
2. Maintaining proper oxygen tensions in the blood.
3. Maintaining normal body temperature in case of warm blooded animals.
4. Aiding in speech production and in sensing odors.

• DISEASES OF RESPIRATORY SYSTEM:-

1. **ASTHMA** – it is also called as bronchial asthma. It is a condition in which person's airways becomes inflamed, narrow and swell and produce extra mucus, which makes it difficult to breathe. Asthma can be minor or it can interfere with daily activities. In some cases, it my lead to a life threatening attack.

Types of asthma –

i. Intermittent – this type of asthma comes and goes so you can feel normal in between asthma flares.
ii. Persistent – it means you have symptoms much of the time. Symptoms can be mild, moderate or severe. Healthcare providers base asthma severity on how often you have symptoms. They also consider how well you can do things during an attack.
iii. Adult onset – this type of asthma starts after the age of 18.
iv. Pediatric – also called childhood asthma, this type of asthma often begins before the age of 5, and can occur in infants and toddlers. Children may outgrow asthma.
v. Exercise induced asthma – this type is triggered by exercise and is also called exercise induced bronchospasm.
vi. Occupational asthma – this type of asthma happens primarily to people who work around irritating substances.

vii. Asthma COPD overlap syndrome (ACOS) – this type happens when you have both asthma and chronic obstructive pulmonary disease (COPD). Both diseases make it difficult to breathe.

Causes of asthma –

i. Allergies.
ii. Environmental factors.
iii. Genetics.
iv. Respiratory infections.

2. **BRONCHITIS** - inflammation of the lining of bronchial tubes, which carry air to and from the lungs. Acute bronchitis is often caused by a viral respiratory infection and improves by itself.

Types of Bronchitis :-

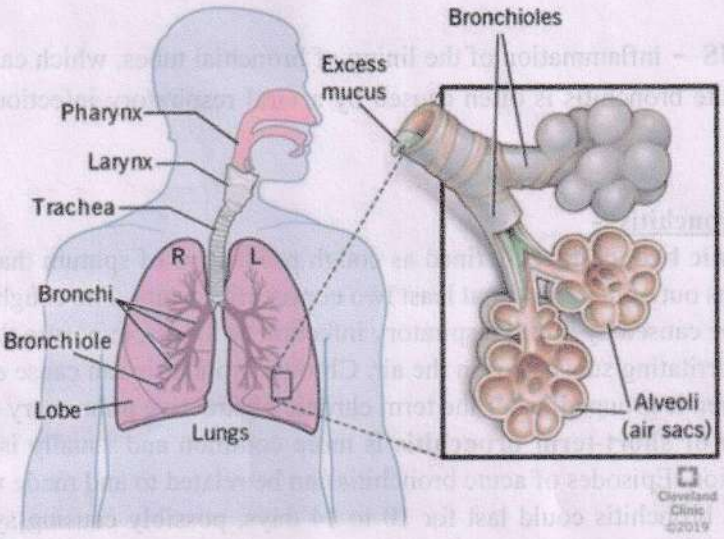
i. **Chronic bronchitis** is defined as cough productive of sputum that persists for three months out of the year for at least two consecutive years. The cough and inflammation may be caused by initial respiratory infection or illness, exposure to tobacco smoke or other irritating substances in the air. Chronic bronchitis can cause airflow obstruction and then is grouped under the term chronic obstructive pulmonary disease (COPD).
ii. **Acute or short-term bronchitis** is more common and usually is caused by a viral infection. Episodes of acute bronchitis can be related to and made worse by smoking. Acute bronchitis could last for 10 to 14 days, possibly causing symptoms for three weeks.

Causes:-

- Acute bronchitis is brought on by a viral infection, though it may also be caused by a bacterial infection. The flu and colds are examples of viral infections.
- Chronic bronchitis is usually, but not always, caused by smoking tobacco. It can also be caused by exposure to secondhand cigarette smoke, air pollution, dust, or toxic gases. Your risk can be increased by family history of bronchitis, having asthma and allergies, and having gastroesophageal reflux disease (GERD).

Symptoms of bronchitis include :-

- A cough that is frequent and produces mucus.
- A lack of energy.
- A wheezing sound when breathing (may or may not be present).
- A fever (may or may not be present).
- Shortness of breath.



3. LUNG CANCER

Cancer is a type of cancer that begins in the lungs. Your lungs are two spongy organs in your chest that take in oxygen when you inhale and release carbon dioxide when you exhale.

Lung cancer is the leading cause of cancer deaths worldwide.

People who smoke have the greatest risk of lung cancer, though lung cancer can also occur in people who have never smoked. The risk of lung cancer increases with the length of time and number of cigarettes you've smoked. If you quit smoking, even after smoking for many years, you can significantly reduce your chances of developing lung cancer.

Symptoms

Lung cancer typically doesn't cause signs and symptoms in its earliest stages. Signs and symptoms of lung cancer typically occur when the disease is advanced.

Signs and symptoms of lung cancer may include:

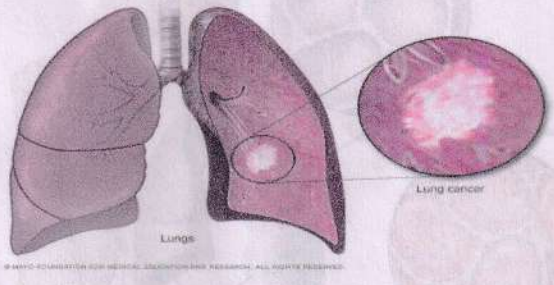
- A new cough that doesn't go away
- Coughing up blood, even a small amount
- Shortness of breath
- Chest pain
- Hoarseness
- Losing weight without trying
- Bone pain
- Headache

Causes

Smoking causes the majority of lung cancers — both in smokers and in people exposed to secondhand smoke. But lung cancer also occurs in people who never smoked and in those who never had prolonged exposure to secondhand smoke. In these cases, there may be no clear cause of lung cancer.

The two **general types of lung cancer** include:

- Small cell lung cancer. Small cell lung cancer occurs almost exclusively in heavy smokers and is less common than non-small cell lung cancer.
- Non-small cell lung cancer. Non-small cell lung cancer is an umbrella term for several types of lung cancers. Non-small cell lung cancers include squamous cell carcinoma, adenocarcinoma and large cell carcinoma.



4.PNEUMONIA –

Pneumonia is an infection that inflames the air sacs in one or both lungs. The air sacs may fill with fluid or pus (purulent material), causing cough with phlegm or pus, fever, chills, and difficulty breathing. A variety of organisms, including bacteria, viruses and fungi, can cause pneumonia.

Symptoms :-

- Chest pain when you breathe or cough
- Confusion or changes in mental awareness (in adults age 65 and older)
- Cough, which may produce phlegm
- Fatigue
- Fever, sweating and shaking chills
- Lower than normal body temperature (in adults older than age 65 and people with weak immune systems)
- Nausea, vomiting or diarrhea
- Shortness of breath

Causes

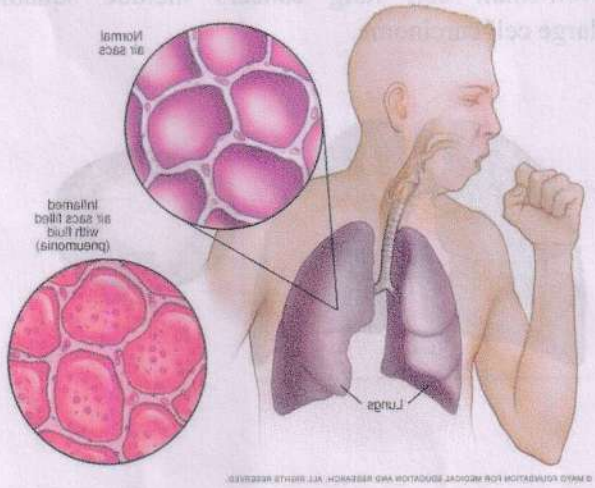
Many germs can cause pneumonia. The most common are bacteria and viruses in the air we breathe. Your body usually prevents these germs from infecting your lungs. But sometimes these germs can overpower your immune system, even if your health is generally good.

Pneumonia is classified according to the types of germs that cause it and where you got the infection.

Risk factors

Pneumonia can affect anyone. But the two age groups at highest risk are:

- Children who are 2 years old or younger
- People who are age 65 or older



5.PULMONARY EMBOLISM

Pulmonary embolism is a blockage in one of the pulmonary arteries in your lungs. In most cases, pulmonary embolism is caused by blood clots that travel to the lungs from deep veins in the legs or, rarely, from veins in other parts of the body (deep vein thrombosis).

Because the clots block blood flow to the lungs, pulmonary embolism can be life-threatening. However, prompt treatment greatly reduces the risk of death. Taking measures to prevent blood clots in your legs will help protect you against pulmonary embolism.

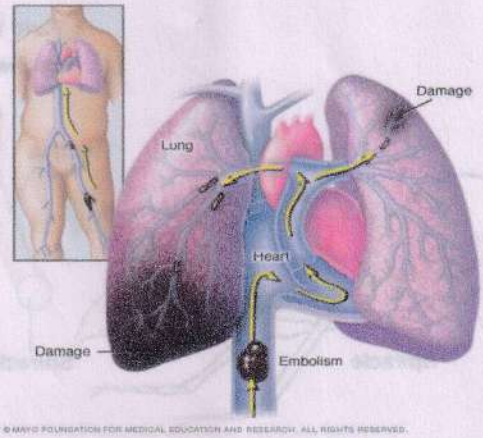
Symptoms

- Shortness of breath. This symptom typically appears suddenly and always gets worse with exertion.
- Chest pain. You may feel like you're having a heart attack. The pain is often sharp and felt when you breathe in deeply, often stopping you from being able to take a deep breath. It can also be felt when you cough, bend or stoop.
- Cough. The cough may produce bloody or blood-streaked sputum.
- Rapid or irregular heartbeat
- Dizziness
- Excessive sweating
- Fever
- Leg pain or swelling, or both, usually in the calf caused by a deep vein thrombosis
- Clammy or discolored skin (cyanosis)

Causes

Blockages in the blood vessels are caused by substances other than blood clots, such as:

- Fat from the marrow of a broken long bone
- Part of a tumor
- Air bubbles



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COMPARATIVE STUDY:-

The respiratory system from different groups of animals, differ morphologically. Although morphologically different, they have in common some characteristics like large capillary network, constant renewal of oxygen rich fluid, free movement of blood within capillary network. Mechanism of respiration in different animals are as follows:-

1. IN INSECTS –

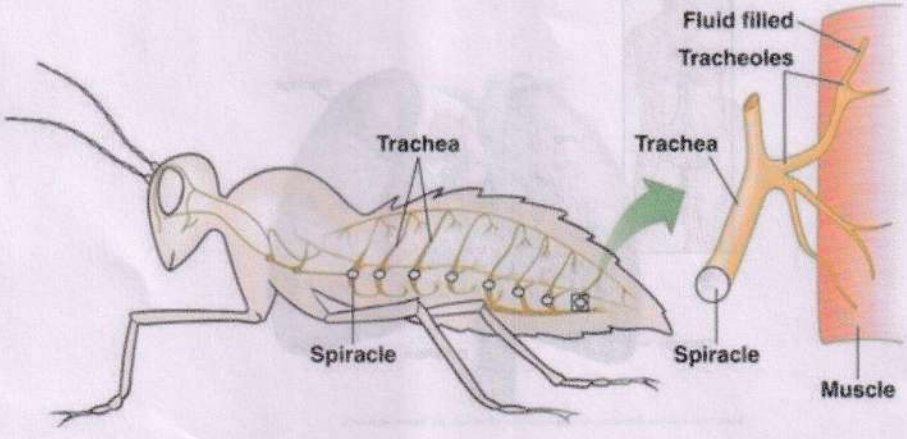
Air enters the respiratory system of insects through a series of external openings called **spiracles.** These external openings, which acts a muscular valve in insects, lead to the internal respiratory system, a densely networked array of tubes called tracheae.
It is responsible for delivering sufficient oxygen (O2) to all cells of the body and for removing CO2 that is produced as a waste product of cellular respiration.

Insects have spiracles on their exoskeleton to allow air to enter the trachea. Tracheal tubes deliver oxygen directly into the insect tissues. The spiracles can be opened and closed in a manner to reduce water loss. This is done by contracting closer muscles surrounding the spiracle. In order to open, the muscles relaxes.

The spiracles are also surrounded by hairs to minimize bulk air movement around the opening, and thus minimize water loss.

The spiracles are located laterally along the thorax and abdomen of most insects usually one pair of spiracle per body segment.

Trachea – tracheal trunk is divides into complex branching network of tracheal tubes. That subdivides into smaller and smaller diameter reaching every part of the body.



2. IN FISHES –

Respiration in fishes is carried out by **gills**. if the respiratory surface of an animal is turned out in the form of appendages they are called as gills. They are highly vascular structure and through them exchange of oxygen and carbon dioxide occurs.

In this system water is moved in through the mouth, over the gill, and out through opercular opening. The water flows over the gill filaments and in between the flat gill lamellae. It is the gill lamellae where gaseous exchange takes place between water and blood. The flow of water across the gills is almost continuous.

In some fishes like *Neoceratodus* there are internal nostrils, and a diverticulum of the pharynx which is used for breathing air. These fishes are, therefore, called **lung fishes.**

Swim bladder – It regulates level of fish in water. It provides oxygen at times of respiratory distress. It is also an organ of sound production in some fishes. It is some sort of connection between swim bladder and inner ear, so also act as sound detector.

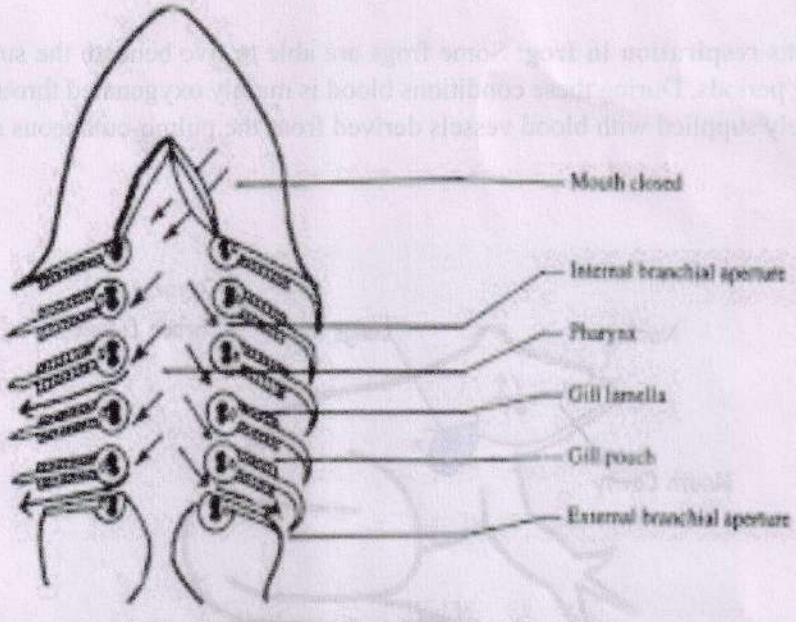


Fig. 1.9.4 Mechanism of respiration in Elasmobranch fishes

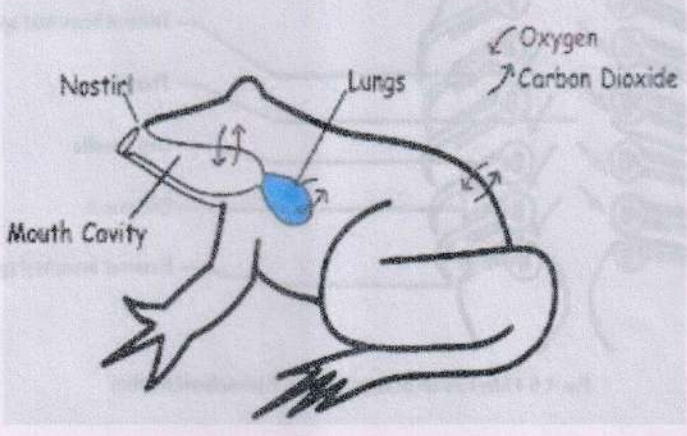
3. IN AMPHIBIANS –

The adult frog is a land animal, at such, has **lung respiration**. Its lung contain alveoli, but they are not as those in the human lungs.

The throat of frog moves 80-120 times per minute when observed at rest. These are bucco-pharyngeal movement. During these movements, the nostrils are partly open and glottis is closed with the result that air contain in the bucco-pharynx is constantly renewed, because these region is highly vascularised structure and as such some sort of gaseous exchange is possible. However, this type of respiration is not efficient and therefore air is occasionally pump down into the lungs by the method similar to swallowing. First the air is suck into the oral cavity through the nostrils as the throat expands.

This is followed by contraction of throat along with simultaneous closure of nostrils, so that the air is forced through the glottis into the larynx and then to the lungs. However, since lungs are elastic structures, expiration occurs mainly due to elastic recoil of lungs. Since the vocal cords are present in their larynx frogs can produce sound during the process of of expiration, if they so desire. It has been observed that frogs show continuous pulmonary ventilation after excursion, but at the rest they usually show bucco-pharyngeal movements only.

Cutaneous respiration in frog: Some frogs are able to live beneath the surface of water for very long periods. During these conditions blood is mainly oxygenated through the skin which is profusely supplied with blood vessels derived from the pulmo-cutaneous arch.



4. IN REPTILES –

Most reptiles have simple lungs with a moderate amount of alveoli which increase their internal surface. They have tracheal tube supported by circular cartilaginous rings.

Snakes have only the right lung. Tis is essential for them since they have linear body, and such have no room for two lungs. Respiratory lung area is considerably reduced in those reptiles who have secondarily acquired aquatic habits such as turtles.

Like amphibians, reptiles also have three type of respiration:-

- Bucco-pharyngeal respiration.
- Pulmonary respiration.
- Cutaneous respiration.

Pulmonary ventilation in reptiles:-

Pulmonary ventilation is most important for gaseous exchange in reptiles. In them, air is sucked in the lung by the action of costal pump as ribs are universally present (inspiration). Expiration, on other hand, brought about by elastic recoil of lung.

Most lizards respiration begins with an expiratory phase, when air is forced out of the lung, this is followed by rapid inspiration. Hence the lung remain in pause, until the next respiratory act begins. At low temperature these pauses are long but during summer the frequency becomes rapid.

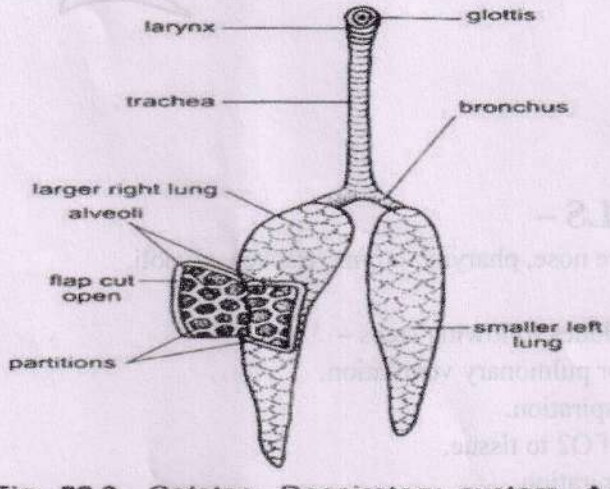
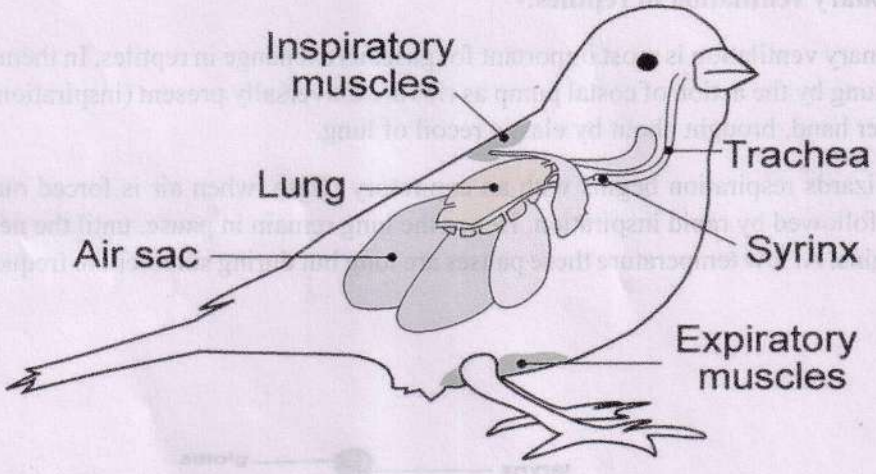


Fig. 22.3. *Calotes*. Respiratory system. A portion of the right lung is cut open to show the internal partitions and alveoli.

5.IN BIRDS –

As birds are homoiothermic animals and have high metabolic rate, their oxygen requirement is very high. Birds have much more elongated lung structure. It is spongy in character and is embedded dorsally in the ribs. One of the distinct features of avian lung is presence of air sacs which extends from them into many parts of the body, between viscera, muscles, even in limbs bones. The **air sacs** of birds are extensions of bronchial tree and occupy as much as 80% of the total body cavity. The trachea in birds is supported by cartilaginous rings. It splits into two primary bronchi, but in birds only, it forms the **syrinx** at that point. Air sacs have bellow-like action. There are no alveoli in the avian lungs.

During flight, when birds need more oxygen, the rhythmic raising and lowering of the sternum produced by the activity of flight muscles actively assists in ventilation of the avian lung.

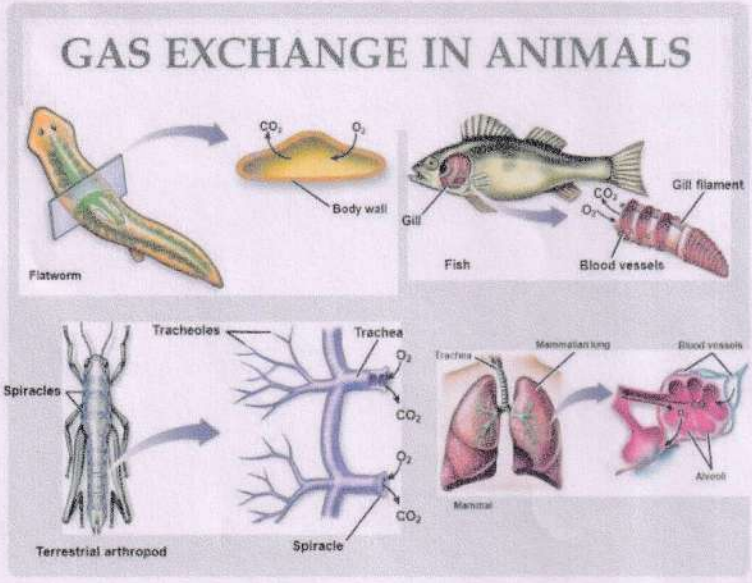


5. IN MAMMALS –

Organs involved are nose, pharynx, larynx, trachea, alveoli.

The respiration includes following steps –

i. Breathing or pulmonary ventilation.
ii. External respiration.
iii. Transport of O2 to tissue.
iv. Internal respiration.
v. Transport of CO2 from tissue.



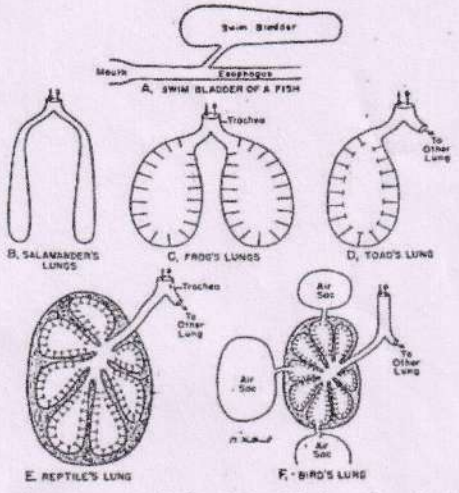


Fig. 6.4—Some stages in the evolution of the lungs. (Reproduced with permission, from Claude A. Villee : Biology : The Human Approach, 6th edition, W.B. Saunders Co., Philadelphia, 1972).

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5. **https://bio.libretexts.org/**
6. **https://my.clevelandclinic.org/health/articles/21205-respiratory-system**