

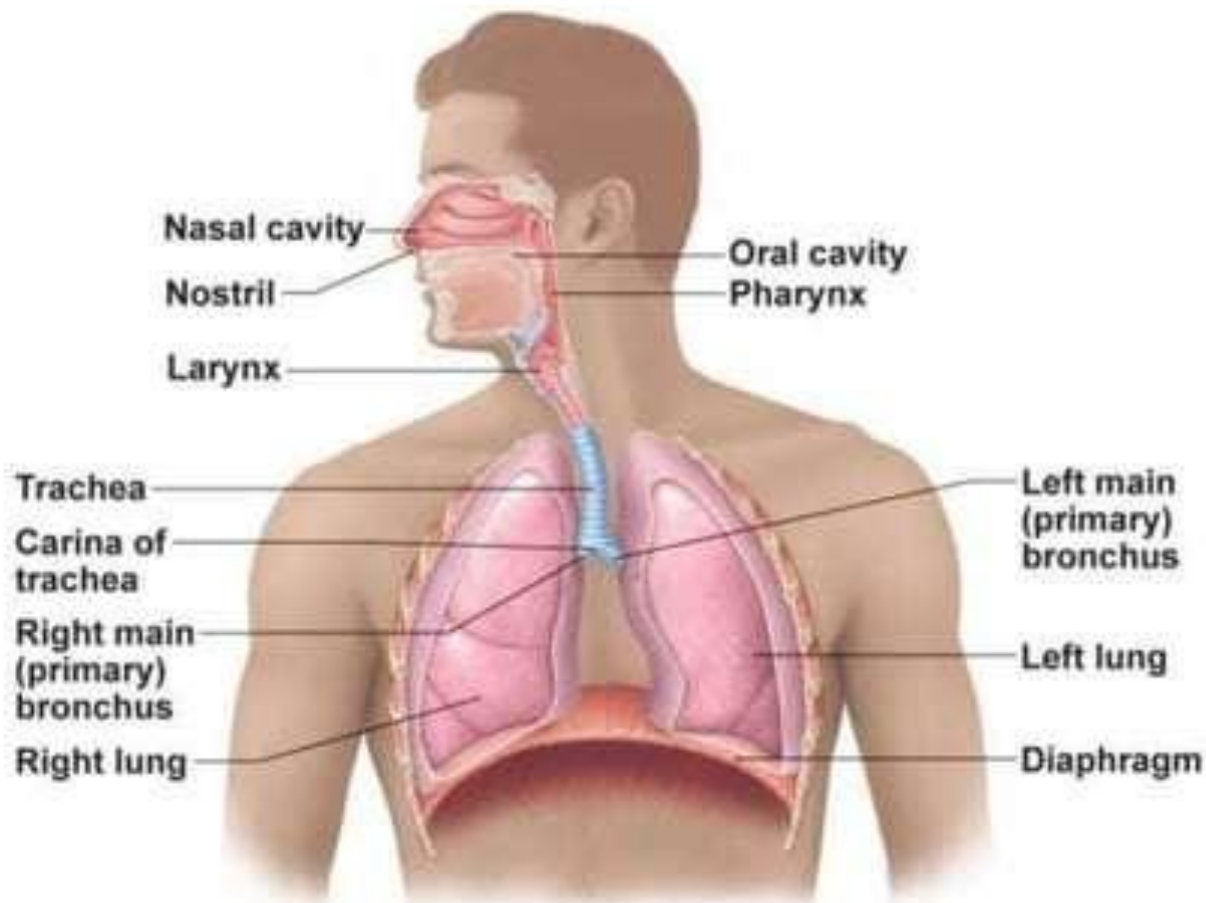


RESPIRATORY SYSTEM ANATOMY & PHYSIOLOGY

- By- Dr.S.Kameshwaran.

Respiratory System

Function: supply O_2 to the blood and remove CO_2



THE HUMAN RESPIRATORY SYSTEM

- Respiratory system forms the path through which the **air passes from the nose to the lungs**
- Exchange of gases during **internal and external respiration is the major function of respiratory system**
- The system also **filters, warms and humidifies the inhaled air**
- The system includes **vocal cord – produces sound**
- Lungs **controls body PH level**
- Olfactory bulb helps in **smelling**

- The human cells need continuous supply of oxygen for its proper functioning
- Also it eliminates CO₂ (carbon dioxide) as metabolic waste product
- The exchange of gas between the atmosphere and human body takes place during the respiration

ANATOMY of “Respiratory Tract”
can be divided into two groups
“STRUCTURALLY”

The Upper Respiratory Tract

- * Nose
- * Nasal cavity
- * Sinuses
- * Pharynx

The Lower Respiratory Tract

- * Larynx
- * Trachea
- * Bronchial Tree
- * Lungs

The organs of the "Respiratory Tract"
can be divided into two groups
"FUNCTIONALLY"

The Conducting Portion

- system of interconnecting cavities and tubes that conduct air into the lungs

- * Nose
- * Pharynx
- * Larynx
- * Trachea
- * Bronchi

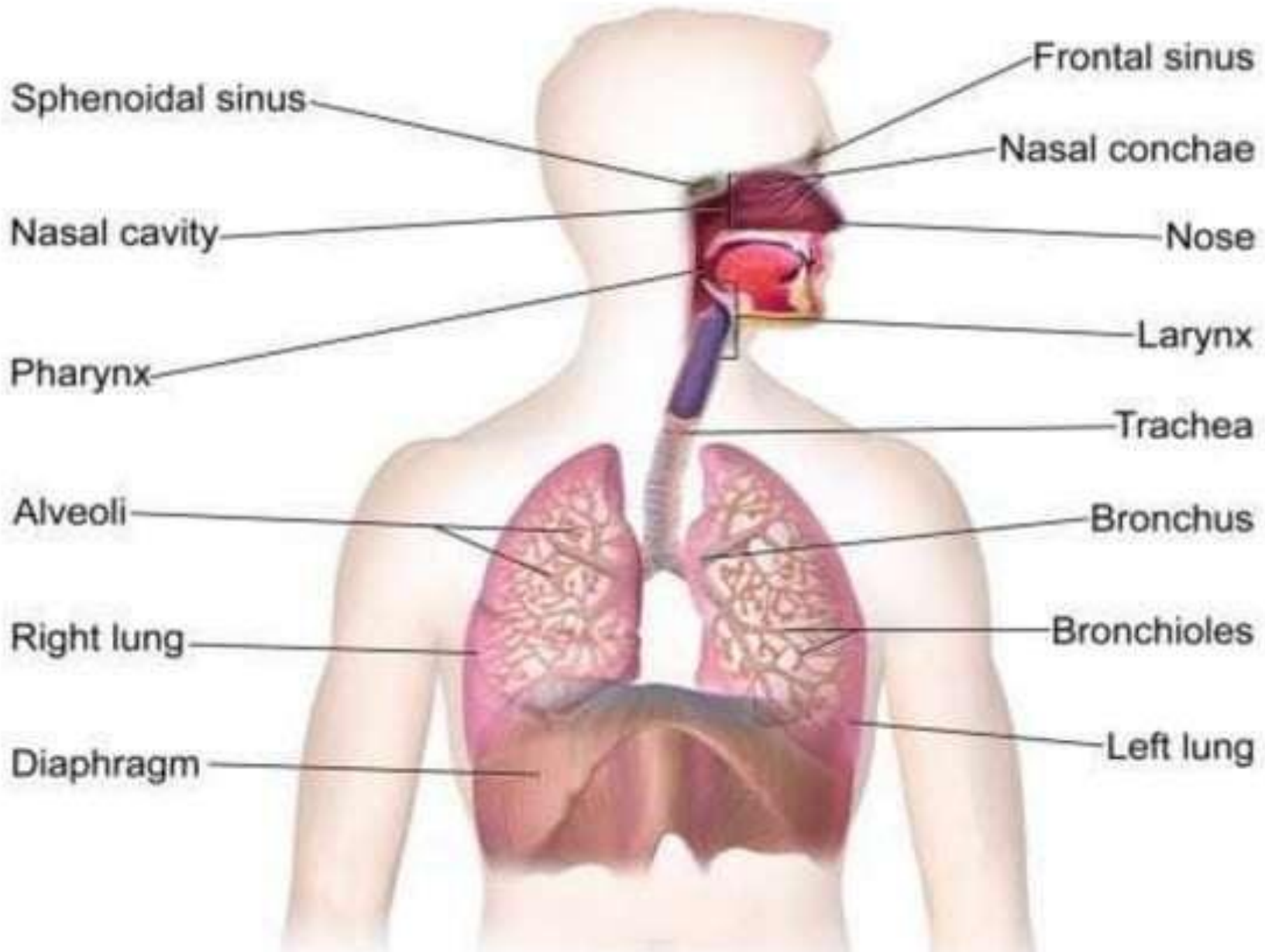
The Respiratory Portion

- system where the exchange of respiratory gases occurs

- * Bronchioles
- * Alveolar Ducts
- * Alveoli

Anatomy

- ⊙ Nose/mouth: filtered, warmed, humidified
 - **Mucus** Traps bacteria & foreign debris
 - **Cilia** sweep mucus toward throat → digested by stomach
- ⊙ Pharynx: throat (passage for food/air)
 - **Tonsils**: clusters of lymphatic tissue
- ⊙ Larynx: contains vocal cords
 - **Epiglottis**: covers larynx when liquids/food swallowed
- ⊙ Trachea: windpipe; lined with cartilage (C-shaped)
- ⊙ Bronchi: branches to lungs
- ⊙ Bronchioles: smaller branches
- ⊙ **Lungs** → Alveoli: air sacs for gas exchange



The Respiratory System

THE NOSE

- The nose is positioned between forehead and upper lip
- It is the **first organ of respiratory tract**
- It provides an **entrance for inhaled air**
- The nose performs the process of **warming, moistening and filtering of inhaled air**
- It has 2 portions :
 - The external nose (The nose)**
 - The internal nose (nasal cavities)**

➤ Nose is a **bony and cartilaginous structure**

Bony part:

➤ It is made up of the frontal, nasal & Maxillae bones

➤ The cartilage part is made up of

- septal cartilage,
- lateral cartilages &
- alar cartilages

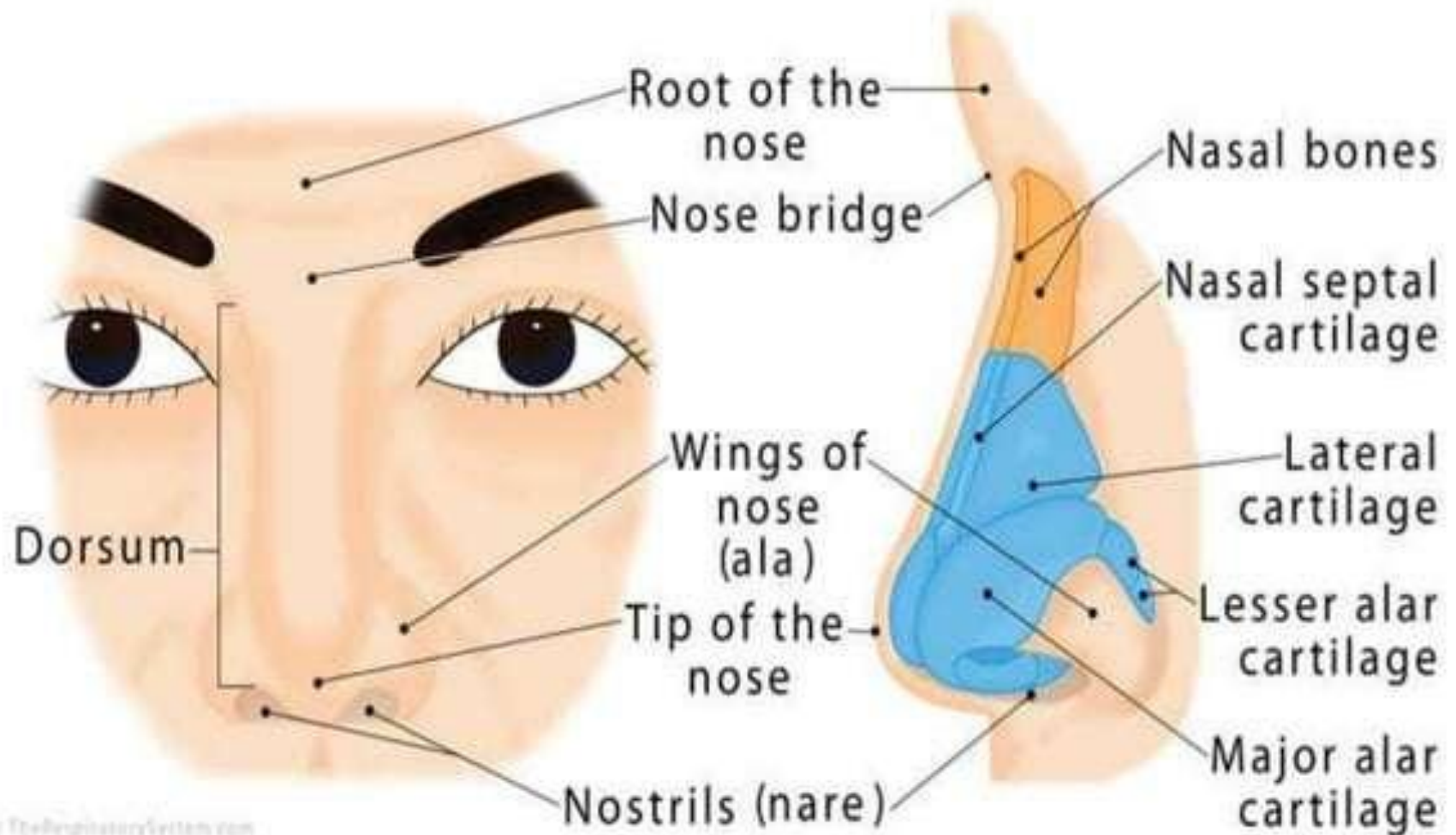
➤ The internal portion is a large cavity in the skull, merging with the external nose anteriorly and communicating with the throat posteriorly.

LINING OF THE NOSE:

➤ The nose is lined with highly vascular ciliated columnar epithelium

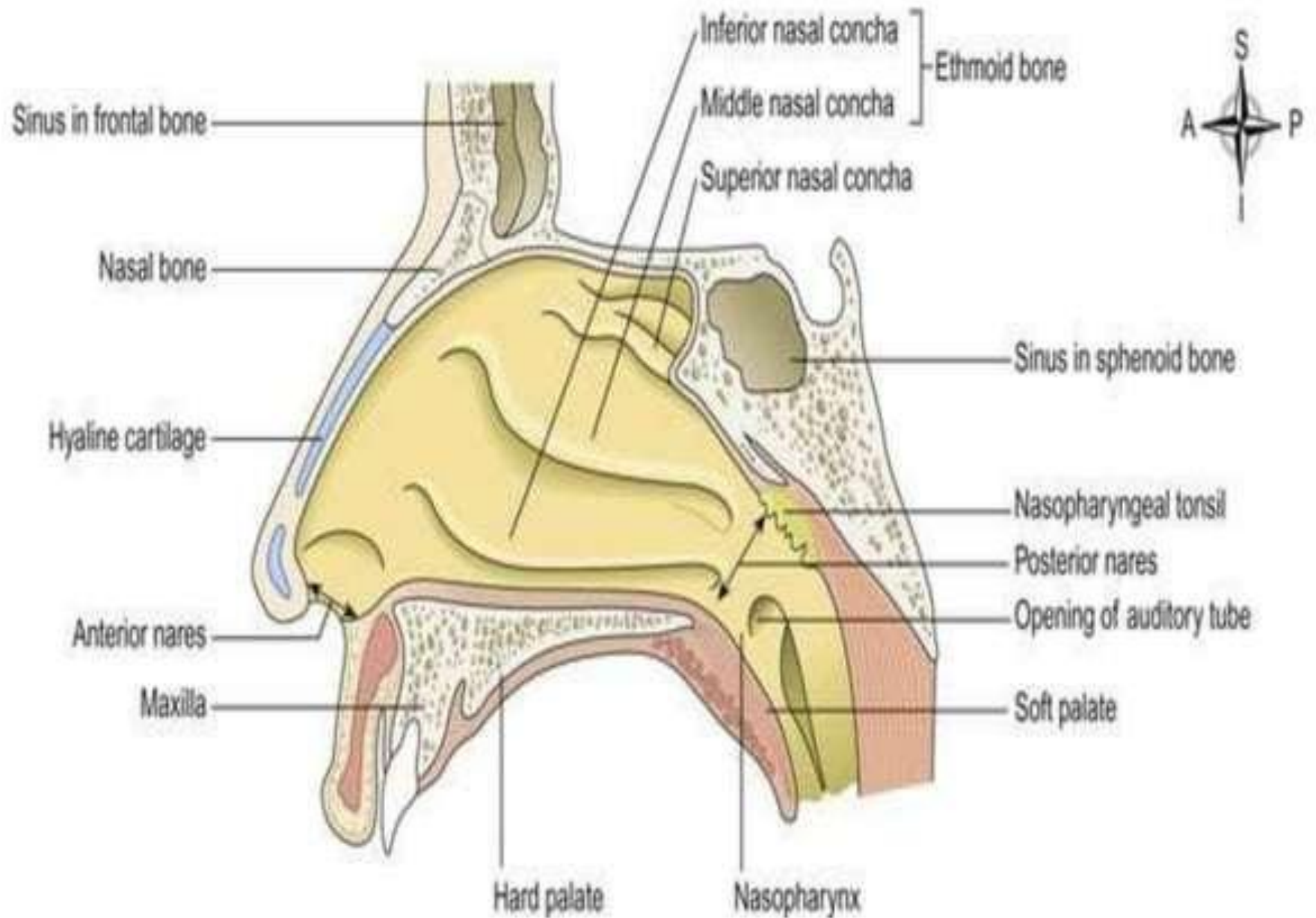
➤ Contains mucus secreting goblet cells

External Nose



The Nasal Cavity

- At the base of the nose two openings separated by **nasal septum** – septum cartilage is present
- The openings are called as **nostrils** (anterior nares) through which the air enters to reach the nasal cavity
- The **anterior nares** are the openings of the nasal cavity – contains **small hairs** in it
- The posterior nares are the nasal cavity openings **in to the pharynx**



Paranasal Sinuses

- Sinuses are air-filled spaces
- They present within the maxillary, frontal, ethmoid and sphenoid bones of the skull.
- These spaces open to the nasal cavity
- The space is lined with mucus membrane
- The sinuses reduce the weight of the skull

Functions of Nasal cavity

Respiration:

- Helps in the passage of air across the nasal cavity

Air conditioning:

- Air with -5 degree C – 55degree C is converted in to 31-37 degree C at the nasopharynx
- Turbinate make the inhaled air water saturated so that the **lungs receive 100% humid air**
- Inhaled air is filtered, warmed, humidified n the nasal cavity

Defense

- Mucociliary system hold back all the microorganism and foreign particles
- Antibodies and enzymes present in the mucus are active against bacteria
- The irritants are expelled from nose forcefully while sneezing
- Olfactory system recognize environment and food

Speech:

- Vocal cord help in the generation of voice

THE PHARYNX

- The “throat” is a **funnel shaped tube** that lies posterior to the nasal cavity, oral cavity and larynx and anteriorly to the cervical vertebra.
- It is composed of:
 - Nasopharynx – uppermost portion
 - Oropharynx – middle portion
 - Laryngopharynx – lowermost portion
- It is a common passageway for air and food and it provides a **resonating chamber for speech sounds**

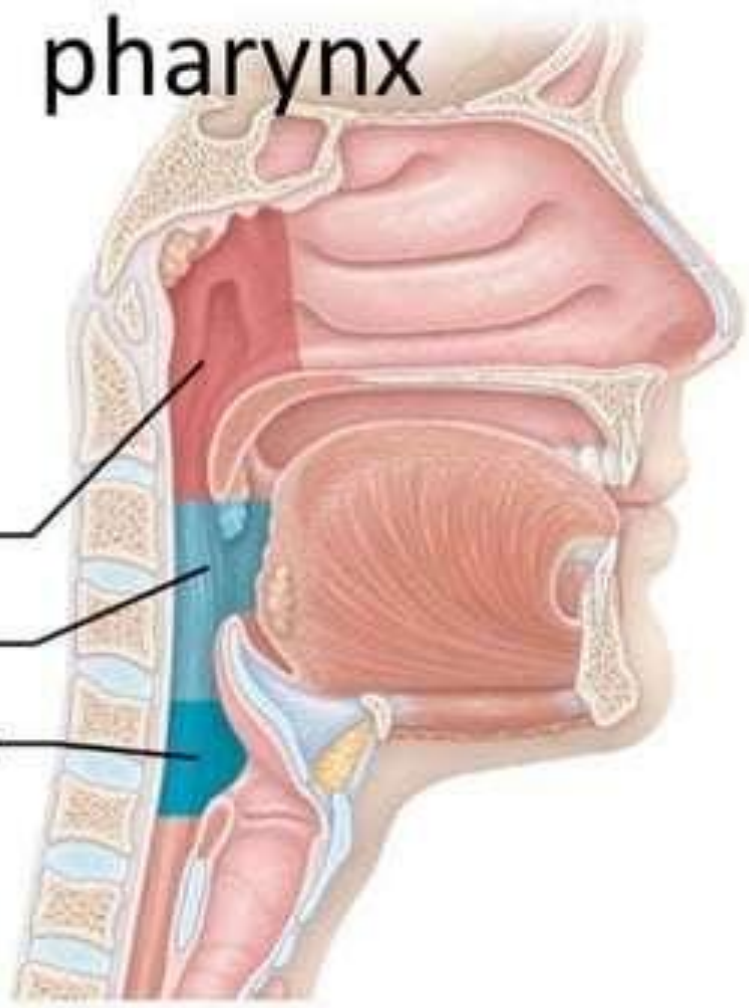
pharynx

Pharynx

Nasopharynx

Oropharynx

Laryngopharynx



(b) Regions of the pharynx

The Epiglottis

- It is a large leaf-shaped piece of cartilage.
- Found in the entrance of larynx
- Epiglottis close the tracheal opening during the swallowing of food
- that prevents food from entering the trachea (or windpipe).
- During swallowing, there is elevation of the larynx

Functions of Pharynx

- **Passage way for food & air**
- **Taste**
- **Warming and humidifying**
- **Hearing**
- **Protection**
- **Speech**

THE LARYNX

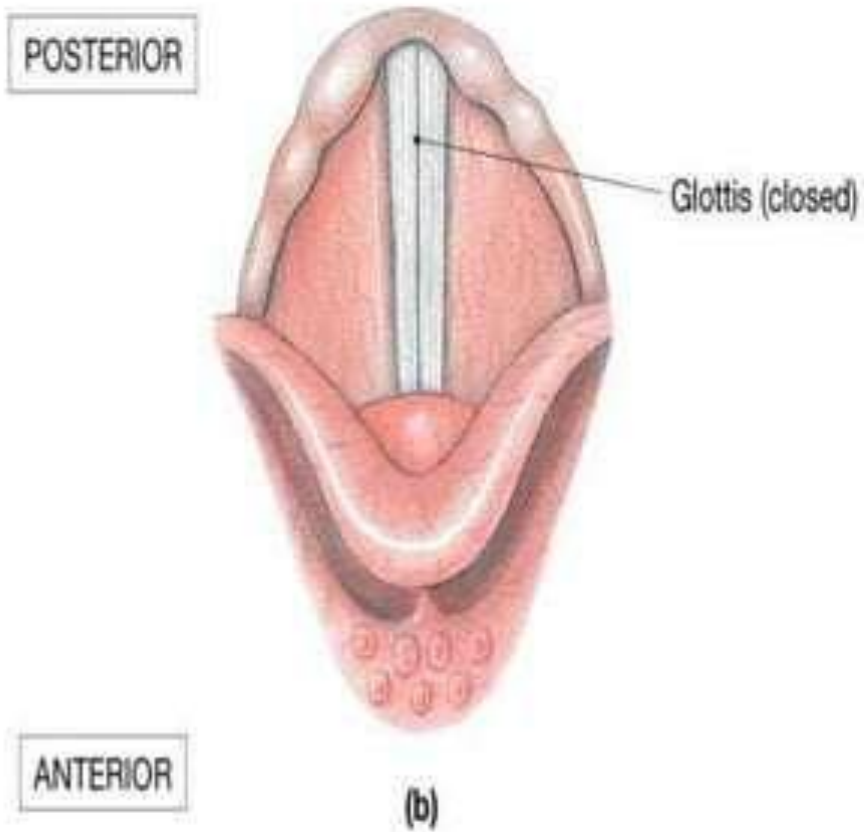
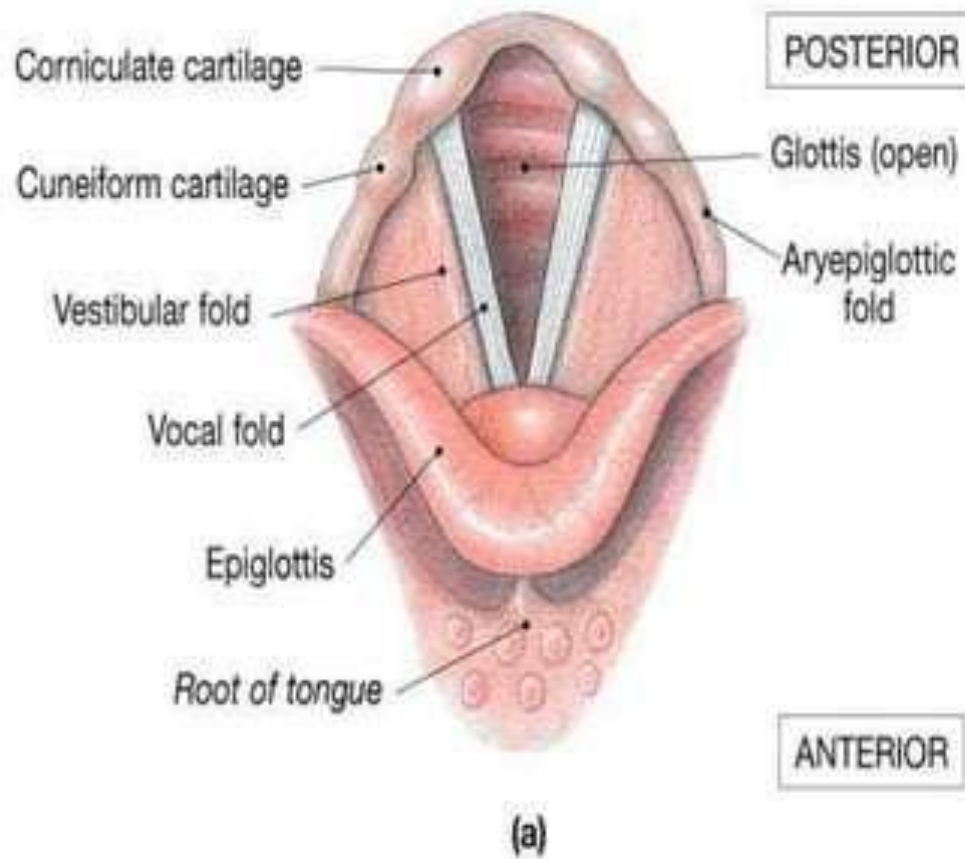
- It is the triangular chamber in the front upper part of the neck
- A prominent elevation present just in front of the larynx – **adam's apple**
- It joints pharynx with trachea
- It is made up of cartilages – 3 single, 3 paired

Single cartilages:

- Thyroid cartilage, cricoid cartilage, epiglottis

Paired cartilages:

- Arytenoids, corniculates, cuneiforms



The Vocal Cords

- Inside the larynx, 2 pairs of folds of muscle and connective tissues covered with mucous membrane make up the **vocal cords**.
- **Changing tension on the vocal cords controls pitch**, while increasing the loudness depends upon increasing the force of air vibrating the vocal cords.
- When vocal cord is opened – **abducted**
- When vocal cord is closed - **adducted**

The Vocal Cords

The larynx contains

- Vestibule – false vocal cord
- Ventricle
- Infraglottic cavity – from the vocal cords to the tracheal cavity

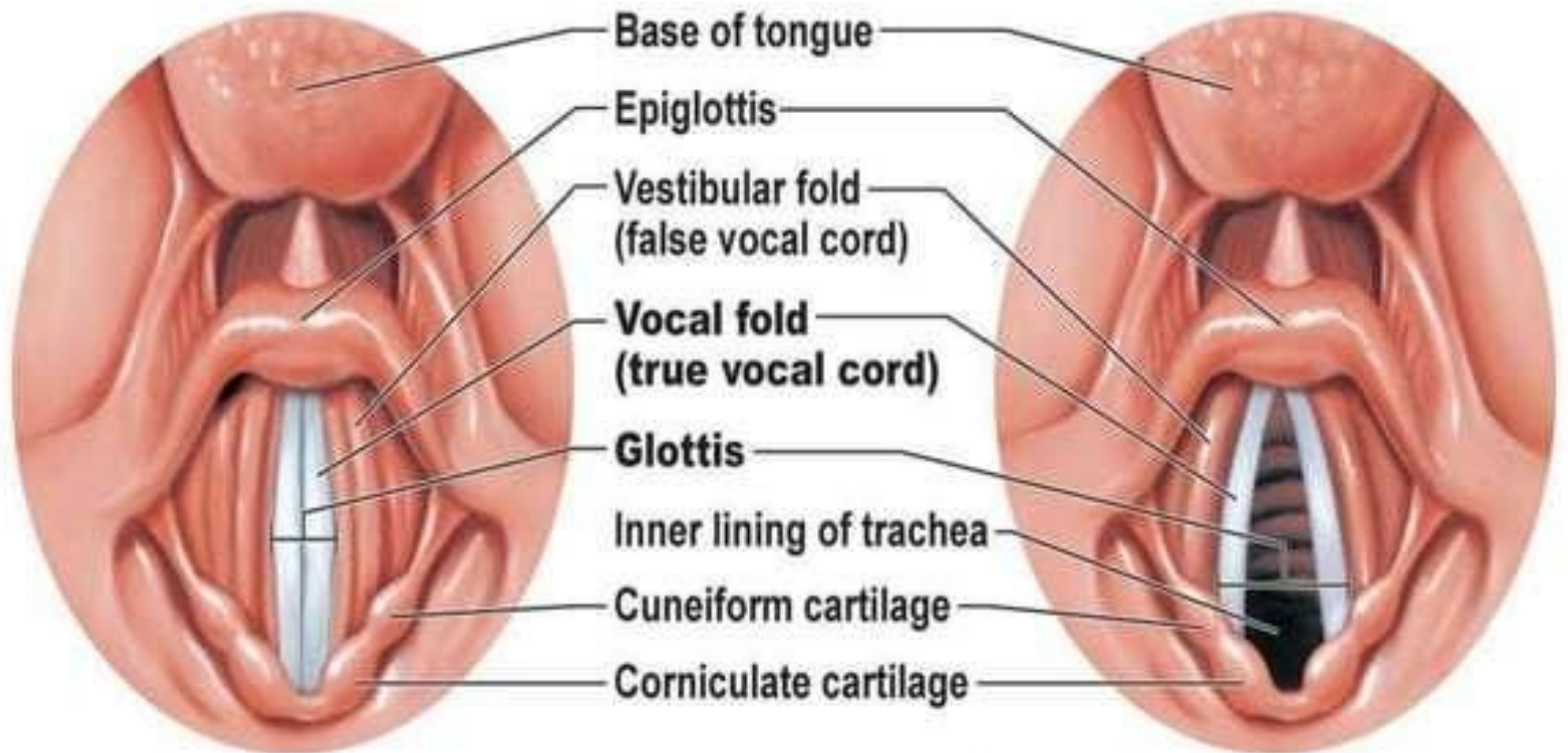
During normal breathing,

The vocal cords are relaxed and the glottis is a triangular slit.

During swallowing,

The False vocal cords and epiglottis close off the glottis.

Vocal cords



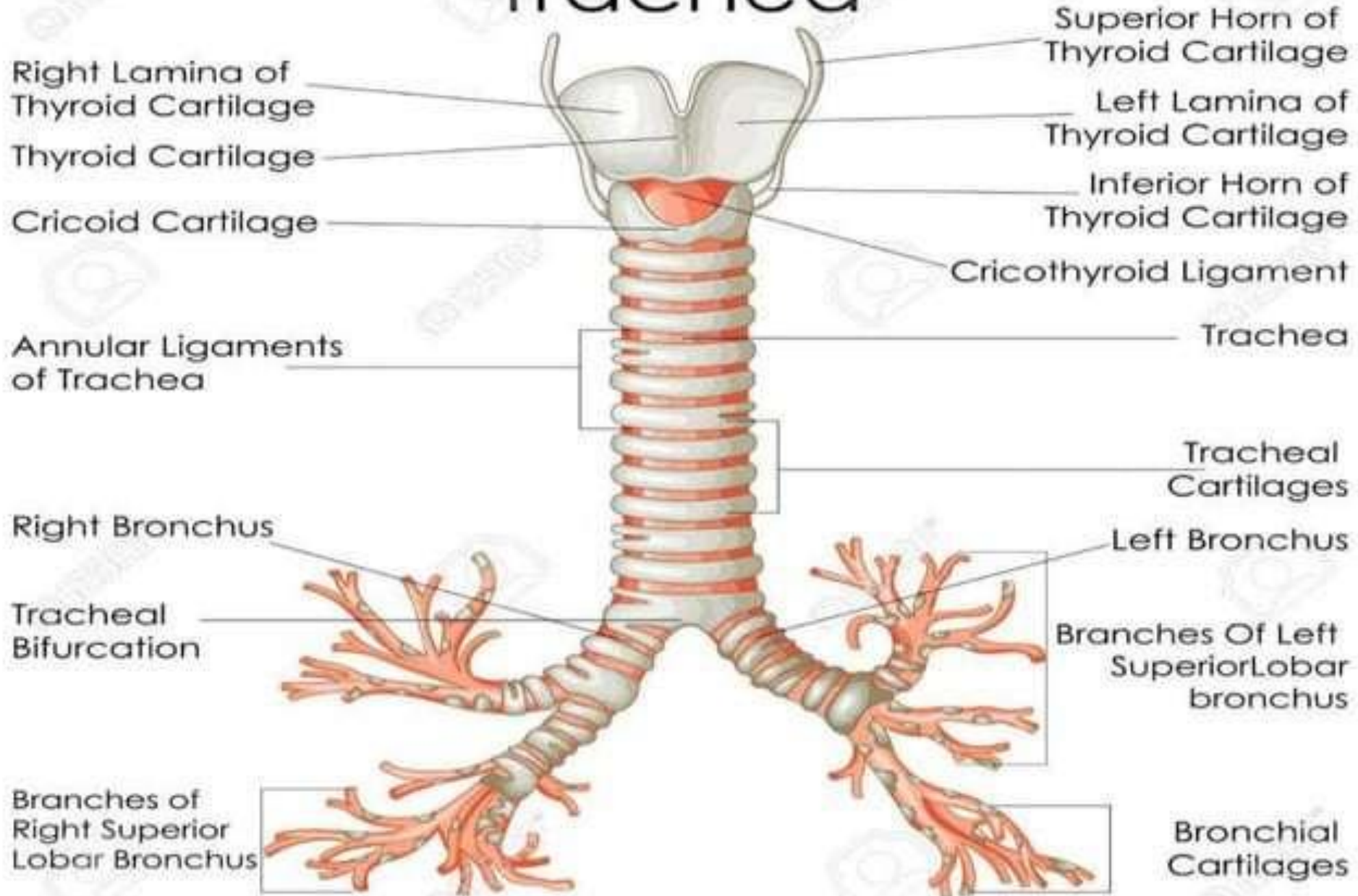
**(a) Vocal folds in closed position;
closed glottis**

**(b) Vocal folds in open position;
open glottis**

THE TRACHEA

- Trachea is a **wind pipe**
- It is measured around **10-11 cm**
- It extends downwards up to **5 th thoracic vertebra**
- At the end its divide in to **right and left bronchi**
- Which enters in to their respective lungs
- It is composed of **16-20 c shaped rings of hyaline cartilage**
- Connective tissues and involuntary muscles joins the cartilage and forms the posterior wall
- The trachea cartilages covered by **3 tissue layers**
- Outer layer, middle layer, inner layer
- It helps in the cough reflex

Trachea

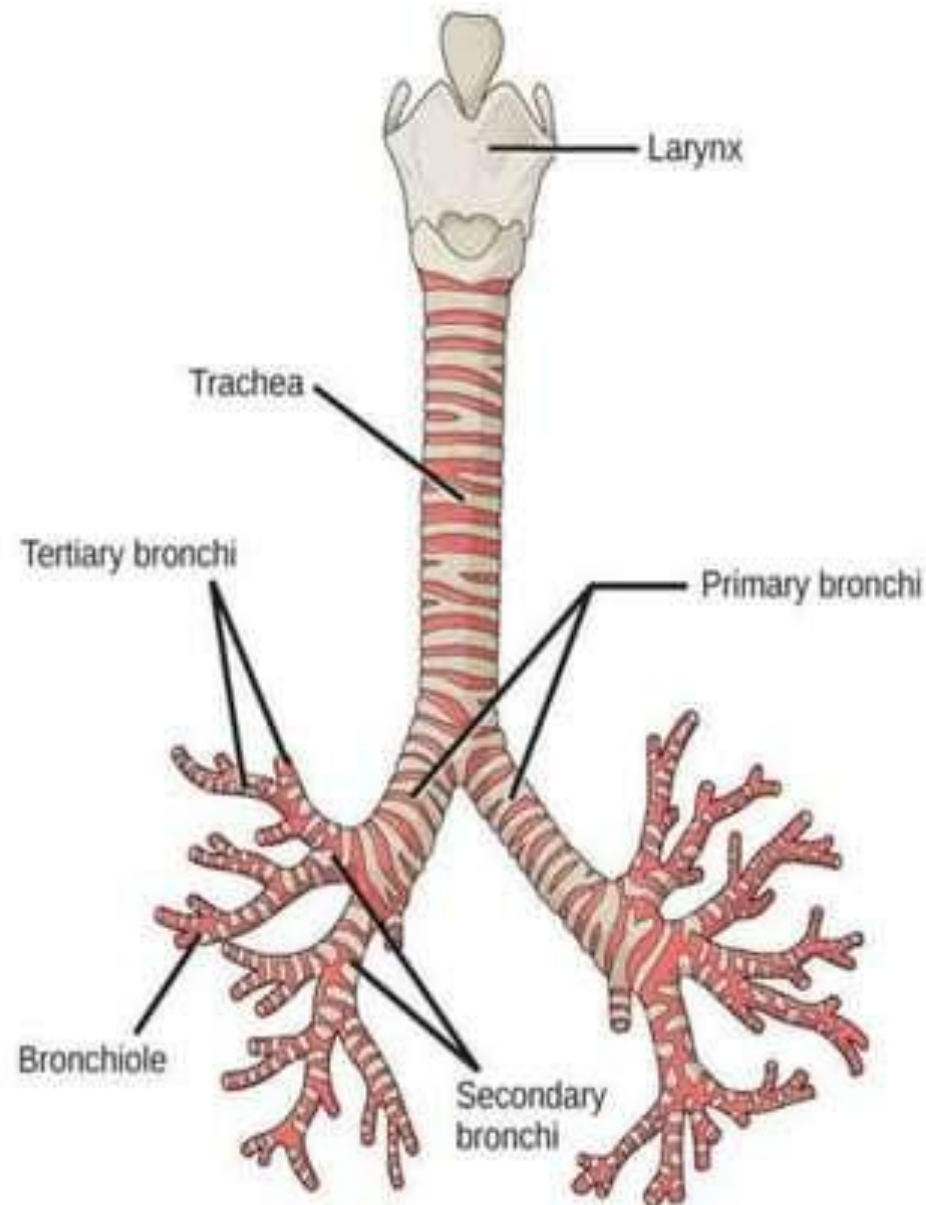


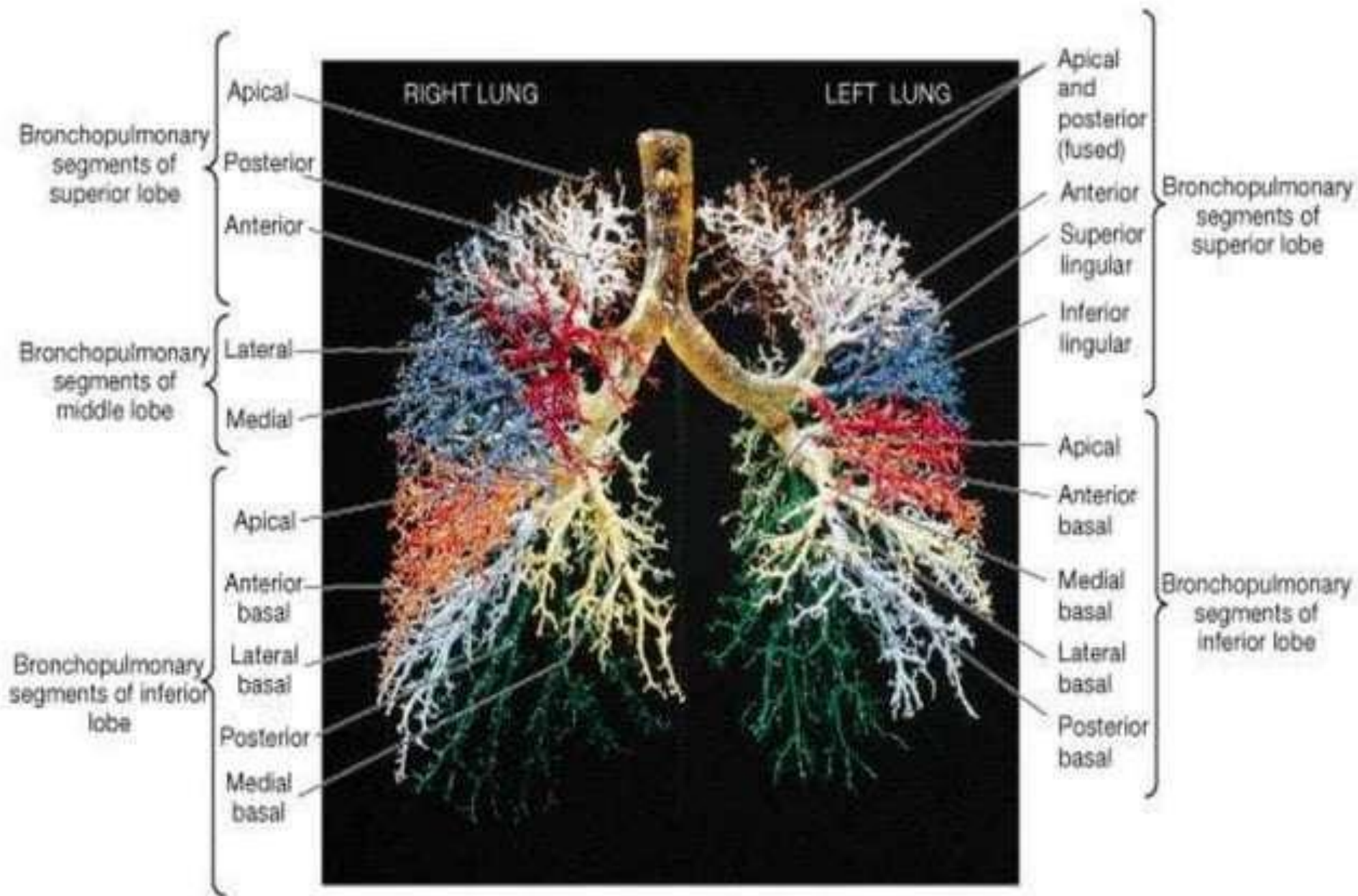
Bronchi

- **It is the air way passage in to the respiratory tract**
- **They carry inhaled air in to lungs**
- **They are two types right bronchi and left bronchi**
- **The primary bronchi split in to three secondary bronchi**
- **They enter in to superior, middle & inferior lobes of the right lung**
- **Secondary bronchi further divide in to tertiary bronchi**
- **The tertiary bronchi then divide in to more smaller branches**

Bronchioles

- Bronchioles are the finest branches of bronchi
- Bronchiole converted in to terminal bronchioles
- Which further subdivided in to two or more respiratory bronchioles
- They terminate at alveolar sacs





(d) The bronchial tree

➤ LUNGS

- Lungs present in the thoracic cavity as two cone shaped lobes separated by heart and other structures
- Present from clavicle to diaphragm
- The paired soft, spongy, cone-shaped lungs, separated medially by the mediastinum and are enclosed by the diaphragm and thoracic cage.
- 2 layers of serous membrane, collectively known as **pleural membrane**, enclose and protect each lung.

Parietal Pleura

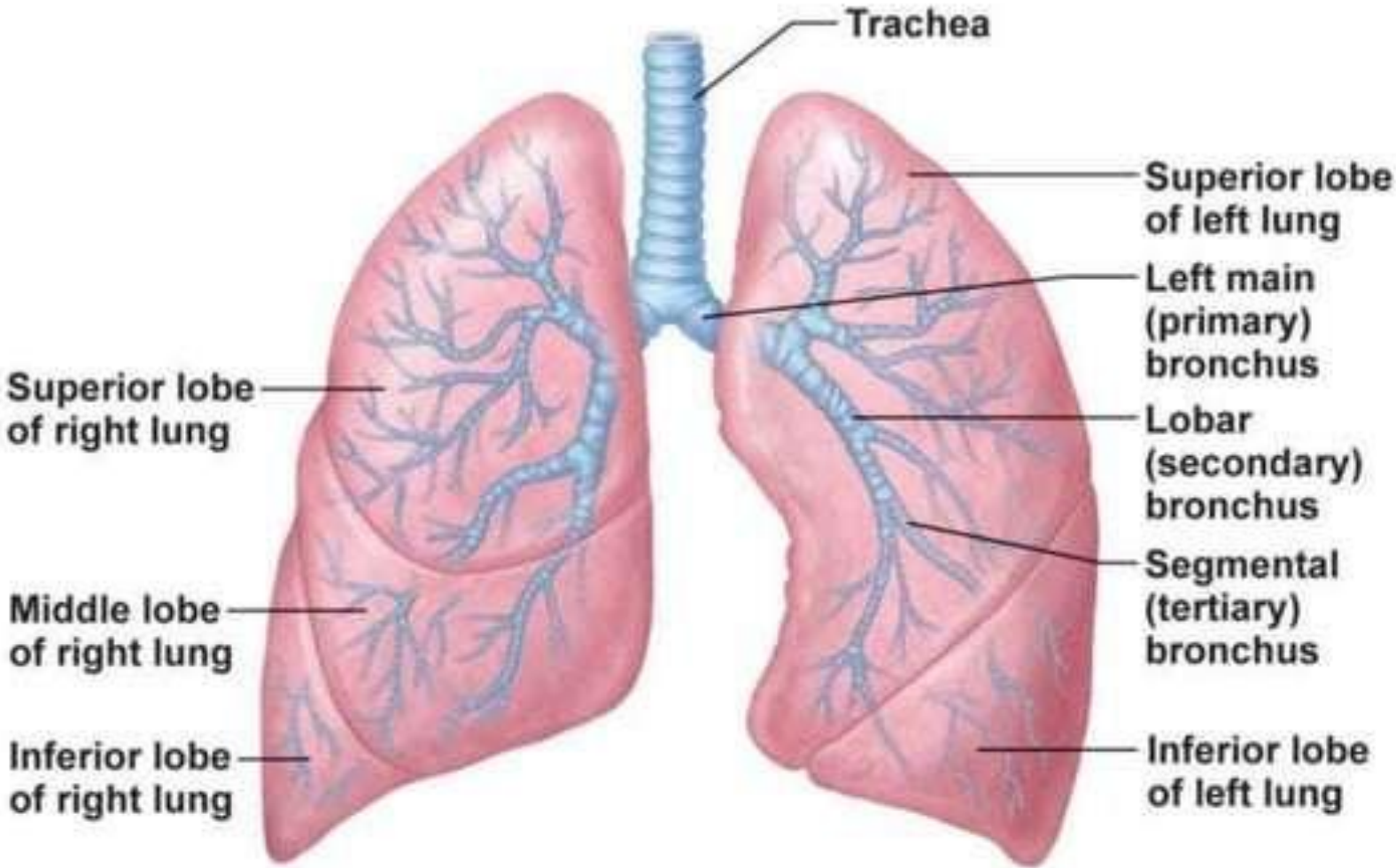
- outer layer attached to the thoracic cavity

Visceral Pleura

- inner layer covering the lung itself

- Left lung is smaller than the right lung due to the space occupied by the heart in the thoracic cavity

Lungs



➤ The various parts of lungs are

➤ Apex, base, costal surface, medial surface

APEX:

➤ Lung has round apex

➤ Which extends up to the root of the neck

BASE:

➤ It has concave and semilunar base

➤ Which associated with the thoracic surface of diaphragm

COSTAL SURFACE:

➤ It has convex costal surface

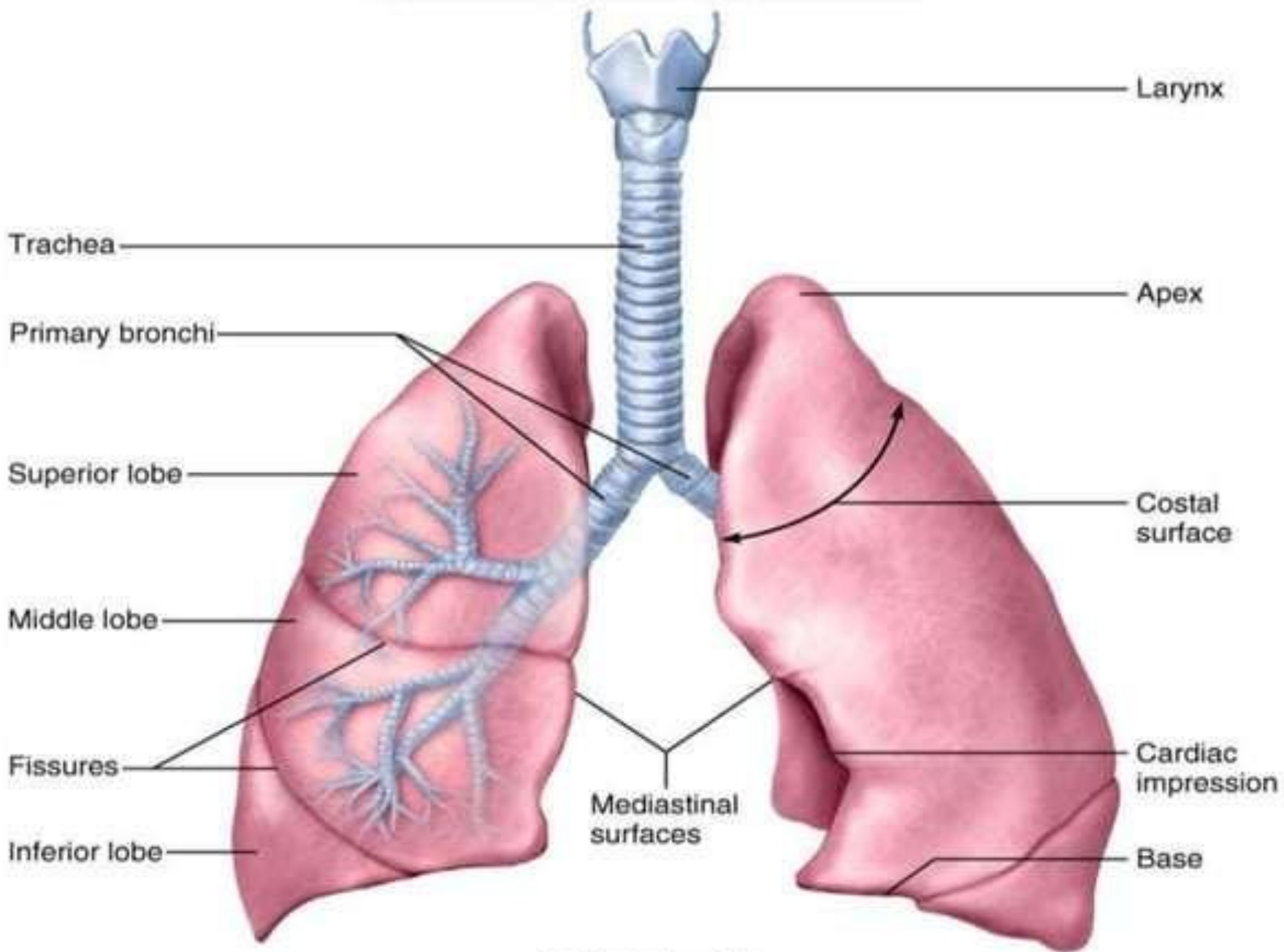
➤ Which is associated with the costal cartilages, ribs & intercostal muscles

MEDIAL SURFACE:

➤ It has concave medial surface

➤ Triangular shaped hilum present 5-7th thoracic vertebra

➤ All artery veins nerve supply pass through this surface



(a) Anterior view

MEDIASTENUM:

- It is an area between the lungs and is occupied by the heart, great vessels, trachea, right and left bronchi, oesophagus, lymph nodes, lymph vessels and nerves.

PLEURA & PLEURAL CAVITY:

- Each lung is enclosed with in a pleural membrane – which is made up of double layered serous membrane
- Parietal pleura – outer layer lines thoracic cavity wall
- Visceral pluera – deep layer – lines the lungs
- Pleural cavity: it is the space between the two layers and contains **pleural fluid**
- pleural fluid lubricating fluid secreted by the membranes – prevents the friction between the layers during breathing

LOBES/FISSURES & LOBULES

- Each lung is separated in lobes
- Left lung: divided in to two lobes
- Right lung: divided in to three lobes
- The lobes are further divided in to numerous lobules – contains alveoli.

FUNCTIONS:

- Respiration
- Alter the blood pH filter out small blood clots formed in the vein
- Alter the concentration of drugs
- Convert angiotensin-I to angiotensin II
- Provides protection by Ig-A

ALVEOLI

- **Hollow cavity found in the mammalian lungs**
- **Pulmonary alveoli is a spherical projections of the respiratory bronchioles**
- **The alveolar membranes are the major sites where exchange of gases occurs with the blood**
- **A human lung has around 300 million alveoli**
- **The alveoli are made up of an epithelial layer**
- **70% of each alveoli is occupied with blood capillaries**

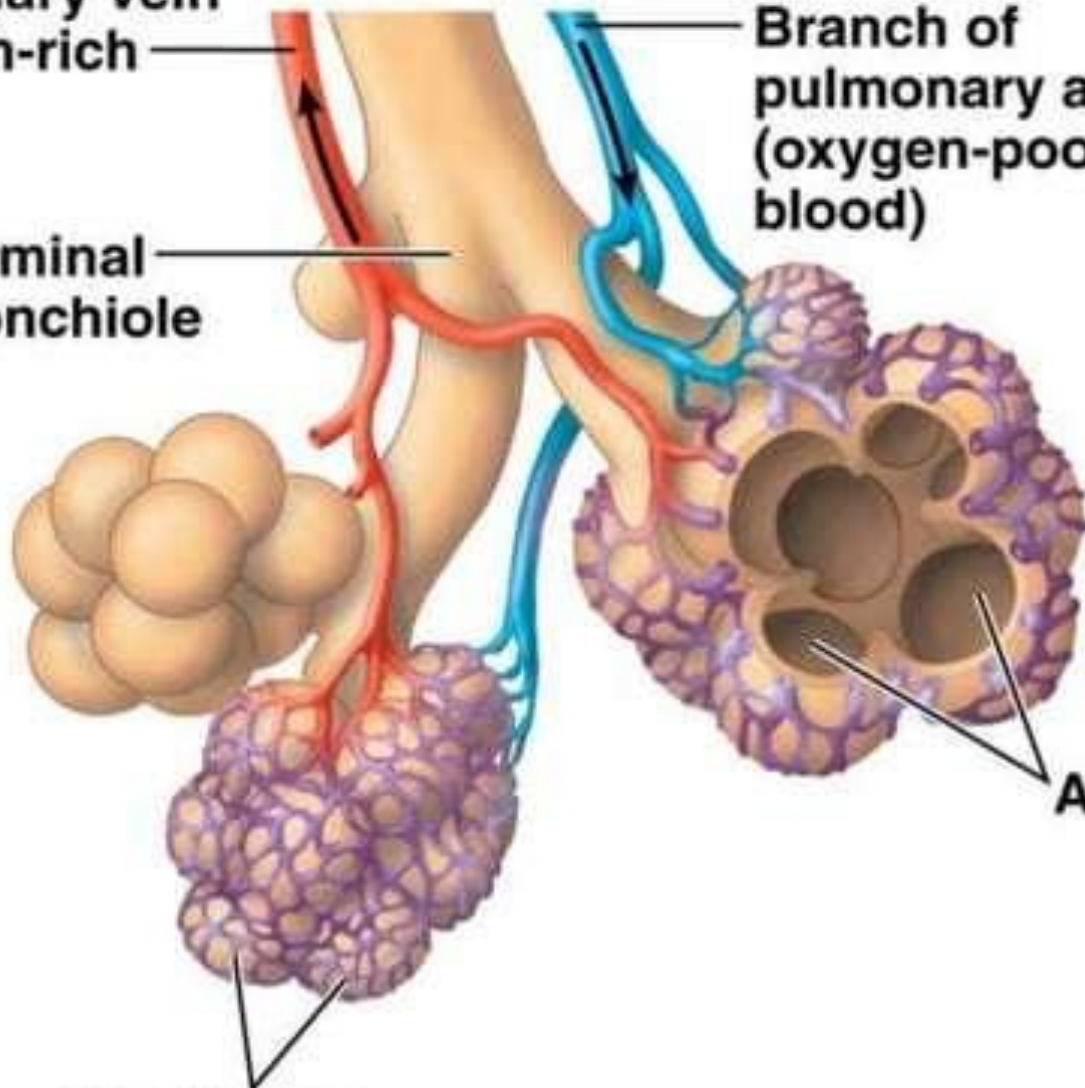
FUNCTIONS:

- **External respiration – gas exchange occurs between alveoli & blood by diffusion**
- **Protection against microbes**

**Branch of
pulmonary vein
(oxygen-rich
blood)**

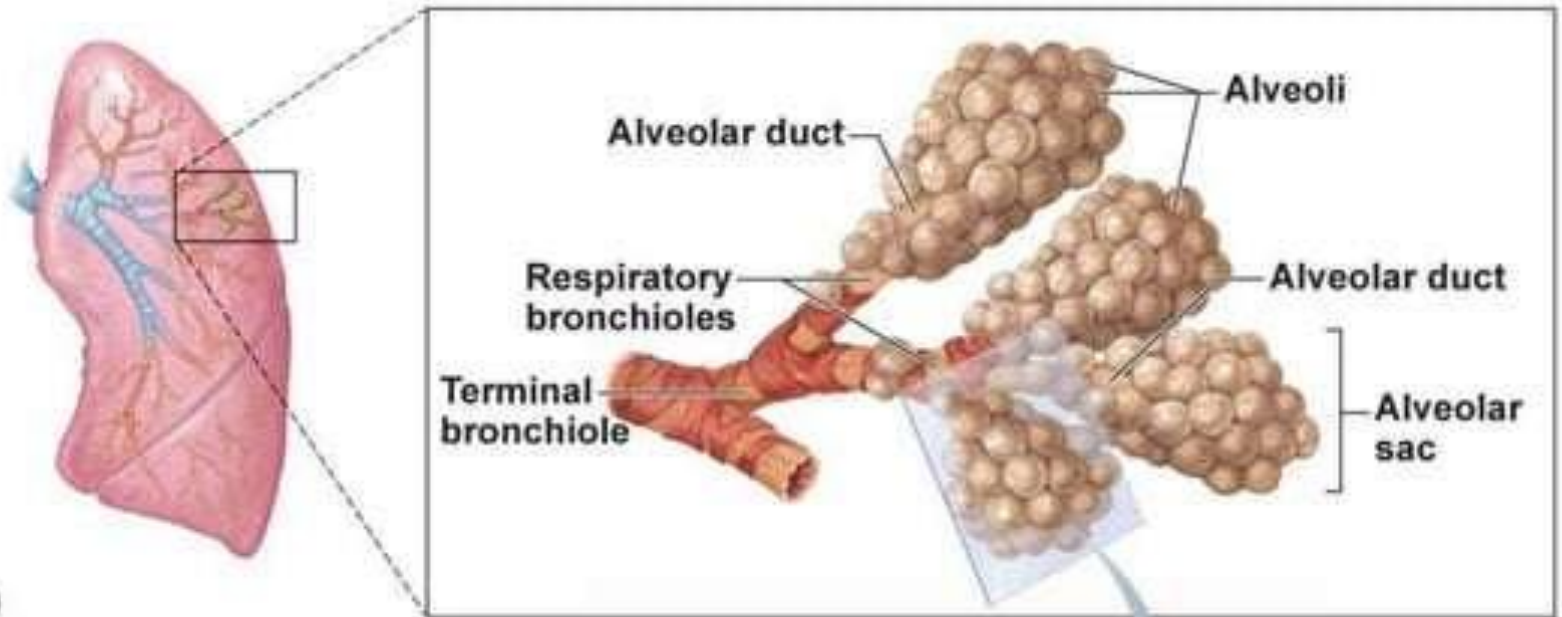
**Branch of
pulmonary artery
(oxygen-poor
blood)**

**Terminal
bronchiole**

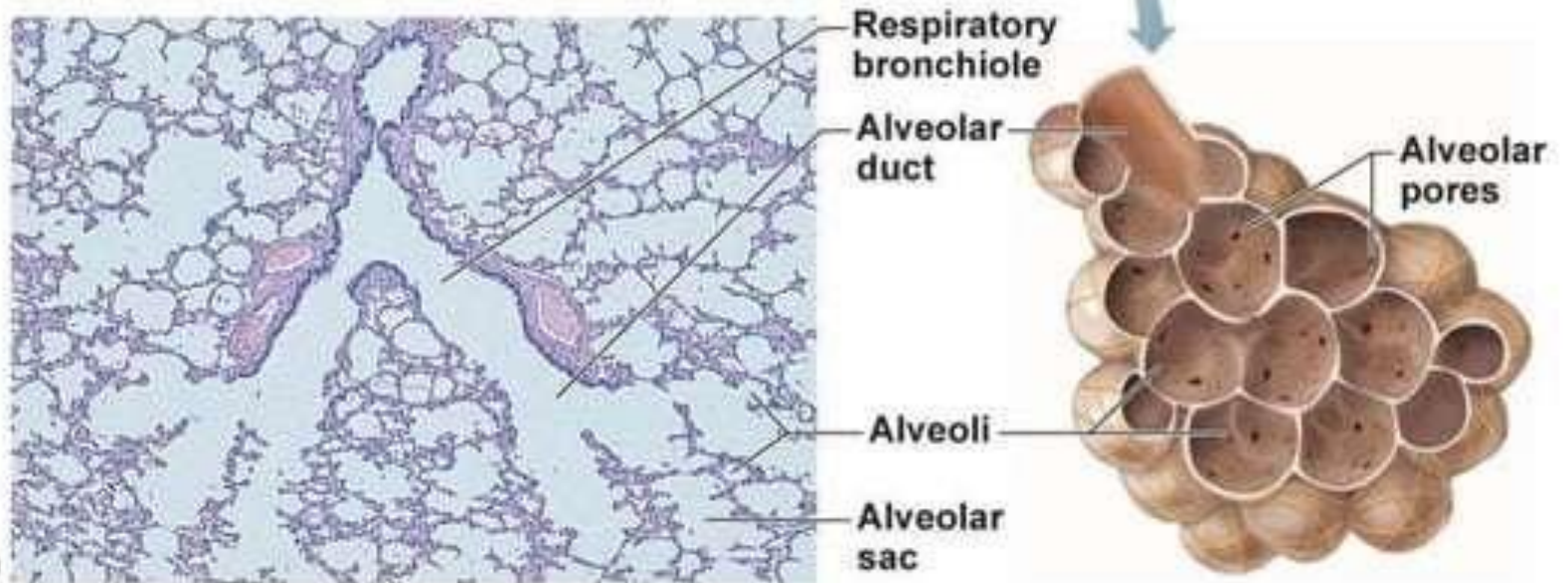


Alveoli

Capillaries



(a)



(b)

MECHANISM OF RESPIRATION:

- The process by which the respiration organs allow the air to move in and out of the lungs – Breathing
- Oxygen rich air is taken in from the atmosphere and in exchange carbon dioxide rich air is given out to the atmosphere
- The entire process of breathing is made up of two processes
 - INHALATION/ INSPIRATION: air flowing into lungs
 - EXHALATION/ EXPIRATION: air leaving lungs
- A single breath comprises of one inhalation and one exhalation
- Breathing rate: number of times an individual breathes in a minute
- Breathing rate increases while walking fast, running or after heavy exercise / decreases when in a relaxed state
- Average breathing rate of an adult is 15-18 times per minute

INHALATION:

It is also known as inspiration, the various steps involved in inspiration is followed by

Contraction of diaphragm – become depressed down and become flat



Increase in the size and height of thoracic cavity



Contraction of external intercostal muscle



Lift the rib cage and pushes the sternum forward



Increases the anterior and posterior dimensions of the thoracic cavity

Increase in the size of the lungs



Increase in the intrapulmonary volume



Decrease in the gas pressure with in the lungs, the pressure become less than the atmospheric pressure



Air moves in to the lungs till the intrapulmonary and the atmospheric pressure attains equilibrium

EXHALATION: also known expiration

- It is passive process

relaxation of diaphragm – moves upward



Decrease in the size and height of thoracic cavity



relaxation of external intercostal muscle



**Lift the rib cage and pulls the sternum backward
decreases the anterior and posterior dimensions of the
thoracic cavity**



decrease in the size of the lungs



decrease in the intrapulmonary volume

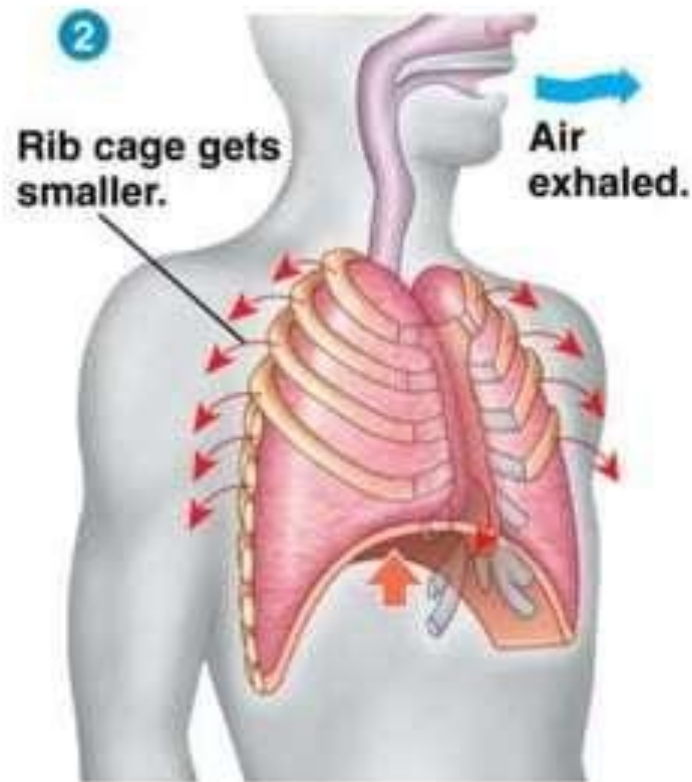


**increase in the gas pressure with in the lungs, the
pressure become greater than the atmospheric
pressure**



**Air moves out from the lungs till the intrapulmonary and
the atmospheric pressure attains equilibrium**

Inspiration vs. expiration



Inspiration

- Diaphragm contracts & flattens
- External intercostals lifts rib cage
- Lungs stretched to larger size
- Air pressure inside lungs decrease
- Air sucked into lungs

Expiration

- Inspiratory muscles relax
- Rib cage descends, lungs recoil
- Gases forced out

REGULATION OF RESPIRATION:

- **The average respiratory rate in adults is 15-18 times per minute**
- **Its more un case of children's**
- **The respiration is regulated by the following ways**

Nervous control

Chemical control

NERVOUS CONTROL:

- Respiration controlled by two mechanisms:

Voluntary control & Autonomic control

Voluntary control:

- This control centre located in the cerebral cortex
- Sends the impulse to the respiratory motor neurons via cortico spinal tracts

Autonomic control

- This control center is located in the pons and medulla
- Also the pneumotaxic and apneustic centres are also responsible for controlling the respiration

CHEMICAL CONTROL:

- There are three chemical factors controlling the respiration
 - Carbon dioxide
 - Oxygen
 - pH
- When increase in the CO_2 and pH levels – increases the ventilation – excessive amount of CO_2 is washed out to normalize the level
- When decrease in CO_2 and pH levels – opposite effect – inhibit the activity of the respiratory centre – normalizes
- When decrease in O_2 concentration – increases the ventilation – excessive amount of O_2 enters in to the lungs to normalizes the level

CYCLE OF BREATHING:

Average breathing rate is 12 – 15 per min

Each breath has 3 phases

- Inspiration – lasts about 2 seconds**
- Expiration – lasts about 3 seconds**
- pause**

LUNG VOLUMES /LUNG CAPACITY /RESPIRATORY CAPACITY

LUNG VOLUMES

- **TIDAL VOLUMES**
- **INSPIRATORY RESERVE VOLUME**
- **EXPIRATORY RESERVE VOLUME**
- **RESIDUAL VOLUME**

LUNG CAPACITY

- **INSPIRATORY CAPACITY**
- **EXPIRATORY CAPACITY**
- **FUNCTIONAL RESIDUAL CAPACITY**
- **VITAL CAPACITY**
- **TOTAL LUNG CAPACITY**

Tidal Volume (TV):

- It is the volume of air inspired or expired during a normal respiration
- An average value of tidal volume is ~500ml

Inspiratory Reserve Volume (IRV):

- Additional volume of air a man can inspire after a forcible inspiration
- The average value is 2500-3000 ml

Expiratory Reserve Volume (ERV):

- Additional volume of air a man can expire after a forcible inspiration
- The average value is 1000-1100 ml

Residual Volume (RV):

- The volume of air remaining in the lungs even after a forcible expiration
- The average value is 1100-1200 ml

Inspiratory capacity (IC):

- Total volume of air a person can inspire after a normal expiration
- It includes $TV+IRV$
- The average value is about 3500ml

Expiratory capacity(EC):

- Total volume of air a person can expire after a normal inspiration
- It includes $TV+ERV$
- The average value is about 1600ml

Functional Residual Capacity (FRC):

- It is the volume of air that will remain in the lungs after a normal expiration
- It includes $ERV+RV$
- The average value is about 2300ml

Vital Capacity (VC):

- It is the maximum amount of air a person can breathe out after a forced inspiration
- It includes ERV, TV & IRV
- The average value is about – 4600ml

Total Lung Capacity (TLC):

- It is the total volume of air accommodated in the lungs at the end of a forced inspiration
- It includes RV, ERV, TV, & IRV/VC+RV
- The average value is about – 5800ml
- $TLC = VC$

TRANSPORT OF RESPIRATORY GASES:

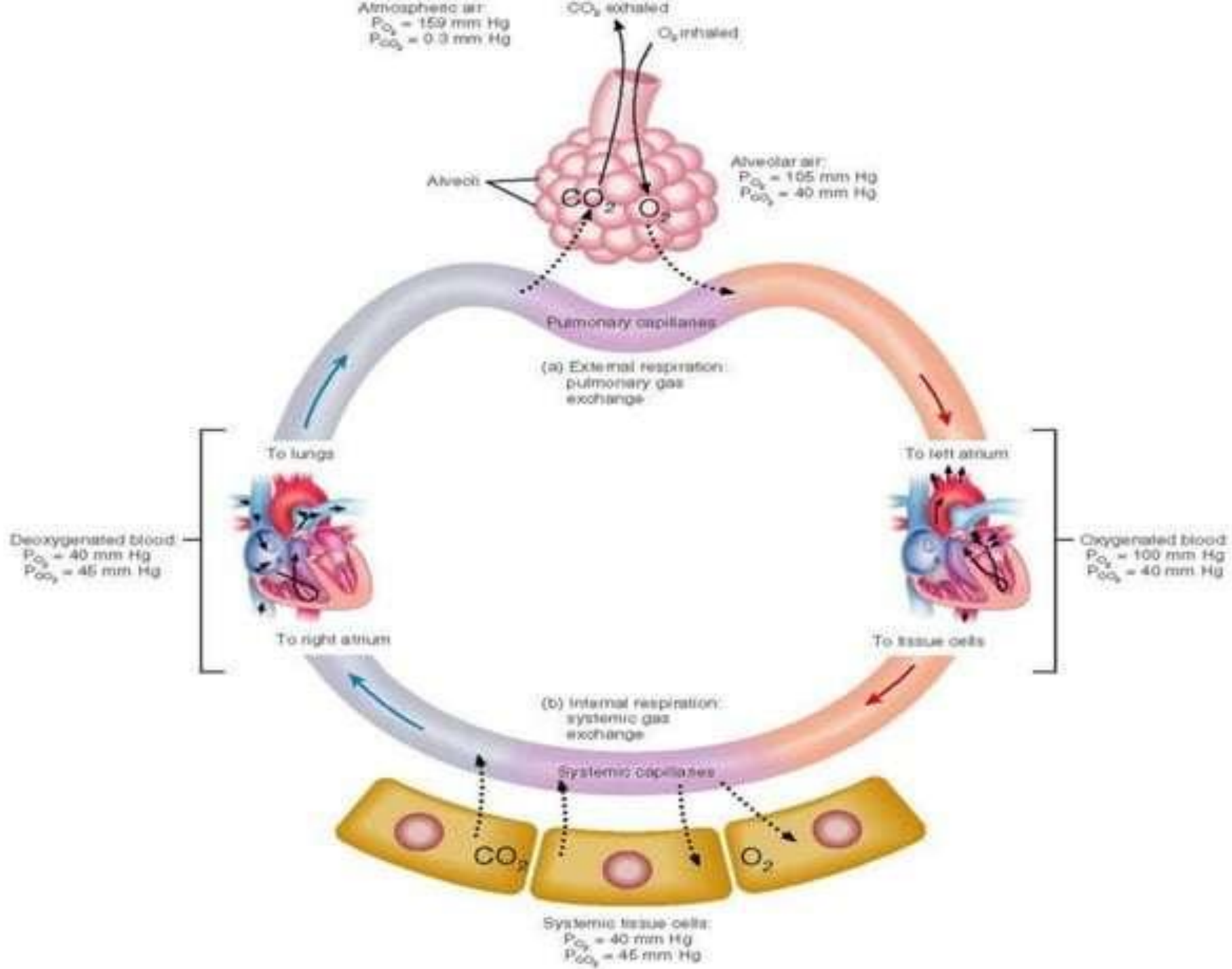
- **Respiration involves inhalation of oxygen and exhalation of carbon di oxide**
- **During respiration O₂ and CO₂ gases are transported by the blood**
- **The oxygen enters the lungs to reach the alveoli.**
- **the alveoli and the capillaries lie in close to one another**
- **Both the alveoli and the capillaries are one cell thick**
- **The air and blood barrier is about one micrometer thick**
- **So the oxygen easily pass from alveoli to capillaries to reach the blood**
- **In the same manner carbon di oxide to be exhaled enters the alveoli from the blood**
- **The oxygenated blood travels to heart and distributed through out the body**

EXCHANGE OF GAS/ TRANSPORT OF RESPIRATORY GAS

- Exchange of gas occurs when a difference in the partial pressure exist across a semipermeable membrane
- Gas moves by diffusion from the region of higher concentration to the lower concentration until the equilibrium attained
- Diffusion of oxygen and CO₂ depends on the pressure difference
- There are two kind of respiration based in the gas exchange they are
 - External respiration
 - Internal respiration

EXTERNAL RESPIRATION – PULMONARY RESPIRATION

- **Exchange of gases by diffusion between the alveoli and blood across the respiratory membrane**
- **Each alveolar sac is surrounded by network of capillaries (one cell thick)**
- **Pulmonary artery brings venous blood (Impure blood) – contains high level of CO₂ and low level of Oxygen**
- **based on concentration gradient (Partial Pressure) CO₂ diffuse to alveoli until equilibrium attains**
- **By the same O₂ is diffused from alveoli to the blood until equilibrium attains**
- **While passing through the alveoli blood flows slowly – so as to increase the time available for gas exchange**
- **When blood leaves from alveoli the CO₂ and O₂ levels are equilibrium in both capillary and alveoli**



INTERNAL RESPIRATION – TISSUE RESPIRATION

- **Exchange of gases by diffusion between the blood and tissue across the capillary membrane**
- **The blood present in the capillary tube is rich in Oxygen–lesser in CO₂ level**
- **based on concentration gradient O₂ diffuse to tissue until equilibrium attains**
- **By the same CO₂ is diffused from tissue to the blood until equilibrium attains**
- **While passing through the capillary- blood flows slowly – so as to increase the time available for gas exchange**
- **When blood leaves from tissue the CO₂ and O₂ levels are equilibrium in both capillary and tissue**

PARTIAL PRESSURE:

Atmosphere:

- P_{O_2} - 105mm Hg
- P_{CO_2} - 40mm Hg

Left Atrium:

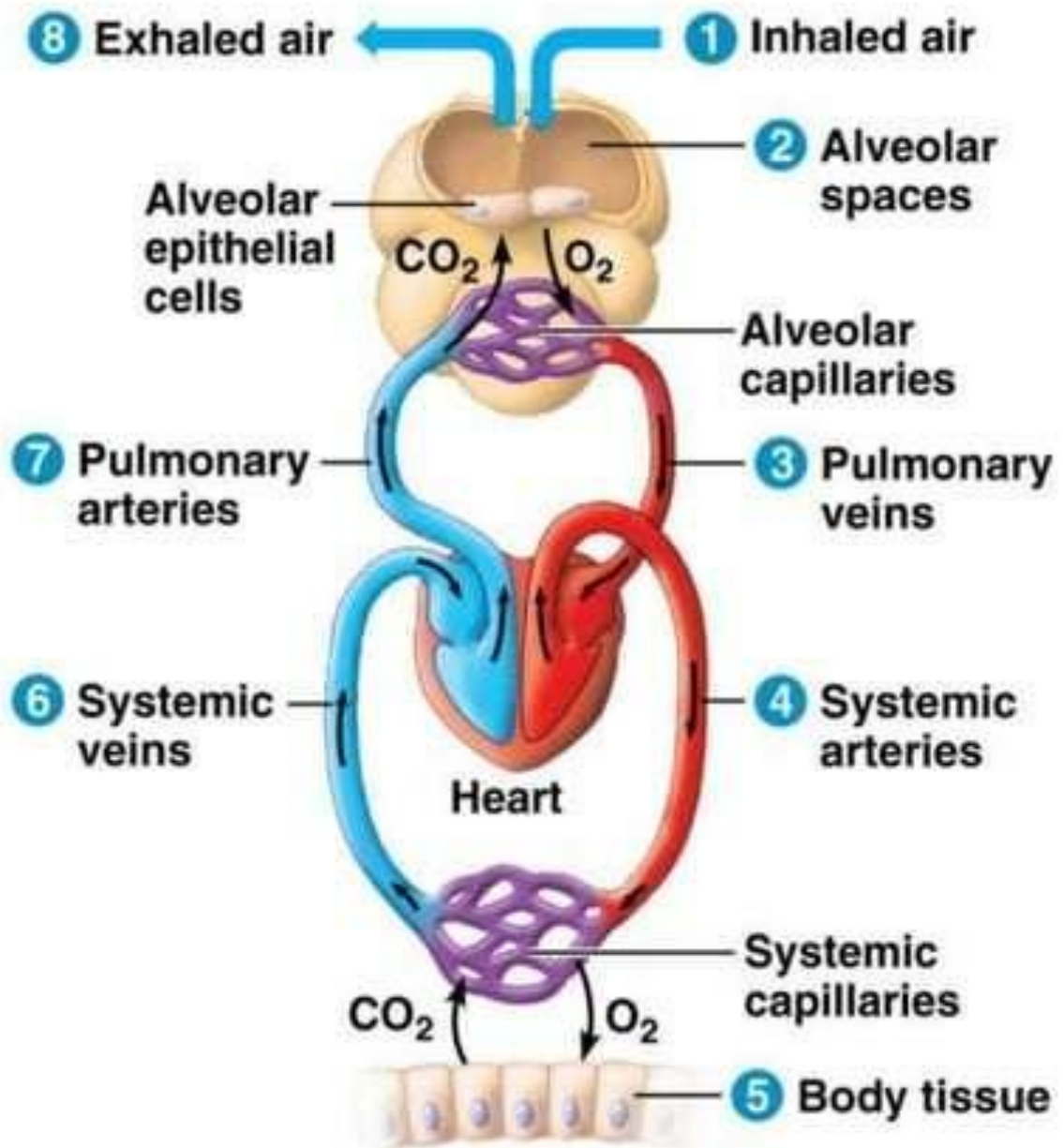
- P_{O_2} - 100mm Hg
- P_{CO_2} - 40mm Hg

Right Atrium:

- P_{O_2} - 40mm Hg
- P_{CO_2} - 45mm Hg

Tissue:

- P_{O_2} - 40mm Hg
- P_{CO_2} - 45mm Hg



(a) The path of respiratory gases in the circulatory system

ARTIFICIAL RESPIRATION:

“A method which allows the air to move in and out of the lungs in case of inadequate/ ceased natural breathing”

Different methods:

- *Artificial lung*
- *Pulmotor*
- *Mechanical respirator*

Or

- *Mouth to mouth*
- *Mouth to nose method*

RESUSCITATION METHOD:

Manual Methods:

- Mouth to mouth respiration
- Prone pressure method (by Schafer)
- Arm Lift chest Pressure method
- Arm lift back pressure method (by Holger – Nielsen)
- Tilting/ Eve Rocking Method
- Instrumental Method

Drinkers method:

- Bragg Paul's method
- Continuous insufflation method
- Tank respirator
- Resuscitator

THANK YOU