HUMAN RESPIRATION

Presented by
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RESPIRATION

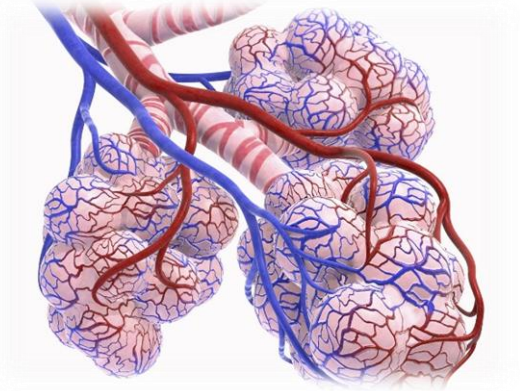
- It is a biochemical process of oxidation of organic compounds in an orderly manner for the liberation of chemical energy in the form of ATP.

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6\,CO_2 + 6H_2O + 38\,ATP$$

- The site of gaseous exchange is called the respiratory surface.

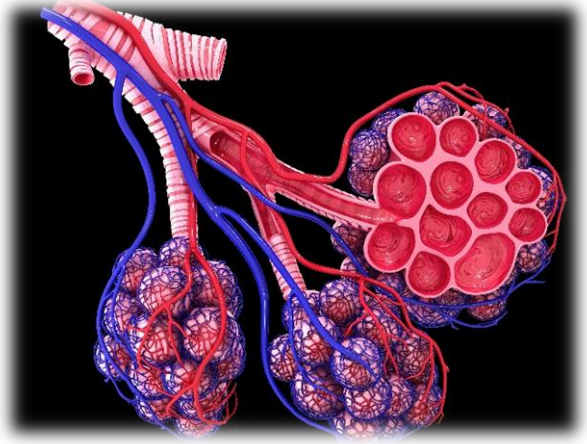
ORGANS OF RESPIRATORY EXCHANGE

- For efficient gaseous exchange, the respiratory surface should have the following features :



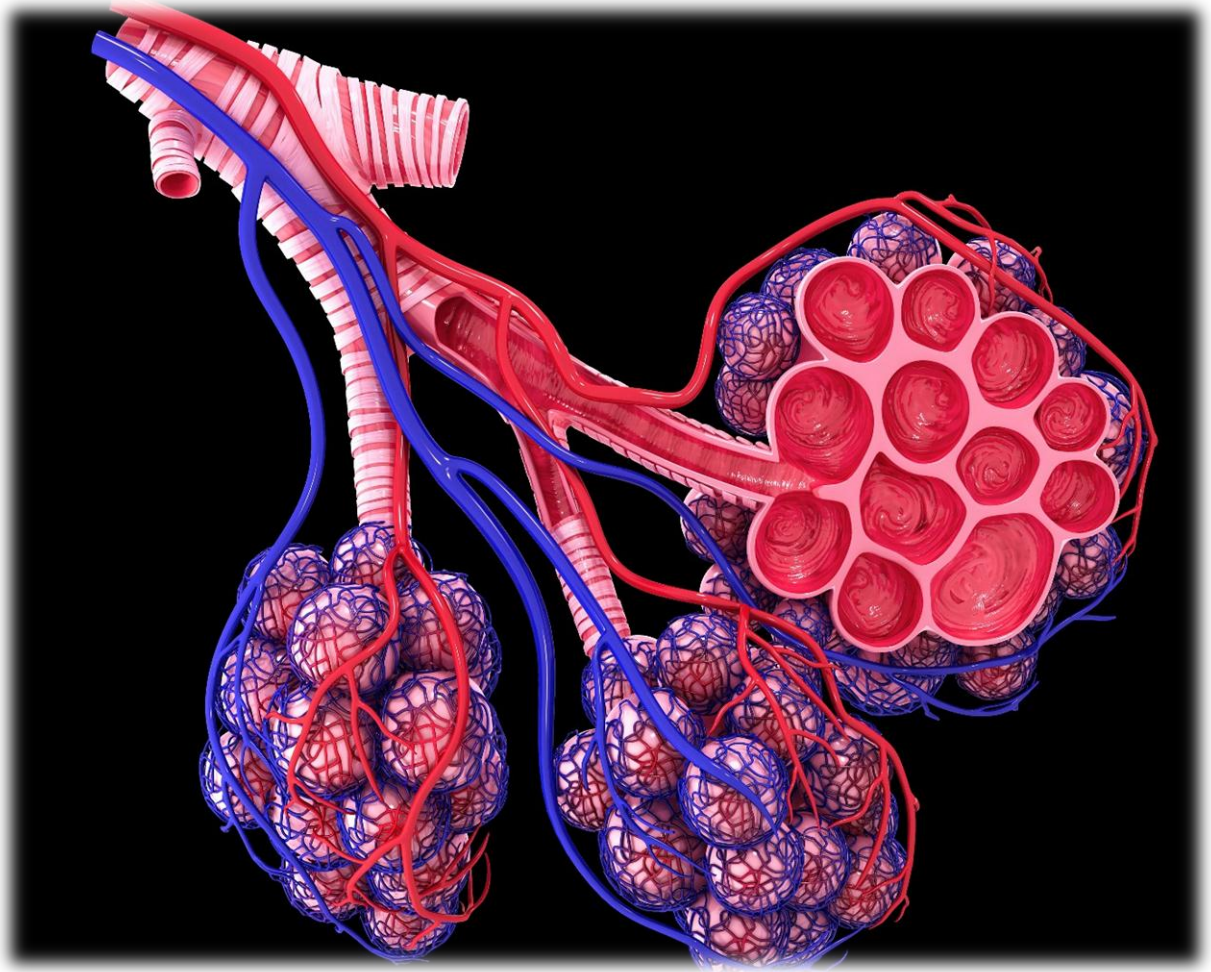
a. **It should have a large surface area**.

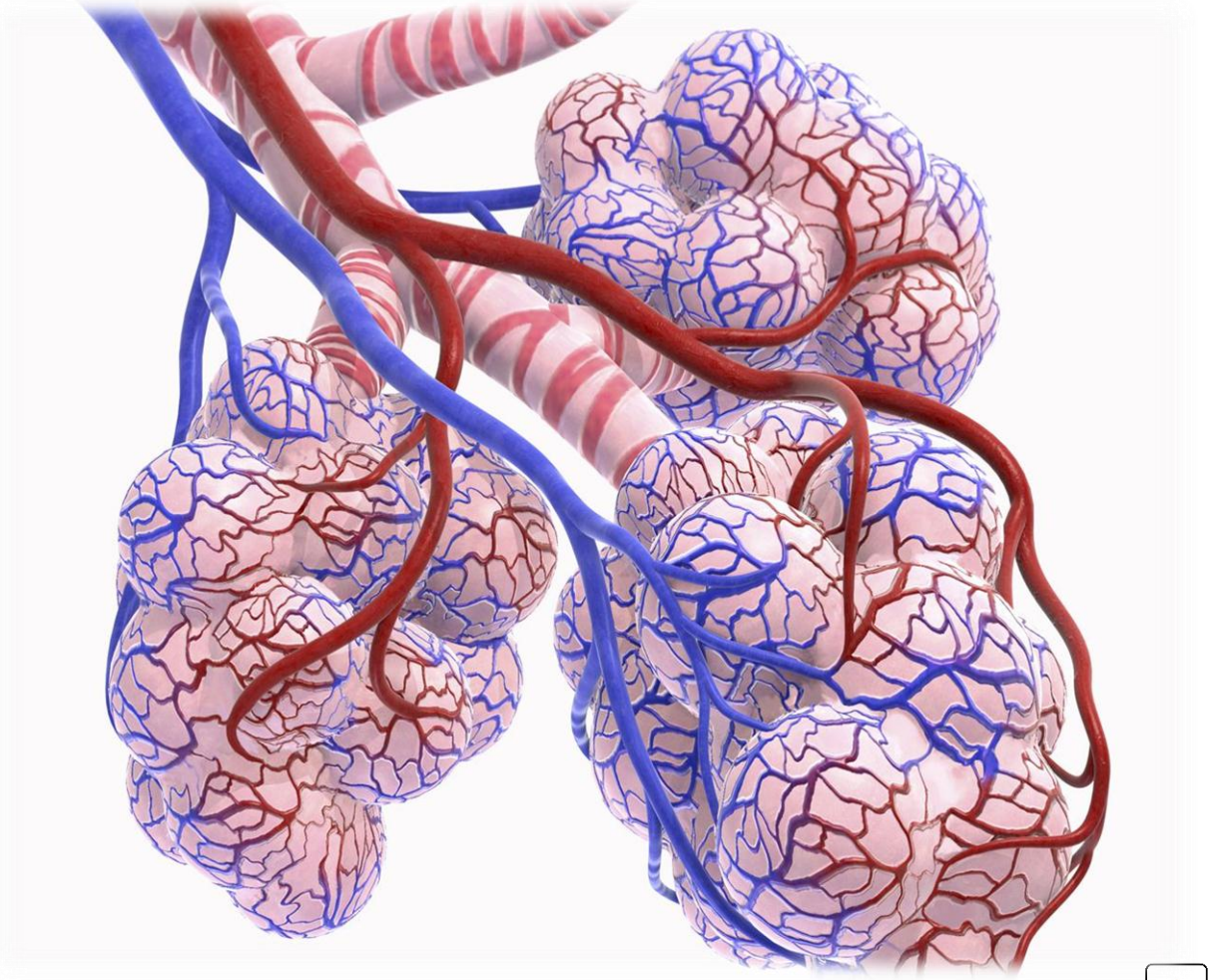
b. **It should be thin, highly vascular and permeable to allow exchange of gases.**



c. **It should be moist.**

ALVEOLI

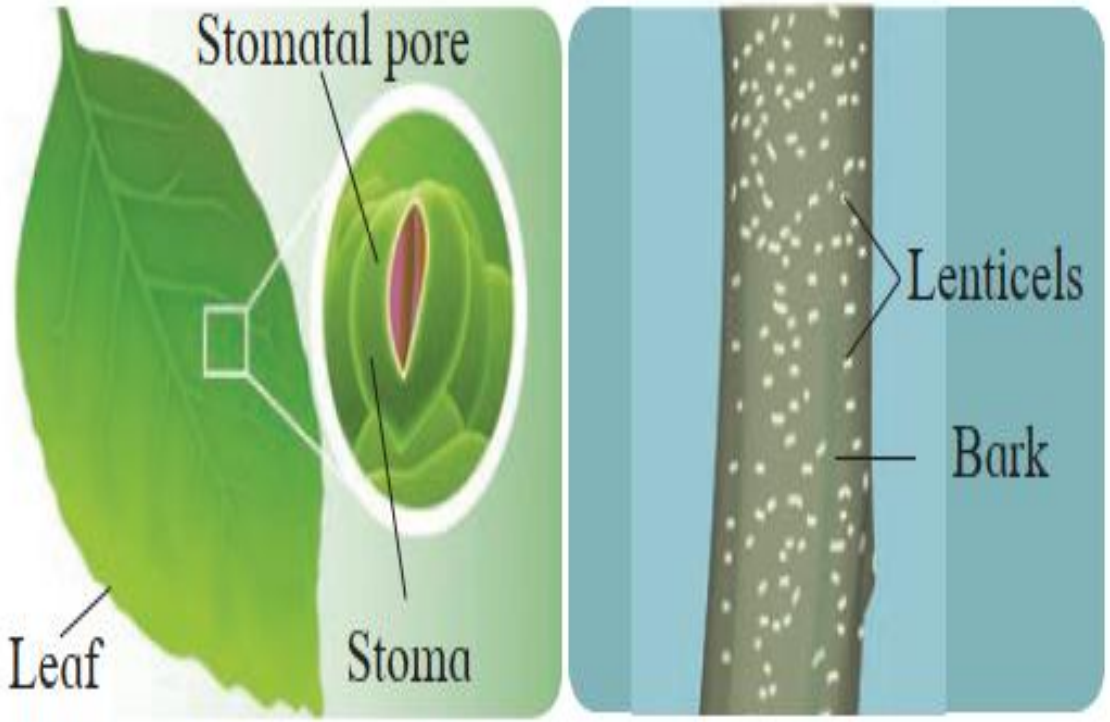




GASEOUS EXCHANGE IN PLANTS

- The shape and structure of plants facilitate gaseous exchange by diffusion.
- Oxygen diffuses into the air space through **stomata** (the pores on leaves and young stems), carbon dioxide and water vapour diffuse out.

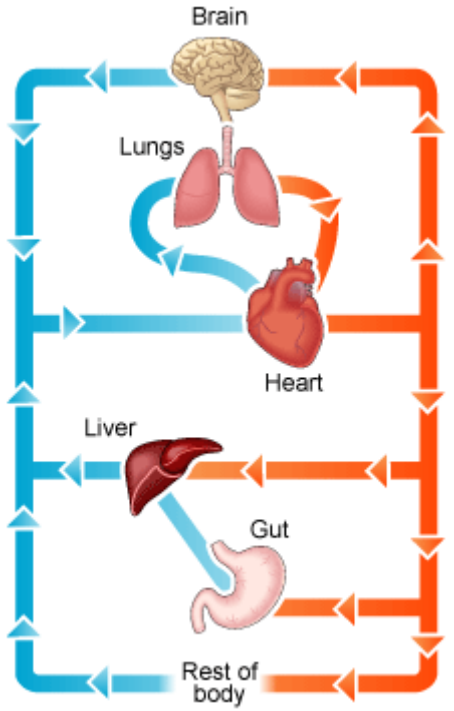
- Woody flowering plants (trees and shrubs) have an external impervious bark.
- Here, gaseous exchange occurs through small pores in the stem surface, called **lenticels.**



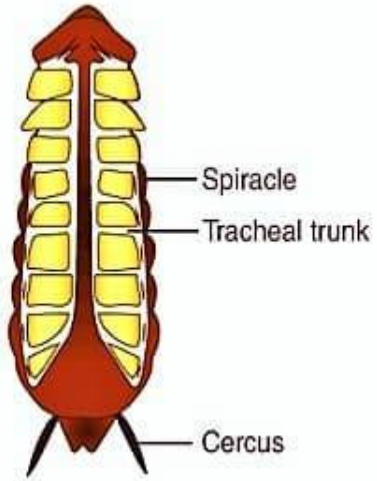
RESPIRATION IN ANIMALS

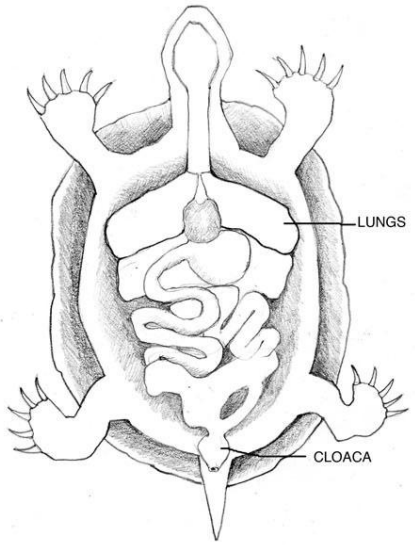
- As compared to plants, animals show wide variety of respiratory surfaces or organs.
- The respiratory surfaces differ in various animals.
- **In animals, depending upon the complexity of organization and the surrounding medium, certain parts of the body have become specialized into different types of respiratory organs.**

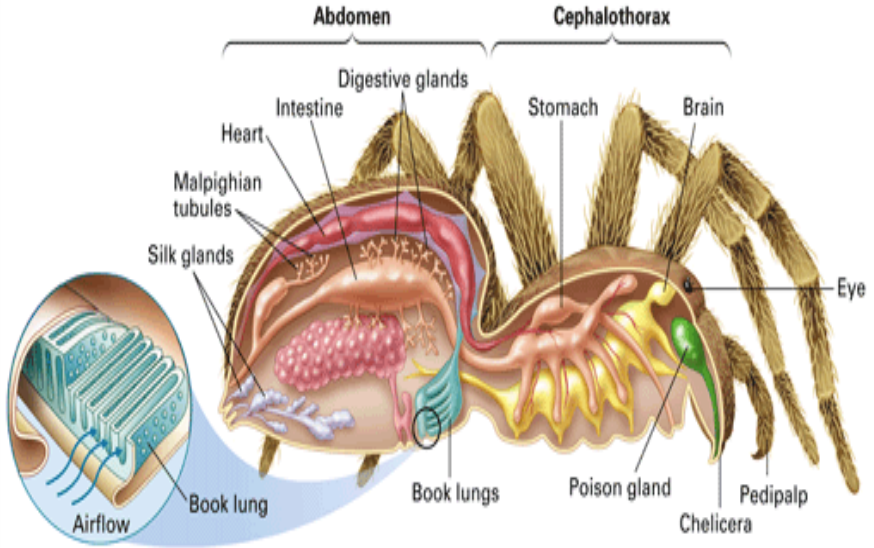
- In the higher animals, these respiratory organs are also associated with a transport system.



RESPIRATORY ORGANS OF OTHER ORGANISMS



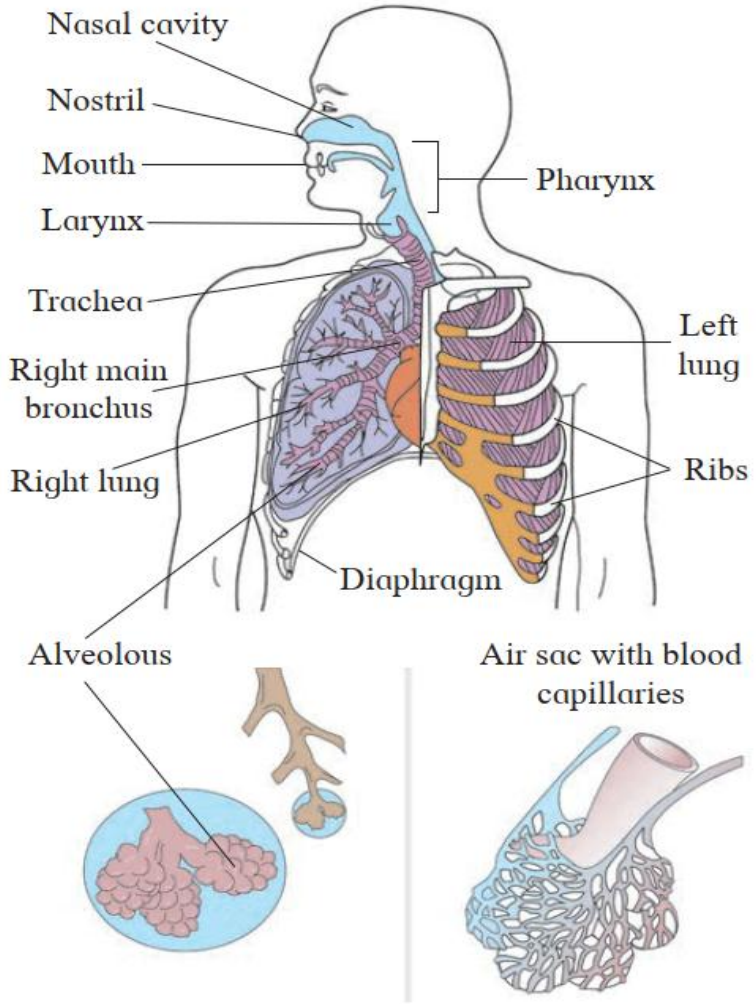




Organism	Habitat	Respiratory surface/ organ
Protists, Sponges and Coelenterates	Aquatic	Plasma membrane
Flatworms like Planaria, Annelids (earthworm, nereis, leech), amphibians (frog)	Aquatic or semiquatic	Plasma membrane, general body surface (moist skin)
Insects	Terrestrial	Tracheal tubes and spiracles
Arachnids like spiders and scorpions	Terrestrial	Book lungs
Limulus (Arthropod)	Aquatic	Book gills
Amphibian tadpoles of frog, salamanders and newts	Aquatic	External gills
Fish	Aquatic	Internal gills
Reptiles, Birds and Mammals	Terrestrial	Lungs
Turtles	Underwater	cloaca

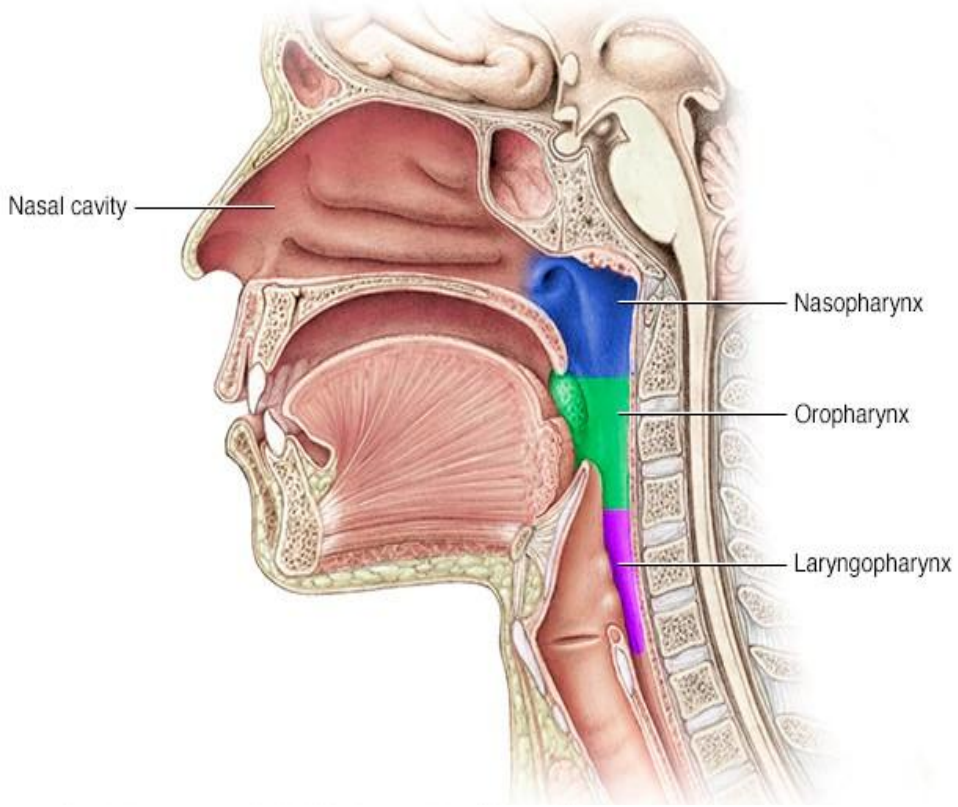
HUMAN RESPIRATORY SYSTEM

- The respiratory system brings about inspiration, expiration and exchange of gases in the lungs.
- These are then transported by blood from the lungs to the different tissues and parts of the body.
- The respiratory system can be divided into an **upper respiratory system** having **external nares, nasal cavities, internal nares, nasopharynx, throat and associated structures.**
- The **lower respiratory system** refers to the **larynx, trachea, bronchi, bronchioles and lungs.**



PHARYNX

- It is divisible into three parts.
- The **nasopharynx** is the uppermost part from the nasal chamber it leads into **oropharynx** (**common passage for food and air**).
- This continues below as the **laryngopharynx**.
- Between the **nasopharynx and oropharynx** is the palate bone.
- The pharynx has a set of **lymphoid organs** called **tonsils**.



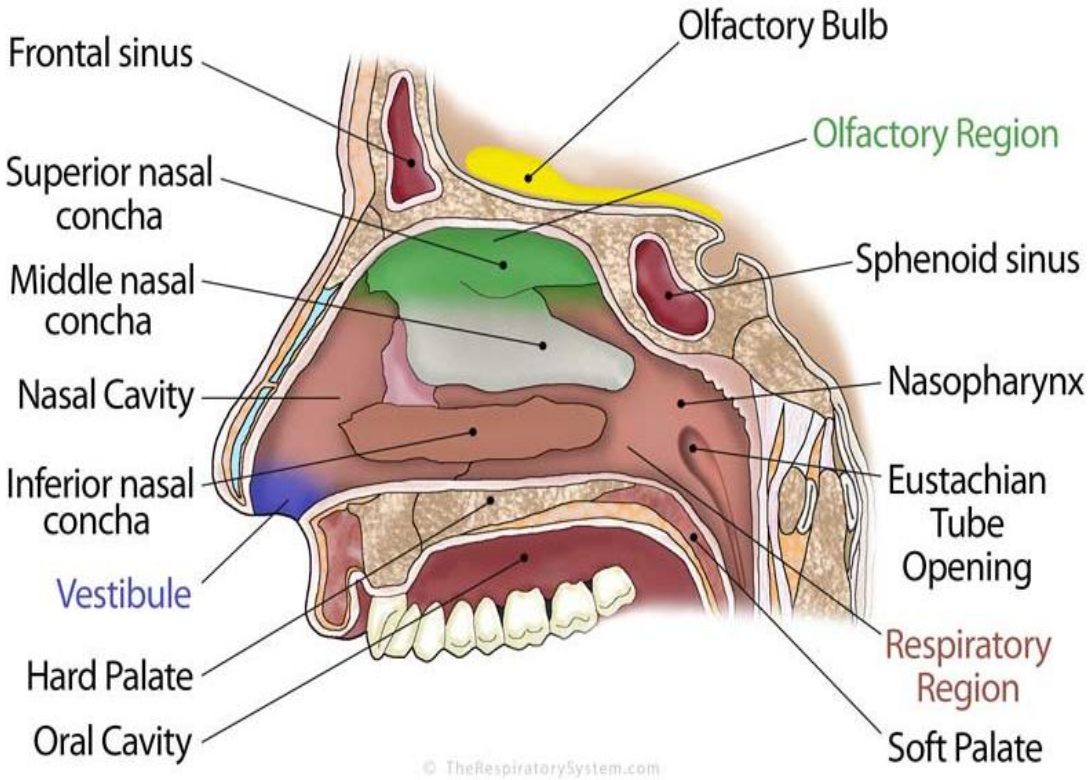
NOSE

- The nose has a pair of slit like openings called external nares or nostrils for entry of air into the nasal cavity.
- The nasal cavity is divisible into right and left nasal chambers by a **mesethmoid cartilage**.
- Each nasal chamber is further divided into three regions.

i. **Vestibule** : It is the proximal part about the nostrils. Its skin has hair for filtering the air and trapping the dust and suspended particles in the inhaled air.

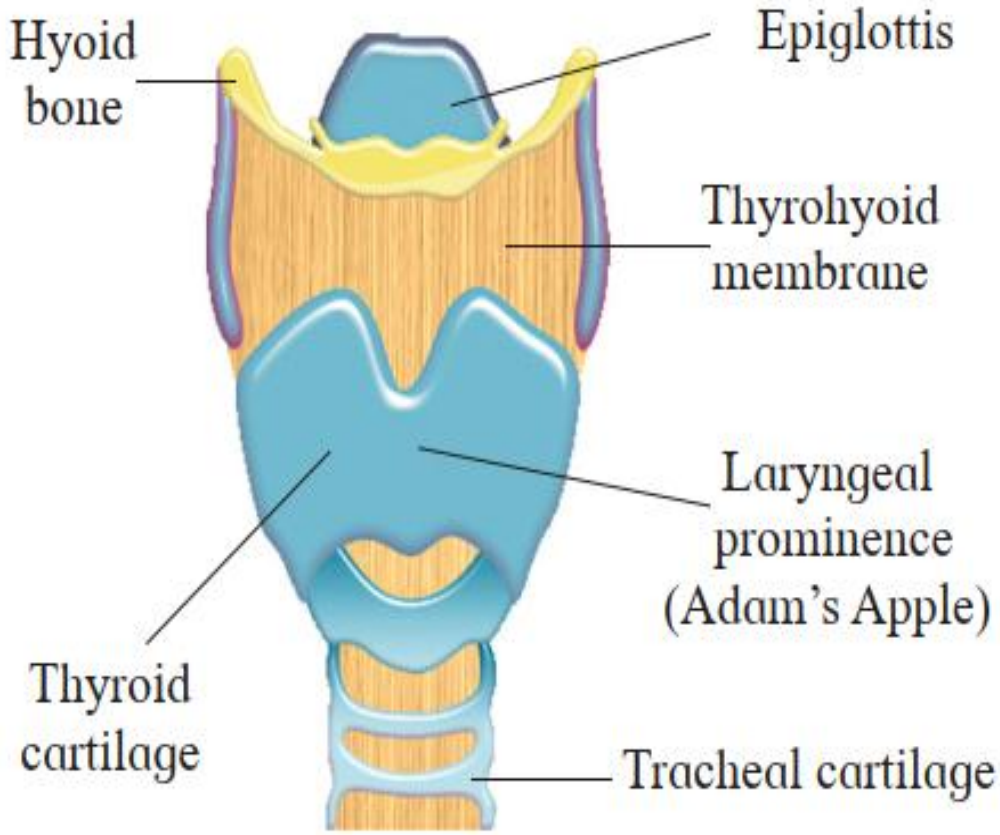
ii. **Respiratory part (conditioner)** : The middle thin walled highly vascular part for warming and moistening the inhaled air.

iii. **Olfactory or sensory chamber** : The uppermost part is lined by olfactory epithelium for detection of smell.

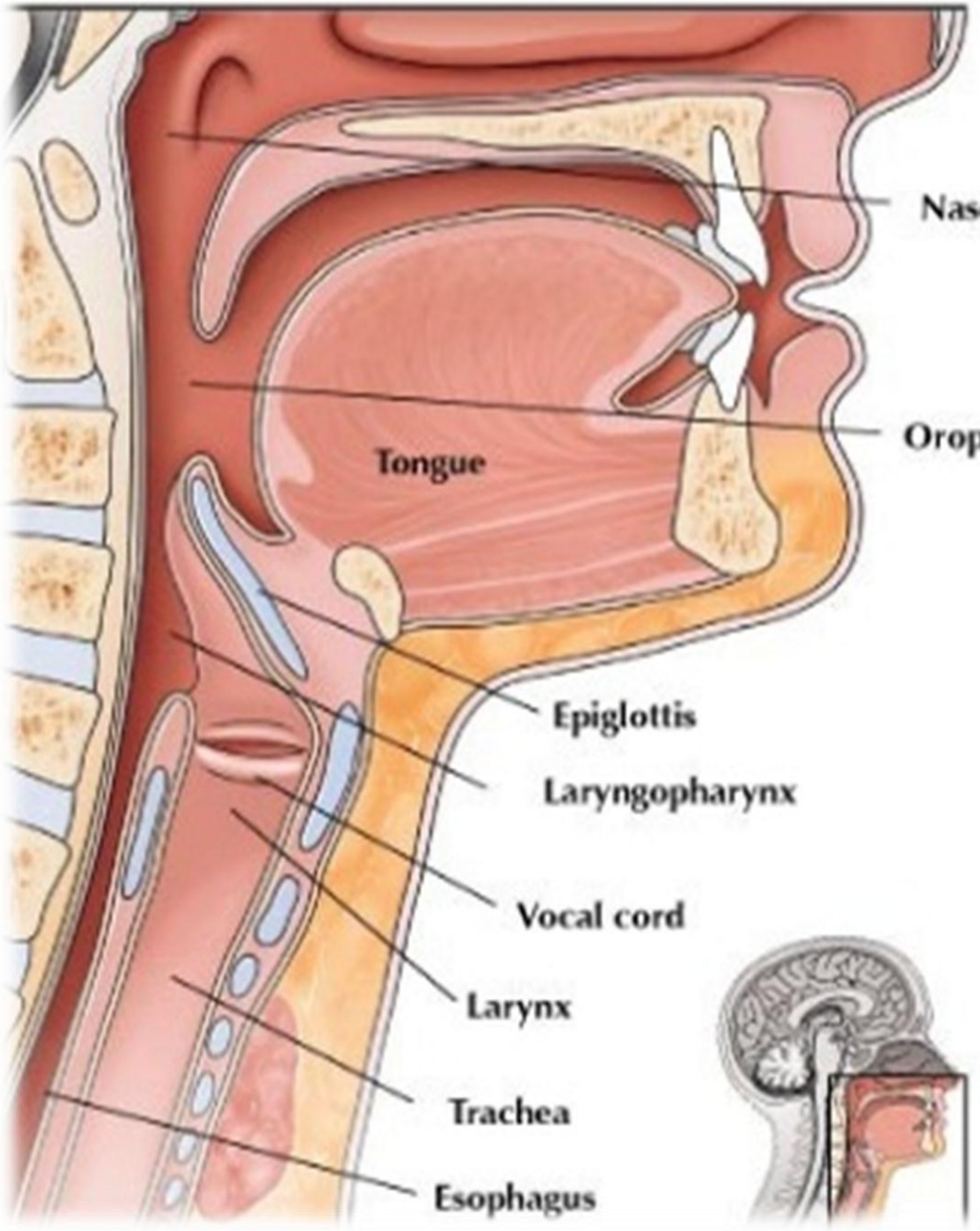


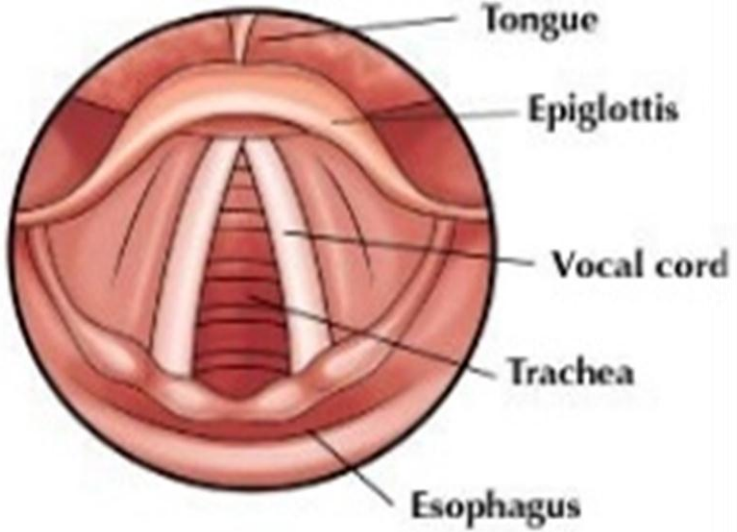
LARYNX

- It is called **voice box**. It is the part of the respiratory tract which contains **vocal cords for producing sound**.
- The larynx extends from the laryngopharynx and the hyoid bone to the trachea.
- It is a hollow, tubular structure.
- Its wall is made up of cartilage plates held by membranes and muscles.
- Internally, it is lined by a pair of folds of elastic vocal cords (true vocal cords).
- Voice is produced by passage of air between the vocal cords and modulations created by tongue, teeth, lips and nasal cavity.
- The larynx opens into the layngopharynx through a slit like opening called glottis.
- This opening of the trachea or wind pipe is guarded by a leaf like flap called epiglottis.
- It prevents the entry of food into trachea.



ANATOMY OF THE LARYNX



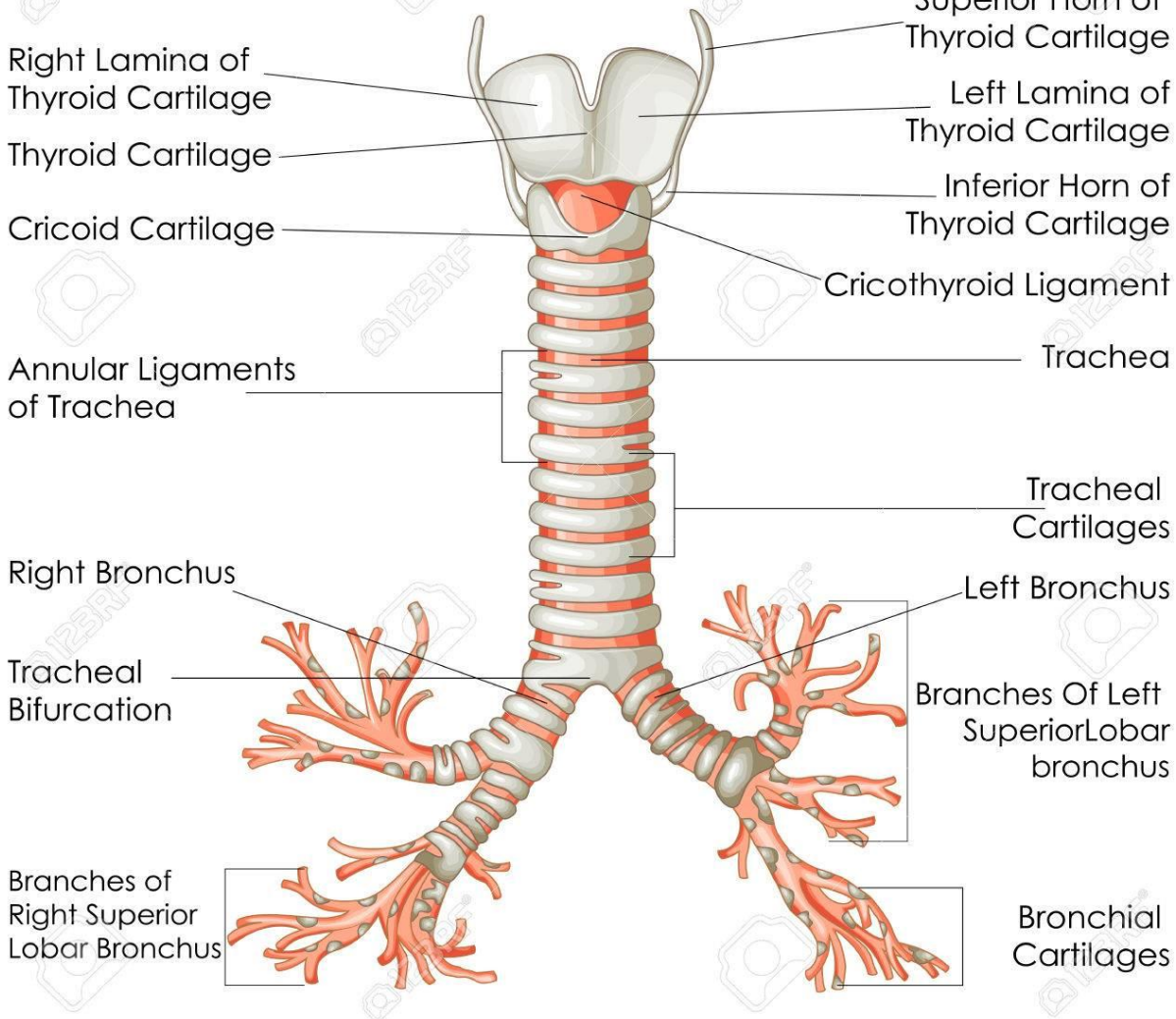


LARYNGOSCOPIC VIEW

TRACHEA (WIND PIPE)

- It is a long tube 10 to 12 cm in length.
- It runs through the neck in front of the oesophagus and extends into and upto the middle of thoracic cavity.
- It is supported by 'C' shaped 16 to 20 rings of cartilage which prevent the collapse of trachea.
- It is lined internally with ciliated, pseudostratified epithelium and mucous glands that **trap the unwanted particles** preventing their entry into the lungs.

Trachea


Superior Horn of Thyroid Cartilage
Right Lamina of Thyroid Cartilage
Left Lamina of Thyroid Cartilage
Thyroid Cartilage
Inferior Horn of Thyroid Cartilage
Cricoid Cartilage
Cricothyroid Ligament
Trachea
Annular Ligaments of Trachea
Tracheal Cartilages
Right Bronchus
Left Bronchus
Tracheal Bifurcation
Branches Of Left SuperiorLobar bronchus
Branches of Right Superior Lobar Bronchus
Bronchial Cartilages

FIND OUT...

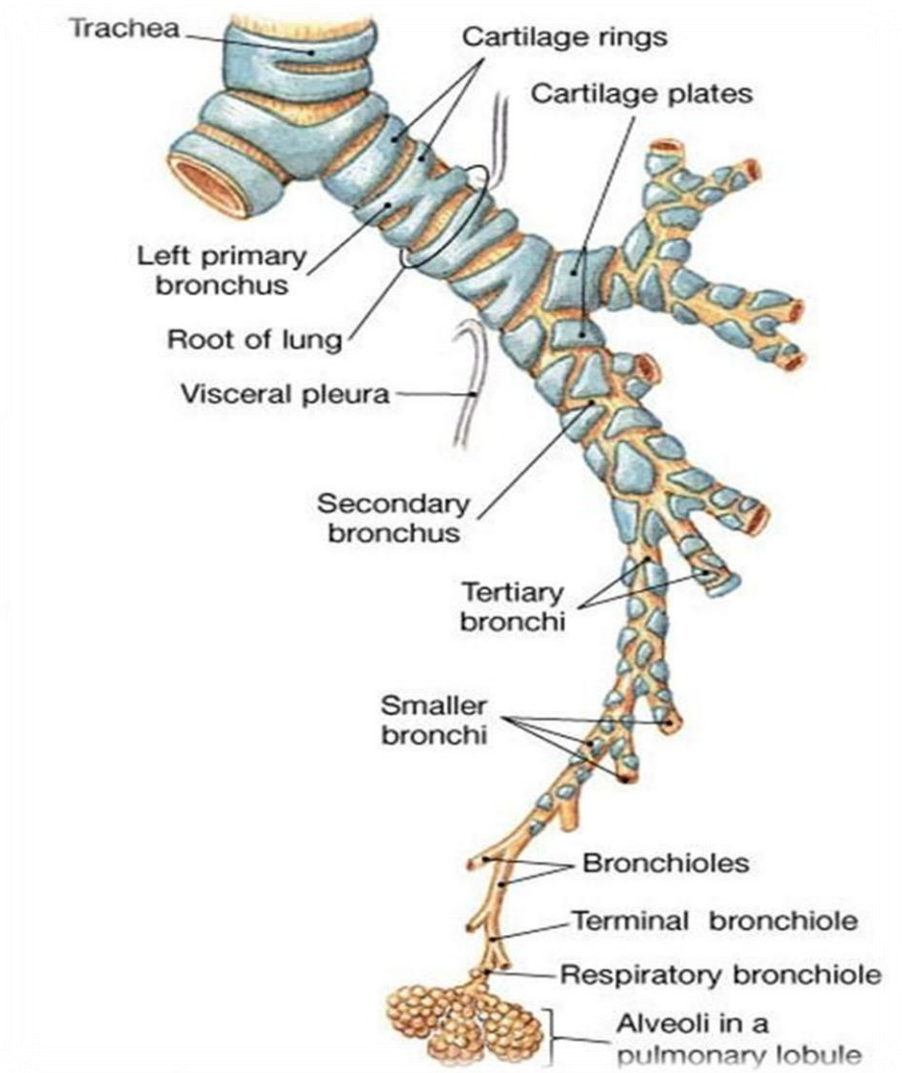
- Kavya underwent a surgical procedure called Rhinoplasty. What could have been the reason for such a surgery? On which part of the body is it carried out?
- What is the role of tonsils in our body? How many pairs of tonsils do we have?

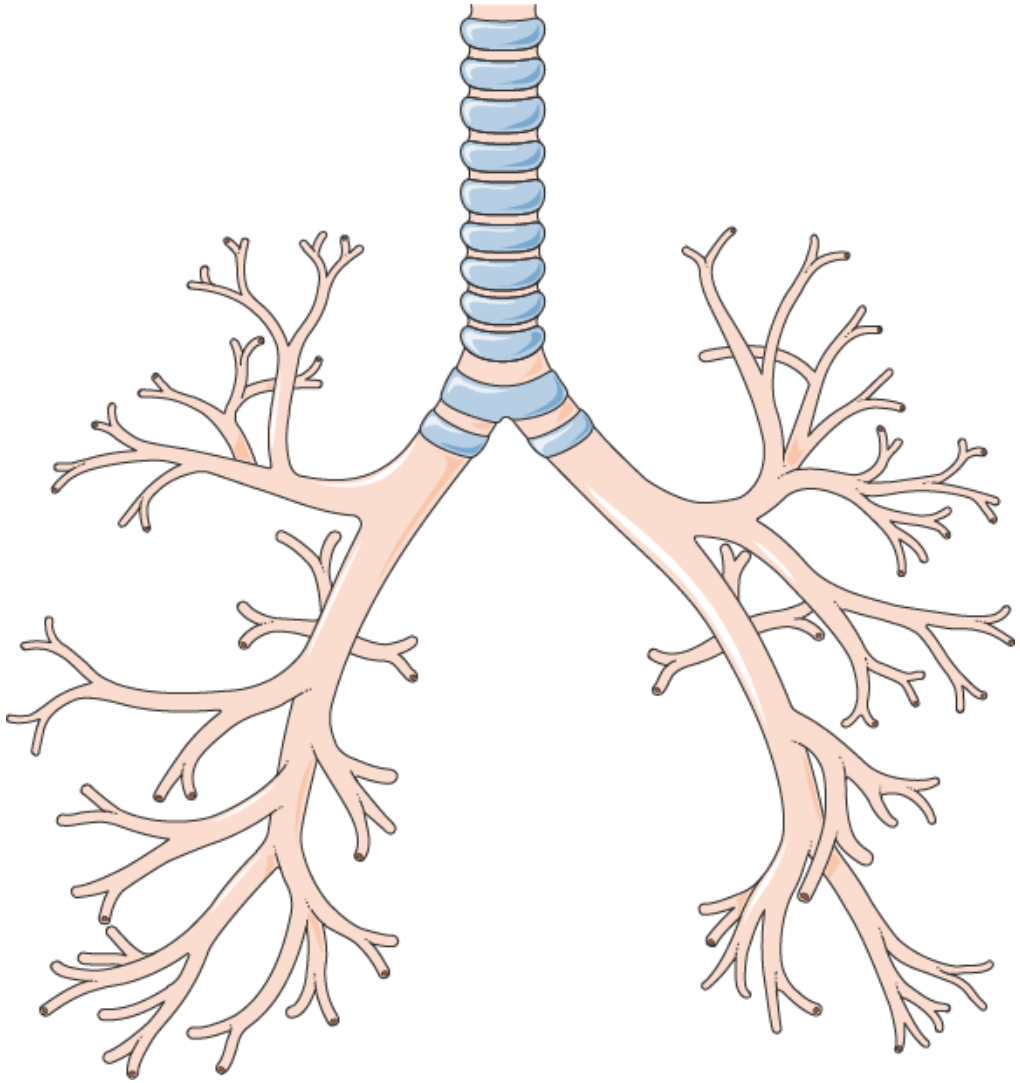
- Shreyas choked while eating dinner. How can you help him? What is the immediate help that can be given to him?
- What is a role of epiglottis?

BRONCHI

- The trachea divides into right and left primary bronchi as it reaches the middle of the thoracic cavity.
- The bronchi are supported internally by ‘C’ shaped incomplete rings of cartilage.
- The primary bronchi divide to form secondary and tertiary bronchi which lead into terminal bronchioles ending into alveoli.

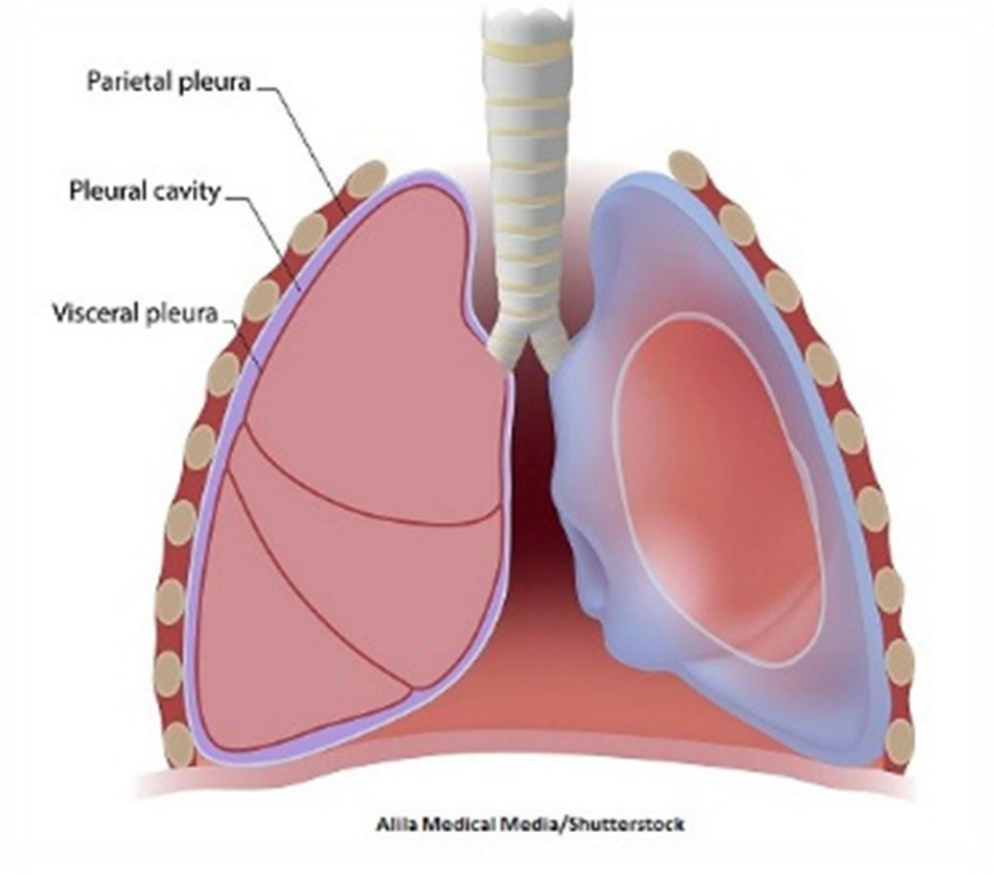
BRONCHI

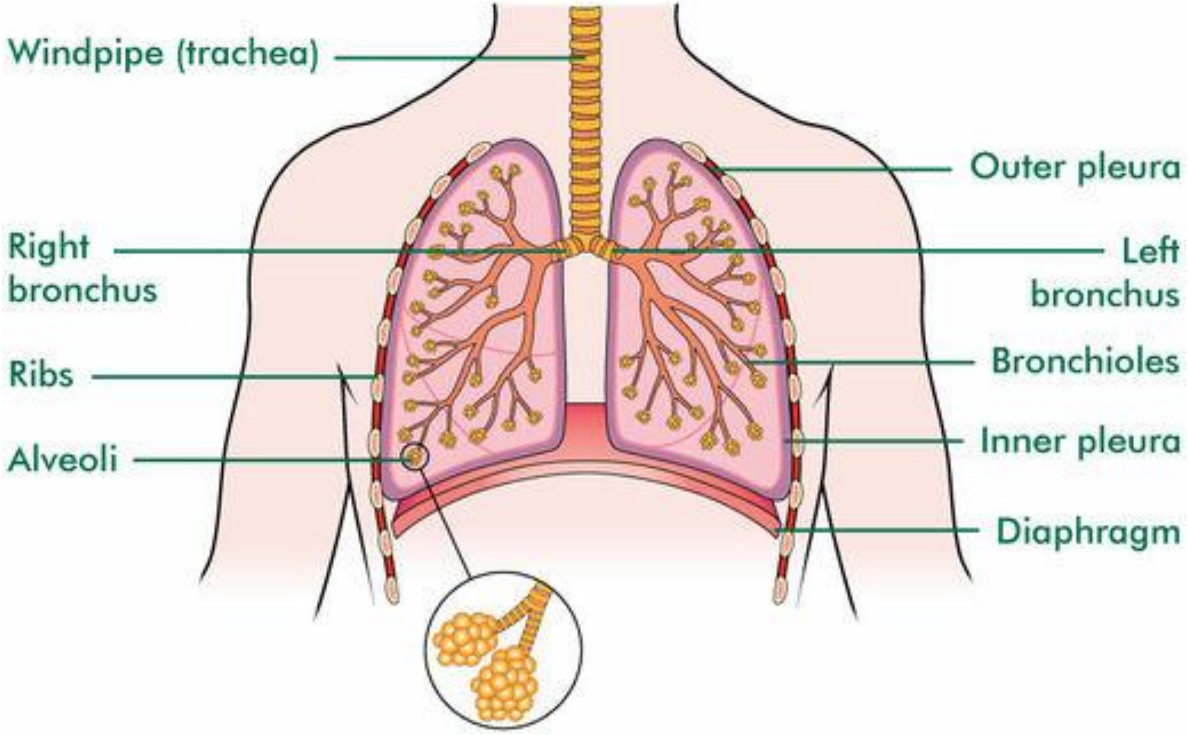

Trachea
Cartilage rings
Cartilage plates
Left primary bronchus
Root of lung
Visceral pleura
Secondary bronchus
Tertiary bronchi
Smaller bronchi
Bronchioles
Terminal bronchiole
Respiratory bronchiole
Alveoli in a pulmonary lobule



LUNGS

- These are the main respiratory organs of humans.
- One pair of spongy and elastic lungs are present in the thoracic cavity.
- Each lung is enclosed and protected by a **double pleural membrane**, **outer parietal and inner visceral membrane.**
- Between the two pleura is a **pleural cavity** filled with a lubricating fluid called pleural fluid. It is secreted by the membranes.
- The **right lung** is larger and divided into **3 lobes**, while the **left lung** is smaller and divided into **2 lobes.**
- Each lobe of the lung has the terminal bronchioles ending in a bunch of **air sacs**, each with 10 to 12 alveoli.

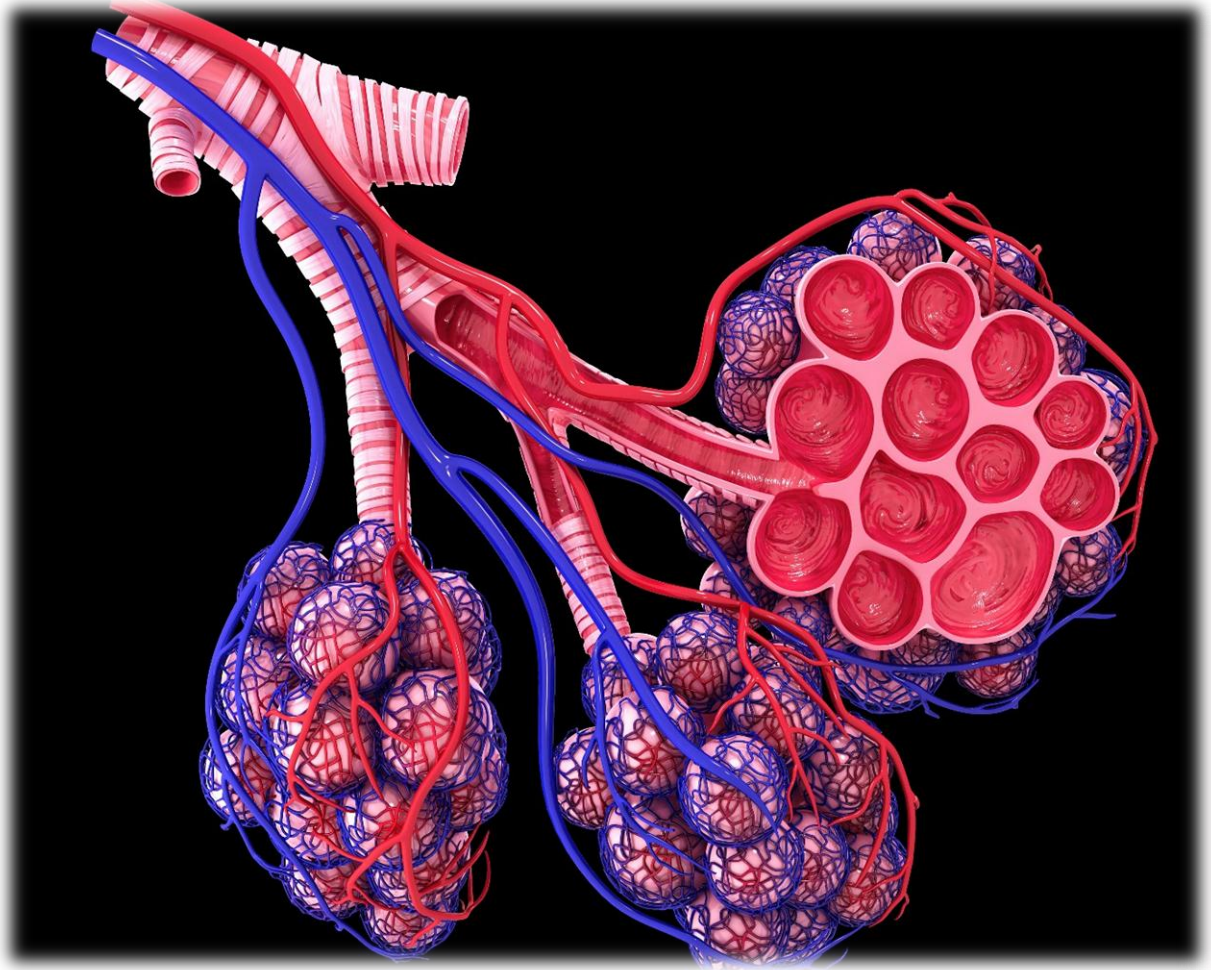

Parietal pleura
Pleural cavity
Visceral pleura
Alila Medical Media/Shutterstock

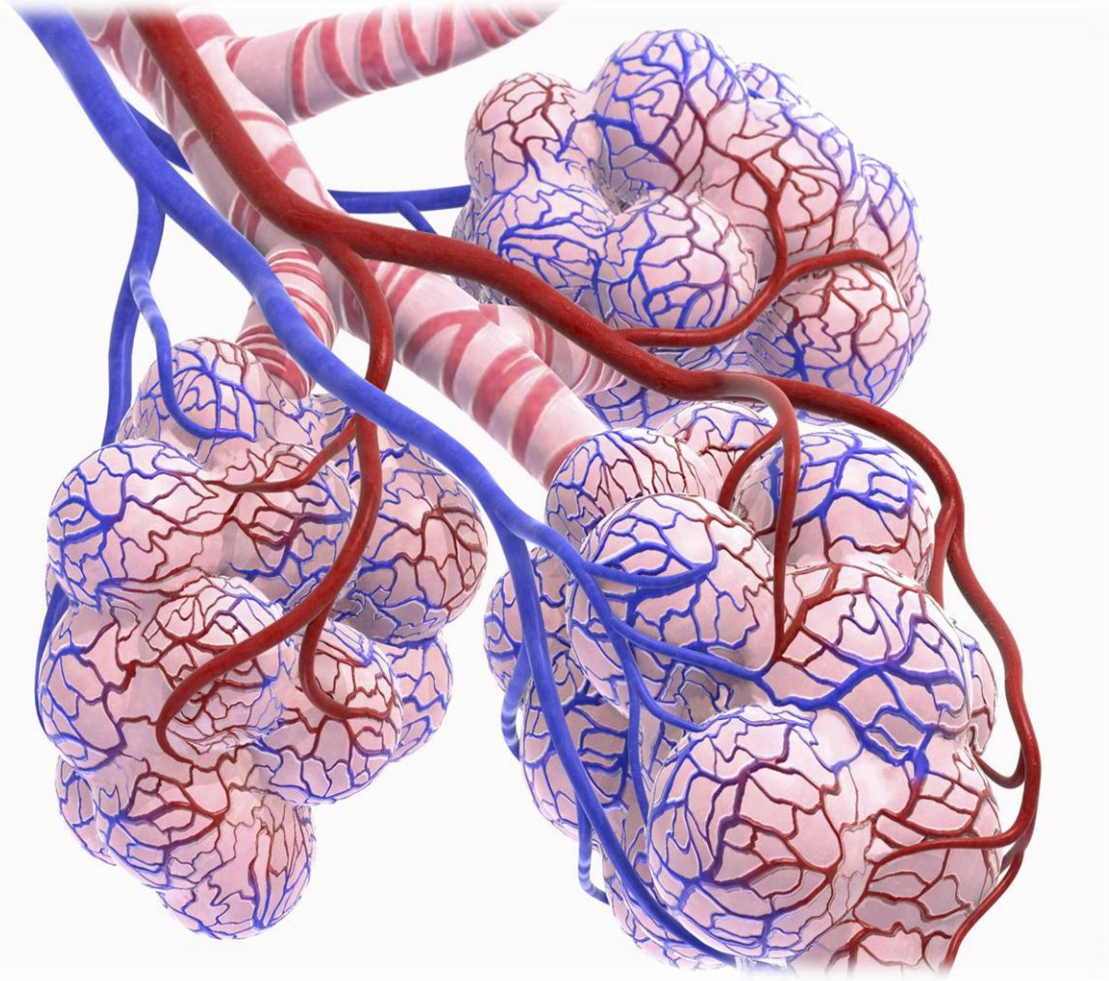

Windpipe (trachea)
Outer pleura
Right bronchus
Left bronchus
Ribs
Bronchioles
Alveoli
Inner pleura
Diaphragm

ALVEOLI

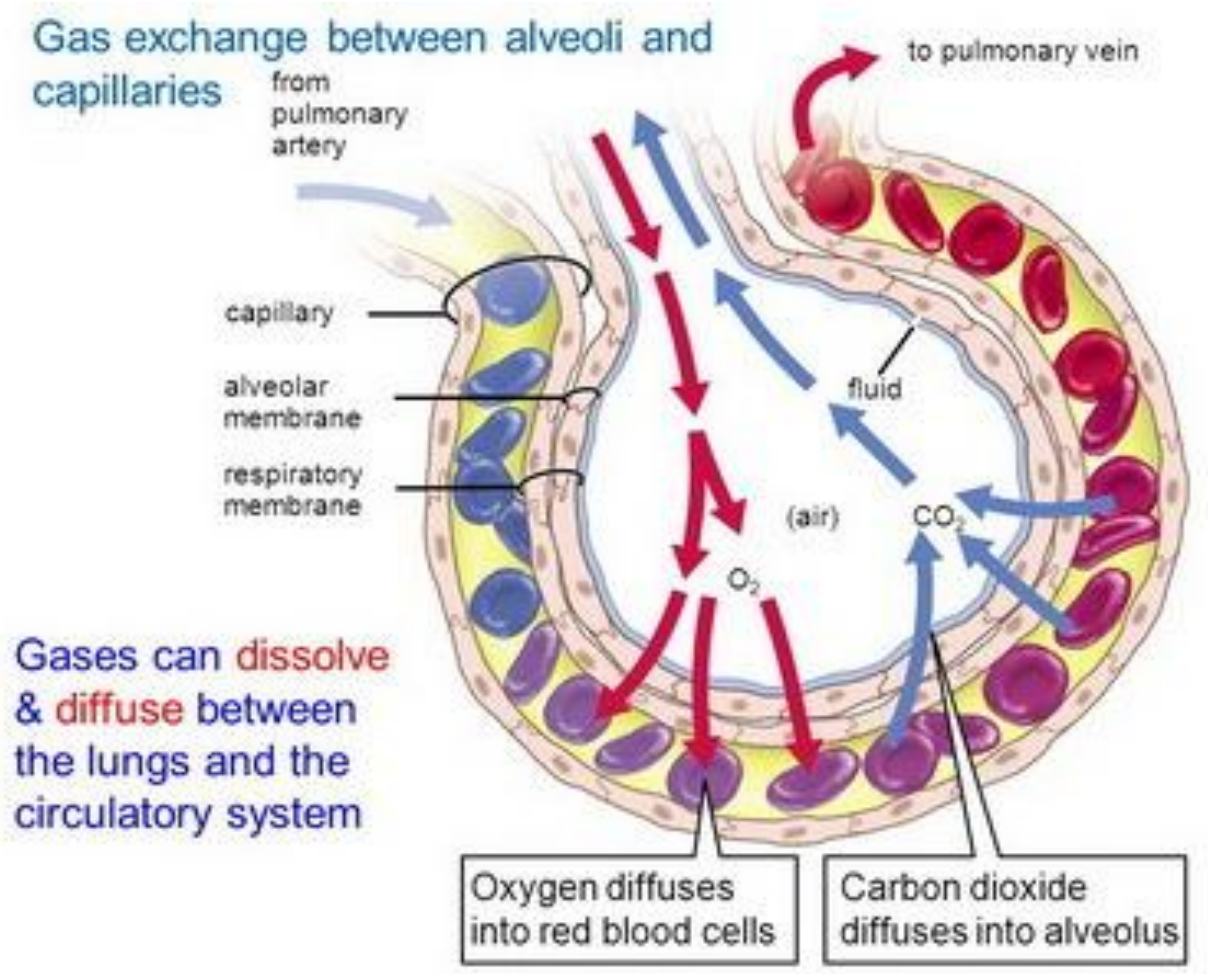
- These are **thin walled lobulated** structures, like a bunch of **grapes**.
- Each **alveolus** is surrounded by a network of capillaries of pulmonary artries and veins.
- These have **highly elastic wall** made up of a single layer **squamous epithelium** resting on a basement membrane of connective tissue.
- There are about **700 million alveoli in the lungs** and they provide the surface area for exchange of gases.

ALVEOLI



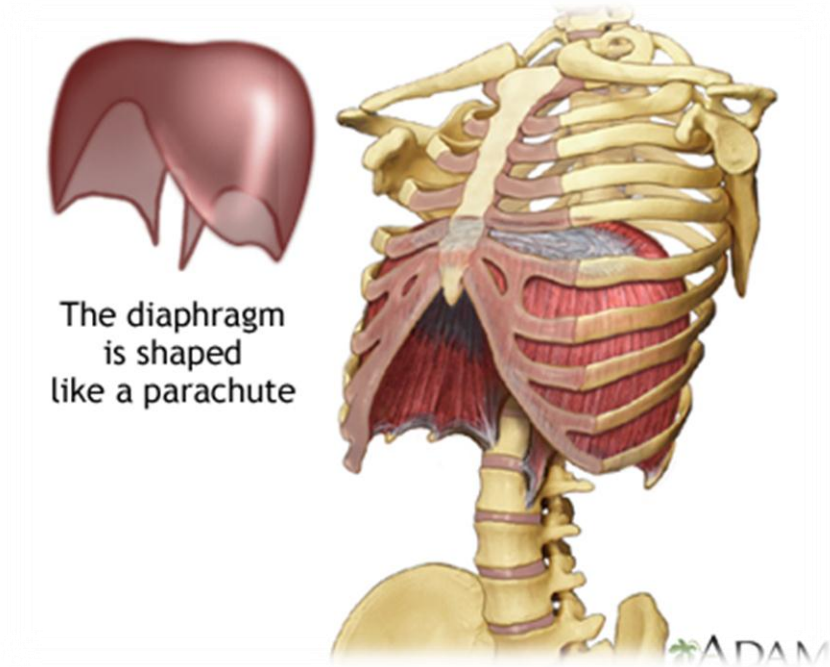


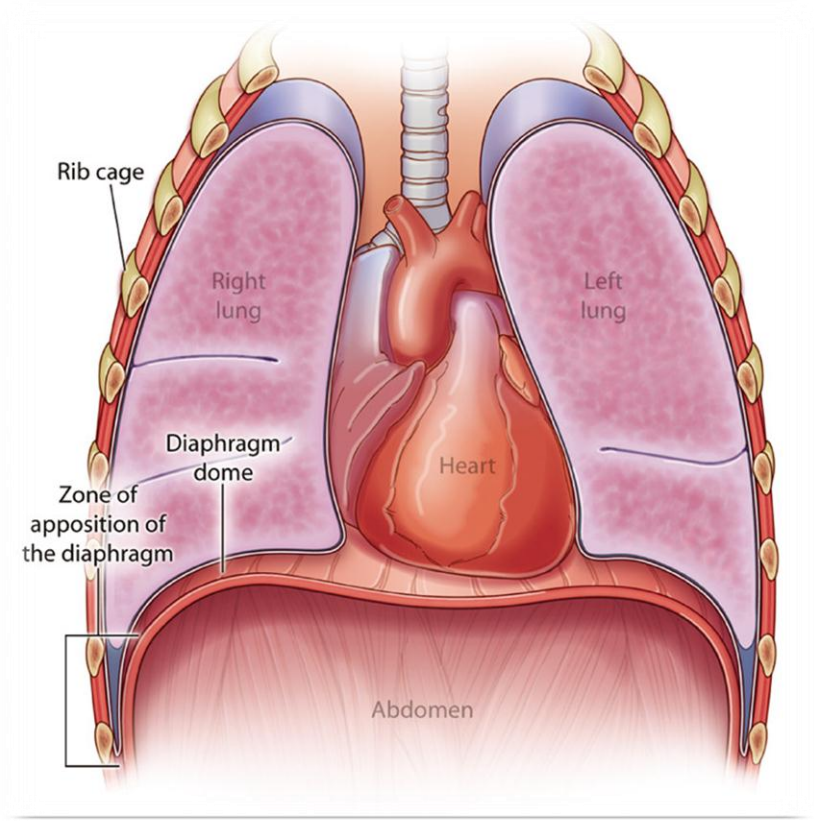
DIFFUSION OF GASES

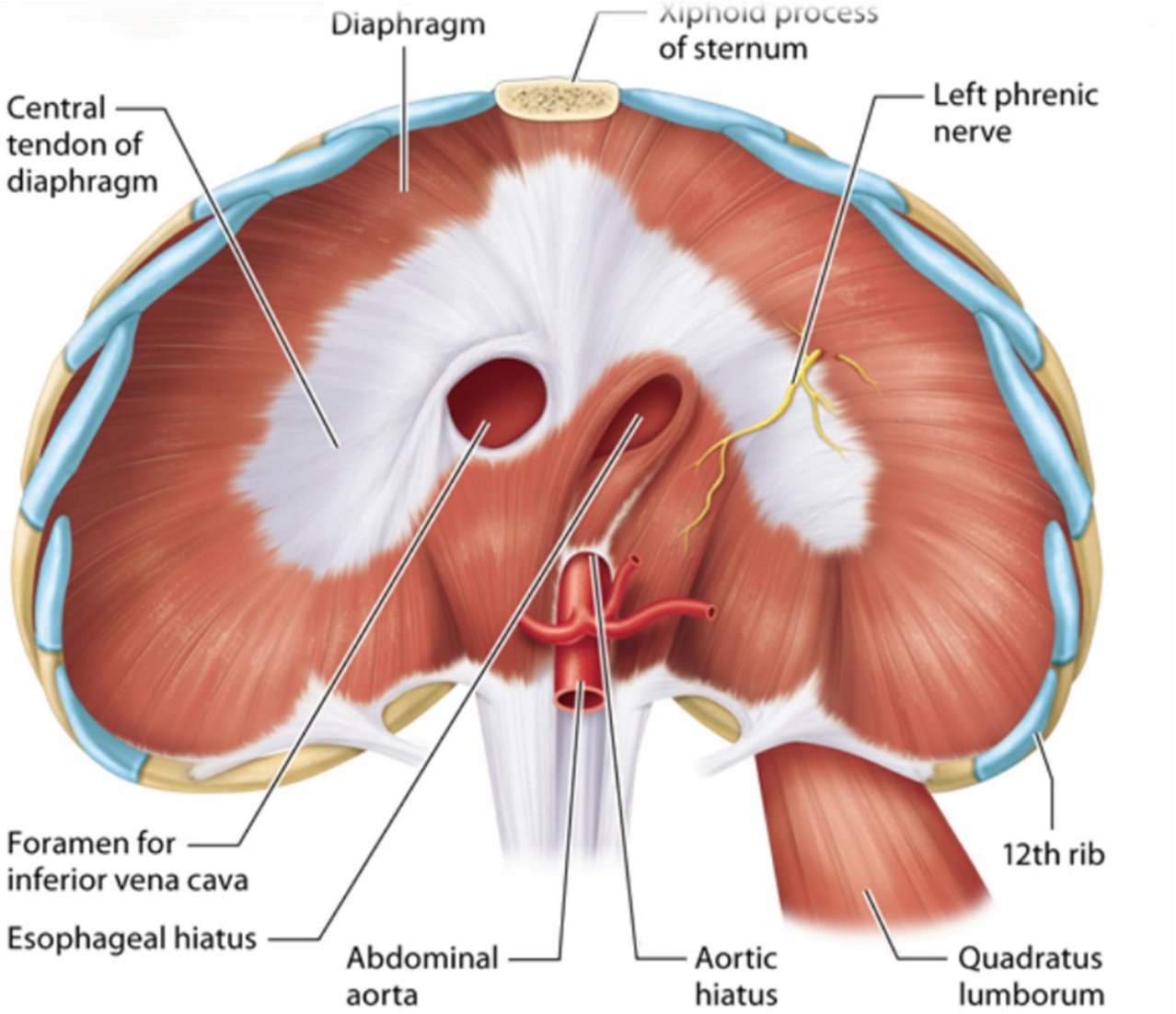


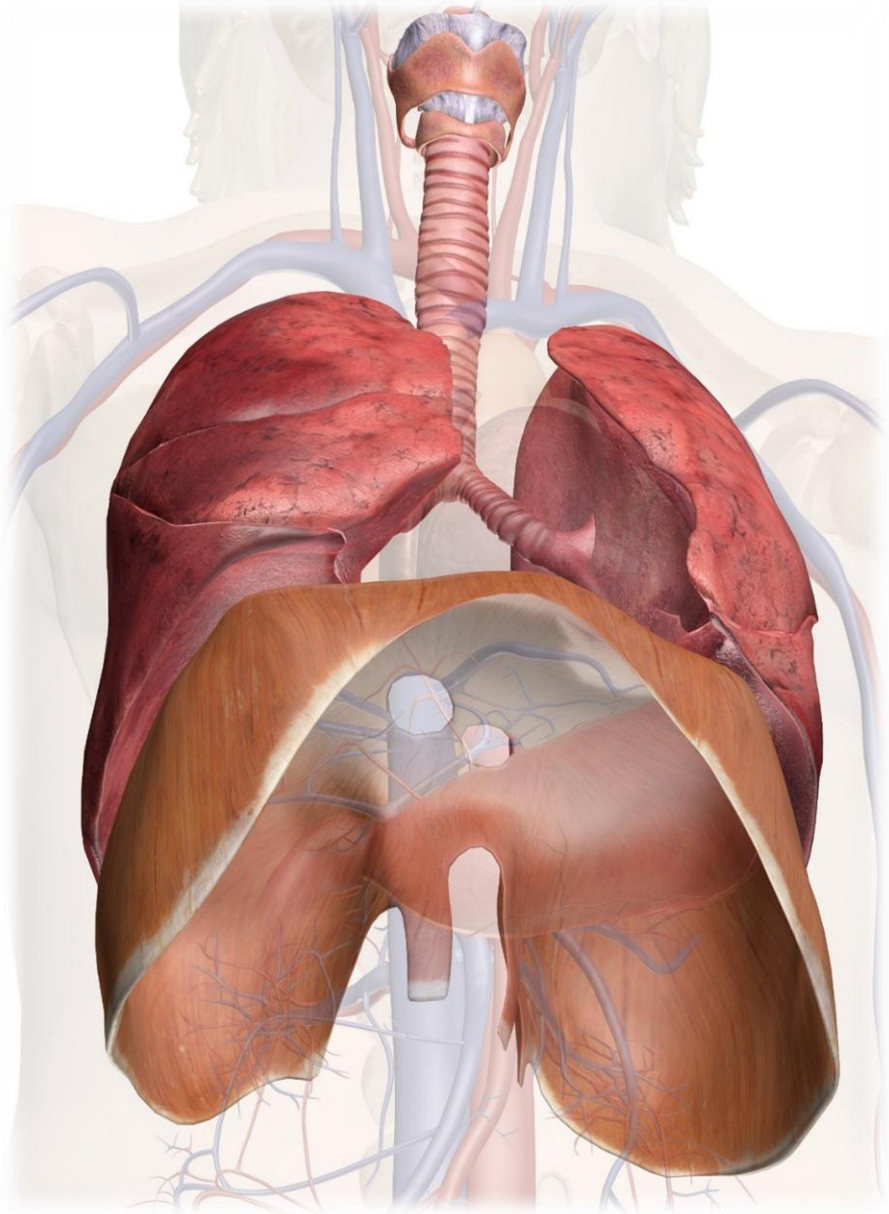
DIAPHRAGM

- It is a muscular septum that separates the **thoracic and abdominal cavity.**
- It is dome shaped and on contraction it becomes flattened.






Diaphragm
Xiphoid process of sternum
Central tendon of diaphragm
Left phrenic nerve
Foramen for inferior vena cava
Esophageal hiatus
Abdominal aorta
Aortic hiatus
12th rib
Quadratus lumborum



MECHANISM OF RESPIRATION

- Respiration is a biological process involving exchange of gases between the atmosphere and the lungs and it results in the formation of ATP.
- It includes the following processes:-

A. Breathing

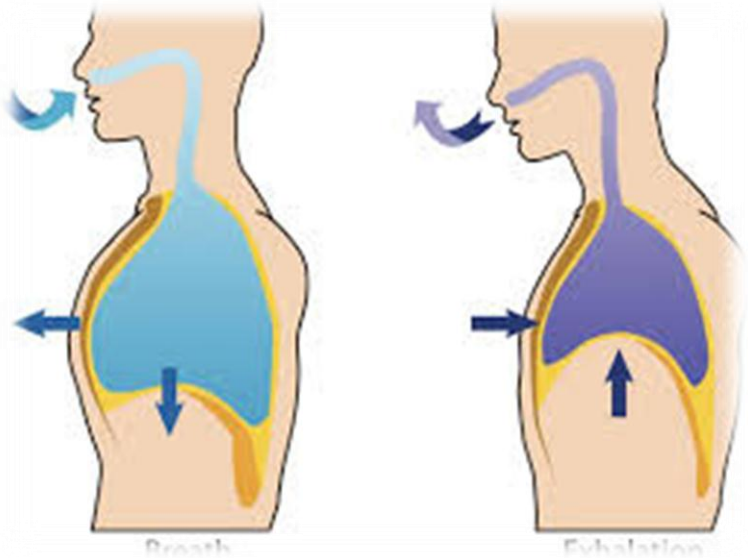
B. External respiration

C. Internal respiration

D. Cellular respiration

A. BREATHING

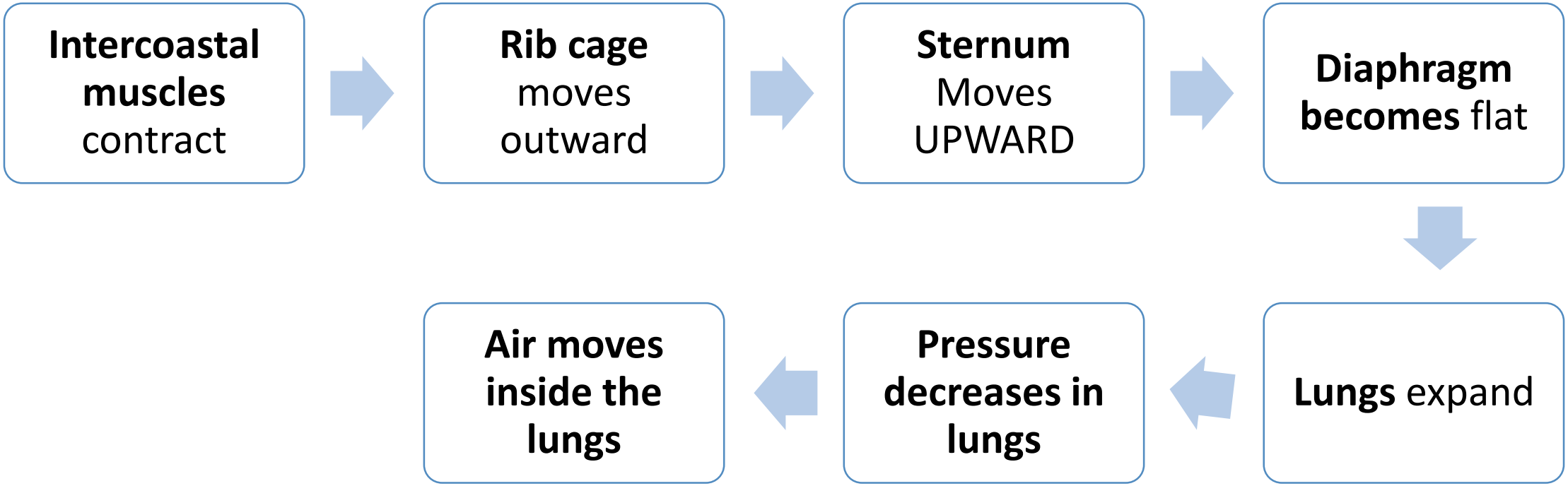
- It is a physical process by which gaseous exchange takes place between the atmosphere and the lungs.
- It involves inspiration and expiration.
- Both these steps involved parts of the thoracic cage, the ribs, sternum and the intercostal muscles and muscles of the diaphragm.



INSPIRATION

- During inspiration, the atmospheric **air is taken in** to the lungs.
- It occurs due to the **pressure gradient** formed between the **lungs and the atmosphere**.
- It is an active process in which the **diaphragm becomes flat and goes downward**, the external **intercostal muscles** **contract** so the ribs and **sternum move upward and outward**.
- This leads to an **increase in the thoracic volume** and a **decrease in pressure of thorax and the lungs**.
- To equalize the **low pressure inside the lungs**, air from the atmosphere rushes into lungs. This is inspiration.

INSPIRATION

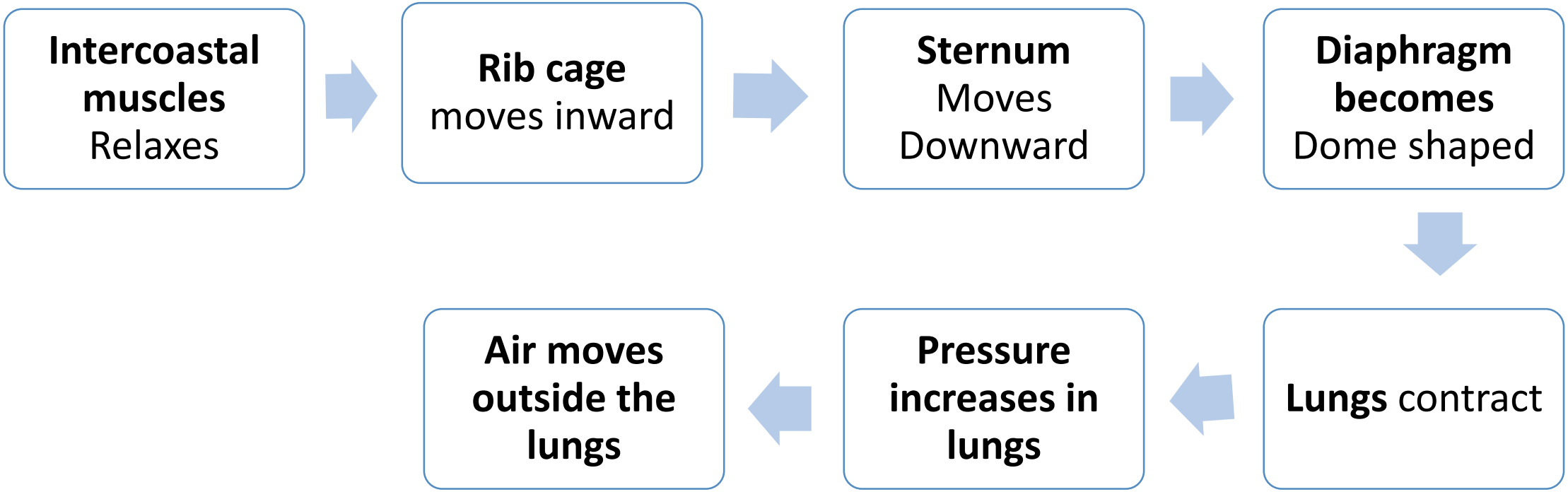


EXPIRATION

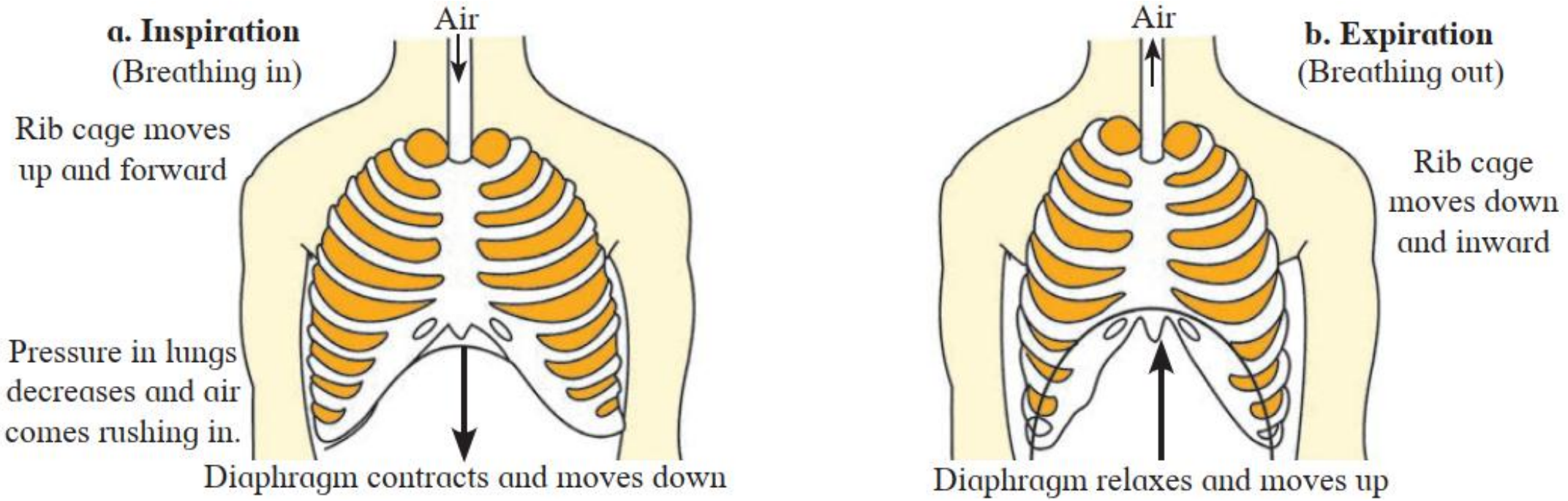
- During expiration, the thorax contracts causing air to be exhaled.
- The **diaphragm** relaxes and is pushed upwards.
- It becomes **dome shaped**.
- The **intercostal muscles also relax** pulling the rib cage inward and downward.
- This causes a **decrease in thoracic volume** and leads to increase in pressure in the thorax and the lungs as compared to the atmospheric pressure.
- So **air from the lungs rushes out**.
- This is expiration.

One inspiration and one expiration is one breath.

EXPIRATION

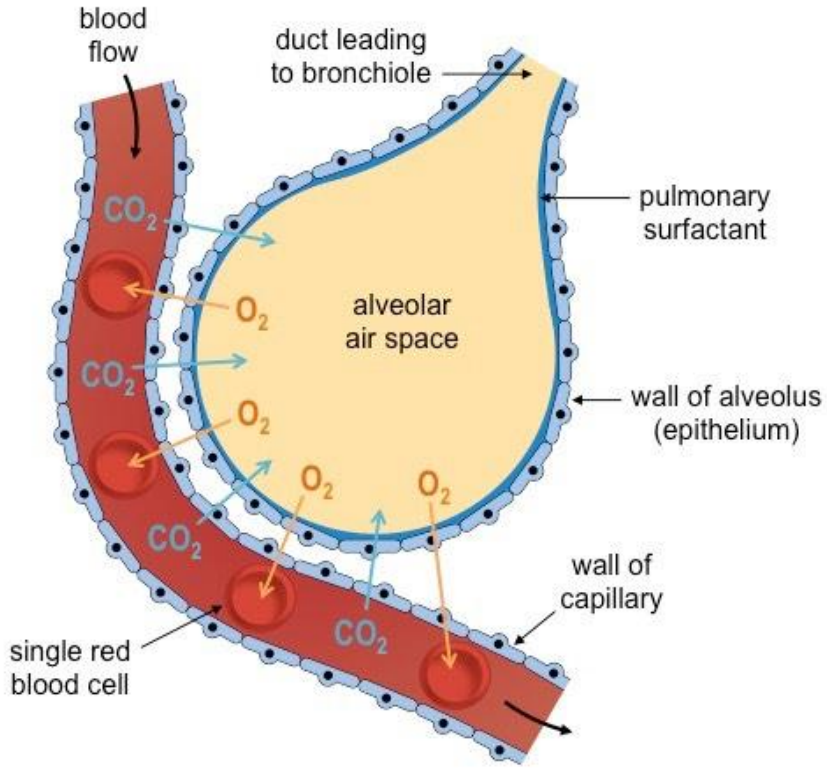

Intercoastal muscles Relaxes
Rib cage moves inward
Sternum Moves Downward
Diaphragm becomes Dome shaped
Lungs contract
Pressure increases in lungs
Air moves outside the lungs

BREATHING


a. Inspiration
(Breathing in)
Air
Rib cage moves up and forward
Pressure in lungs decreases and air comes rushing in.
Diaphragm contracts and moves down
Air
b. Expiration
(Breathing out)
Rib cage moves down and inward
Diaphragm relaxes and moves up

B. EXTERNAL RESPIRATION/ EXCHANGE OF GASES AT THE ALVEOLAR LEVEL

- An alveolus consists of a layer of **simple squamous epithelium** resting on a basement membrane.
- It is intimately associated with a dense network of capillaries.
- The capillary wall is also made up of simple squamous epithelium resting on a thin basement membrane.
- Both the layers have similar structure and are thin walled.
- Together they make up the **respiratory membrane** through which gaseous exchange occurs i.e. **between the alveolar air and the blood.**



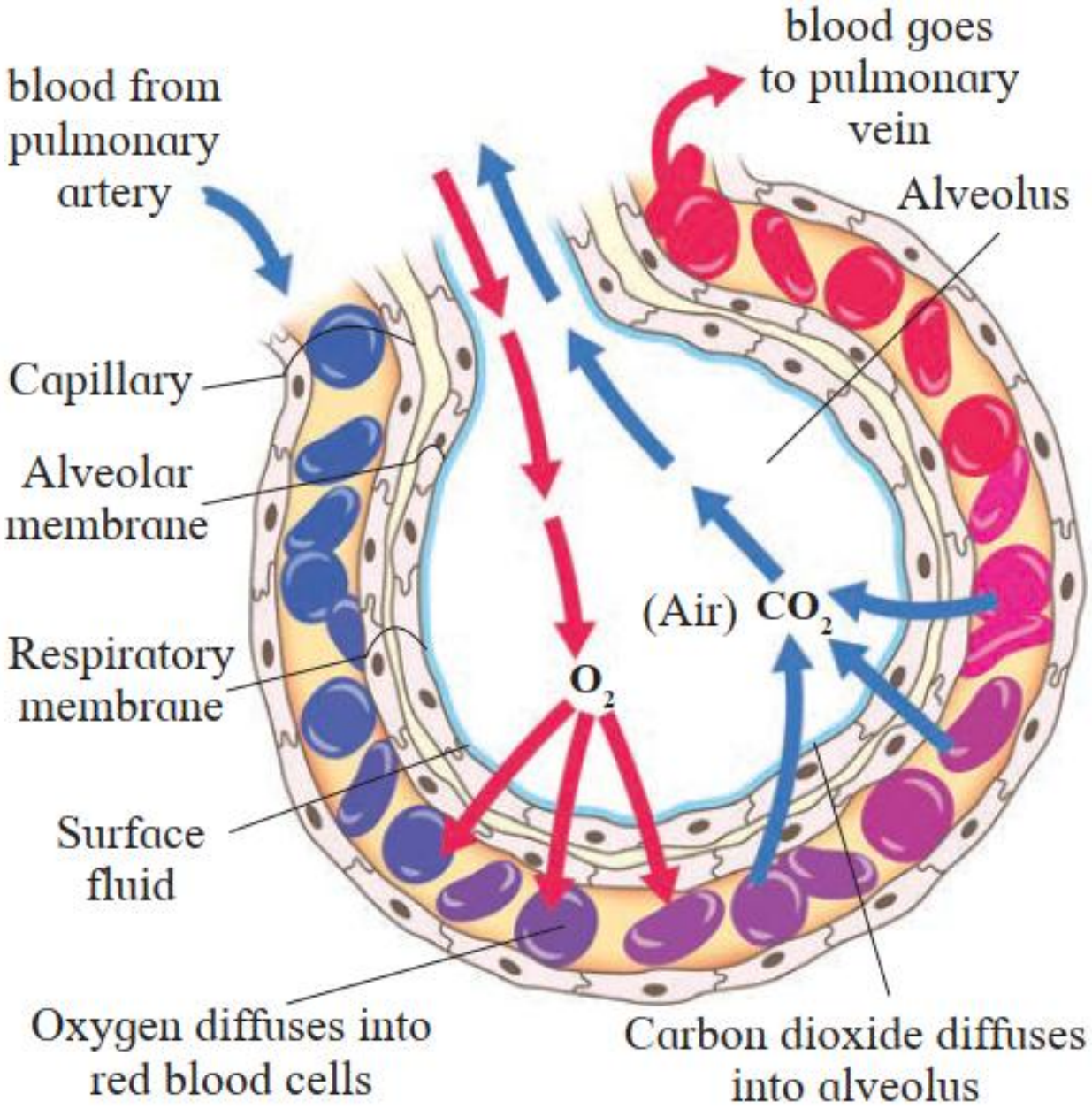
- Diffusion of gases will take place **from an area of higher partial pressure** to an **area of lower partial pressure** until the partial pressure in the two regions reaches equilibrium.

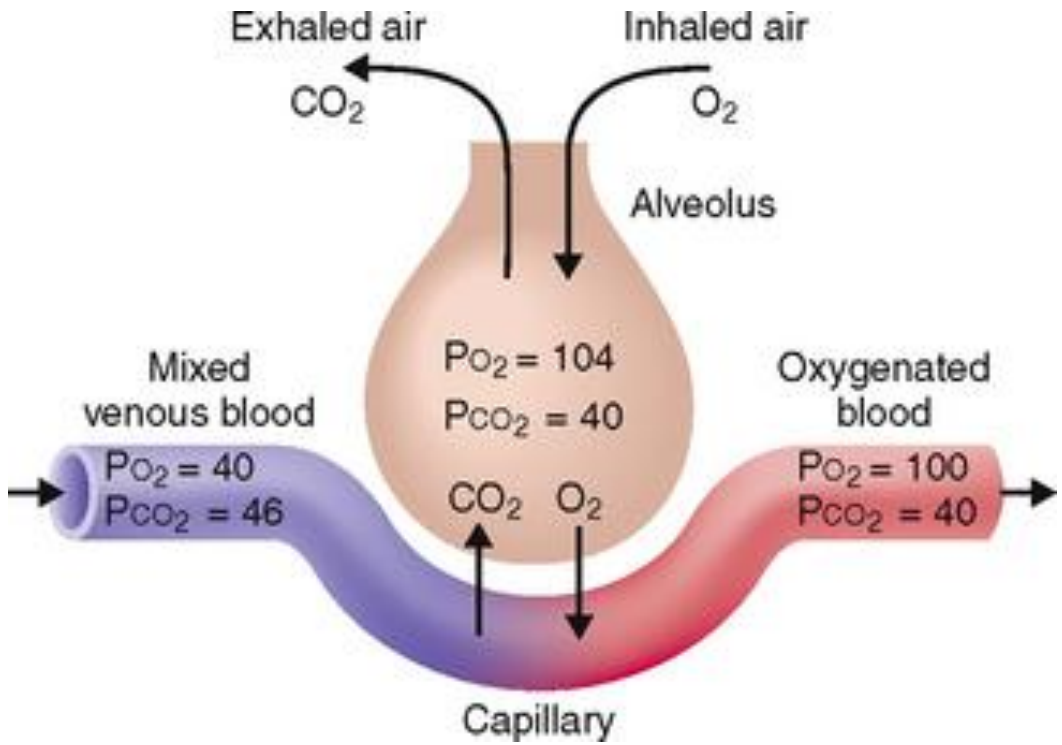
- The **partial pressure of carbon-dioxide** of blood entering the **pulmonary capillaries is 45 mmHg** while partial pressure of **carbon-dioxide in alveolar air is 40 mmHg.**

- Due to this difference, **carbon dioxide diffuses from the capillaries into the alveolus**.

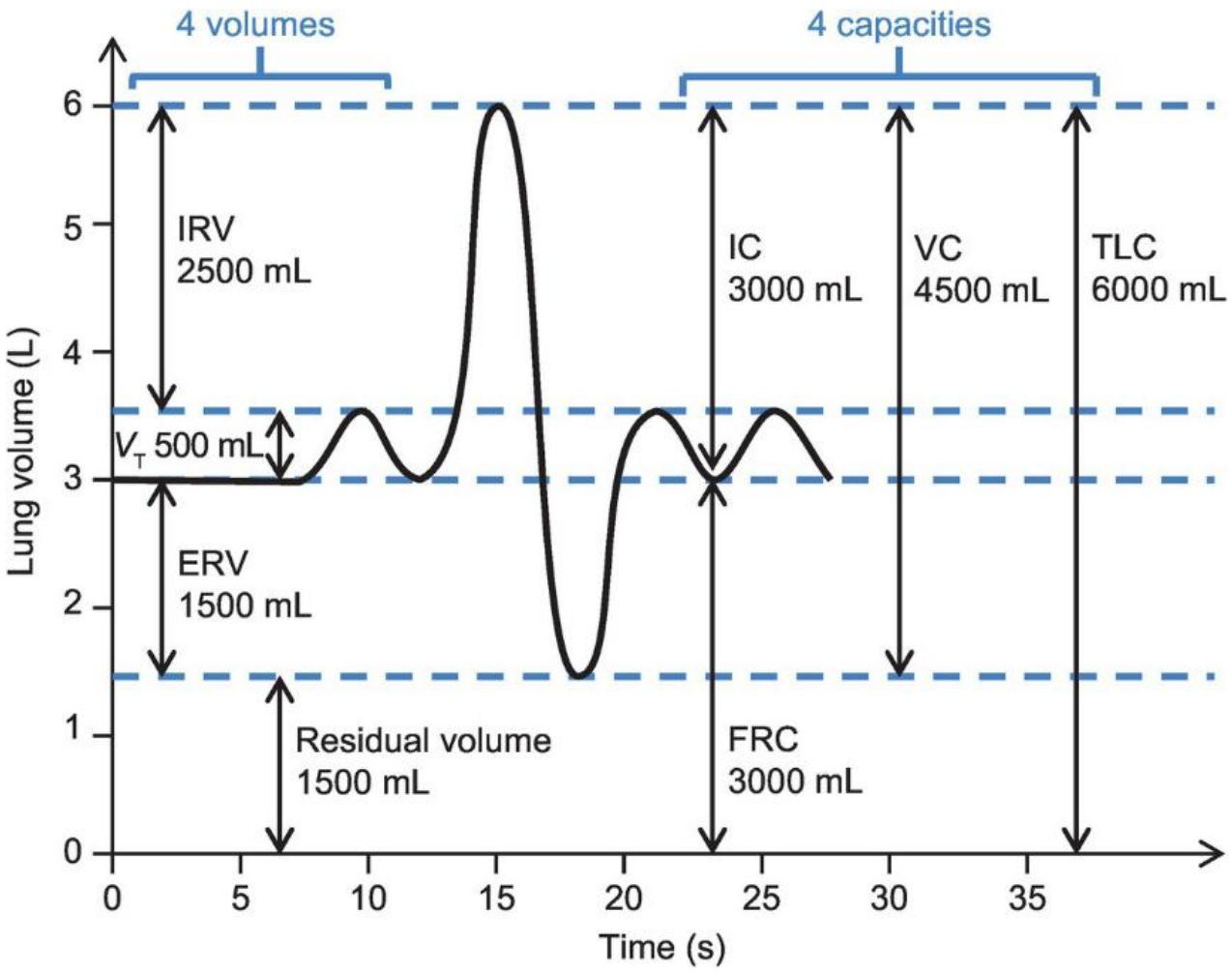
- Similarly, partial pressure of oxygen of blood in **pulmonary capillaries is 40 mmHg** while in **alveolar blood it is 104 mmHg**.

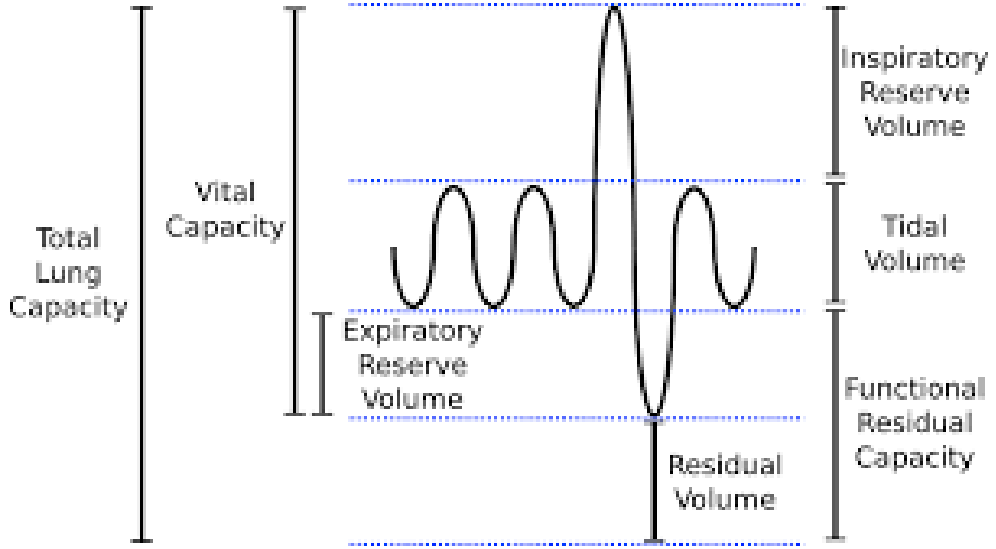
- Due to this difference **oxygen diffuses from alveoli to the capillaries**.


blood from pulmonary artery
blood goes to pulmonary vein
Alveolus
Capillary
Alveolar membrane
Respiratory membrane
Surface fluid
(Air) CO_2
O_2
Oxygen diffuses into red blood cells
Carbon dioxide diffuses into alveolus


Exhaled air
CO_2
Inhaled air
O_2
Alveolus
$P_{O_2} = 104$
$P_{CO_2} = 40$
Mixed venous blood
$P_{O_2} = 40$
$P_{CO_2} = 46$
CO_2 O_2
Oxygenated blood
$P_{O_2} = 100$
$P_{CO_2} = 40$
Capillary

PULMONARY VOLUMES AND CAPACITIES





PULMONARY VOLUMES AND CAPACITIES

Tidal volume (T.V.): It is the volume of air inspired or expired during normal breathing. **It is 500 ml**.

Inspiratory reserve volume (IRV): The maximum volume of air, or the extra volume of air, that is inspired during forced breathing in addition to T.V. **Its value is 2000 to 3000ml.**

Expiratory reserve volume (ERV) : The maximum volume of air that is expired during forced breathing after normal expiration. **Its value is 1000 to 1100ml**.

Dead space (DS): The volume of air that is present in the respiratory tract (from nose to the terminal bronchioles), but not involved in gaseous exchange. **It is 150 ml**.

Residual volume (RV) : The volume of air that remains in the lungs and the dead space even after maximum expiration. **It is 1100 to 1200ml**.

LUNG CAPACITIES

Total Lung capacity : The maximum amount of air that the lungs can hold after a maximum forcefull inspiration **(5200 to 5800ml).**

Vital capacity (VC) : The maximum amount of air that can be breathed out after a maximum inspiration. **It is the some total of TV, IRV and ERV and is 4100 to 4600ml**.

C. INTERNAL RESPIRATION

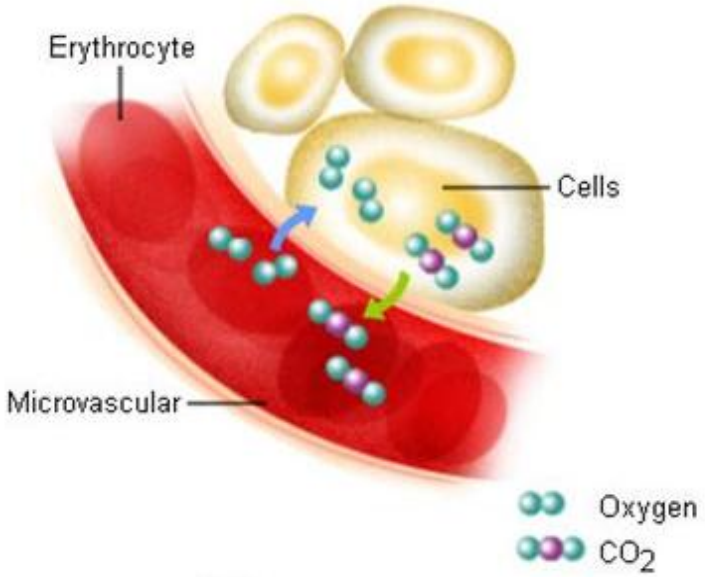
- The two main components of blood involved in transport of the respiratory gases- **CO_2 and O_2**, are the **RBCs and the plasma**.

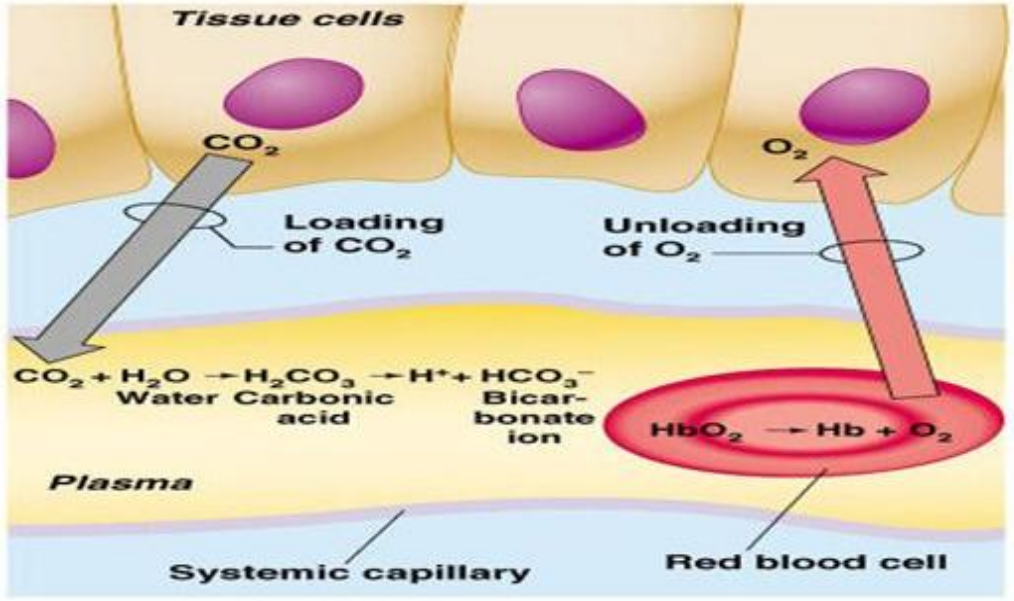
i. **Transport of oxygen**

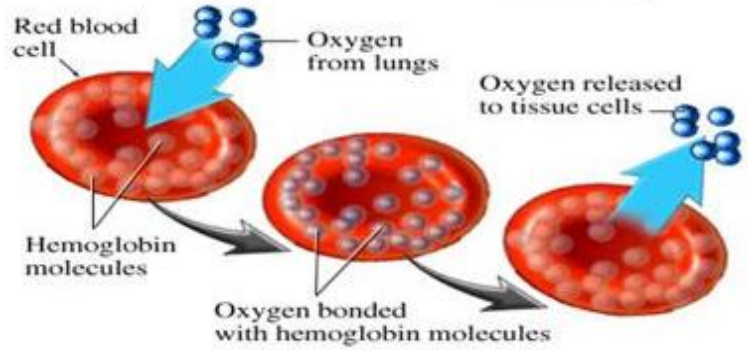
- Out of the total oxygen transported only **3%** is transported in a dissolved state by the **plasma**.
- The remaining **97%** is bound to the **haemoglobin (Hb)** present in the **RBCs.**

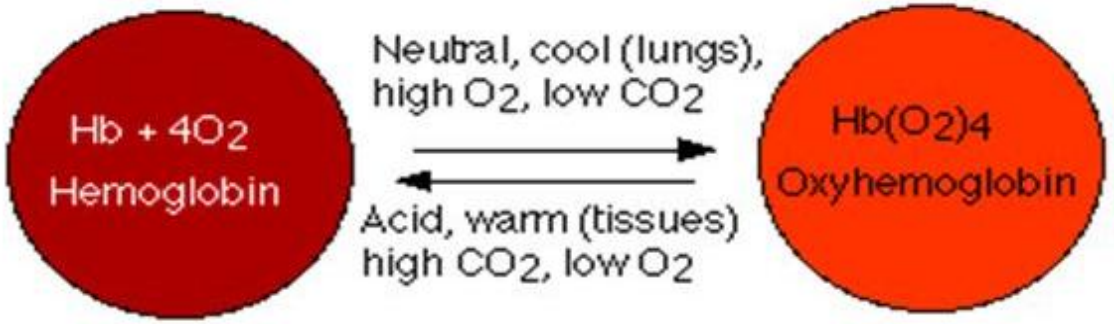
Internal respiration is the diffusion of O_2 from systemic capillaries into tissues and CO_2 from tissue fluid into systemic capillaries.

Oxyhemoglobin gives up O_2, which diffuses out of the blood and into the tissues because the partial pressure of O_2 of tissues fluid is lower than that of the blood.









HEMOGLOBIN

- Hemoglobin acts as the respiratory carrier. It has a high affinity for O_2 and combines with it to form **oxyhaemoglobin**.
- Theoretically, one molecule of Hb has **4 Fe++,** each of which can pick up a molecule of **oxygen (O_2).**

AT LUNGS $Hb + 4O_2 \longrightarrow Hb\,(4O_2)$

- **Oxyhaemoglobin** is transported from lungs to the tissues where it readily dissociates to release O_2.

AT ORGANS $Hb\,(4O_2) \longrightarrow Hb + 4O_2$

- However, the degree of saturation of Hb with O_2 depends upon the O_2 tension i.e. ppO_2.

- **100% saturation is rare**.

- **Maximum saturation** of 95 to 97% is at ppO_2 in alveoli **(100 mmHg).**

- Degree of saturation decreases with the drop in ppO_2. This begins the dissociation of HbO_2.

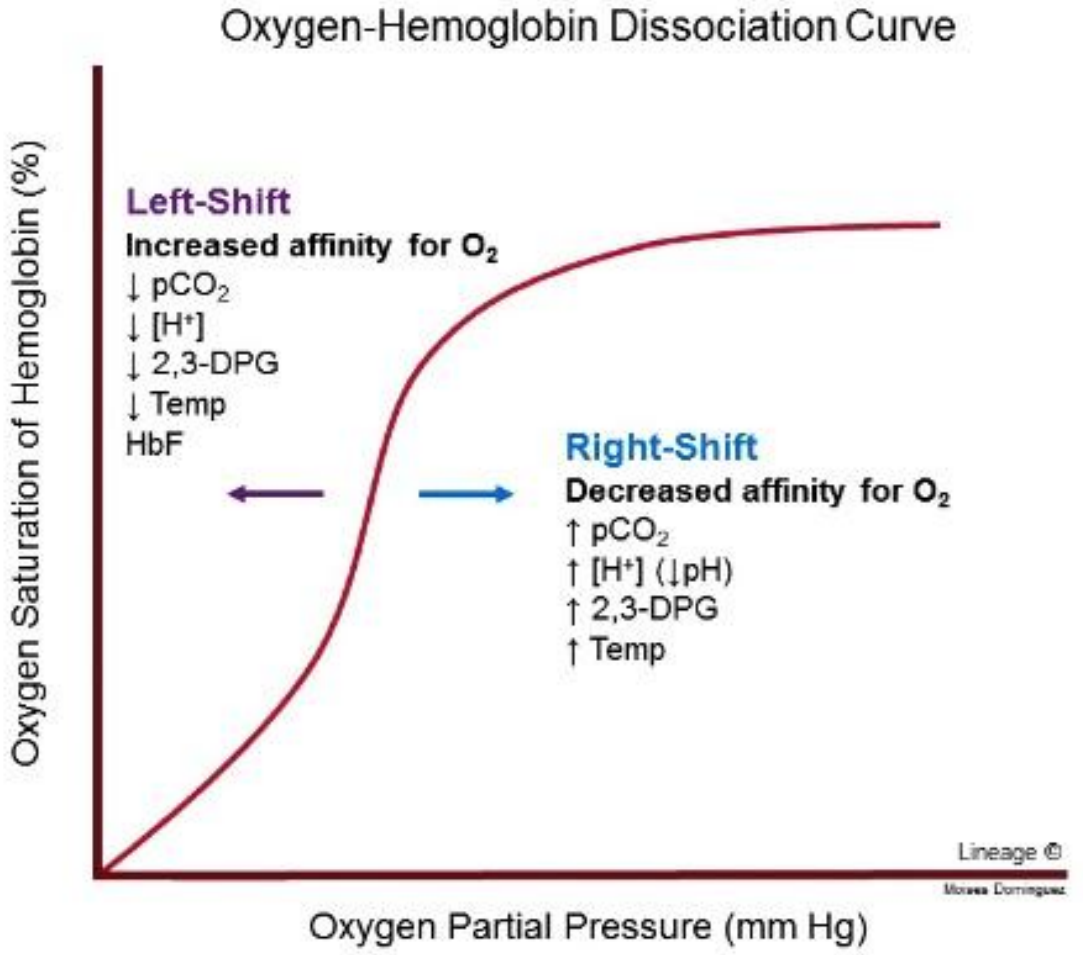
- At **30 mmHg** of ppO_2, only **50% saturation** can be maintained.

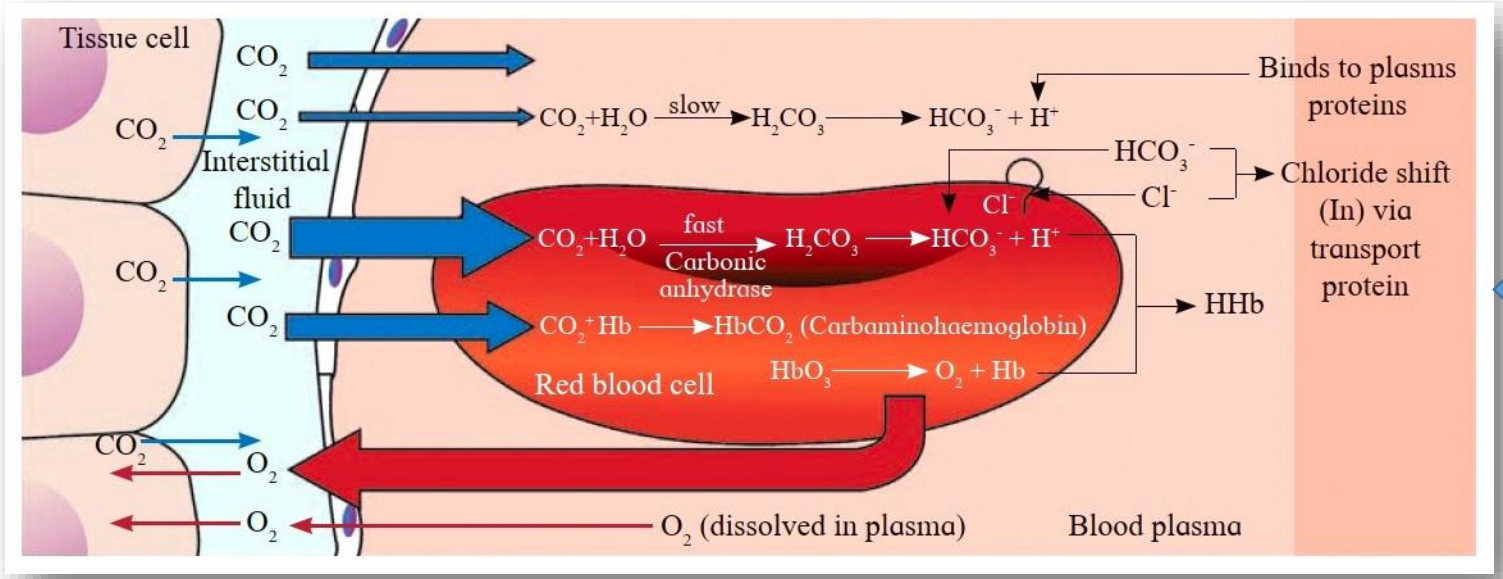
- The relationship between HbO_2 saturation and oxygen tension (ppO_2) is called **oxygen dissociation curve**.

OXYGEN-HAEMOGLOBIN DISSOCIATION CURVE

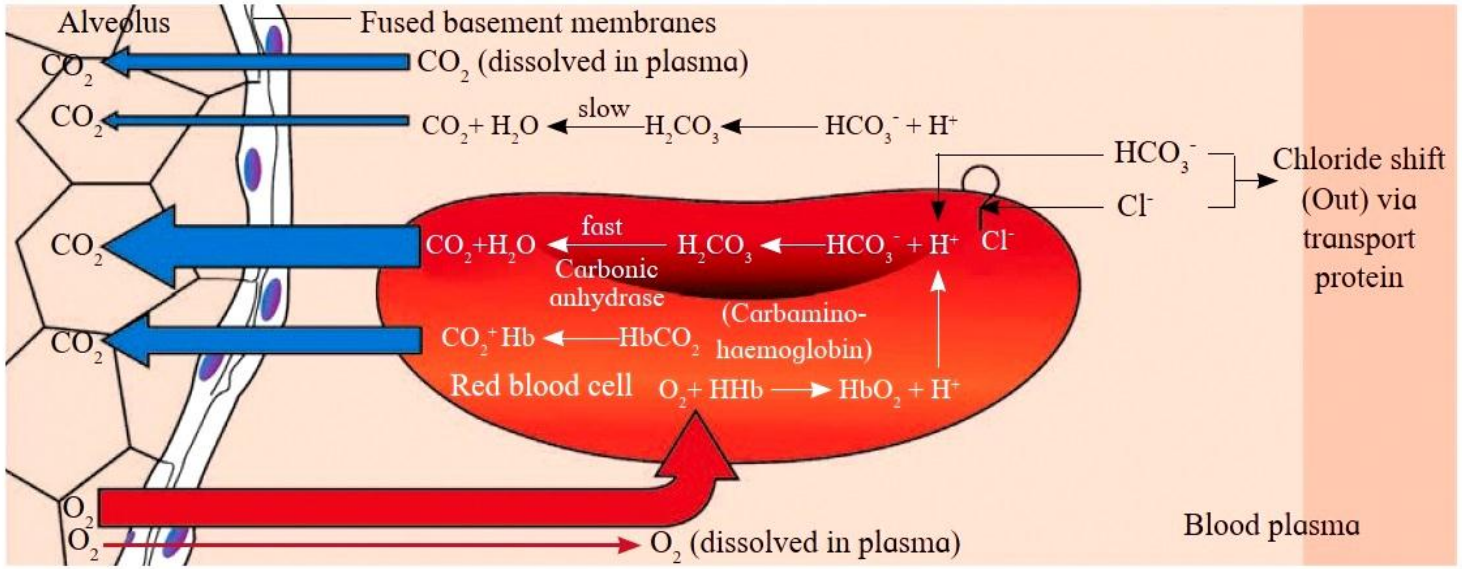
- This oxygen-haemoglobin dissociation curve is a sigmoid curve and it shifts towards the **right** due to increase in **H+ concentration**, **increase in ppCO$_2$** and rise in **tempreature** and **rise in DPG (2, 3 diphosphoglycerate)**, formed in the RBCs during glycolysis. It lowers the affinity of haemoglobin for oxygen.

- **Bohr effect** : It is the shift of oxyhaemoglobin dissociation curve due to change in partial pressure of CO_2 in blood.



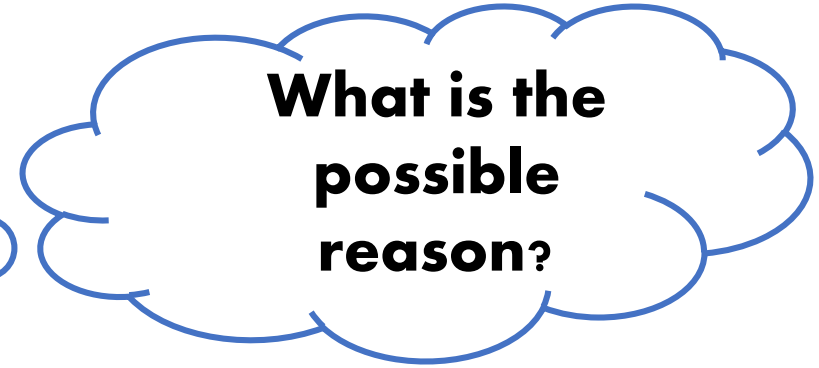


PICK UP OF CO_2
RELEASE OF O_2



RELEASE OF CO_2
PICK UP OF O_2

While working with the car engine in a closed garage, John suddenly felt dizzy and fainted.



- Affinity of haemoglobin for carbon monoxide is about 250 times more, than for oxygen.
- In the presence of carbon monoxide, haemoglobin readily combines to form a stable compound **carboxyhaemoglobin**.
- The **haemoglobin is blocked by carbon monoxide**, preventing oxygen from binding with haemoglobin.
- Thus, less haemoglobin is available for oxygen transport depriving the cells of oxygen.
- **This is carbon monoxide poisoning**.

Transport of CO_2

A. IN THE PLASMA IN THE FORM OF SOLUTION (7%).

B. IN THE FORM OF BICARBONATE IONS (70%).

C. IN THE RBC'S (23%).

IN THE PLASMA IN THE FORM OF SOLUTION

- Only **7%** of CO2 is transported in a dissolved form as **carbonic acid** (which can breakdown into CO_2 and H_2O).

$$CO_2 + H_2O \rightleftharpoons H_2CO_3 \text{ (CARBONIC ACID)}$$

CARONIC ANHYDRASE
(Zn)

IN THE FORM OF BICARBONATE IONS.

- Nearly 70% of carbondioxide released by the tissue cells diffuses into the plasma and then into the RBCs.
- In the RBCs, CO_2 combines with water in the presence of a **Zn** containing enzyme, **carbonic anhydrase** to form **carbonic acid.**
- **Carbonic anhydrase** enzyme is found in the **RBCs** and not in the plasma.
- The rate of formation of carbonic acid inside the RBC is very high as compared to its formation in the plasma.

- **Carbonic acid being unstable almost immediately dissociates into HCO_3^- and H^+ in the presence of the enzyme carbonic anhydrase (CA) leading to large accumulation of HCO^-_3 inside the RBCs.**

BICARBONATE IONS

LEADS TO DECREASE IN pH

By red blood cells (23%)

- Carbon dioxide binds with the amino group of the haemoglobin and form a loosely bound compound **carbaminohaemoglobin.**
- This molecule readily decomposes in region where the partial pressure of carbon dioxide **(ppCO2)** is low **(alveolar region)** , releasing the carbon dioxide.

Cellular Respiration

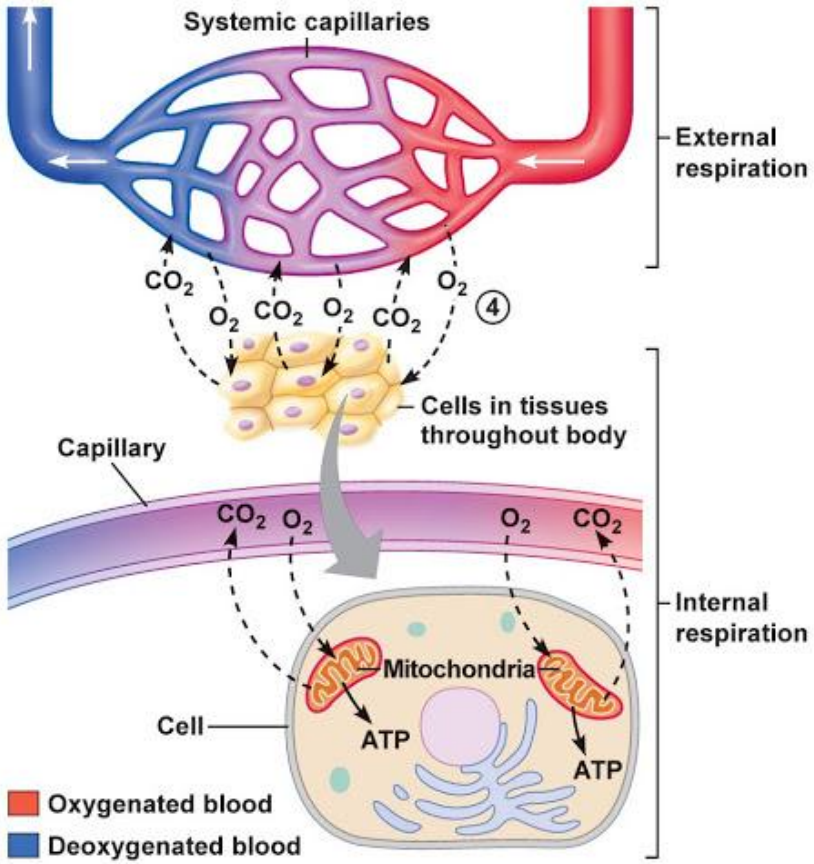
- It is the last step taking place inside the cell where food is oxidized and ATP is generated.
- It can be shown by two steps:

1. OXIDATION.
2. PHOSPHORYLATION.

1. Oxidation

- Breaking down of complex organic molecules into simple inorganic molecules with release of heat energy.

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + 686\ Kcal$$



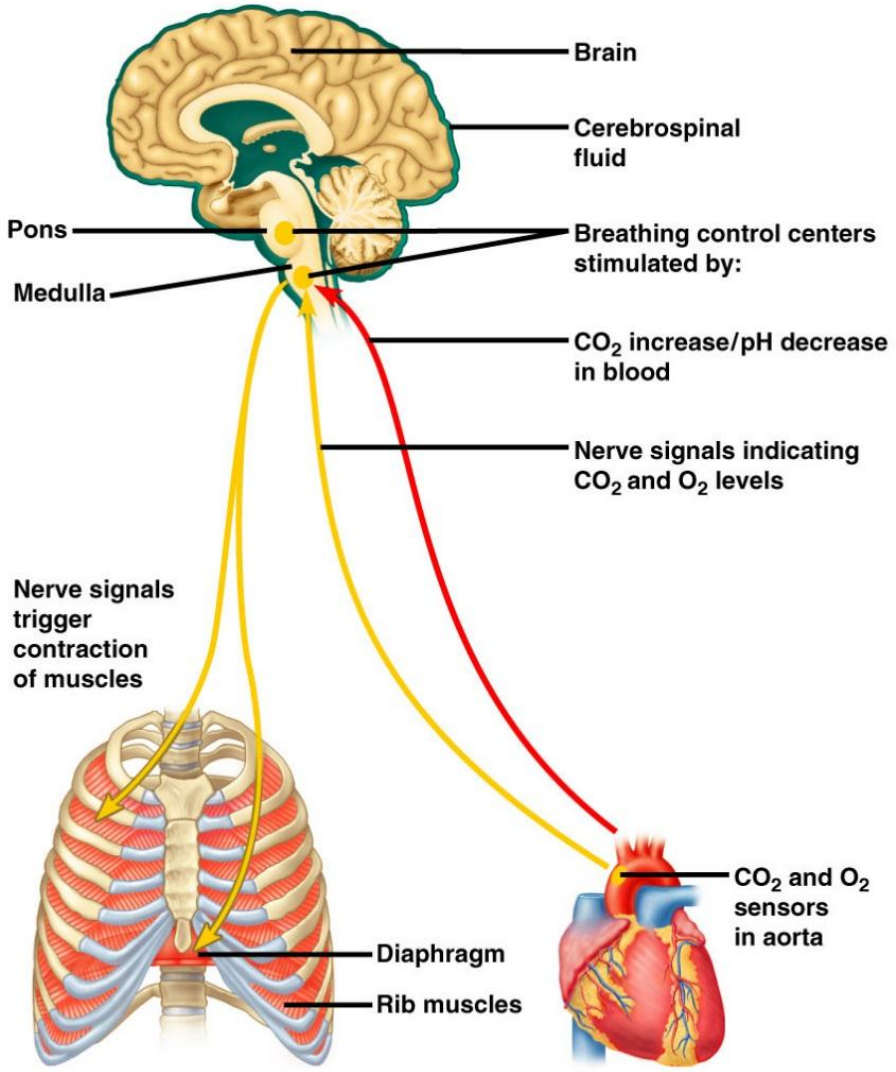
2. Phosphorylation

- It involves trapping the heat energy in the form of high energy bond of ATP molecule.
- ATP is used to carry out vital life processes and so is called as energy currency of the cell.

$$ADP + iP + 7.3\ Kcal \longrightarrow ATP$$

Regulation of Breathing

- Respiration is under dual control : nervous and chemical.
- Human adults breathe about 12 times/minute while a new born about 44 times/ minute.
- Normal breathing is an involuntary process.
- Steady rate of respiration is controlled by neurons located in the **pons** and **medulla** and are known as the **respiratory centres**.
- It regulates the rate and depth of breathing.

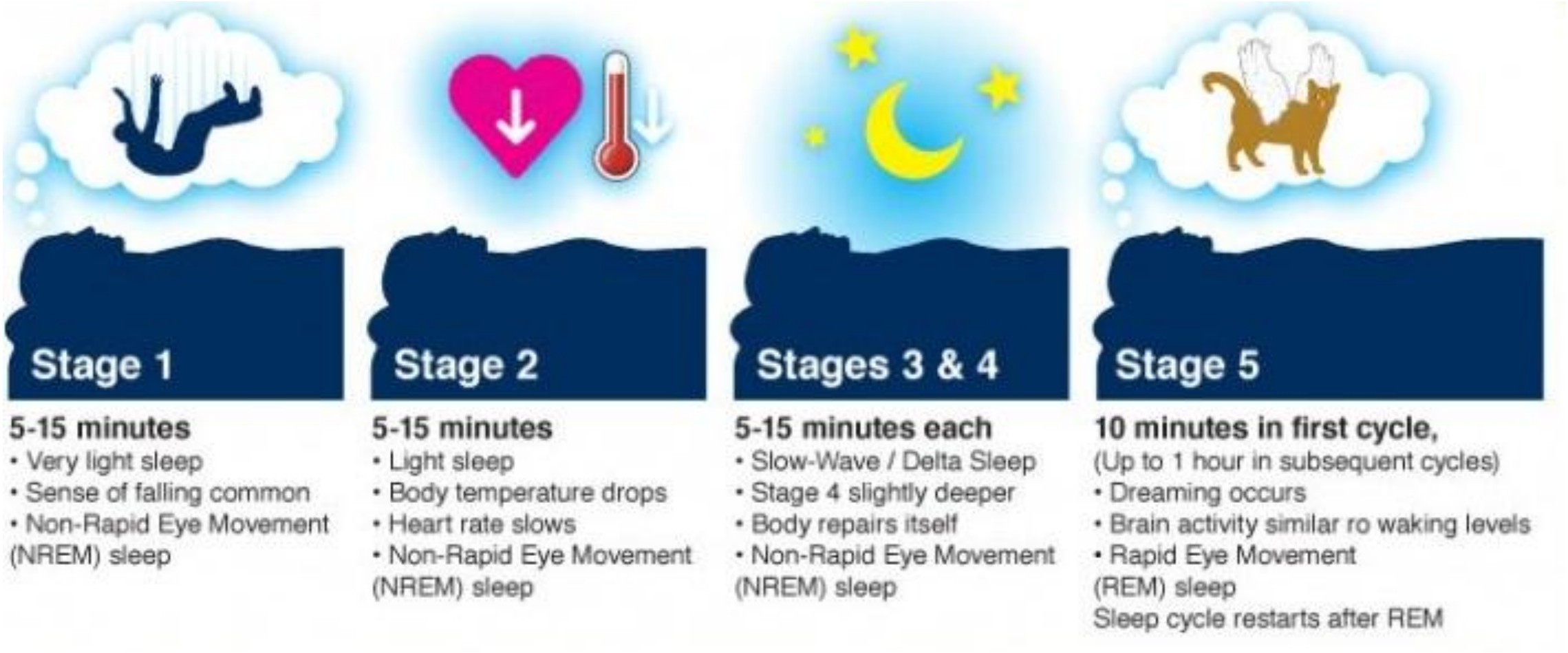


THREE GROUPS OF RESPIRATORY CENTRE

1. **Dorsal group of neurons** in the medulla (inspiratory center),
2. **Ventro lateral group of neurons** in medulla (inspiratory and expiratory center)
3. **Pneumotaxic center** located in pons (primarily limits inspiration, slow wave sleep and rapid eye movement sleep).

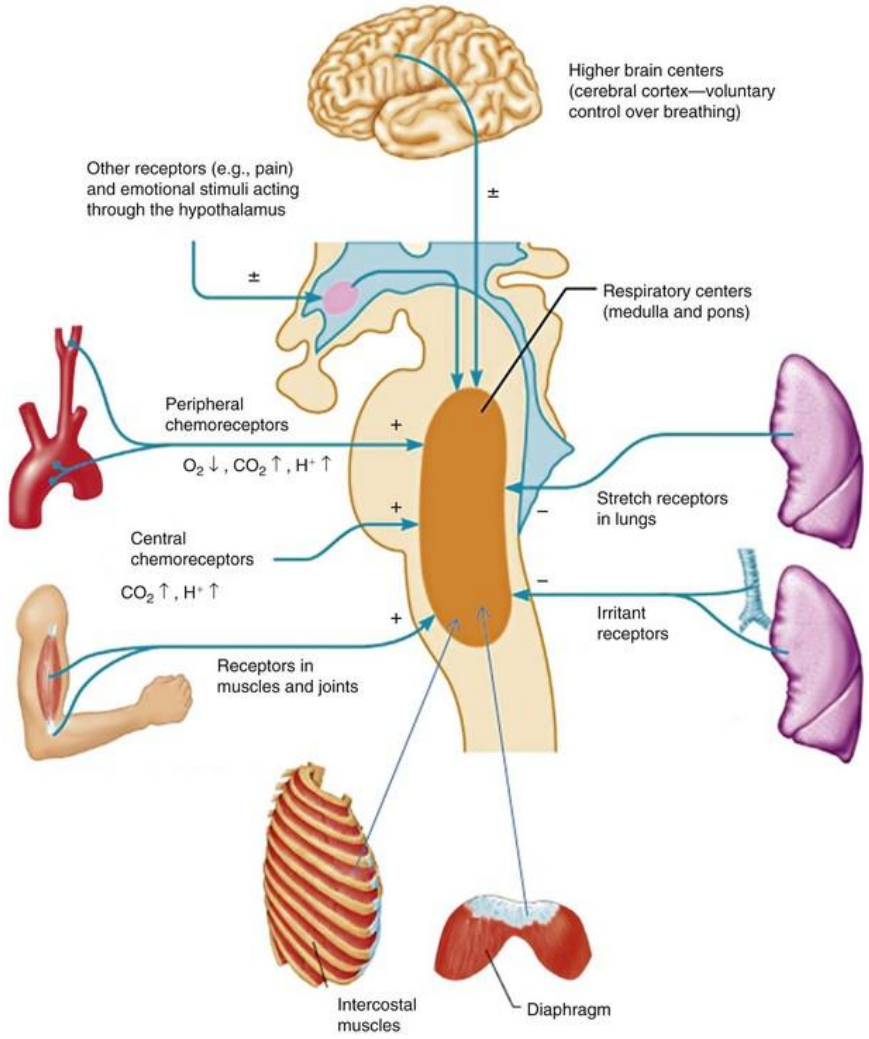
- **Apneustic center** in the medulla is **antagonistic** to the Pneumotaxic center.
- It controls non rapid eye movement sleep and wakefullness.

SLEEPING STAGES

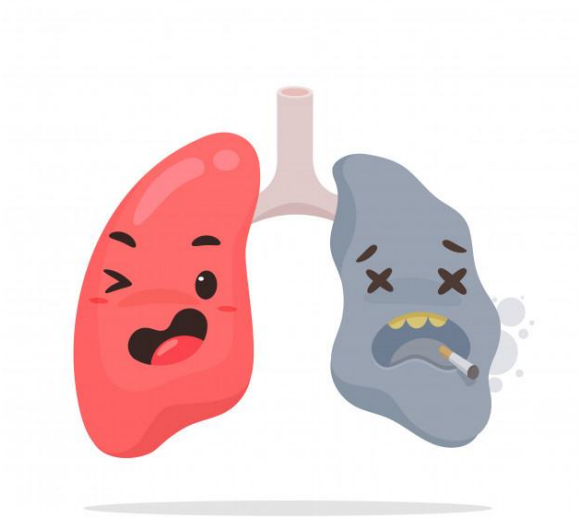


Hering-Breuer reflex

- During inspiration when the lungs expand to a critical point, the stretch receptors are stimulated and impulses are sent along the vagus nerves to the expiratory centre.
- It then sends out inhibitory impulses to the inspiratory center.
- The inspiratory muscles relax and expiration follows.
- As air leaves the lungs during expiration, the lungs are deflated and the stretch receptors are no longer stimulated.
- Thus, the inspiratory centre is no longer inhibited and a new respiration begins.
- These events are called the **Hering-Breuer reflex**.
- The **Hering-Breuer reflex** controls the depth and rhythm of respiration.



RESPIRATORY DISORDERS



Disorder	Symptoms	Cause	Treatment
Emphysema	Breakdown of alveoli, shortness of breath	Smoking, air pollution	Quit smoking, avoid polluted air, administer oxygen to relieve symptoms
Chronic bronchitis	Coughing, shortness of breath	Smoking, air pollution	Quit smoking, avoid polluted air, if possible move to warmer, drier climate
Acute bronchitis	Inflammation of bronchi, shortness of breath, yellow mucous coughed up.	Viruses and bacteria	If bacterial, take antibiotics, cough medicine, use vaporizer
Sinusitis	Inflammation of the sinuses, mucous discharge	Viruses and bacteria	If bacterial, take antibiotics and decongestants, use vaporizer
Laryngitis	Inflammation of larynx, vocal cords, sore throat, hoarseness of voice, mucous build up and cough	Viruses and bacteria	If bacterial, take antibiotics, cough medicines, voice rest, avoid irritants like smoke
Pneumonia	Inflammation of lungs ranging from mild to severe, cough and fever, shortness of breath, chills, sweating, chest pain, blood in mucous	Bacteria, viruses	Consult physician immediately, antibiotics, cough medicines, stay warm
Asthma	Constriction of bronchioles, mucus build up in bronchioles, periodic wheezing, difficulty in breathing.	Allergy to pollen, some foods, food additives, pet hair, etc.	Use of inhalants to open passage ways, avoid irritants
Occupational Respiratory Disorders- silicosis, asbestosis	Inflammation fibrosis, lung damage.	Long term exposure to dust particles silica and asbestos, particles during occupation	Protective mask and gear during work.

ARTIFICIAL VENTILATION

- It is also called artificial respiration. It is the method of inducing breathing in a person when natural respiration has ceased or is faltering.
- If used properly and quickly, it can prevent death due to drowning, choking, suffocation, electric shock, etc.
- **The process involves two main steps :-**

1. **Establishing and maintaining an open air passage from the upper respiratory tract to the lungs.**
2. **Force inspiration and expiration as in mouth to mouth respiration or by mechanical means like ventilator.**

VENTILATOR

- A ventilator is a machine that supports breathing and is used during surgery, treatment for serious lung diseases or other conditions when normal breathing fails.
- It is mainly used in hospitals as part of life support system.
- **Ventilators do the following :-**

1. Get oxygen into the lungs.

2. Remove carbon dioxide from the lungs.

3. Help the patient breathe.

THANK YOU