



# **SNS COLLEGE OF TECHNOLOGY**

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## **Department of Biomedical Engineering**

**Course Name: 19BMT201 – Human Anatomy & Physiology**

**II Year : III Semester**

**Topic : UNIT 2- Respiratory System**



# 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 CO<sub>2</sub> (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

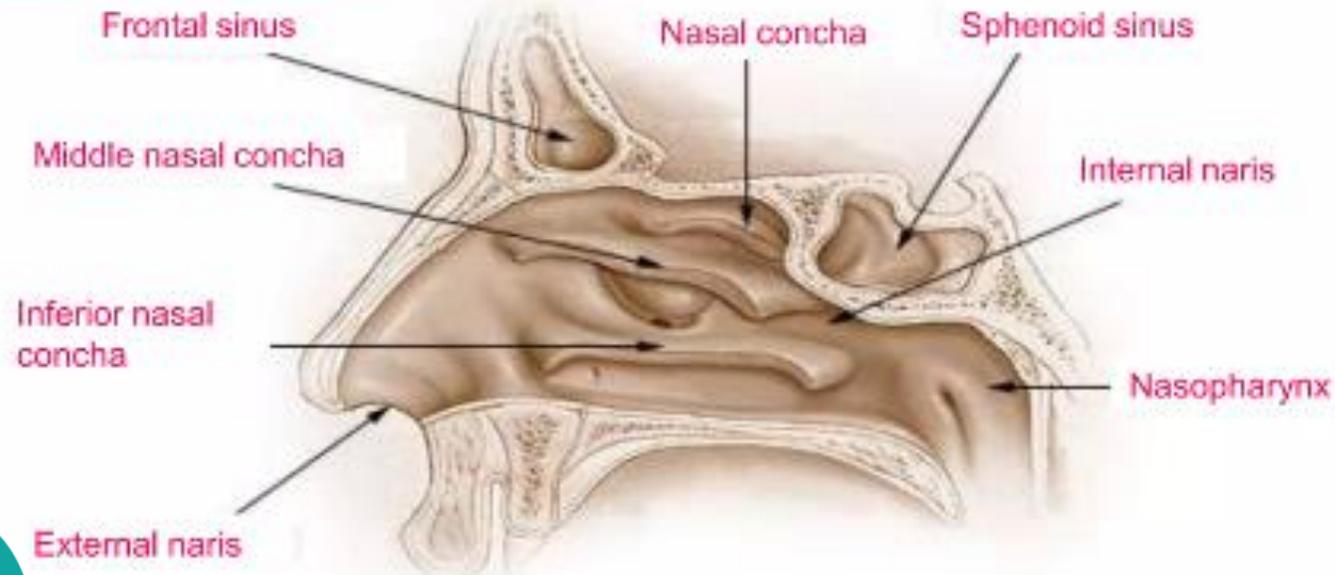
- \* Bronchioles
- \* Alveolar Ducts
- \* Alveoli



# Nose

- Also called external nares.
- Divided into two halves by the **nasal septum**.
- Contains the **paranasal sinuses** where air is warmed.
- Contains **cilia** which is responsible for filtering out foreign bodies.

**Nose and Nasal Cavities**





- **Internal nares** - opening to exterior
- **External nares** - opening to pharynx
- **Nasal conchae** - folds in the mucous membrane that increase air turbulence and ensures that most air contacts the mucous membranes

### **Provides and airway for respiration**

- Moistens and warms entering air
- Filters and cleans inspired air
- Resonating chamber for speech
  - detects odors in the air stream



# Pharynx

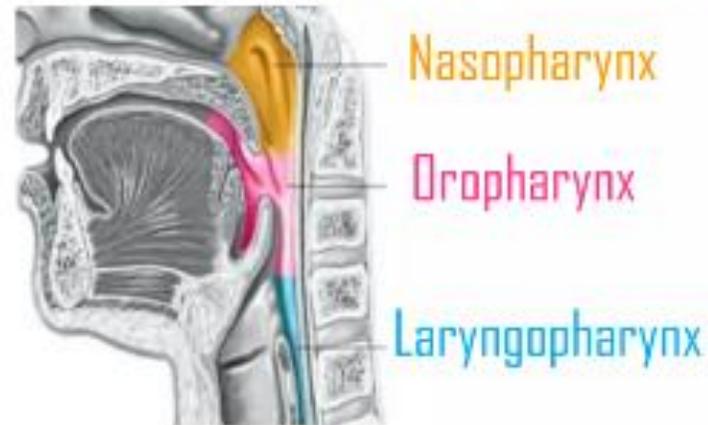
- Common space used by both **the respiratory and digestive systems**.
- Commonly called **the throat**.
- Originates posterior to the nasal and oral cavities and extends inferiorly near the level of the bifurcation of the **larynx and esophagus**.
- Common **pathway** for both **air and food**.
- Walls are lined by a mucosa and contain skeletal muscles that are primarily used for swallowing.
- Flexible lateral walls are distensible in order to force swallowed food into the esophagus.





## Three Sections of the Pharynx

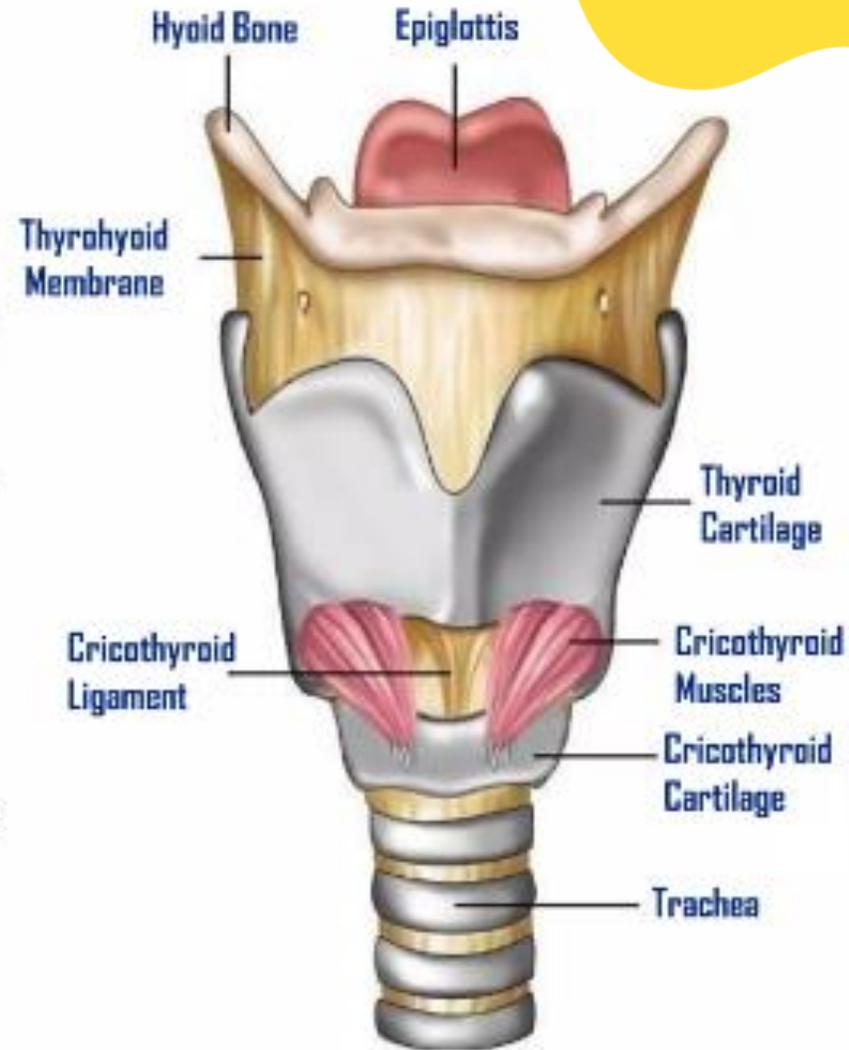
- **Nasopharynx**
  - contains the *pharyngeal tonsils* (adenoids) which aid in the body's immune defense.
- **Oropharynx**
  - back portion of the mouth that contains the *palatine tonsils* which aid in the body's immune defense.
- **Laryngopharynx**
  - bottom section of the pharynx where the respiratory tract divides into the *esophagus* and the *larynx*.





# Larynx

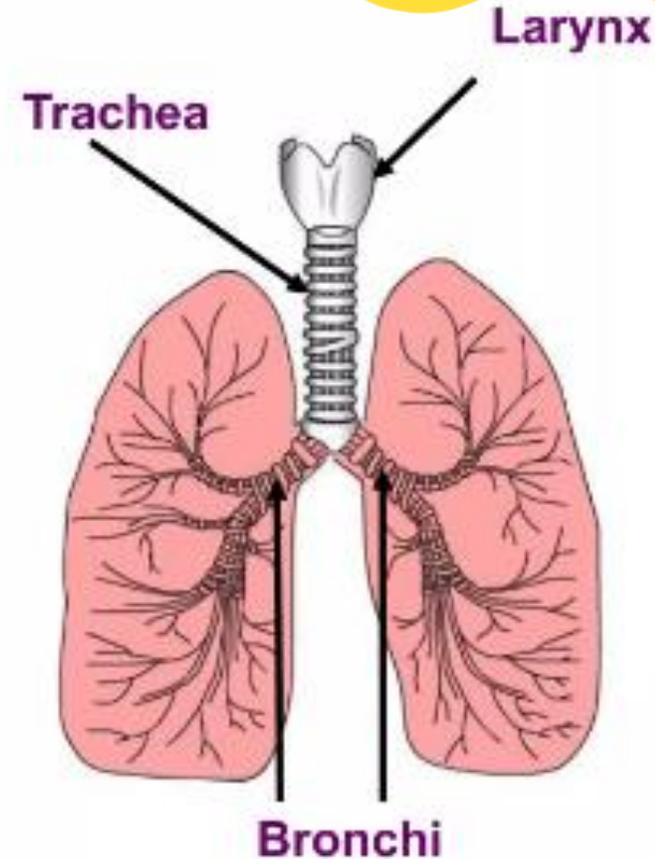
- **Voice box** is a short, somewhat cylindrical airway ends in **the trachea**.
- Prevents swallowed materials from entering the lower respiratory tract.
- Conducts air into the lower respiratory tract.
- Produces sounds.
- Supported by a framework of nine pieces of cartilage (three individual pieces and three cartilage pairs) that are held in place by ligaments and muscles.





# Trachea

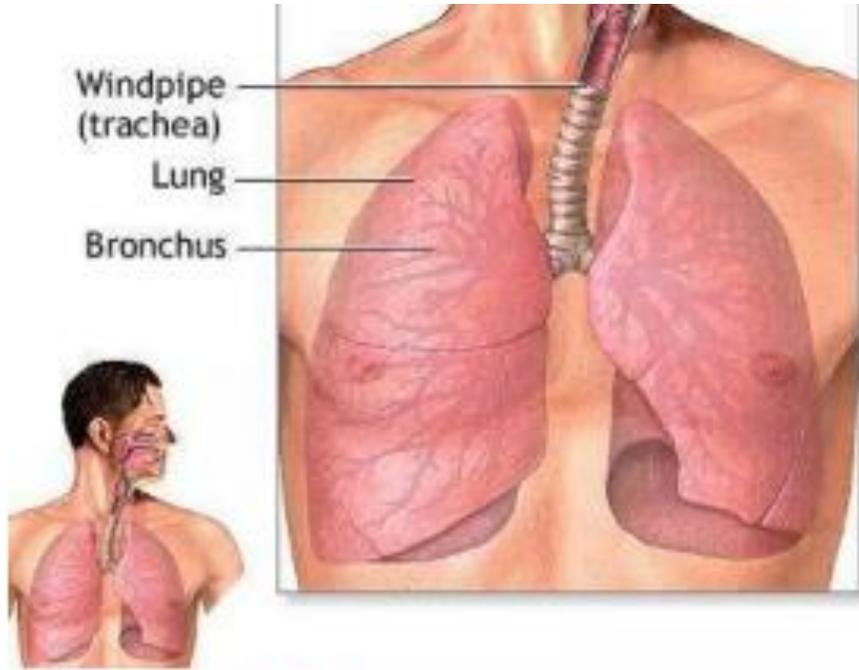
- A flexible tube also called *windpipe*.
- Extends through the mediastinum and lies anterior to the esophagus and inferior to the larynx.
- Cartilage rings reinforce and provide rigidity to the tracheal wall to ensure that the trachea remains open at all times.
- At the level of the sternal angle, the trachea bifurcates into two smaller tubes, called the **right and left primary bronchi**.  
Each primary bronchus projects laterally toward each lung.





# Lungs

- Each lung has a conical shape. Its wide, concave base rests upon the muscular diaphragm.
- Its superior region called the **apex** projects superiorly to a point that is slightly superior and posterior to the clavicle.
- Both lungs are bordered by the thoracic wall anteriorly, laterally, and posteriorly, and supported by the rib cage.
- Toward the midline, the lungs are separated from each other by the **mediastinum**.
- The relatively broad, rounded surface in contact with the thoracic wall is called the **costal surface** of the lung.



# Lungs

## Left lung

- divided into 2 lobes by **oblique fissure**
- smaller than the right lung
- **cardiac notch** accommodates the heart

## Right lung

- divided into 3 lobes by **oblique and horizontal fissure**
- located more superiorly in the body due to liver on right side



# Pleura

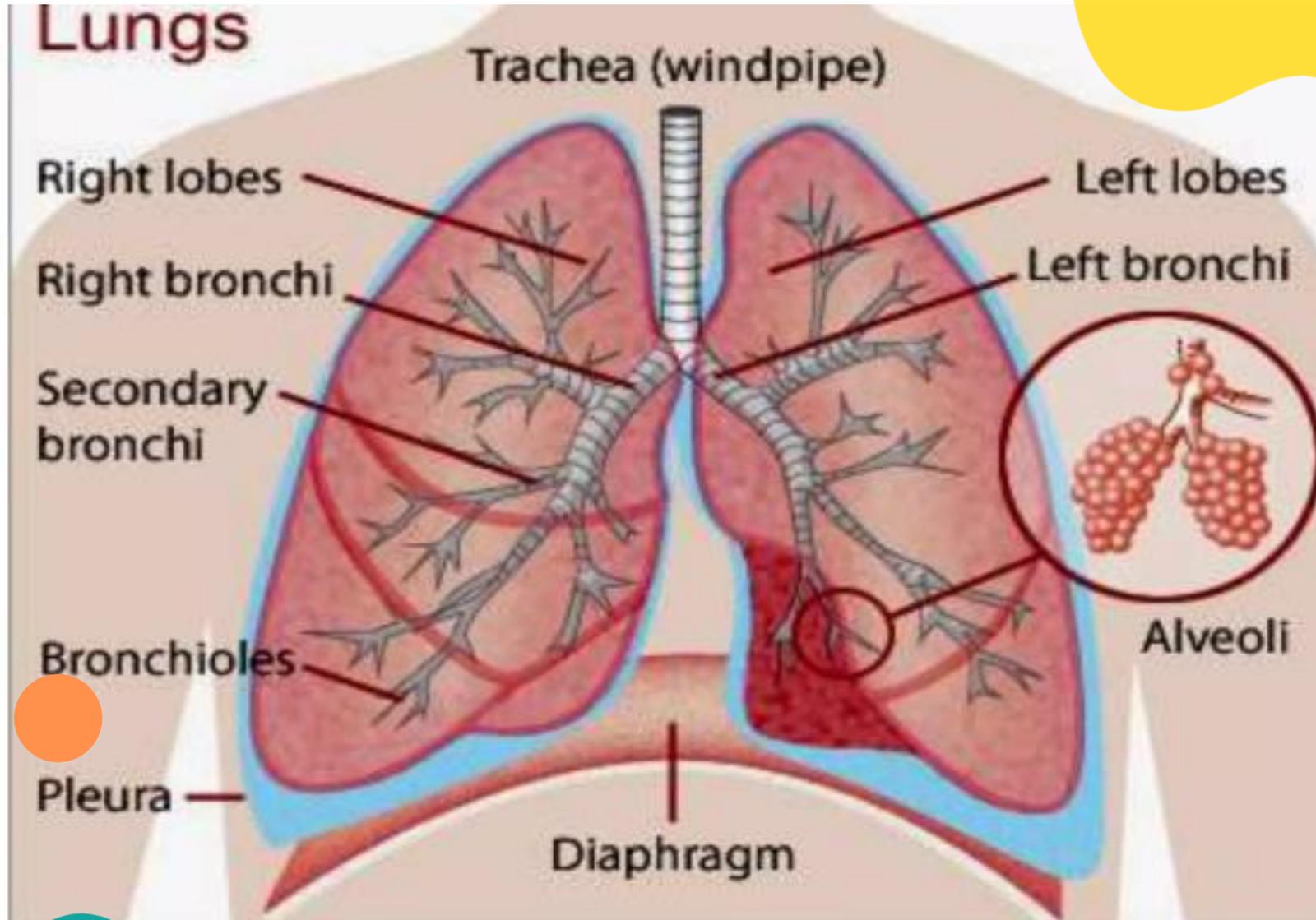
- The outer surface of each lung and the adjacent internal thoracic wall are lined by a serous membrane called **pleura**.
- The outer surface of each lung is tightly covered by the **visceral pleura**.
- while the internal thoracic walls, the lateral surfaces of the mediastinum, and the superior surface of the diaphragm are lined by the **parietal pleura**.
- The parietal and visceral pleural layers are continuous at the **hilus** of each lung

## Pleural Cavities

The potential space between the serous membrane layers is a **pleural cavity**.

- The pleural membranes produce a thin, serous **pleural fluid** that circulates in the pleural cavity and acts as a lubricant, ensuring minimal friction during breathing.

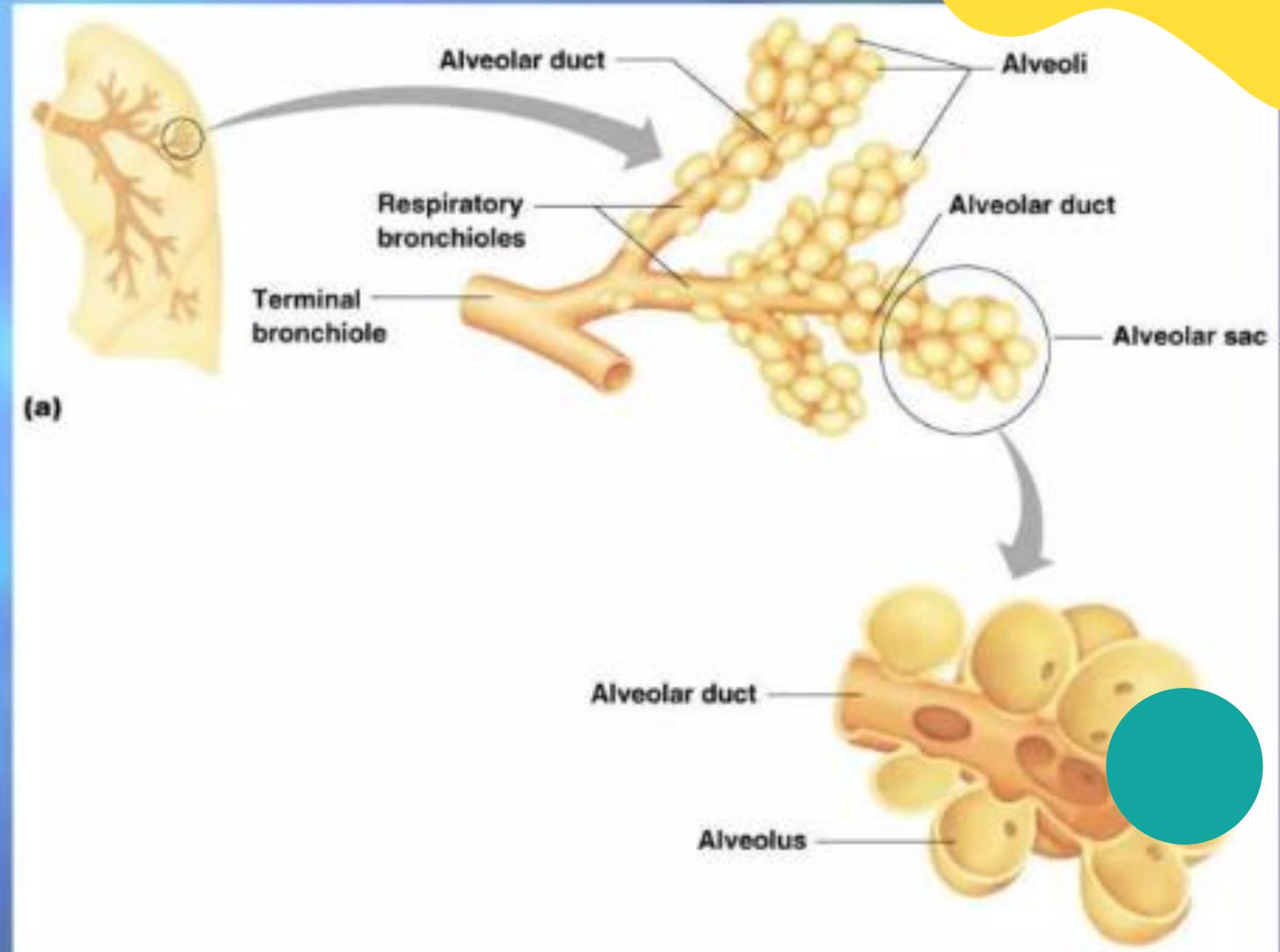
**Pleural effusion** – pleuritis with too much fluid





# Bronchioles

- Smallest branches of the bronchi
- All but the smallest branches have reinforcing cartilage
- Terminal bronchioles end in alveoli



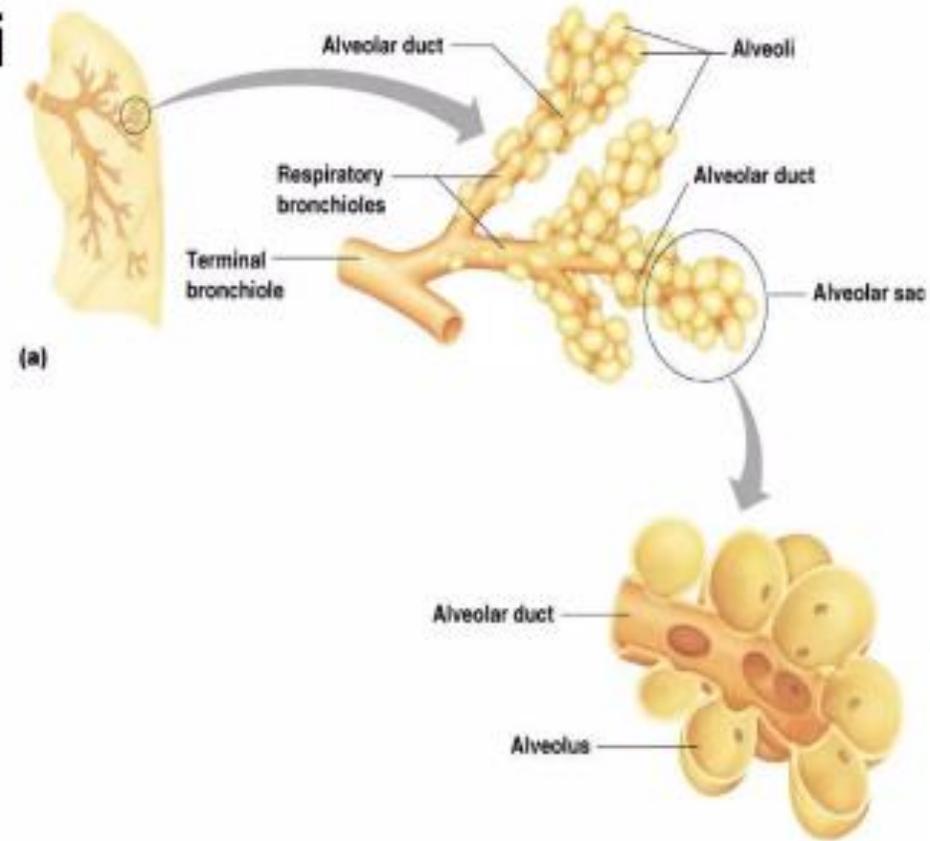




# Alveoli

## Structure of alveoli

- Alveolar duct
- Alveolar sac
- Alveolus
- Gas exchange





## Respiratory Membrane (Air-Blood Barrier)

- Thin squamous epithelial layer lining alveolar walls
- Pulmonary capillaries cover external surfaces of alveoli



# Respiratory Membrane (Air-Blood Barrier)

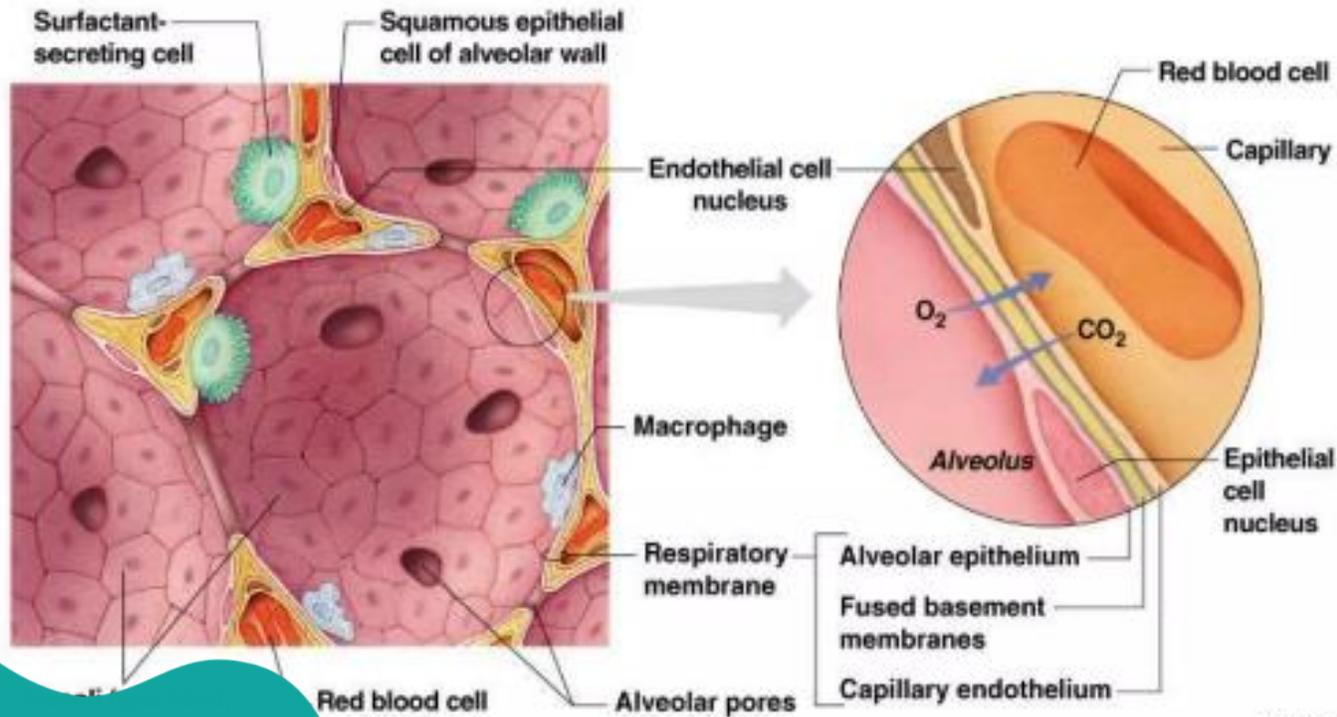


Figure 13.6



Component	Structure	Function
Epiglottis	<ul style="list-style-type: none"><li>• Small flap of cartilage</li></ul>	Prevents food entering the trachea
Trachea	<ul style="list-style-type: none"><li>• Tube which carries air</li><li>• Covered in hairs (Cilia)</li><li>• Surrounded by C-shaped cartilage rings (Protect)</li></ul>	Also known as the wind pipe; passage for oxygen to travel through
Bronchus	<ul style="list-style-type: none"><li>• Cartilage rings</li><li>• Smooth muscle</li></ul>	Splits trachea into two tube to allow oxygen in right and left lungs
Bronchioles	<ul style="list-style-type: none"><li>• Further division of bronchi</li><li>• Very narrow tubes</li><li>• Lead to alveoli</li></ul>	Allows oxygen to filter into alveoli
Alveoli	<ul style="list-style-type: none"><li>• Air sacs</li><li>• Thin walls</li></ul>	Site for exchange of gasses
Diaphragm	<ul style="list-style-type: none"><li>• Muscle that sits underneath lungs</li><li>• Attached to the ribs and sternum</li><li>• Base of thoracic cavity</li></ul>	Enables thoracic cavity to be increased and decreased
Intercostal muscles	<ul style="list-style-type: none"><li>• Muscles that sit between the ribs</li><li>• Internal and external</li></ul>	Enables thoracic cavity to be increased and decreased



# Events of Respiration

- Pulmonary ventilation – moving air in and out of the lungs
- External respiration – gas exchange between pulmonary blood and alveoli
- Respiratory gas transport – transport of oxygen and carbon dioxide via the bloodstream
- Internal respiration – gas exchange between blood and tissue cells in systemic capillaries



# Mechanics of Breathing (Pulmonary Ventilation)

- Completely mechanical process
- Depends on volume changes in the thoracic cavity
- Volume changes lead to pressure changes, which lead to the flow of gases to equalize pressure



# Mechanics of Breathing (Pulmonary Ventilation)

- Two phases
  - Inspiration – flow of air into lung
  - Expiration – air leaving lung



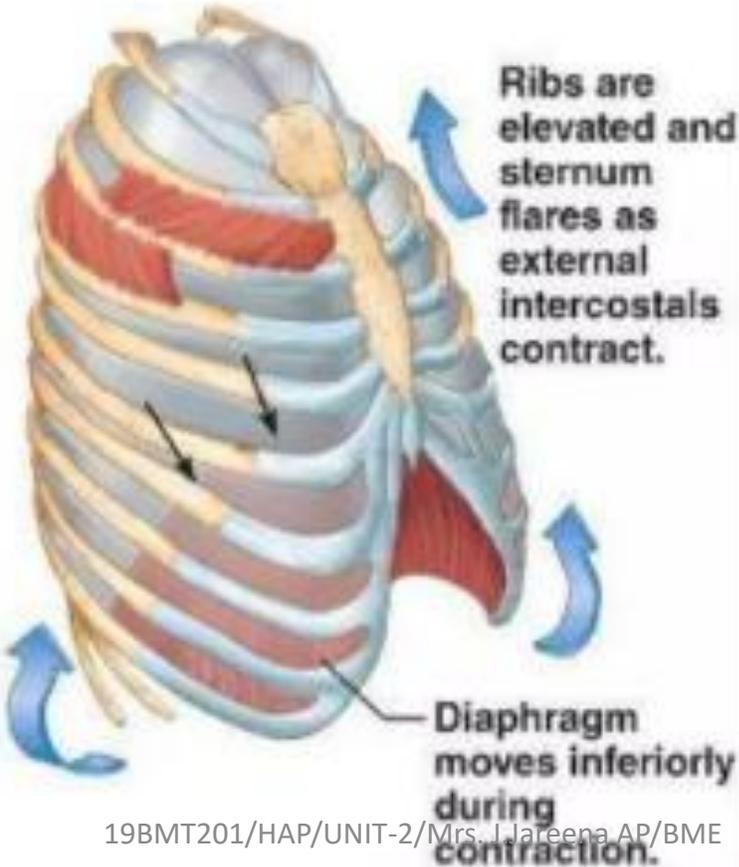
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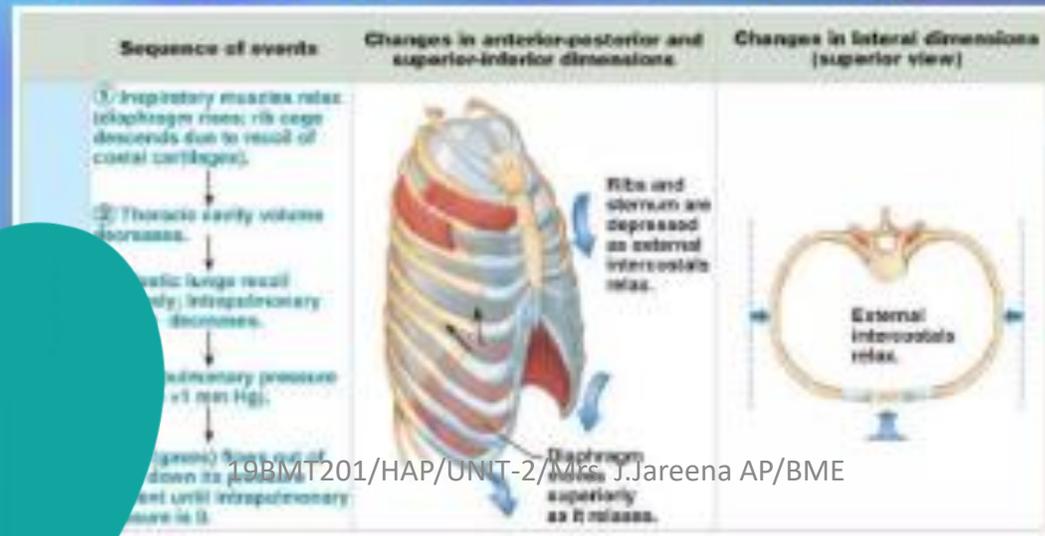
# Inspiration

	Sequence of events	Changes in anterior-posterior and superior-inferior dimensions	Changes in lateral dimensions (superior view)
Inspiration	<ol style="list-style-type: none"><li>1 Inspiratory muscles contract (diaphragm descends; rib cage rises).</li><li>2 Thoracic cavity volume increases.</li><li>3 Lungs are stretched; intrapulmonary volume increases.</li><li>4 Intrapulmonary pressure drops (to <math>-1</math> mm Hg).</li><li>5 Air (gases) flows into lungs down its pressure gradient until intrapulmonary pressure is 0 (equal to atmospheric pressure).</li></ol>	 <p>Ribs are elevated and sternum flares as external intercostals contract.</p> <p>Diaphragm moves inferiorly during contraction.</p>	 <p>External intercostals contract.</p>



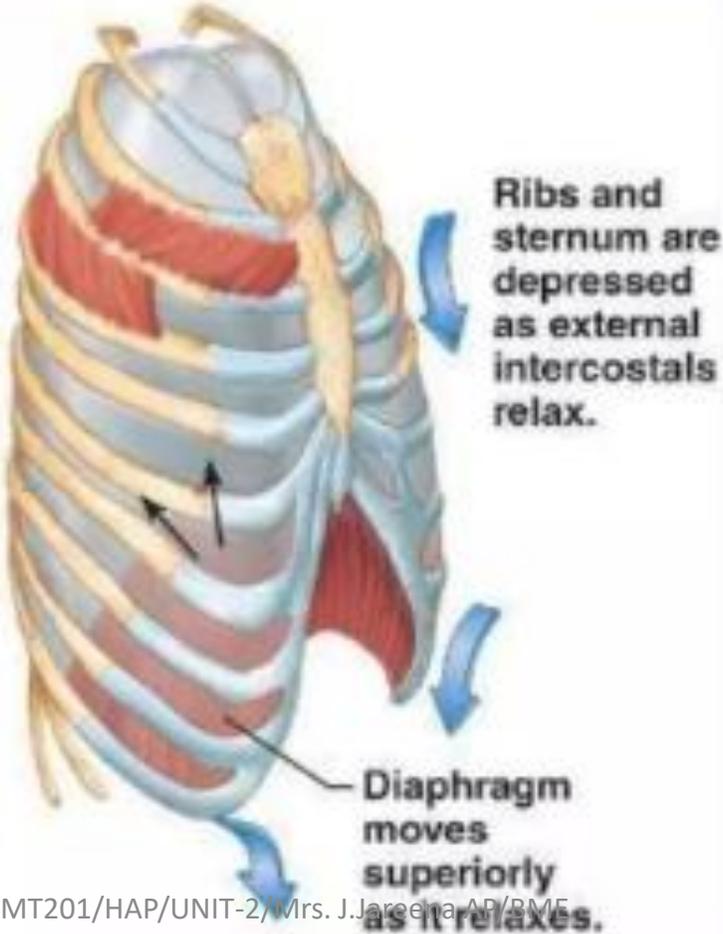
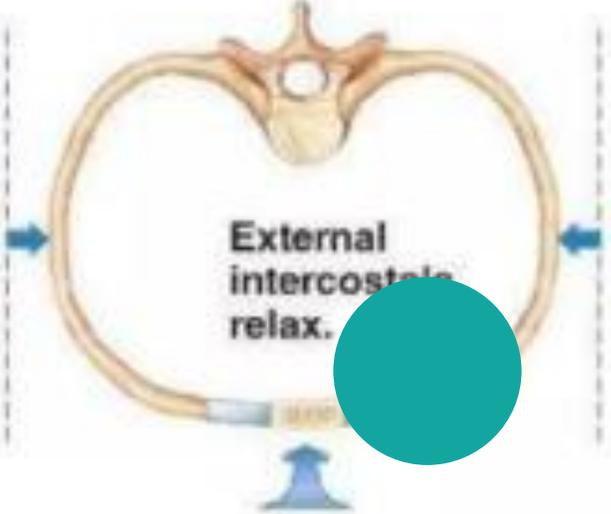
# Exhalation

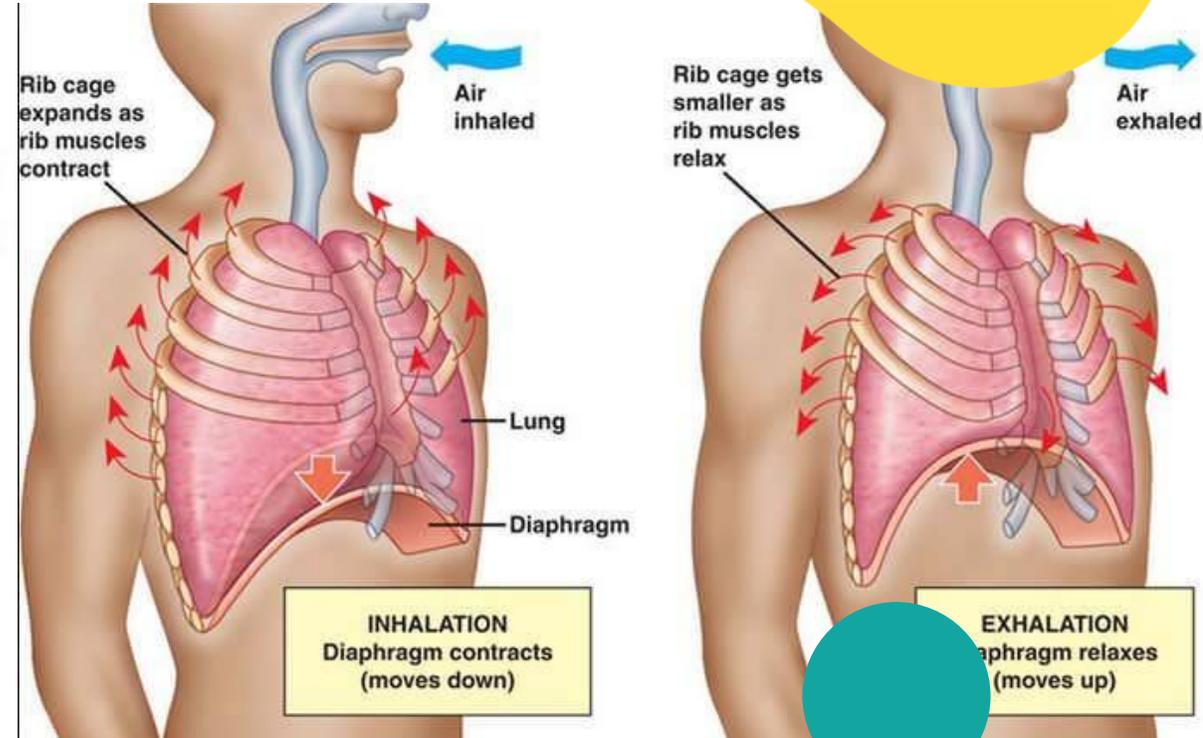
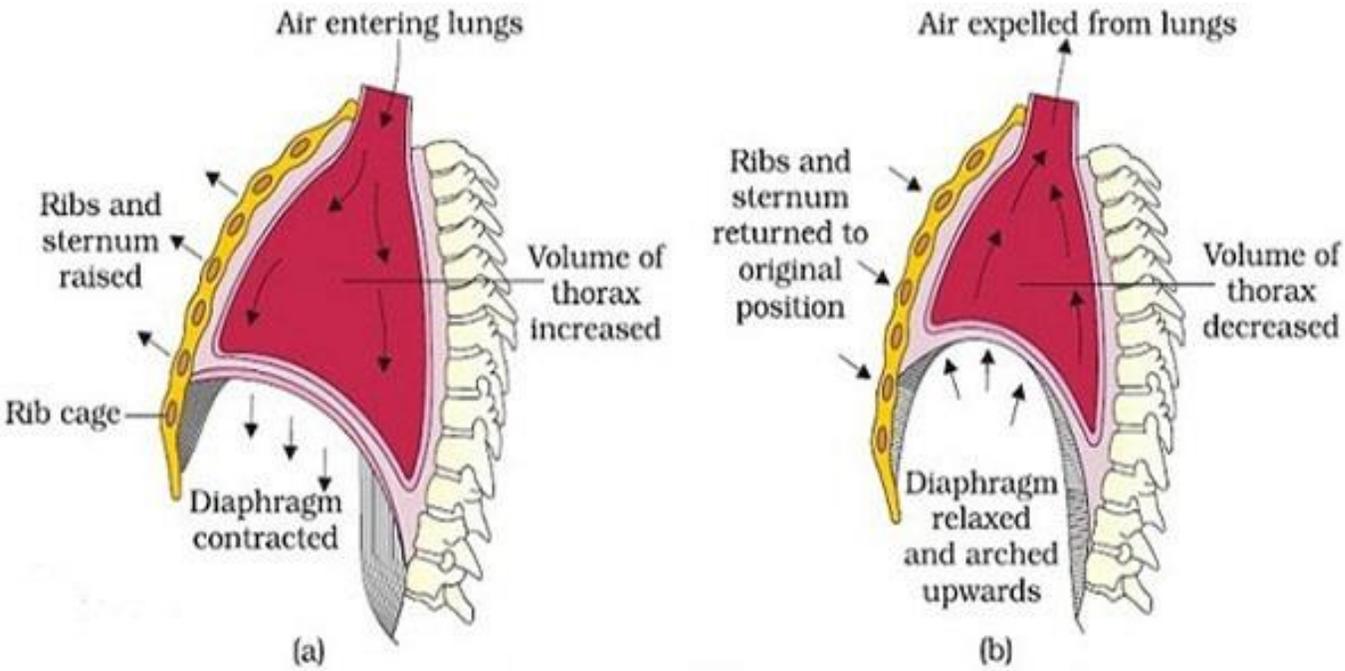
- Largely a passive process which depends on natural lung elasticity
- As muscles relax, air is pushed out of the lungs
- Forced expiration can occur mostly by contracting internal intercostal muscles to depress the rib cage





# Exhalation

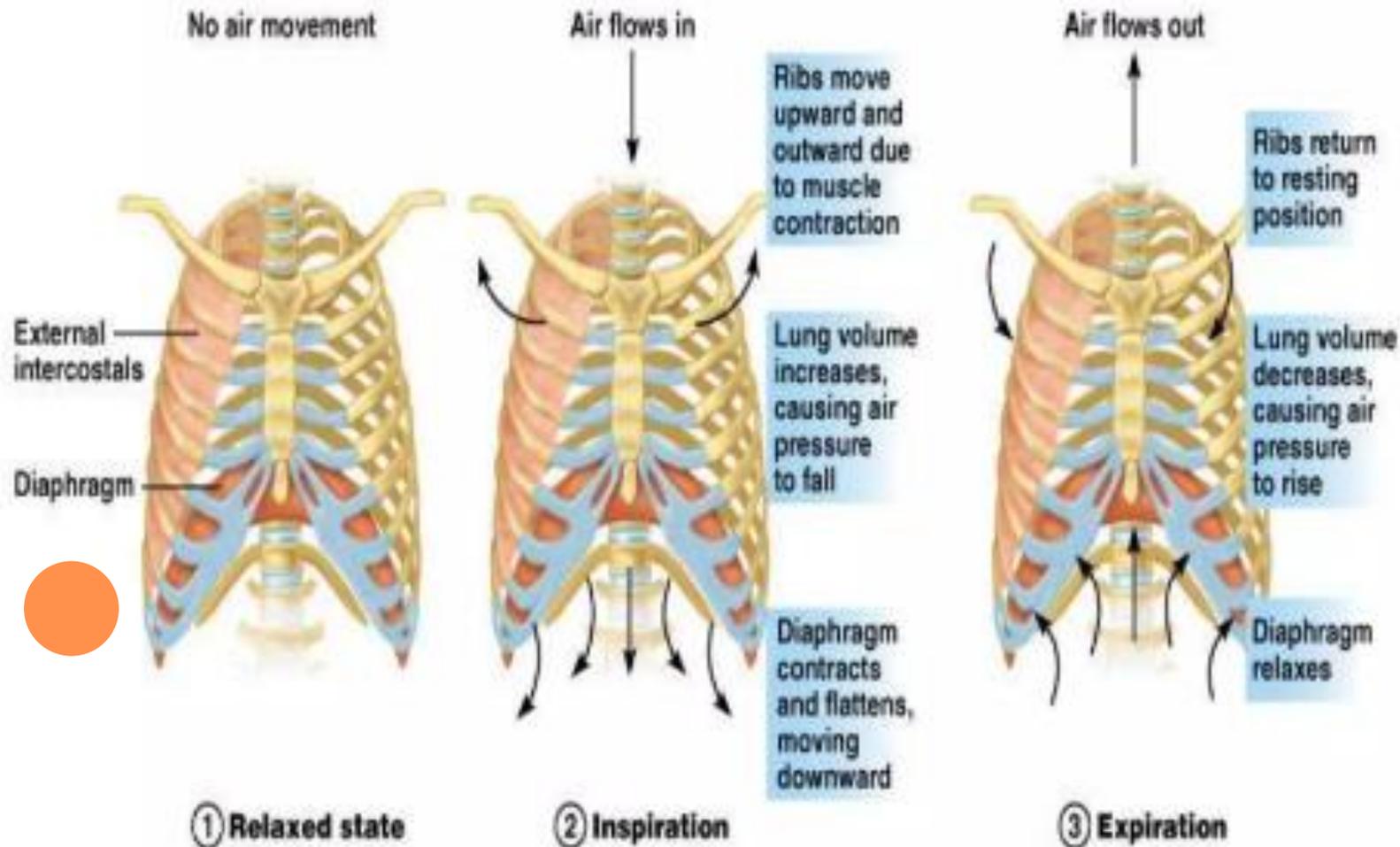
	Sequence of events	Changes in anterior-posterior and superior-inferior dimensions	Changes in lateral dimensions (superior-inferior)
<b>Expiration</b>	<p>① Inspiratory muscles relax (diaphragm rises; rib cage descends due to recoil of costal cartilages).</p> <p>② Thoracic cavity volume decreases.</p> <p>③ Elastic lungs recoil passively; intrapulmonary volume decreases.</p> <p>④ Intrapulmonary pressure rises (to +1 mm Hg).</p> <p>⑤ Air (gases) flows out of lungs down its pressure gradient until intrapulmonary pressure is 0.</p>	 <p>Ribs and sternum are depressed as external intercostals relax.</p> <p>Diaphragm moves superiorly as it relaxes.</p>	 <p>External intercostals relax.</p>



## Mechanism of Breathing



# FUNCTIONS OF THE RESPIRATORY MUSCLES





# Nonrespiratory Air Movements

- Can be caused by reflexes or voluntary actions
- Examples
  - Cough and sneeze – clears lungs of debris
  - Laughing
  - Crying
  - Yawn
  - Hiccup





# External Respiration

- Oxygen movement into the blood
  - The alveoli always has more oxygen than the blood
  - Oxygen moves by diffusion towards the area of lower concentration
  - Pulmonary capillary blood gains oxygen



# External Respiration

- Carbon dioxide movement out of the blood
  - Blood returning from tissues has higher concentrations of carbon dioxide than air in the alveoli
  - Pulmonary capillary blood gives up carbon dioxide
- Blood leaving the lungs is oxygen-rich and carbon dioxide-poor





# Gas Transport in the Blood

- Oxygen transport in the blood
  - Inside red blood cells attached to hemoglobin (oxyhemoglobin [ $\text{HbO}_2$ ])
  - A small amount is carried dissolved in the plasma



# Gas Transport in the Blood

- Carbon dioxide transport in the blood
  - Most is transported in the plasma as bicarbonate ion ( $\text{HCO}_3^-$ )
  - A small amount is carried inside red blood cells on hemoglobin, but at different binding sites than those of oxygen

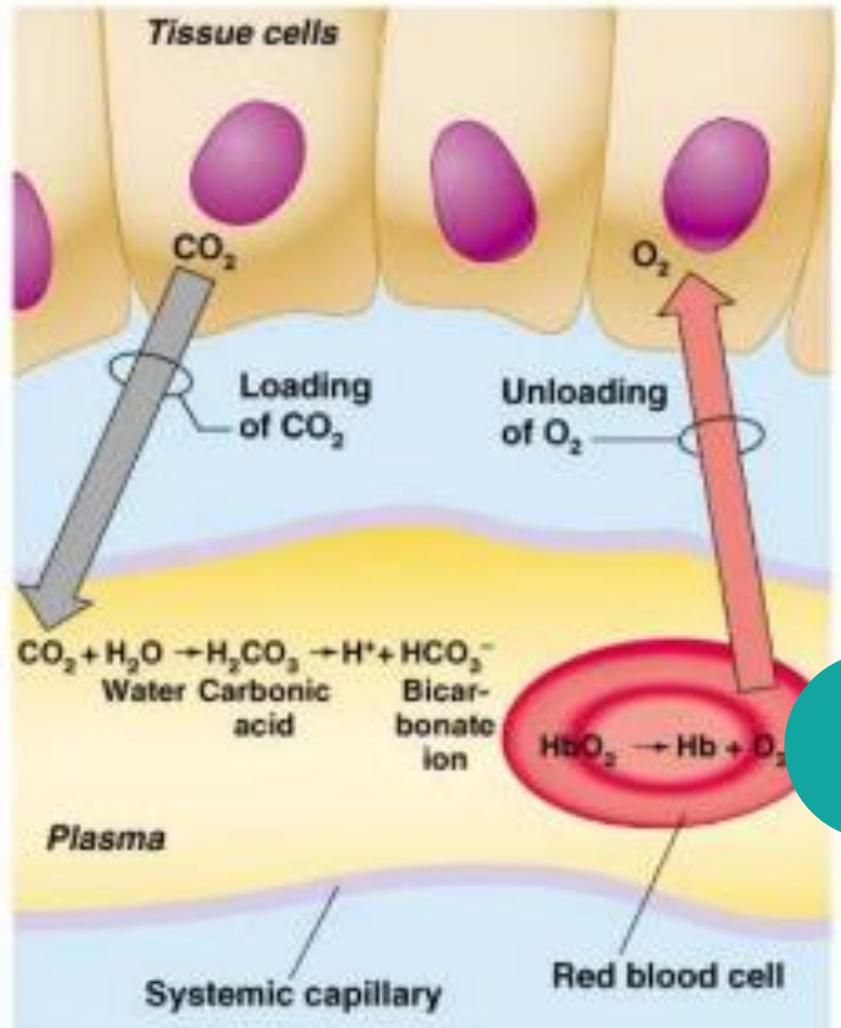
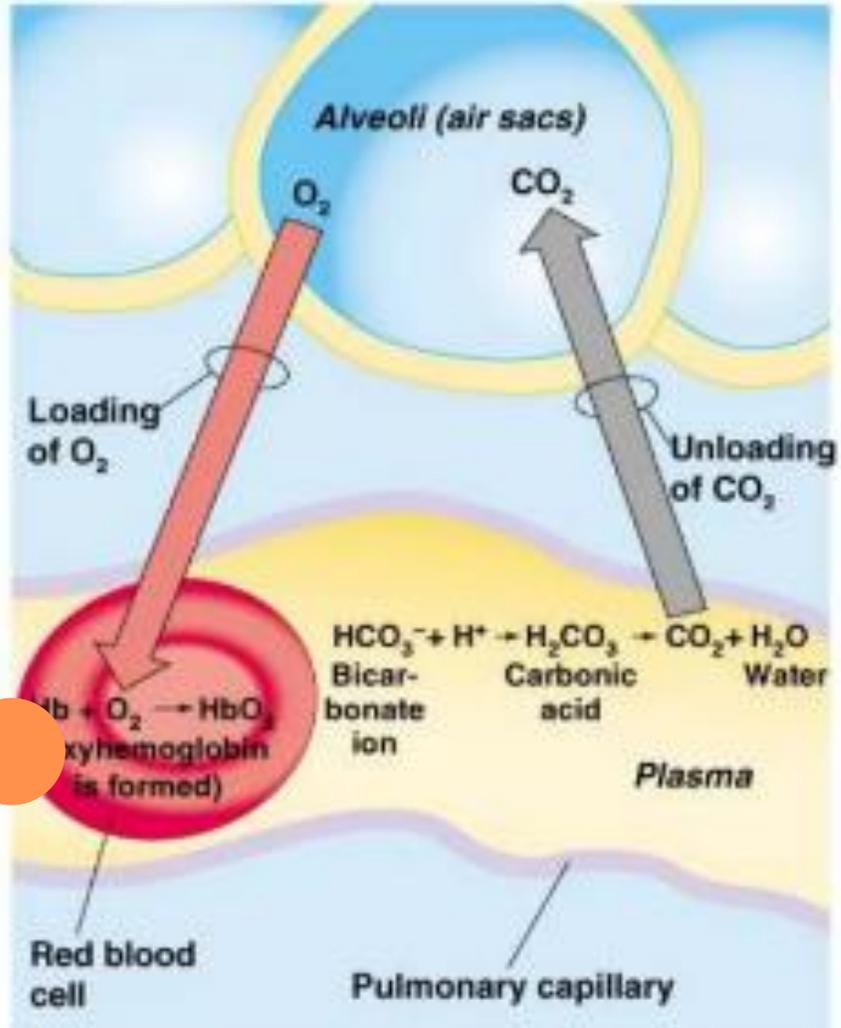


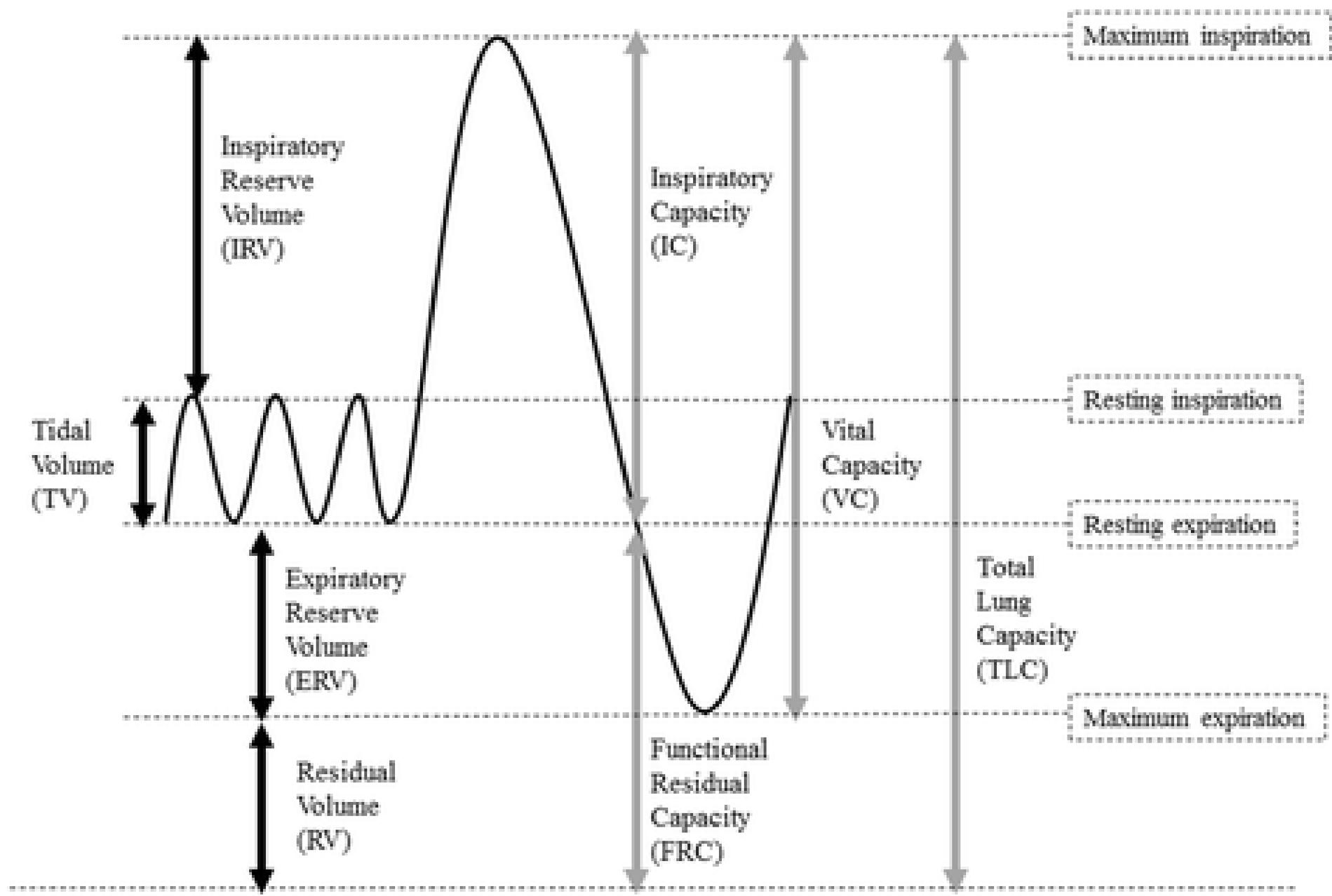
# Internal Respiration

- Exchange of gases between blood and body cells
- An opposite reaction to what occurs in the lungs
  - Carbon dioxide diffuses out of tissue to blood
  - Oxygen diffuses from blood into tissue



# Internal Respiration





## VENTILATION PARAMETERS

### A. Lung Volumes

#### 1. Basic volumes:

- a. **Tidal Volume ( $V_T$ ,  $T_V$ )**: volume of gas exchanged each breath; can change as ventilation pattern changes .(500 ml)
- b. **Inspiratory Reserve Volume (IRV)**: maximum volume that can be inspired, starting from the end inspiratory position (potential volume increase at the end of inspiration).(3000ml)
- c. **Expiratory Reserve Volume (ERV)**: maximum volume that can be expired, starting from the end expiratory position (potential volume decrease at the end of expiration)(1200ml)
- d. **Residual Volume (RV)**: volume remaining in the lungs and airways following a maximum expiratory effort (1300 ml)

## 2. Capacities: combined volumes

a. **Vital Capacity (VC):** maximum volume of gas that can be exchanged in a single breath

$$VC = TV + IRV + ERV \quad (4700 \text{ ml})$$

b. **Total Lung Capacity (TLC):** maximum volume of gas that the lungs (and airways) can contain

$$TLC = VC + RV = TV + IRV + ERV + RV \quad (6000 \text{ ml})$$

c. **Functional Residual Capacity (FRC):** volume of gas remaining in the lungs (and airways) at the end expiratory position

$$FRC = RV + ERV \quad (2500 \text{ ml})$$

d. **Inspiratory capacity (IC):** maximum volume of gas that can be inspired from the end expiratory position .

$$IC = TV + IRV \quad (3500 \text{ ml})$$

