

## 16. RESPIRATORY SYSTEM

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## 16. RESPIRATORY SYSTEM

**PREPARED BY**

**DR. UPAMA N. TRIVEDI,**

**M. PHARM, PH. D**

**PROFESSOR & H.o.D.,**

**SARDAR PATEL COLLEGE OF PHARMACY, BAKROL**

**E-mail: ups.aasthu@gmail.com**

**&**

**DR. NAITIK D. TRIVEDI,**

**M. PHARM, PH. D**

**LECTURER AT GOVERNMENT AIDED,**

**A. R. COLLEGE OF PHARMACY & G. H. PATEL INSTITUTE OF  
PHARMACY, VALLABH VIDYANAGAR, ANAND.**

**Mobile: +91 - 9924567864**

**E-mail: mastermindnaitik@gmail.com**

## 16. RESPIRATORY SYSTEM

### Respiration:

Respiration means exchange of gases—oxygen and carbon dioxide—between the atmospheric air, blood, and tissue cells. Inhalation and exhalation, inspiration and expiration, breathing in and breathing out known as respiration.

The respiratory system consists of the nose, pharynx (throat), larynx (voice box), trachea, windpipe), bronchi, and lungs.

Its parts can be classified according to either structure or function.

**Structurally**, the respiratory system consists of two parts:

1. **The upper respiratory system:** It includes the nose, pharynx, and associated structures.
2. **The lower respiratory system:** It includes the larynx, trachea, bronchi, and lungs.

**Functionally**, the respiratory system also consists of two parts:

1. **The conducting zone:**
  - It consists of a series of interconnecting cavities and tubes both outside and within the lungs.
  - These contain the nose, pharynx, larynx, trachea, bronchi, bronchioles, and terminal bronchioles.
  - Their function is to filter, warm, and moisten air and conduct it into the lungs.
2. **The respiratory zone**
  - It consists of tissues within the lungs where gas exchange occurs.
  - These include the respiratory bronchioles, alveolar ducts, alveolar sacs, and alveoli. They are the main sites of gas exchange between air and blood.

### Types of respiration:

There are 3 types of respiration:

1. **Pulmonary Ventilation:** Exchange of Oxygen and Carbon Dioxide between air and lungs known as pulmonary ventilation.
2. **External respiration:** Exchange of Oxygen and Carbon Dioxide between lungs and blood known as external respiration.
3. **Internal Respiration:** Exchange of Oxygen and Carbon Dioxide between blood and cell known as internal respiration.

### 1. NOSE:

Nose is made up by two kind of frame work:

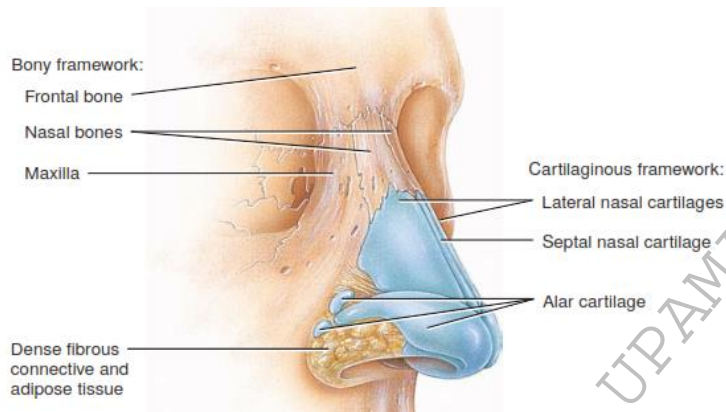
- i. Bony frame work:

It is made up by Frontal bone, Nasal Bone and Maxilla

- ii. Cartilage Frame Work:

It is made up by Lateral Nasal Cartilage, Septal Nasal Cartilage and Alar Cartilage

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The nose can be divided into external and internal portions.

### The external nose:

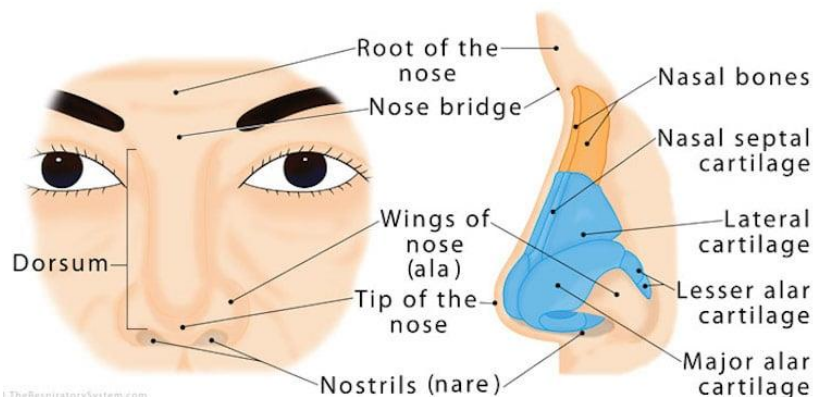
- It is the portion of the nose visible on the face and consists of a supporting framework of bone and hyaline cartilage covered with muscle and skin

and lined by a mucous membrane.

- The external nose is somewhat flexible because it consists of hyaline cartilage.
- External nose consists of two openings which are known as external nares or nostrils divided by the vertical septum.
- External nose also consists of hair inside the nostril.
- The external nose has three functions:
  - i. Warming, moistening, and filtering incoming air;
  - ii. Detecting olfactory stimuli or identifying the smell
  - iii. Modifying speech

### The internal nose:

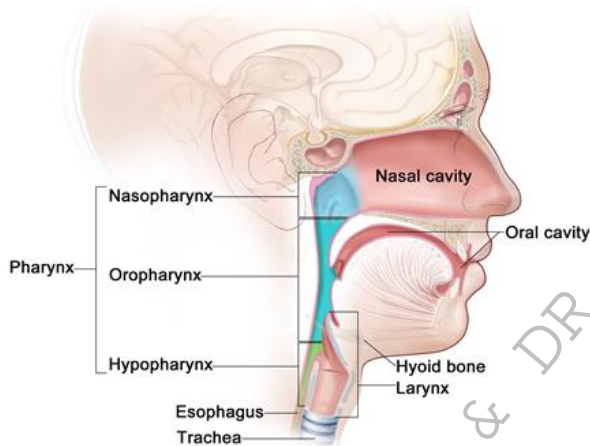
- Anteriorly, the internal nose merges with the external nose, and posteriorly it communicates with the pharynx through two openings called the internal nares or choanae.
- The space within the internal nose is called the nasal cavity.
- The anterior portion of the nasal cavity just inside the nostrils, called the nasal vestibule, is surrounded by cartilage.
- The superior part of the nasal cavity is surrounded by bone.
- A vertical partition, the nasal septum, divides the nasal cavity into right and left sides.



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- Superior attachment of the nose to the frontal bone is known as Root.
- Tip of nose known as Apex.

### 3. PHARYNX (THROAT)



It is a funnel-shaped tube about 13 cm (5 in.) long

- It starts from the internal nares and extends to the level of the cricoid cartilage, the most inferior cartilage of the larynx (voice box)
- Its wall is composed of skeletal muscles and is lined with a mucous membrane.
- Contraction of the skeletal muscles

assists in deglutition (swallowing).

- The pharynx functions as a passageway for air and food.
- It provides a resonating chamber for speech sounds, and houses the tonsils, which participate in immunological reactions against foreign invaders.
- The pharynx can be divided into three anatomical regions:

#### i. Nasopharynx:

- It is the superior portion of the pharynx.
- It lies posterior to the nasal cavity and extends to the soft palate.
- There are five openings in its wall: two internal nares, two openings that lead into the auditory tubes (commonly known as the Eustachian tubes), and the opening into the oropharynx.

#### ii. Oropharynx:

- It extends behind the mouth from the soft palate to the level of the hyoid bone.
- This portion of the pharynx has both respiratory and digestive functions, serving as a common passageway for air, food, and drink. Because the oropharynx is subject to abrasion by food particles, it is lined with nonkeratinized stratified squamous epithelium.
- Oropharynx consists of the palatine and lingual tonsils.

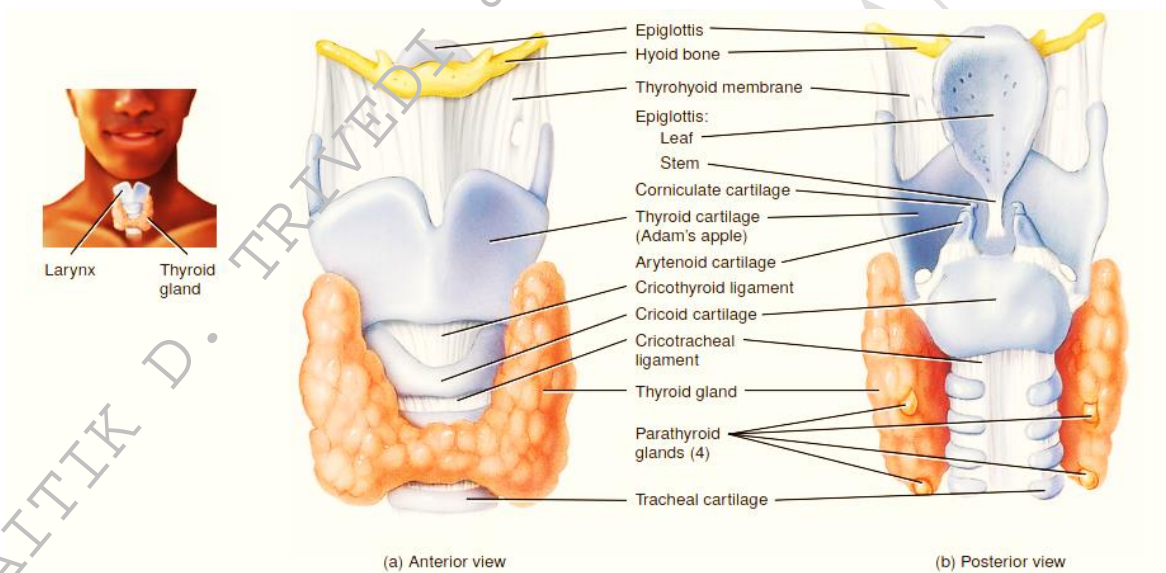
#### iii. Laryngopharynx:

Its end portion opens into the esophagus (food tube) and the larynx (voice box).

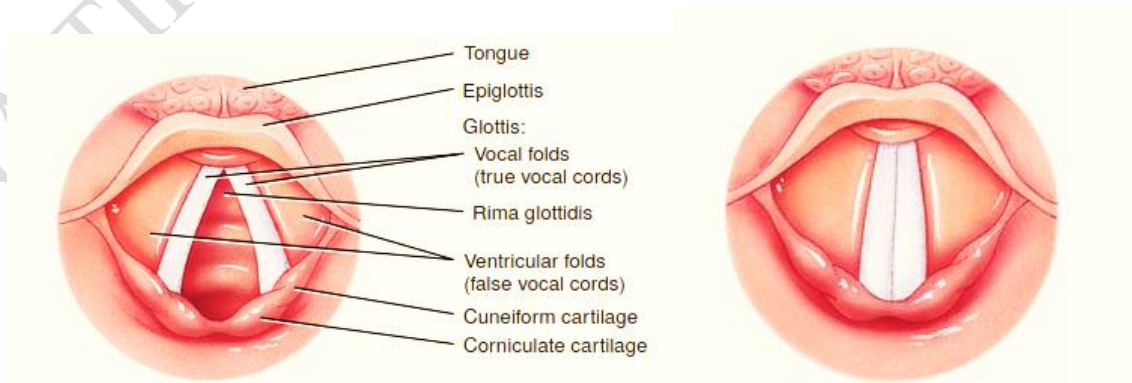
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### 3. LARYNX (VOICE BOX)

- The larynx is known as voice box.
- It connects the laryngopharynx with the trachea.
- The wall of the larynx is composed of nine pieces of cartilage:
  - Three occur singly (thyroid cartilage, epiglottis, and cricoid cartilage), and
  - Three occur in pairs (arytenoid, cuneiform, and corniculate cartilages).
- The arytenoid cartilages are the most important because they influence changes in position and tension of the vocal folds (true vocal cords for speech).
- During swallowing, the pharynx and larynx rise. Elevation of the pharynx widens it to receive food or drink and elevation of the larynx move down the the epiglottis so food not enter into the wind pipes.



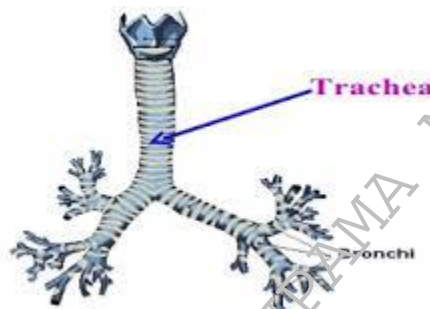
- The mucous membrane of the larynx forms two pairs of folds a superior pair called the ventricular folds (false vocal cords) and an inferior pair called the vocal folds (true vocal cords).





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### 4. TRACHEA

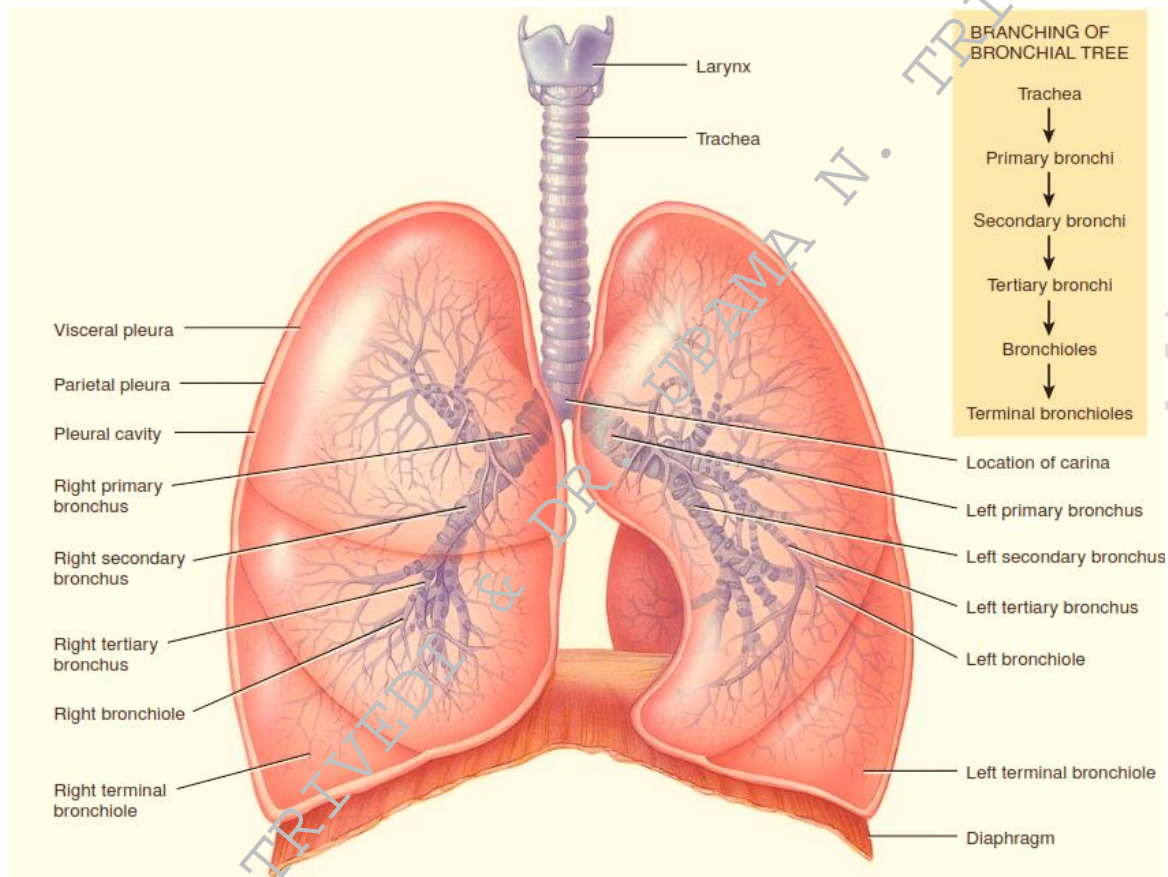


- Trachea is also known as windpipe.
- It is a tubular passageway for air.
- It is about 12 cm (5 in.) long and 2.5 cm (1 in.) in diameter.
- It extends from the larynx bronchi.
- Trachea consist 16–20 incomplete, horizontal rings of hyaline cartilage resemble the letter C.
- The open part of each C-shaped cartilage ring faces posteriorly toward the esophagus.

### 5. BRONCHI

- The trachea divides into a right and left primary bronchi.
- Right primary bronchi goes into the right lung, and a left primary windpipe bronchi, which goes into the left lung.
- The right primary bronchi is more vertical, shorter, and wider than the left.
- As a result, an aspirated object is more likely to enter and lodge in the right primary bronchus than the left.
- The primary bronchi contain incomplete rings of cartilage like trachea.
- The primary bronchi in to the lungs divide to form smaller bronchi known as the secondary (lobar) bronchi, one for each lobe of the lung. (The right lung has three lobes; the left lung has two.)
- The secondary bronchi branches known as tertiary (segmental) bronchi it further divide in to bronchioles.
- Bronchioles further divide in to smaller branches known as terminal bronchioles.
- This branch like structure resembles an inverted tree and is commonly referred to as the bronchial tree.

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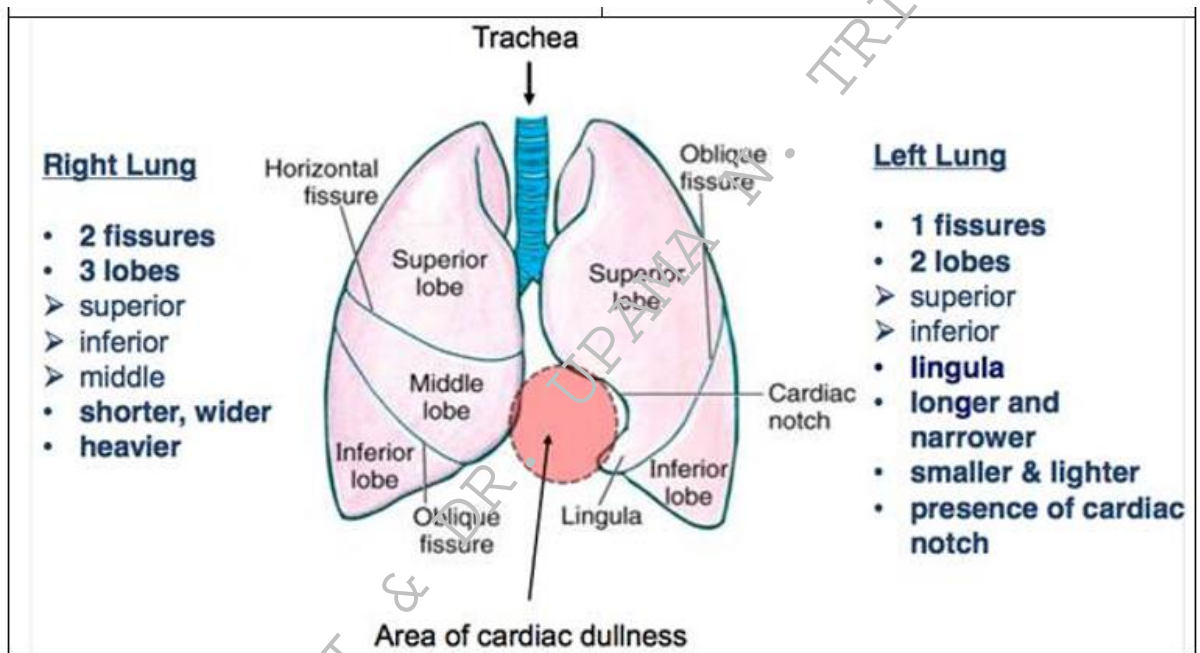


### 6. LUNGS

- There are two lungs in human body.
- It is cone-shaped organs reside in the thoracic cavity.

Lungs are separated from each other by the heart and other structures in the mediastinum.
- Each lung is enclosed and protected by a double-layered serous membrane known as the pleural membrane.
- The superficial layer is parietal pleura and the deep layer is the visceral pleura.
- Between the visceral and parietal pleurae there is a small space which is known as the pleural cavity, which contains a small amount of lubricating fluid secreted by the membranes.
- This pleural fluid reduces friction between the membrane of lungs and allowing them to slide easily over one another during breathing.
- The broad inferior portion of the lung is known as the base and narrow superior portion of the lung is the apex.

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- Right lung is shorter and wider than the left lungs because right side lobes of liver occupy more space than the left lobes.
- Left lung is long and narrow and it has lingula portion because left side of lung consist cardiac notch.
- Right lung capsular layer is thicker than the left lung.
- Right side of lung consist horizontal and oblique fissure so it divide in to three lobes, 1. Superior lobe 2. Middle lobe 3. Inferior lobe
- Left side of lung consist only oblique fissure so it divide in to two lobes, 1. Superior lobe and 2. Inferior lobe

### 7. BRONCHIOLES

- It is a smallest branches of respiratory tree having <1mm diameter.
- It do not consist cartilage rings but larger branches may have small patches of cartilage
- Asthma like disease condition affects the smallest terminal bronchioles

### 8. ALVEOLI

- Smallest bronchioles have clusters of tiny sacs branching off known as alveoli which produce “grapelike clusters.”
- Each lung consist 300-500 million alveoli.
- It is made up by Single cell layer of thick squamous epithelium.
- Alveoli are the “functional units” of the respiratory system
- It is the actual site of gas exchange with blood.



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- Alveoli increase in number and size until adolescence after adolescence, can increase in size only and if damaged, it has limited ability to repair themselves

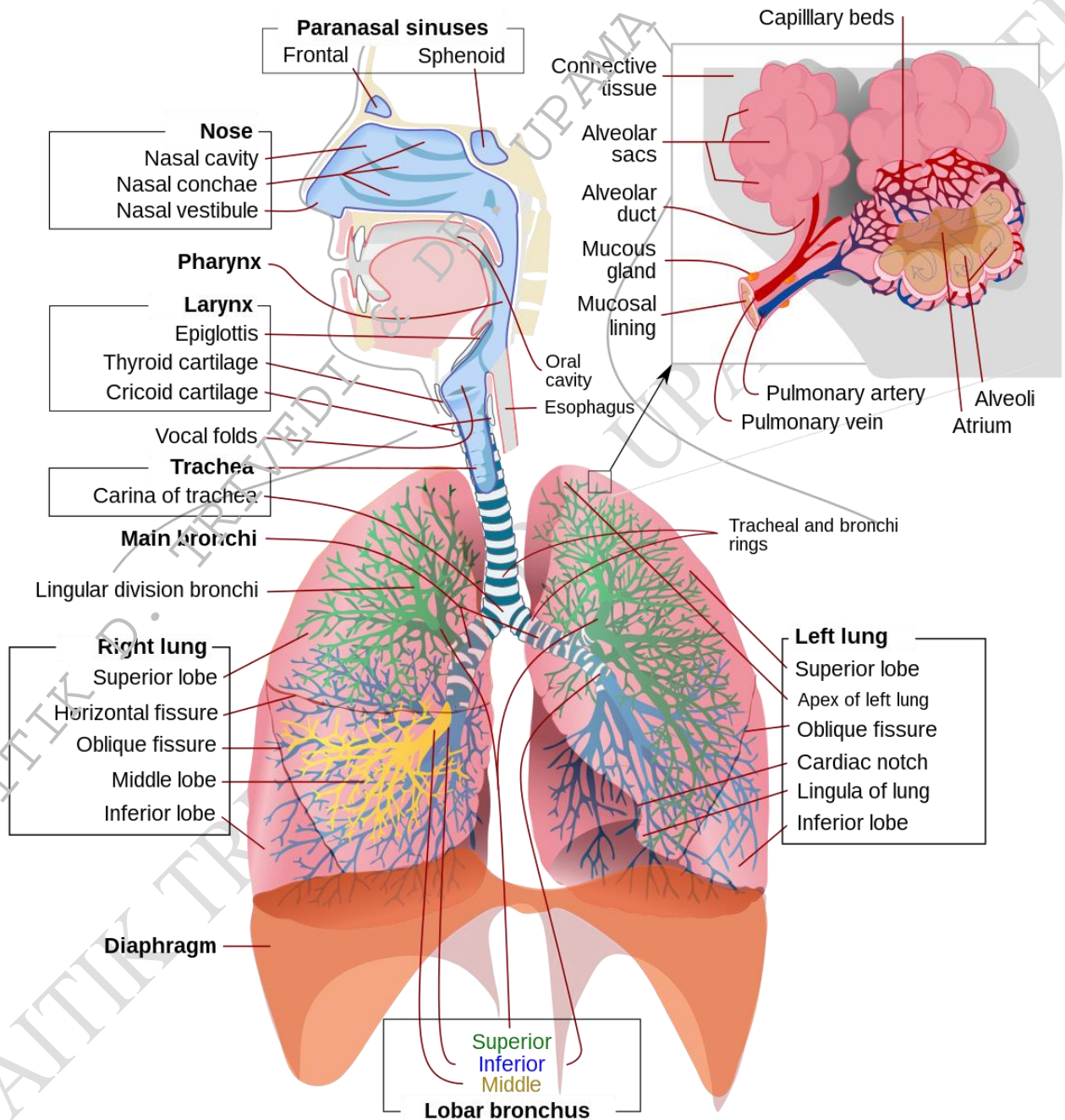


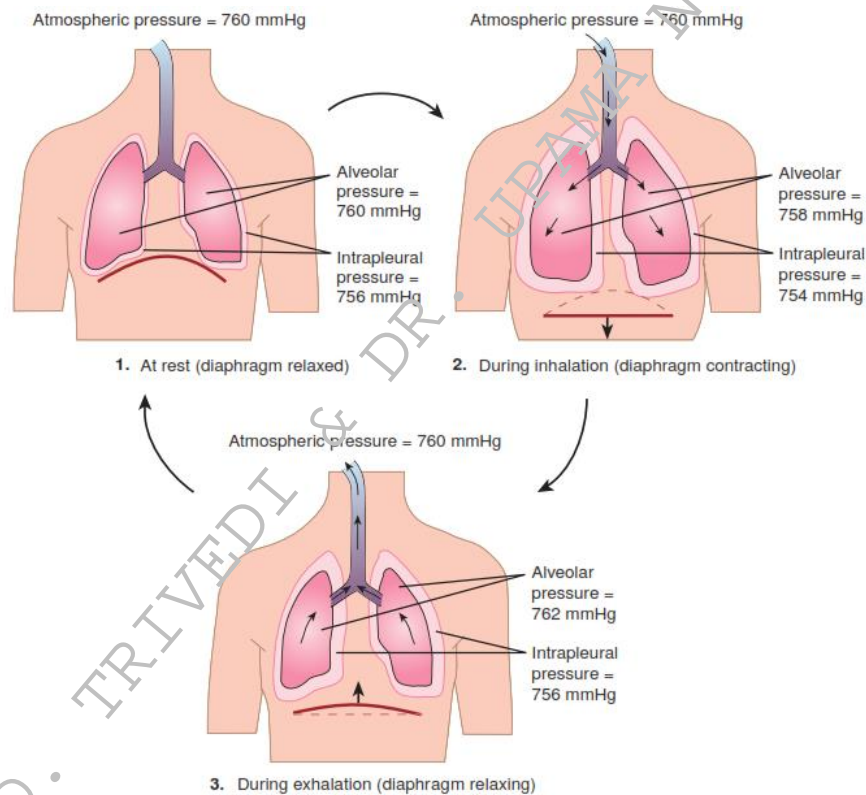
DIAGRAM OF RESPIRATORY SYTEM

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### SPIROMETER

According to Boyle's law pressure is inversely proportional to the volume.

During breathing our body follows Boyle's law.



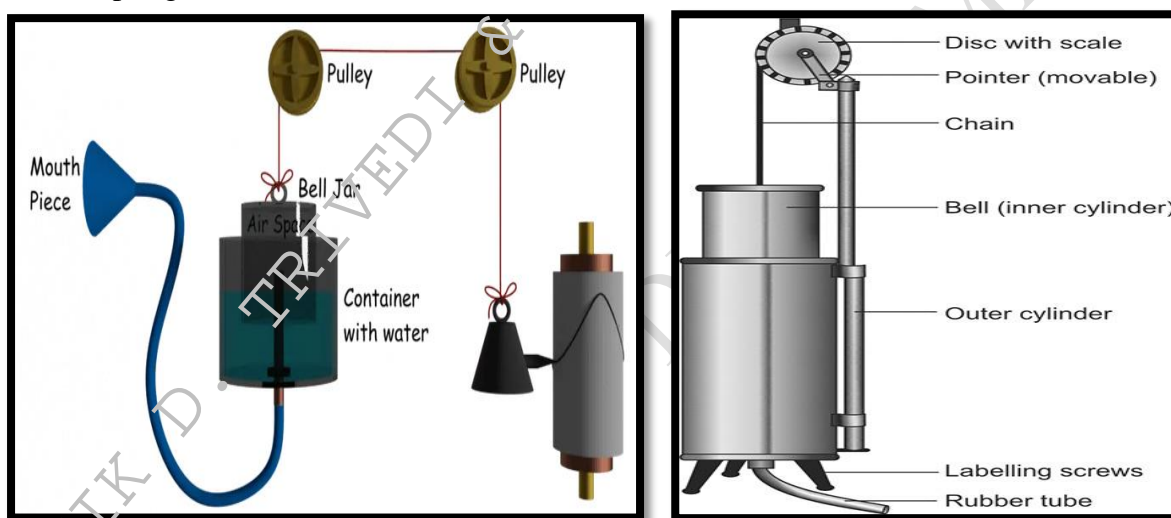
- ❖ Spirometer is a biomedical device which measures the lung capacity and lung volume.
- ❖ Pulmonary function tests (PFTs) are one of the main diagnostic tools employed by pulmonary physicians.
- ❖ They can be used for a variety of purposes including to help identify the etiology of dyspnea, to follow progression of pulmonary diseases and response to treatment and to evaluate fitness to undergo other procedures or treatments such as thoracic surgery or peripheral blood stem cell transplantation.
- ❖ Given this wide range of uses, it is critical that a pulmonary physician be able to read and interpret these tests.
- ❖ There are essentially four categories of information which can be obtained with routine pulmonary function testing:
  1. Lung volumes which can allow us to measure the maximum volume of the lungs as well as sub-compartments thereof.
  2. Flow rates which measure the maximal flow of gas out of (and sometimes into) the lung.
  3. Diffusing capacity which measures the transfer of gas from the alveolar space into the capillary blood stream.
  4. Maximal inspiratory and expiratory pressures which measure the applied strength of the respiratory muscles.

### Principle of Spirometer

- ❖ It is made of metal and consists of two chambers- outer chamber is filled with water and called the water chamber, and inner chamber is a floating drum immersed in water in an inverted manner.

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- ❖ The drum is counterbalanced by a weight attached to the top of floating drum by means of a chain or string.
- ❖ The inner chamber has a small hole at the top, and a long metal tube passes from bottom towards top through inner chamber and penetrates into the outer water chamber above the level of water.
- ❖ A rubber tube is connected to the outer metal tube and a mouth piece is attached to the other end of the rubber tube.
- ❖ The subject/participant respire through the mouth piece.
- ❖ During expiration the inner drum moves up by balancing weight comes down and during inspiration it is vice-versa.
- ❖ The upward and downward movements of the counter balancing weights are recorded in the form of ink pen attached to the weight indicating inspiration and expiration, respectively.
- ❖ The record of lung volumes and lung capacities can be recorded by a Spirometer as a Spirogram.


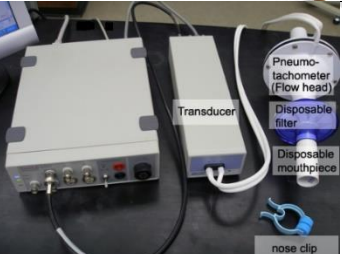





Traditional Water Tank Spirometer

### Types of spirometer

Sr. No	Types of spirometer	Figure
1.	<b>Basic Incentive Spirometer</b> <ul style="list-style-type: none"> <li>✓ An incentive spirometer is a handheld medical device used to help patients improve the functioning of their lungs.</li> <li>✓ By training patients to take slow and deep breaths, this simplified spirometer facilitates lung expansion and strengthening.</li> <li>✓ Patients inhale through a mouthpiece, which causes a piston inside the device to rise.</li> <li>✓ This visual feedback helps them monitor their inspiratory effort.</li> <li>✓ Incentive spirometers are commonly used after surgery or other illnesses to prevent pulmonary complications.</li> </ul>	<p><b>FLOW ORIENTED INCENTIVE SPIROMETER</b></p> <p><b>VOLUME ORIENTED SPIROMETER</b></p>

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<p><b>2.</b></p>	<p><b>Whole body plethysmograph</b></p> <ul style="list-style-type: none"> <li>✓ This type of spirometer gives a more accurate measurement for the components of lung volumes as compared to other conventional spirometers.</li> <li>✓ A person is enclosed in a small space when the measurement is taken.</li> </ul>	
<p><b>3.</b></p>	<p><b>Pneumotachometer</b></p> <ul style="list-style-type: none"> <li>✓ This spirometer measures the flow rate of gases by detecting pressure differences across the fine mesh.</li> <li>✓ One advantage of this spirometer is that the subject under investigation can breathe in fresh air during the experiment.</li> </ul>	
<p><b>4.</b></p>	<p><b>Fully electronic spirometer</b></p> <ul style="list-style-type: none"> <li>✓ Electronic spirometers have been developed that compute airflow rates in a channel without the need for fine meshes or moving parts.</li> <li>✓ They operate by measuring the speed of the airflow with techniques such as ultrasonic transducers, or by measuring pressure difference in the channel.</li> <li>✓ These spirometers have greater accuracy.</li> </ul>	
<p><b>5.</b></p>	<p><b>Peak flow meter</b></p> <ul style="list-style-type: none"> <li>✓ The peak expiratory flow (PEF), also called peak expiratory flow rate (PEFR), is a person's maximum speed of expiration, as measured with a peak flow meter, a small, hand-held device used to monitor a person's ability to breathe out air.</li> <li>✓ It measures the airflow through the bronchi and thus the degree of obstruction in the airways.</li> <li>✓ Peak expiratory flow is typically measured in units of liters per minute (L/min).</li> </ul>	
<p><b>6.</b></p>	<p><b>Windmill-type spirometer</b></p> <ul style="list-style-type: none"> <li>✓ Used specially for measuring forced vital capacity without using water and has broad measurements ranging from 1000 ml to 7000 ml.</li> <li>✓ It is more portable and lighter as compared to traditional water-tank type spirometer.</li> <li>✓ This spirometer should be held horizontally while taking measurements because of the presence of rotating disc.</li> </ul>	



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### Calculation steps for Total Lung volume/Minute Volume:

#### 1. Tidal volume (VT)

- ❖ Healthy adult doing 12 breaths in each minute and with each inhalation and exhalation moving about 500 mL of air into and out of the lungs. The volume of one breath is called the tidal volume (VT).

#### 2. Minute Ventilation (MV )

- ❖ We are doing 12 breaths in each minute so the minute ventilation (MV ) is the the total volume of air inhaled and exhaled in each minute.

$$\begin{aligned}\text{Minute Ventilation (MV )} &= \text{Tidal volume (VT)} \times 12 \\ &= 500 \text{ mL/ breath} \times 12 \text{ breaths/min} = 6 \text{ litres/min}\end{aligned}$$

- ❖ In a typical adult, about 70% of the tidal volume (350 mL) actually reaches the respiratory zone of the respiratory system namely the respiratory bronchioles, alveolar ducts, alveolar sacs, and alveoli and participates in external respiration.
- ❖ The other 30% (150 mL) remains in the conducting airways of the nose, pharynx, larynx, trachea, bronchi, bronchioles, and terminal bronchioles known as dead space because these part does not undergo respiratory exchange of gases.
- ❖ Not all of the minute ventilation can be used in gas exchange because some of it remains in the anatomic dead space.

#### 3. Alveolar Ventilation Rate

- ❖ The **alveolar ventilation rate** is the volume of air per minute that actually reaches the respiratory zone.
- ❖ In the example just given, alveolar ventilation rate would be -----  
 $350 \text{ mL/breath} \times 12 \text{ breaths/min} = 4200 \text{ mL/min}.$

#### 4. Inspiratory Reserve Volume

- ❖ When we do very deep breath, we can inhale more than 500 mL of air. This additional inhaled air, called the inspiratory reserve volume which is about 3100 mL in an average adult male and 1900 mL in an average adult female

#### 5. Expiratory Reserve Volume or Force Expiratory Volume

- ❖ If inhalation follows forced exhalation we can more air in addition to the 500 mL of tidal volume which is 1200 mL in males and 700 mL in females is called the **expiratory reserve volume or force expiratory volume**.

#### 6. Residual Volume

- ❖ When we do force expiration not all amount of air go out some amount remain in anatomical dead space that is 1200 mL in male and 1100 mL in female which is known as **residual volume**.

#### 7. Inspiratory capacity

- ❖ **Inspiratory capacity** is the sum of tidal volume and inspiratory reserve volume ( $500 \text{ mL} + 3100 \text{ mL} = 3600 \text{ mL}$  in males and  $500 \text{ mL} + 1900 \text{ mL} = 2400 \text{ mL}$  in females).



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### 8. Functional residual capacity

- ❖ Functional **residual capacity** is the sum of residual volume and expiratory reserve volume (1200 mL + 1200 mL = 2400 mL in males and 1100 mL + 700 mL = 1800 mL in females).

### 9. Vital capacity

- ❖ **Vital capacity** is the sum of inspiratory reserve volume, tidal volume, and expiratory reserve volume (4800 mL in males and 3100 mL in females).

### 10. Total lung capacity

- ❖ Finally, **total lung capacity** is the sum of vital capacity and residual volume (4800 mL + 1200 mL = 6000 mL in males and 3100 mL + 1100 mL = 4200 mL in females).

