

The Respiratory System

(Anatomy & Histology)

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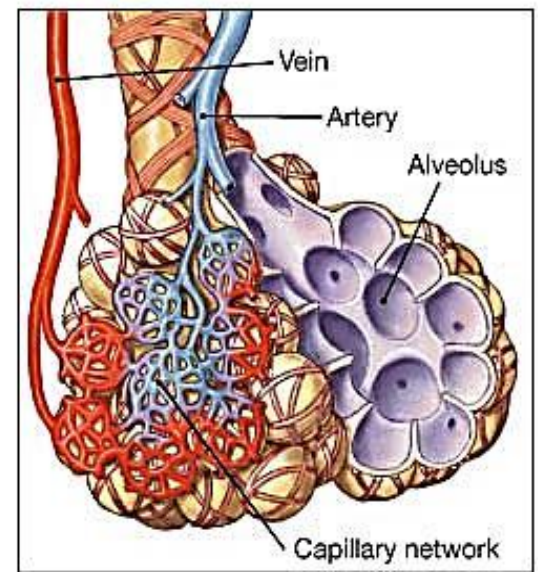
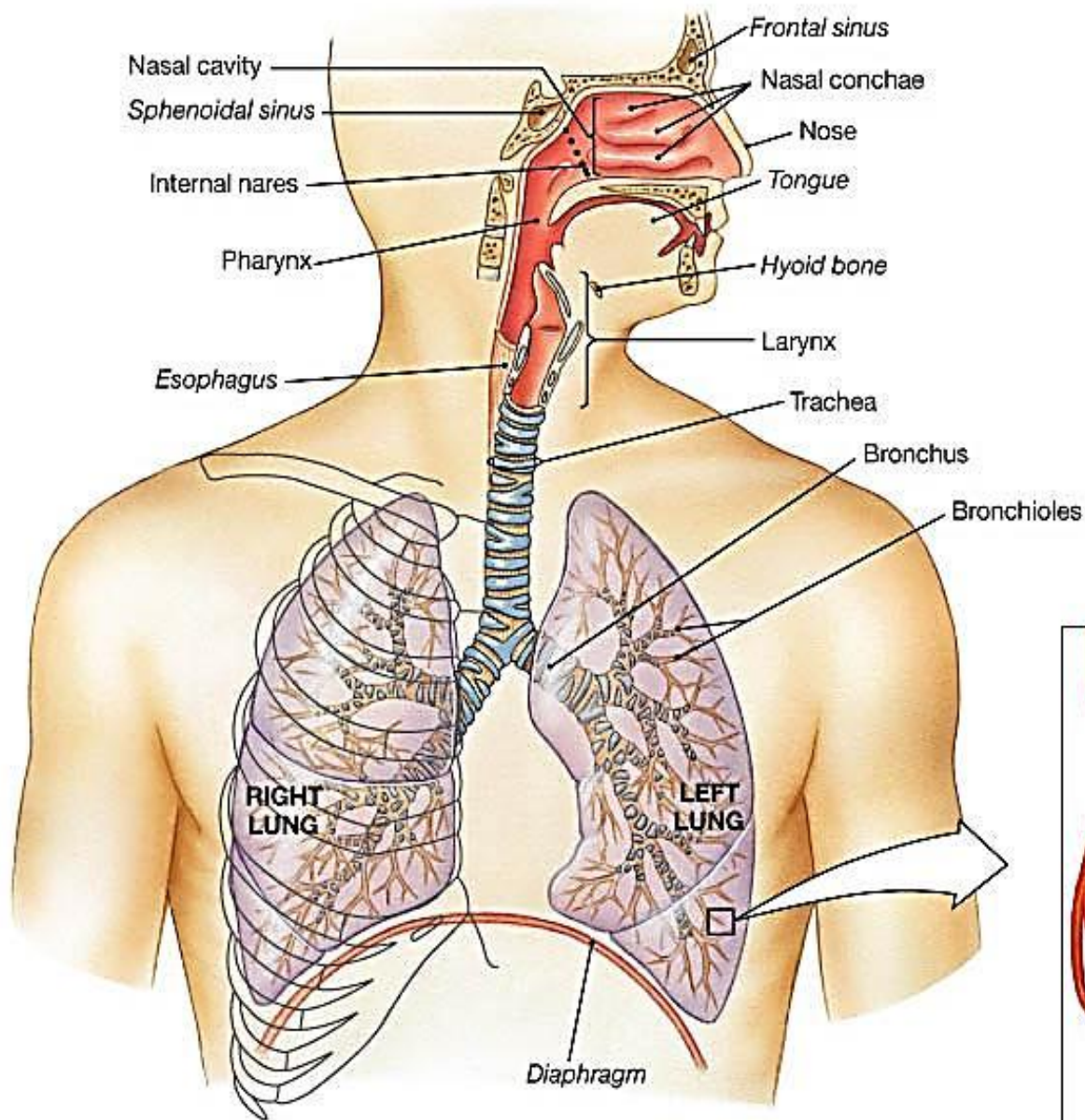


Introduction

- The Respiratory System is mainly concerned with gaseous exchange which occurs in the lungs at the blood-air barrier between the blood contained in the capillaries and the inspired air in the lungs.
- Parts of the system are also concerned with the sense of smell, sense of taste, phonation (production of sound) and with excretion of water through exhaled air.

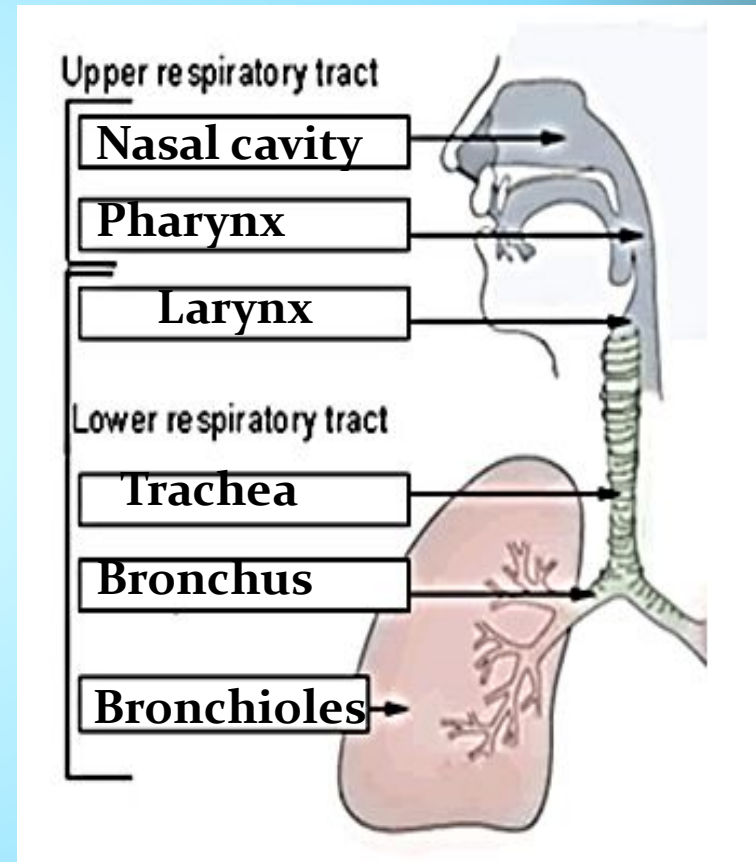
Objectives:

- Description of the main functional units of the respiratory system and its division into upper and lower respiratory tracts.
- Description of the component parts of the upper & lower respiratory tracts and their general functions.
- Description of the structure of each part of the respiratory tract.



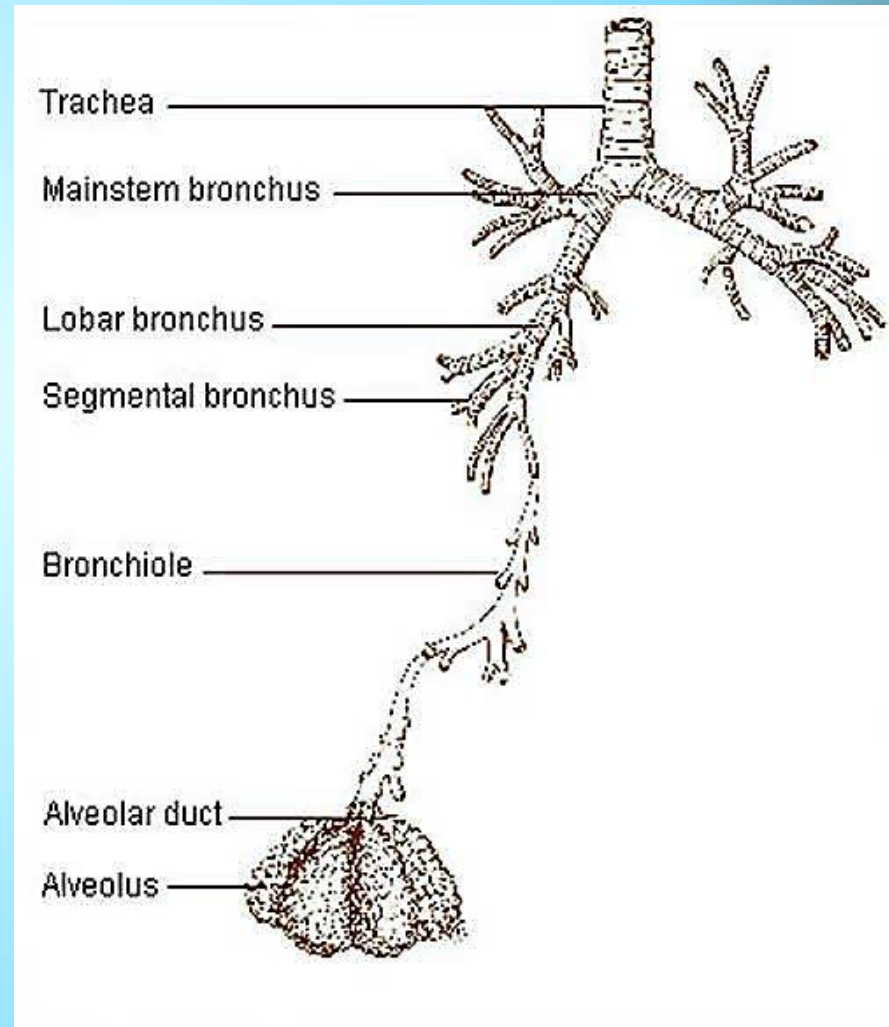
Organization of the Respiratory System

- The upper respiratory tract consists of:
(Nose and nasal cavity, Pharynx and Larynx)
- The lower respiratory tract consists of:
(Trachea, Bronchi, and Bronchioles)

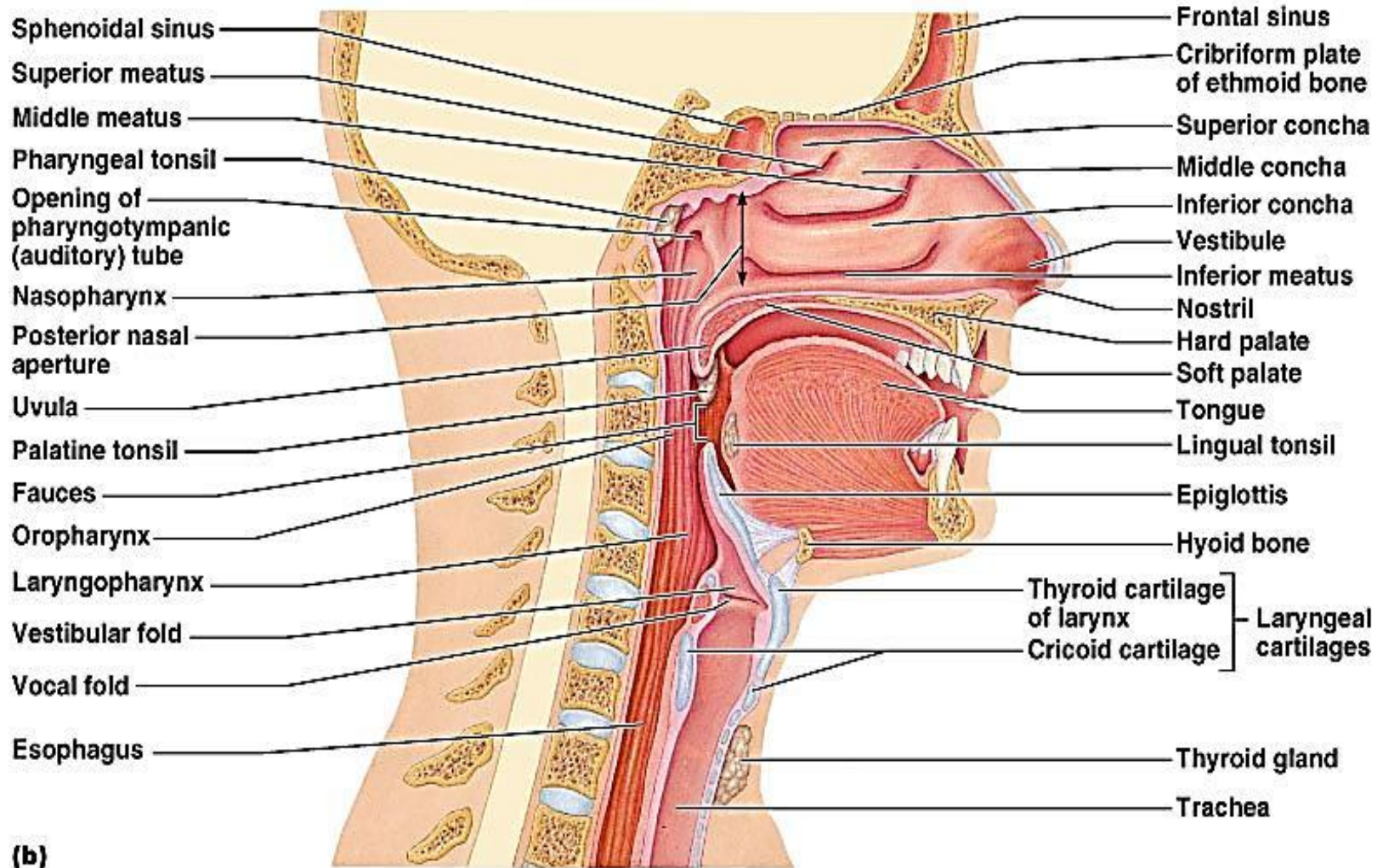


Function of the Respiratory System

- **Conducting portion** transports air.
 - includes the nose, nasal cavity, pharynx, larynx, trachea, and progressively smaller airways, from the primary bronchi to the terminal bronchioles .
- **Respiratory portion** carries out gas exchange.
 - composed of small airways called respiratory bronchioles and alveolar ducts as well as air sacs called alveoli .

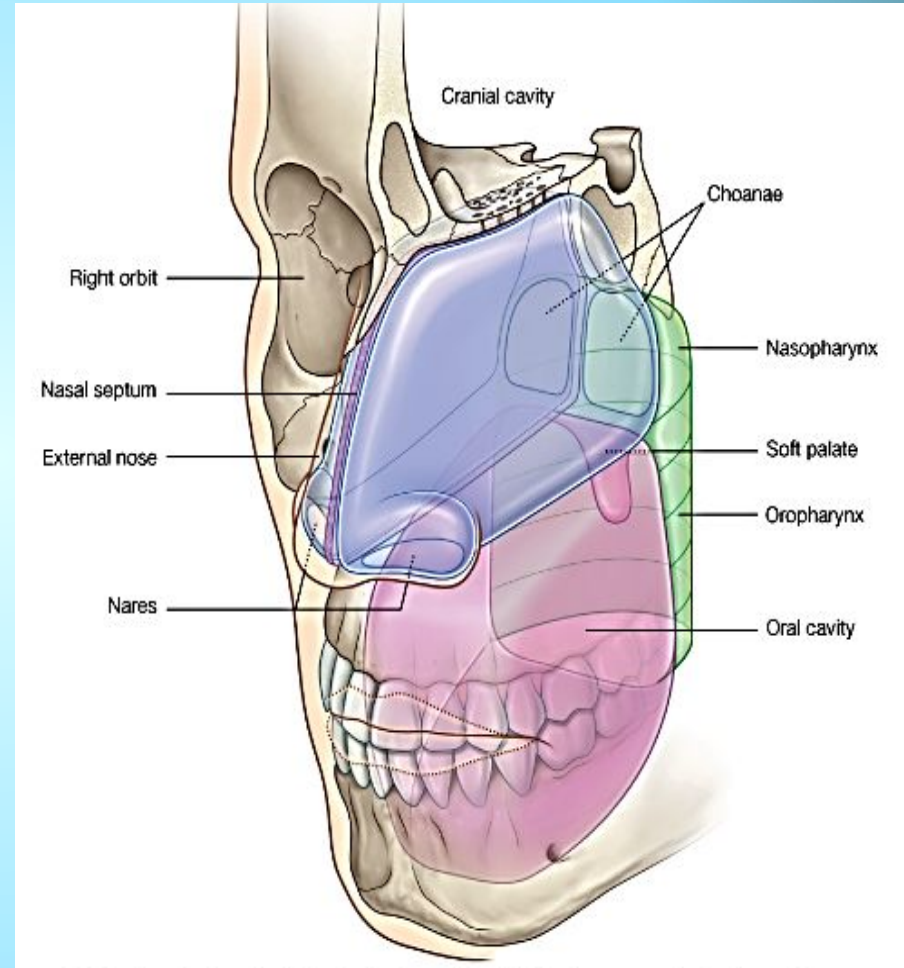


Upper Respiratory Tract



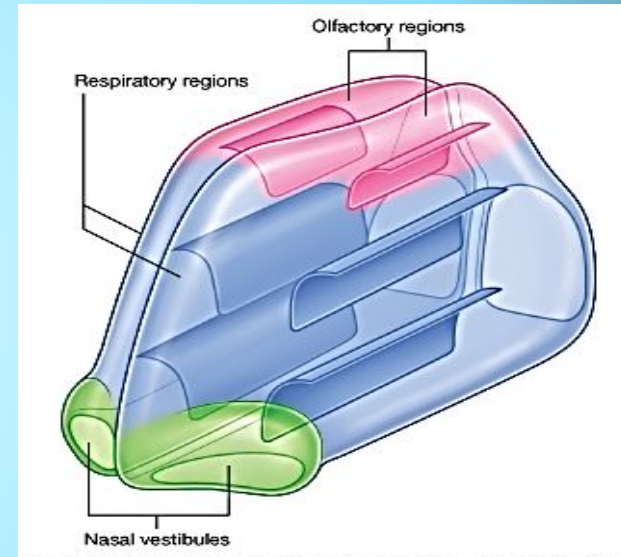
Nose

- It consists of external nose and nasal cavity.
- The external nose extends the nasal cavities onto the front of the face and positions the nares so that they point downwards .
- Bony part consists of nasal bones and parts of maxillae and frontal bones.
- Cartilaginous part consists of Septal and Alar cartilages



Nasal Cavity

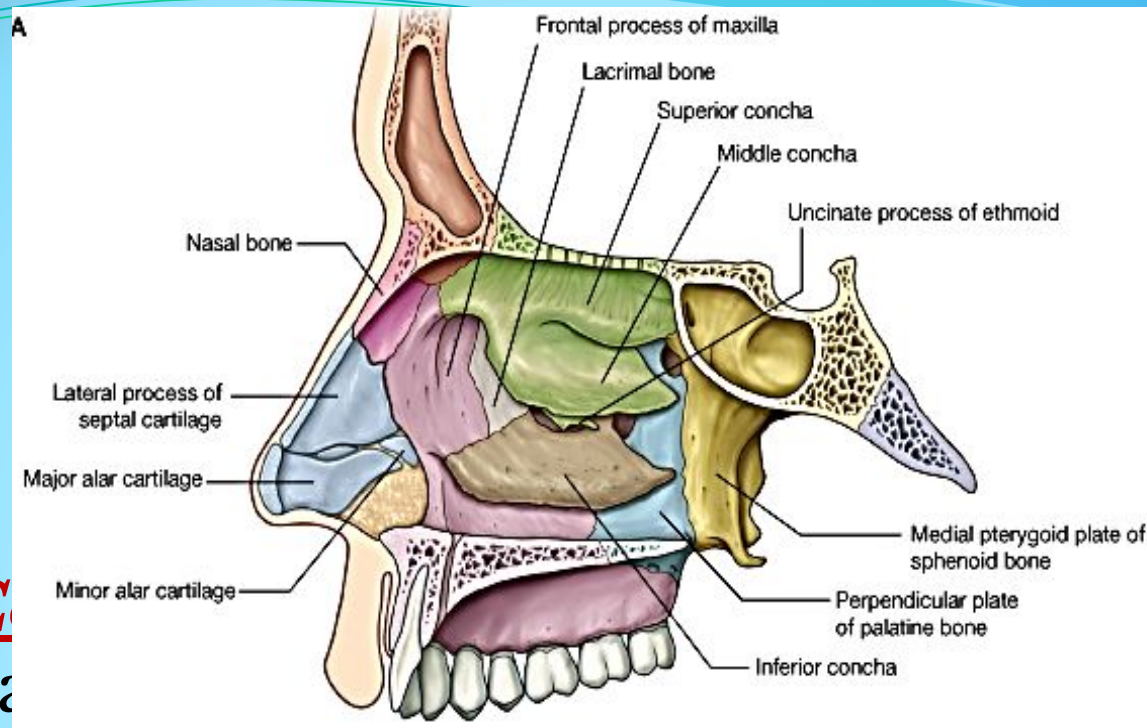
- Four walled pyramidal space.
- Each nasal cavity consists of three general regions-the nasal vestibule, the respiratory region, and the olfactory region.
- **Nasal vestibule** is a small dilated space just internal to the naris that is lined by skin and contains hair follicles.
- **Respiratory region** is the largest part of the nasal cavity, has a rich neurovascular supply, and is lined by respiratory epithelium composed mainly of ciliated and mucous cells.
- **Olfactory region** is small, is at the apex of each nasal cavity, is lined by olfactory epithelium, and contains the olfactory receptors.



Nasal Cavity

membrane

ensures that most air contacts the mucous membranes. The inferior, middle, and superior conchae extend medially across the nasal cavity, separating it into four air channels, an inferior, middle, and superior meatus, and a spheno-ethmoidal recess.

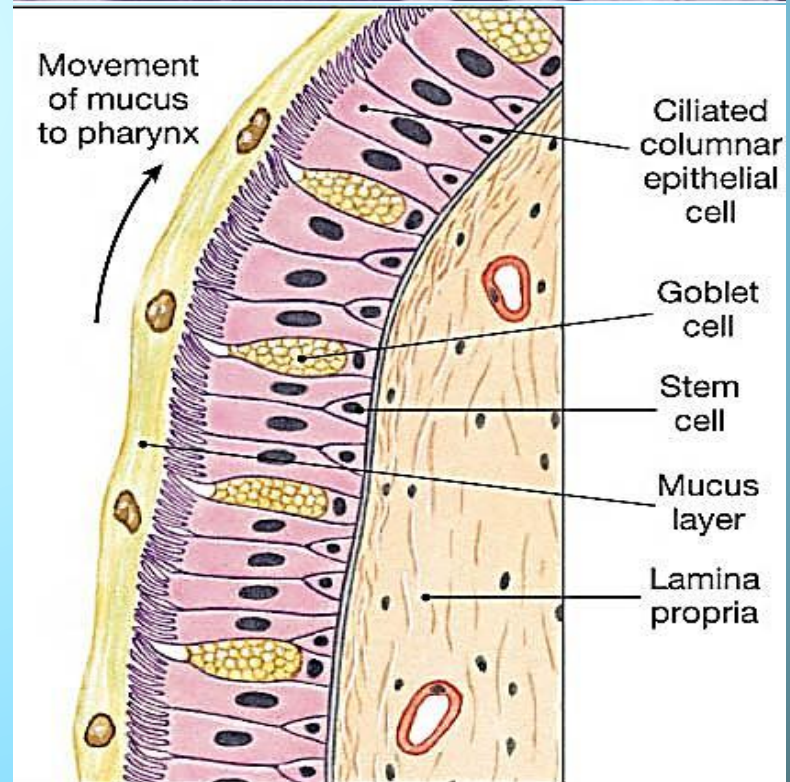
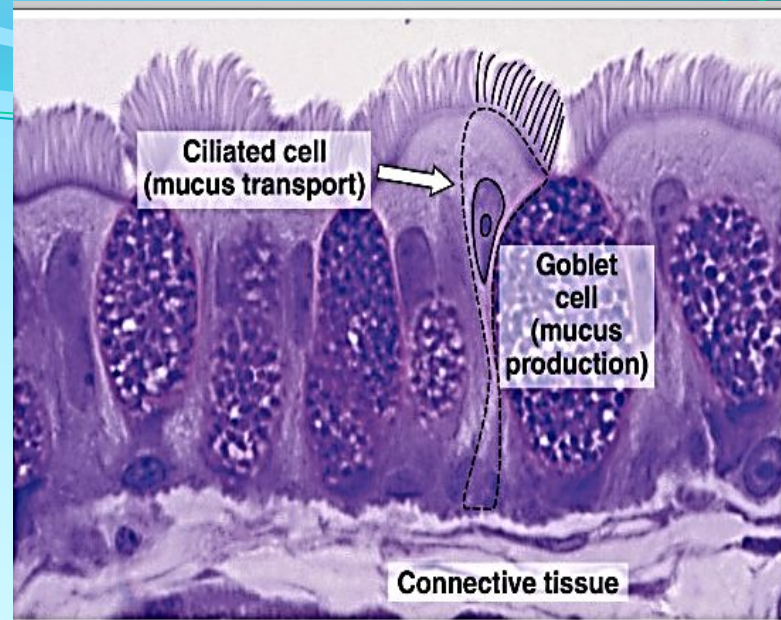


Respiratory mucosa

Most of the conducting portion is lined with ciliated pseudostratified columnar epithelium that contains a rich population of goblet cells and is known as **respiratory epithelium**.

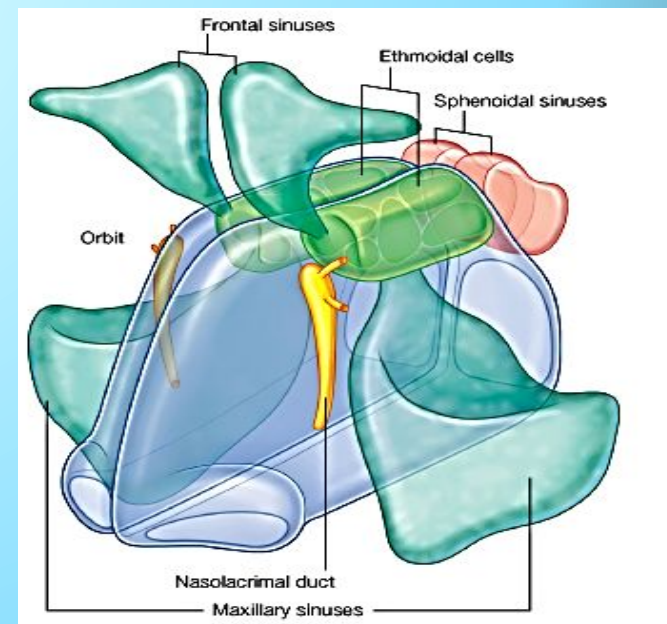
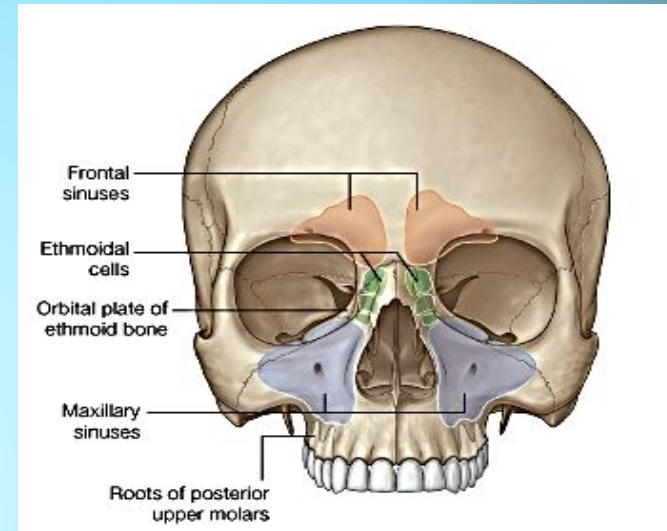
Mucus can trap contaminants.

Cilia move mucus up towards mouth.



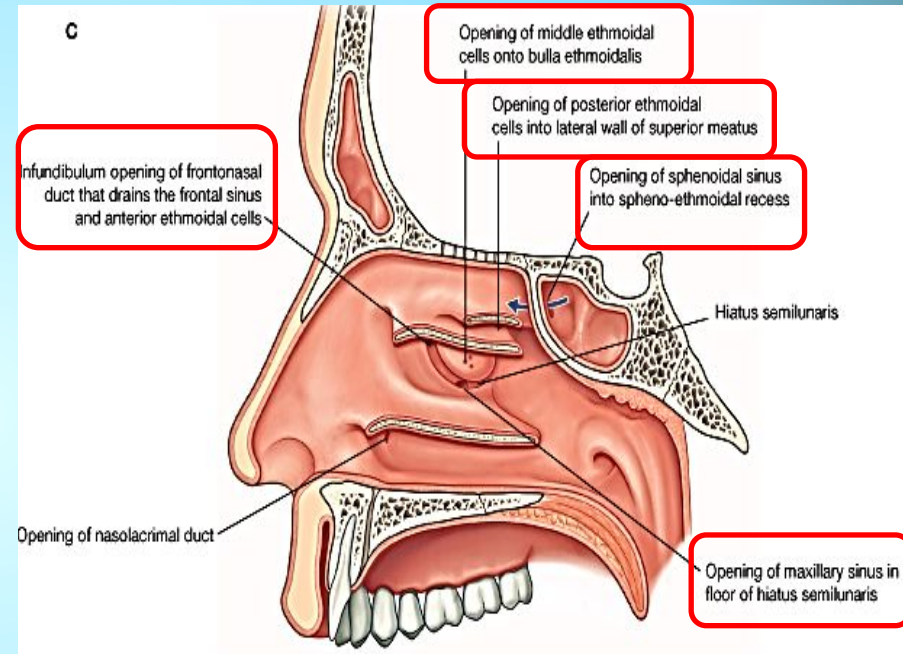
Paranasal Sinuses

- They are closed cavities in the frontal, maxillary, ethmoid, and sphenoid bones.
- They are lined with a thinner respiratory epithelium that contains few goblet cells.
- They communicate with the nasal cavity through small openings. The mucus produced in these cavities drains into the nasal passages as a result of the activity of its ciliated epithelial cells.



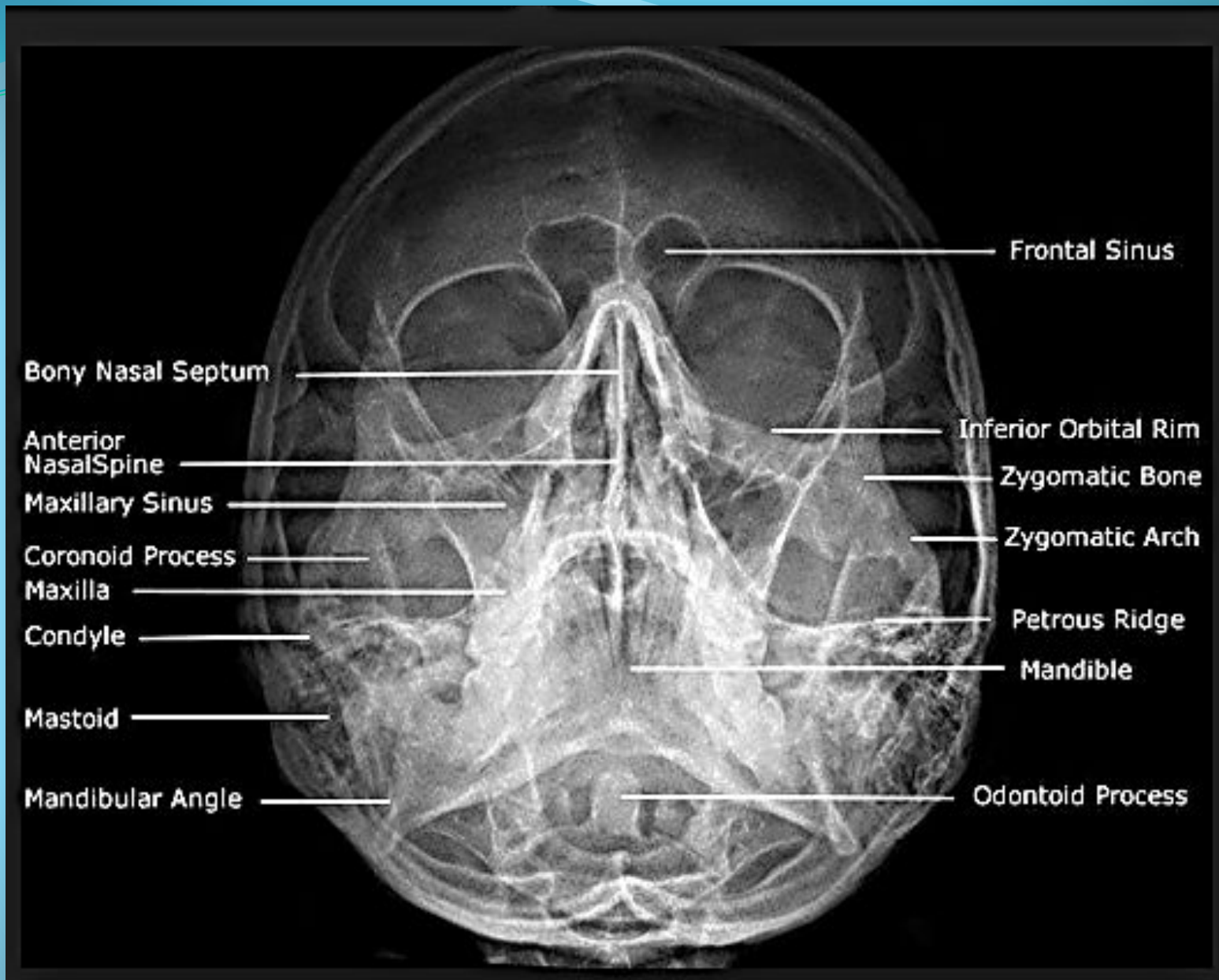
Communication with nasal cavity

- The frontal sinus drains through frontonasal duct to the semilunar hiatus of the middle nasal meatus.
- The sphenoidal sinus drains into the sphenoidal recess.
- The anterior and middle ethmoidal sinuses drain directly into the middle meatus, while the posterior one drains to superior meatus.
- The maxillary sinus drains into the middle nasal meatus.



Functions of the Paranasal sinuses

1. Decrease skull bone weight.
2. Warm, moisten and filter incoming air.
3. Add resonance to voice.
4. Regulation of intranasal pressure.
5. Increasing surface area for olfaction.
6. Absorbing shock.



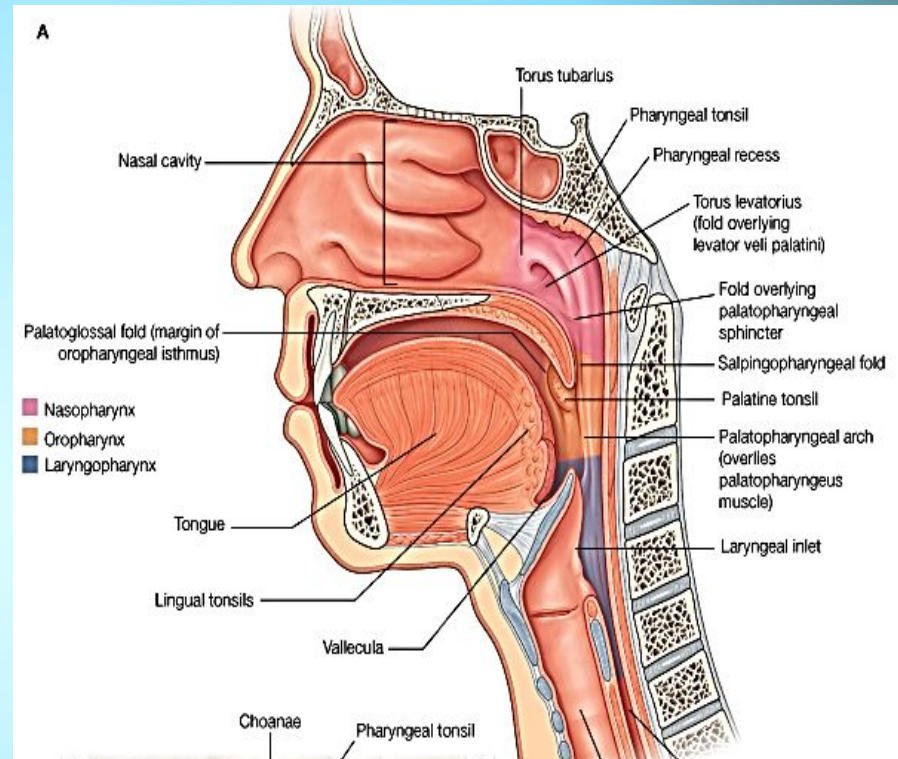
Paranasal sinuses X-Ray

Pharynx

The pharynx is a musculo-fascial half cylinder that links the oral and nasal cavities in the head to the larynx and esophagus in the neck. The pharyngeal cavity is a common pathway for air and 'food'.

It is divided into three parts:

1. Nasopharynx
2. Oropharynx
3. Laryngopharynx

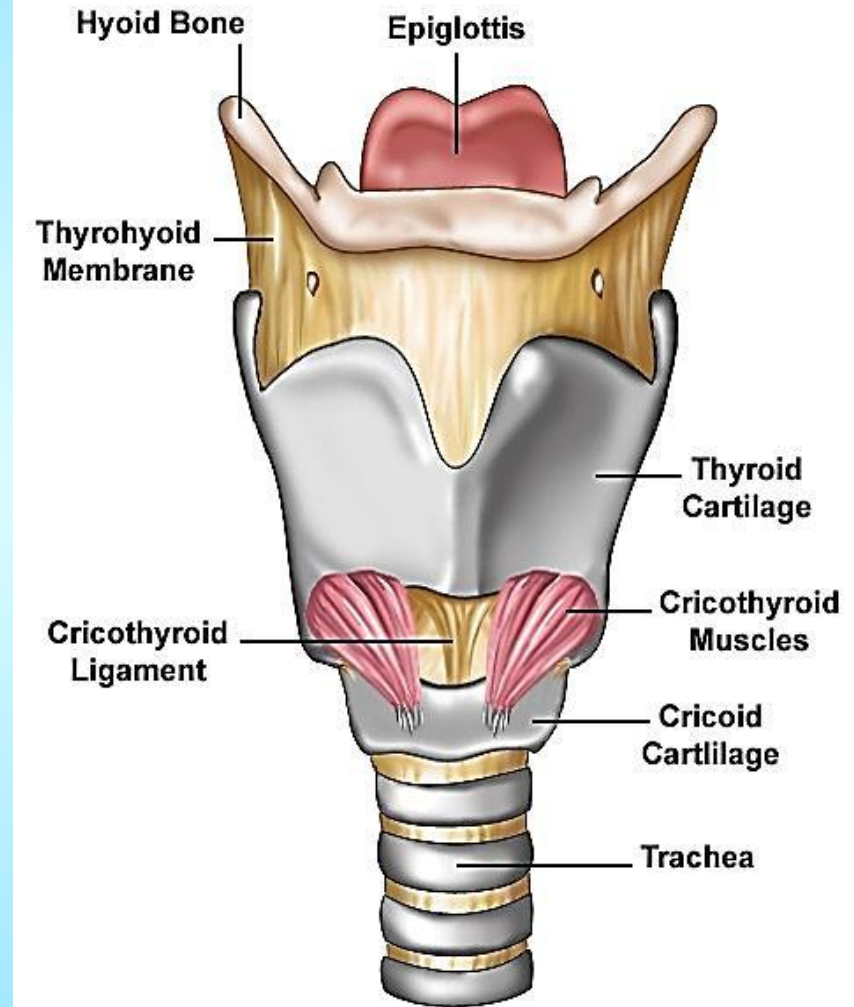


Pharyngeal mucosa

- Superior-most region of the nasopharynx is covered with **pseudostratified ciliated columnar epithelium**.
- Posterior nasopharynx wall also houses a single pharyngeal tonsil (commonly called the **adenoids**).
- The oropharynx contains **non-keratinized stratified squamous epithelium**.
- **Palatine tonsils** are on the lateral wall between the arches, and the **lingual tonsils** are at the base of the tongue.
- **Laryngopharynx** lined with a **nonkeratinized stratified squamous epithelium**.

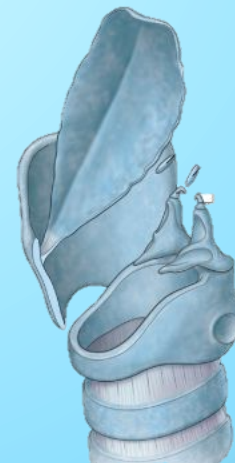
Larynx

- It is a cylindrical musculo-ligamentous structure with a cartilaginous framework that caps the lower respiratory tract.
- The larynx is both a valve (or sphincter) to close the lower respiratory tract, and a voice box.
- 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.



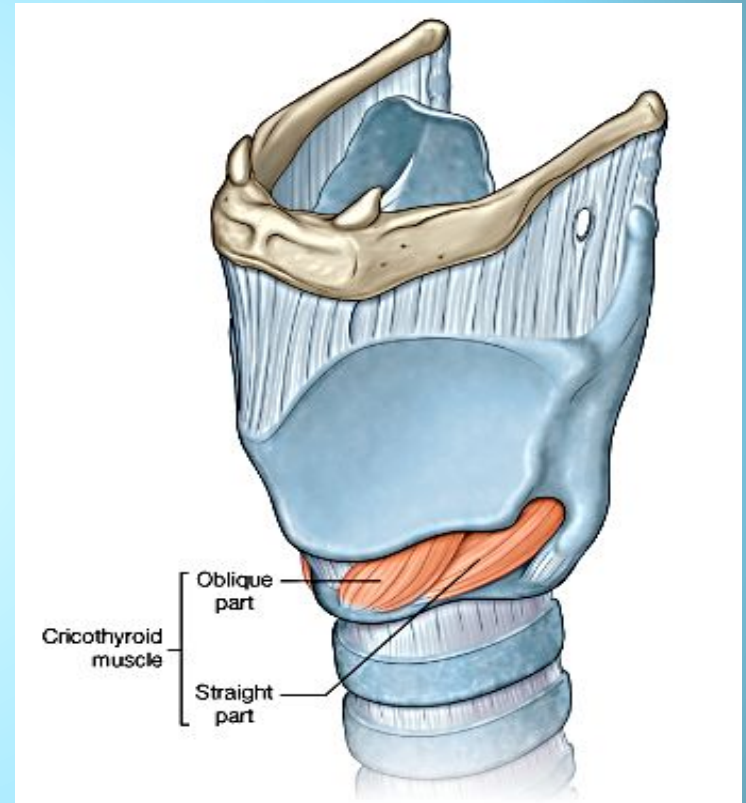
Laryngeal Cartilages

- Nine C-rings of cartilage form the framework of the larynx
- **Thyroid cartilage** – (1) Adam’s apple, hyaline, anterior attachment of vocal folds.
- **Epiglottis** – (1) elastic cartilage.
- **Cricoid cartilage** – (1) ring-shaped, hyaline.
- **Arytenoid cartilages** – (2) hyaline, posterior attachment of vocal folds.
- **Cuneiform cartilages** - (2) hyaline.
- **Corniculate cartilages** - (2) hyaline.



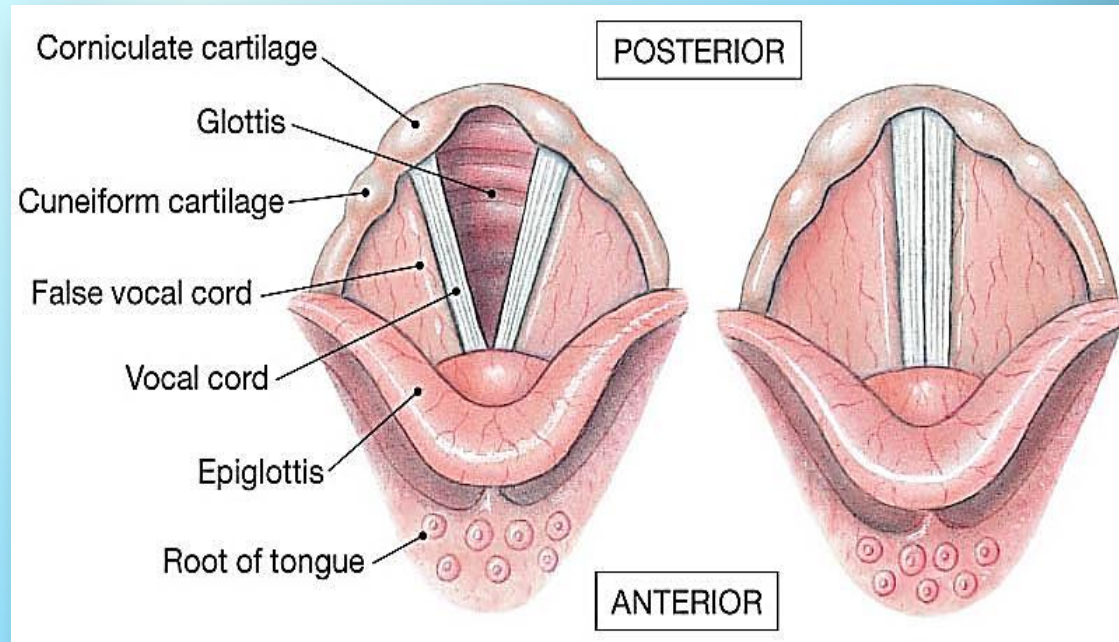
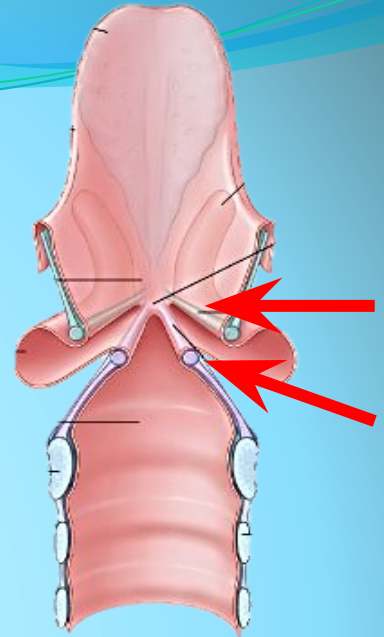
Larynx

- Muscular walls aid in voice production and the swallowing reflex.
- **Glottis** – the superior opening of the larynx.
- **Epiglottis** – prevents food and drink from entering airway when swallowing.
- The lining epithelium is pseudostratified ciliated columnar epithelium.



Sound Production

- The cavity of larynx has two folds (ligaments):
 - a. Upper Vestibular folds are false vocal folds because they have no role in voice production but protect the lower folds.
 - b. Lower True vocal folds produce voice when air passes between them.
- The tension, length, and position of the vocal folds determine the quality of the sound.



Sound Production

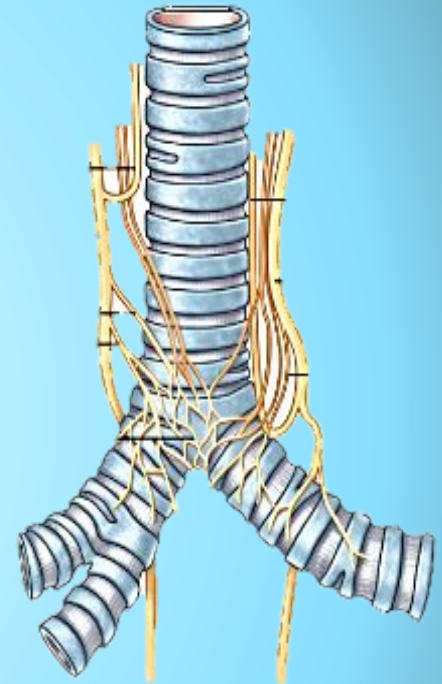
- Intermittent release of exhaled air through the vocal folds
- Loudness – depends on the force with which air is exhaled through the cords
- Pharynx, oral cavity, nasal cavity, paranasal sinuses act as **resonating chambers** that add quality to the sound
- Muscles of the face, tongue, and lips help with **expression of words.**

Conducting zone of lower respiratory tract



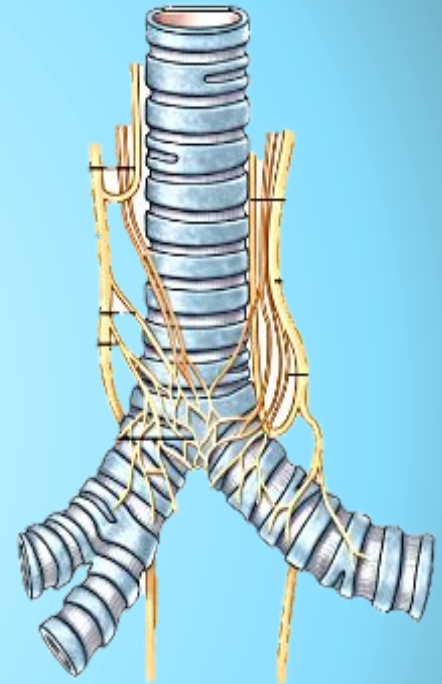
Trachea

- A flexible tube also called **windpipe**.
- Extends through the mediastinum and lies anterior to the esophagus and inferior to the larynx.
- Anterior and lateral walls of the trachea supported by 15 to 20 C-shaped **tracheal cartilages**.
- Cartilage rings reinforce and provide rigidity to the tracheal wall to ensure that the trachea remains open at all times
- Posterior part of tube lined by **trachealis** muscle
- Lined by **ciliated pseudostratified columnar epithelium**.



Trachea

- 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.
- The most inferior tracheal cartilage separates the primary bronchi at their origin and forms an internal ridge called the **carina**.



Bronchial Tree

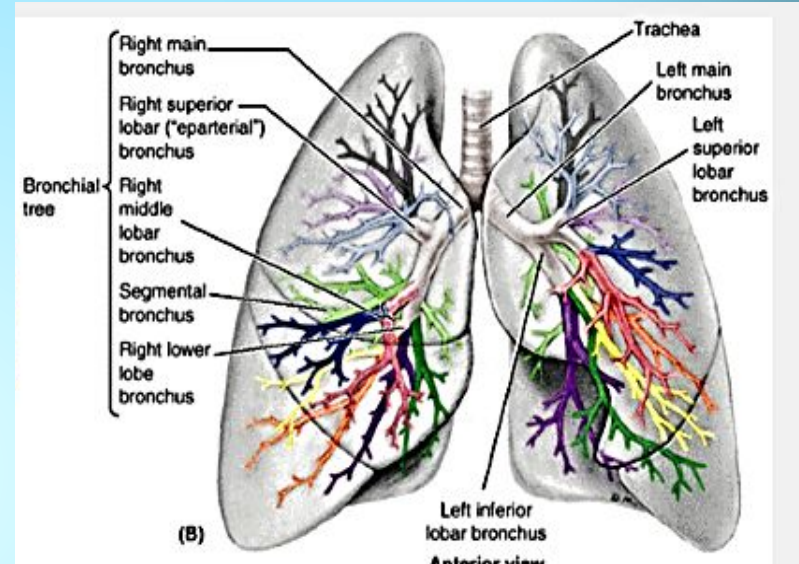
- A highly branched system of air-conducting passages that originate from the left and right primary bronchi.

- Progressively branch into narrower tubes as they diverge throughout the lungs before terminating in **terminal bronchioles**.

- **Incomplete rings of hyaline cartilage** support the walls of the primary bronchi to ensure that they remain open.

- Right primary bronchus is shorter, wider, and more vertically oriented than the left primary bronchus.

- Foreign particles are more likely to lodge in the right primary bronchus.



Bronchial Tree

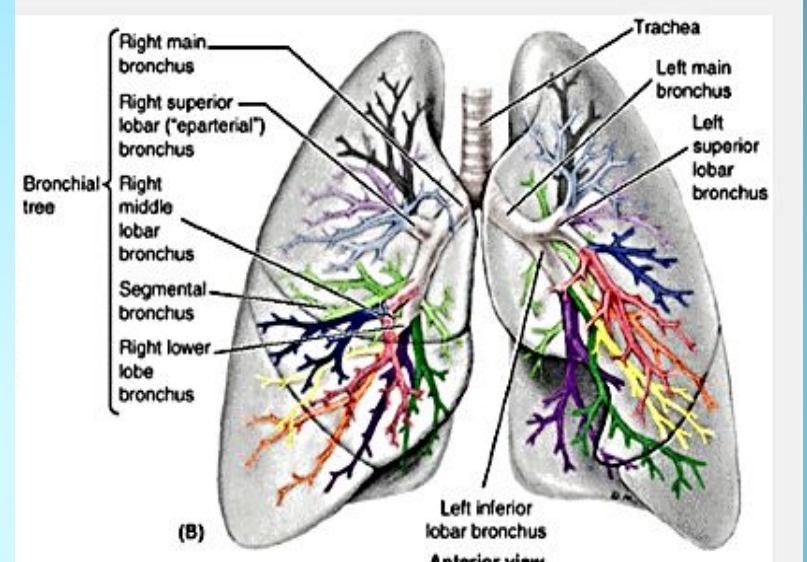
- The primary bronchi enter the **hilus** of each lung together with the pulmonary vessels, lymphatic vessels, and nerves.

- Each primary bronchus branches into several **secondary bronchi** (or lobar bronchi).

- The left lung has two secondary bronchi. The right lung has three secondary bronchi.

- They further divide into **tertiary bronchi**.

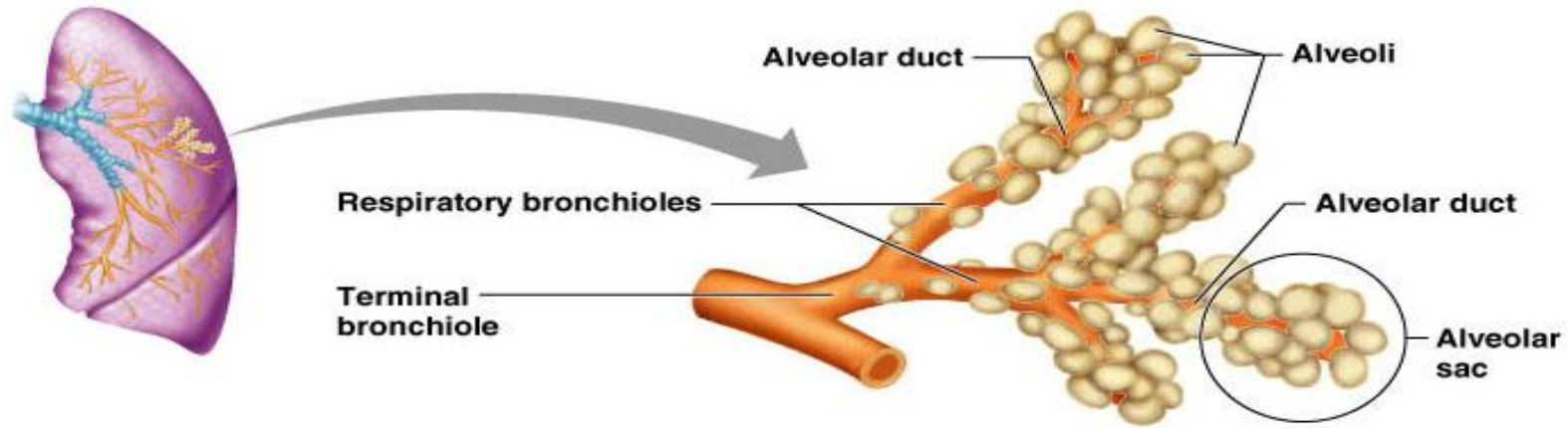
- Each tertiary bronchus is called a segmental bronchus because it supplies a part of the lung called a **bronchopulmonary segment**.



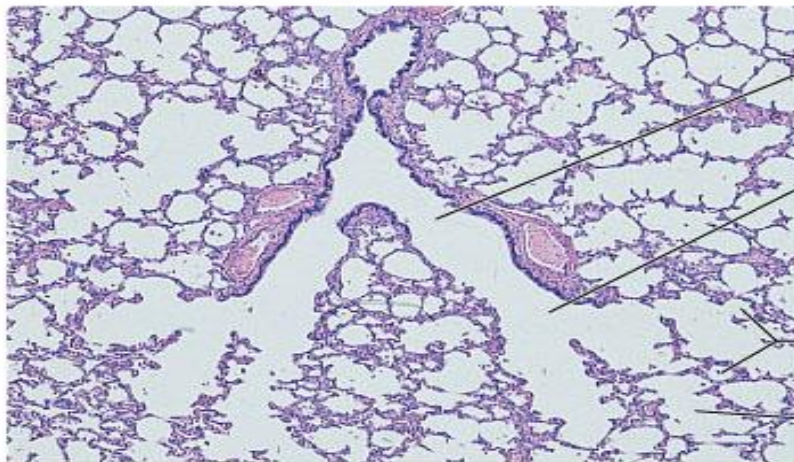
Bronchial Tree

- **Secondary bronchi** □ **Tertiary bronchi** □ **Bronchioles** □ **Terminal bronchioles.**
- With successive branching amount of cartilage decreases and amount of smooth muscle increases, this allows for variation in airway diameter.
- During exertion and when sympathetic division active □ **bronchodilation.**
- Mediators of allergic reactions like histamine □ **bronchoconstriction.**
- Epithelium gradually changes from **ciliated pseudostratified columnar epithelium** to **simple cuboidal epithelium** in terminal bronchioles.

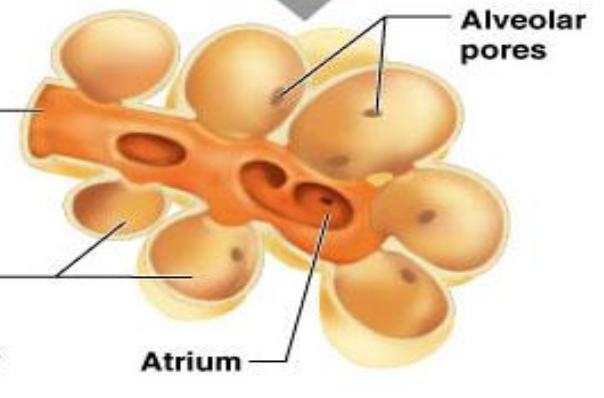
Respiratory Zone of Lower Respiratory Tract



(a)



(b)

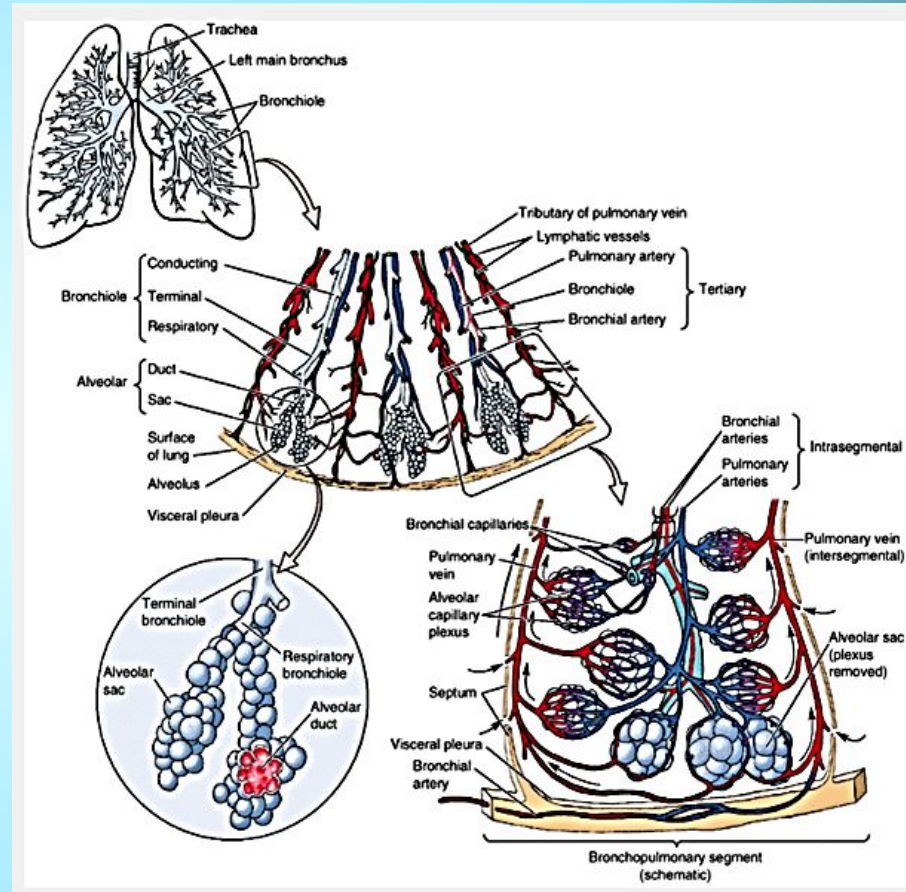


Conduction vs. Respiratory zones

- Most of the tubing in the lungs makes up **conduction zone**.
 - Consists of nasal cavity to terminal bronchioles
- The **respiratory zone** is where gas is exchanged
 - Consists of alveoli, alveolar sacs, alveolar ducts and respiratory bronchioles

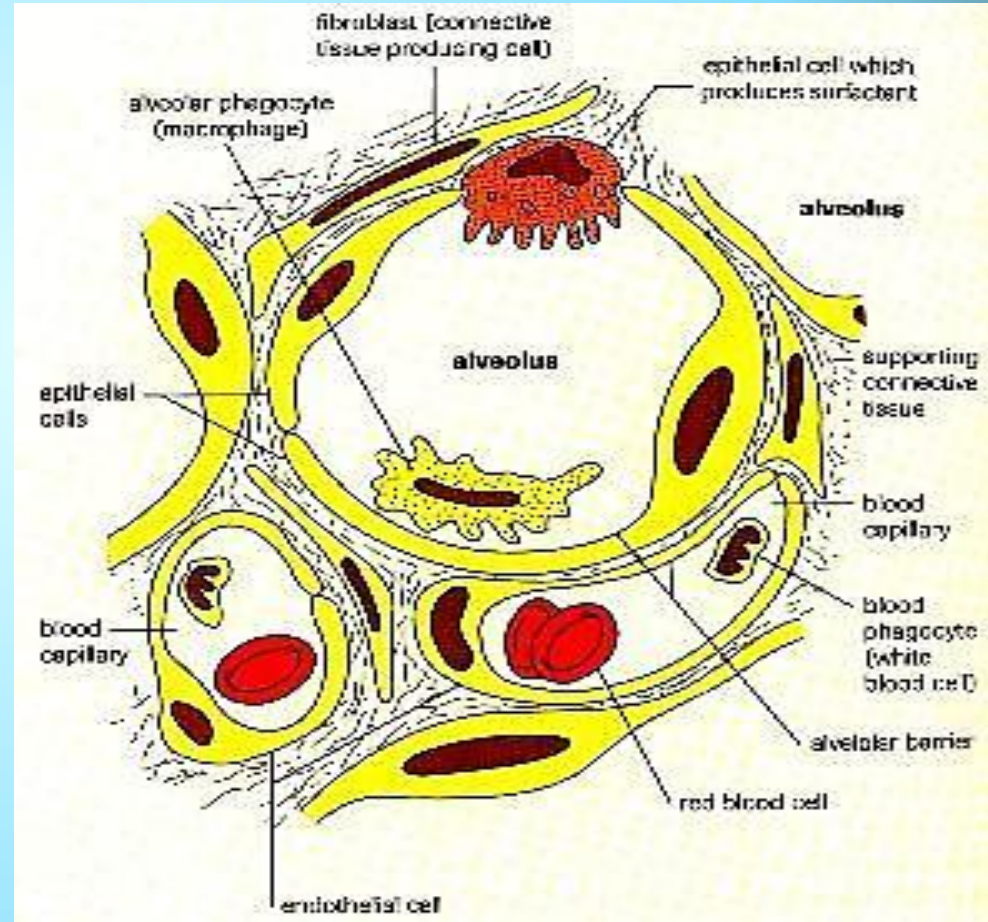
Respiratory Bronchioles, Alveolar Ducts, and Alveoli

- Lungs contain small saccular outpocketings called **alveoli**.
- They have a thin wall specialized to promote diffusion of gases between the alveolus and the blood in the pulmonary capillaries.
- Gas exchange can take place in the **respiratory bronchioles and alveolar ducts** as well as in the **alveoli**, each lung contains approximately 300 to 400 million alveoli.
- The spongy nature of the lung is due to the packing of millions of alveoli together.



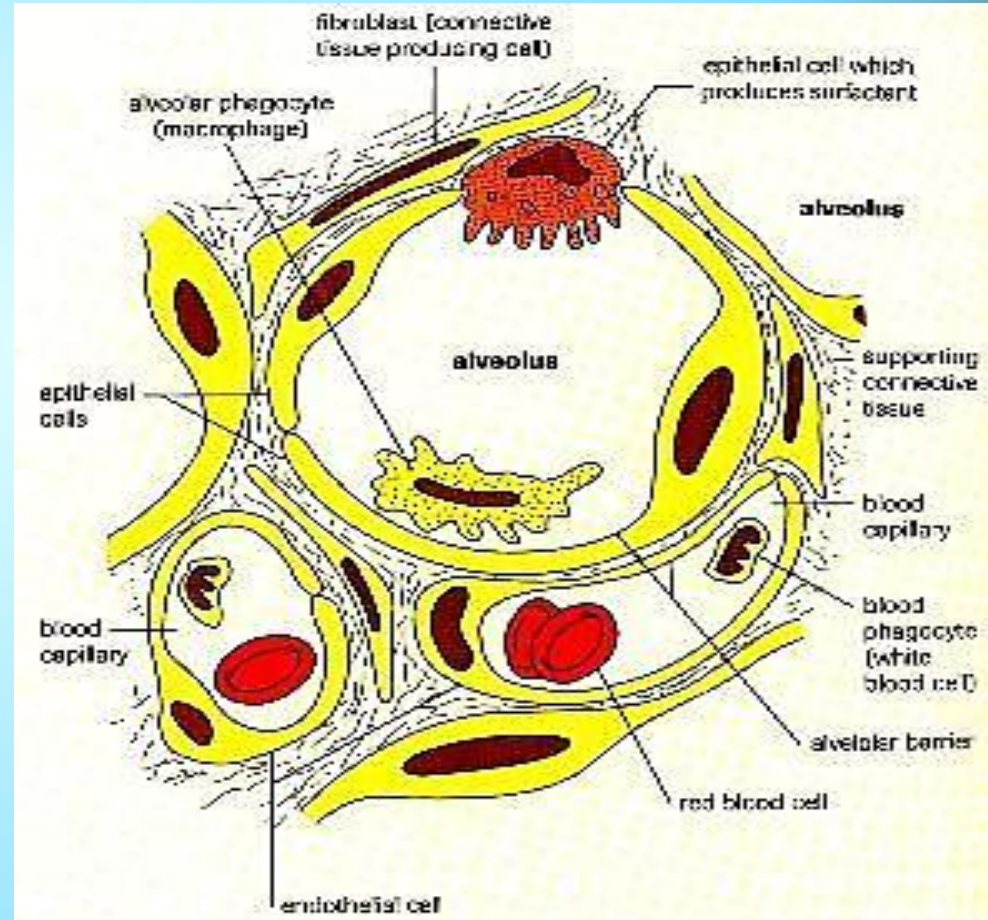
Respiratory Membrane

- Squamous cells of alveoli .
- Basement membrane of alveoli.
- Basement membrane of capillaries
- Simple squamous cells of capillaries
- About $.5 \mu$ in thickness



Cells in the Alveolus

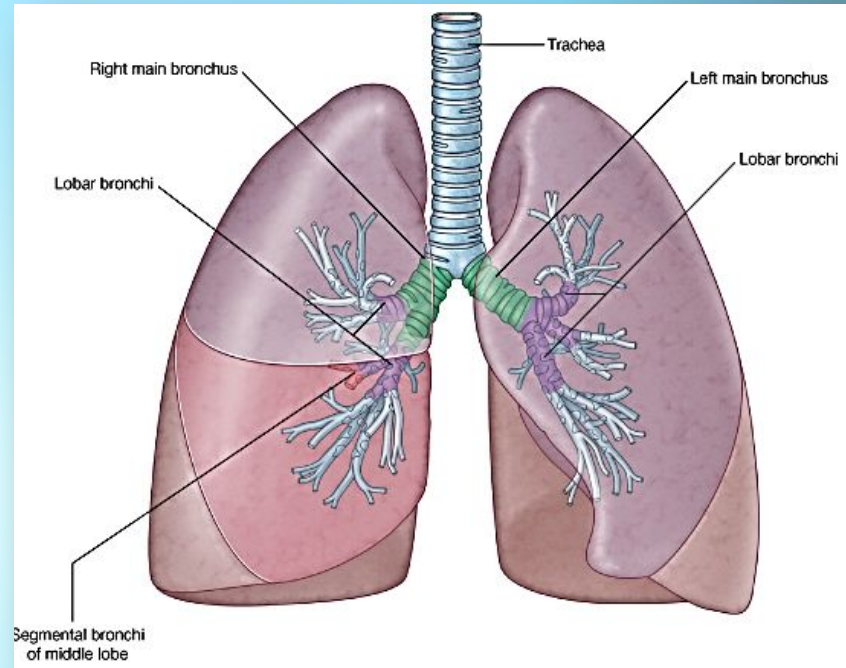
- Type I cells : simple squamous cells forming lining.
- Type II cells : or septal cells secrete **surfactant** (that lowers alveolar surface tension).
- Alveolar macrophages.



Gross Anatomy of the

Lungs

- Each lung has a conical shape.
- 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.



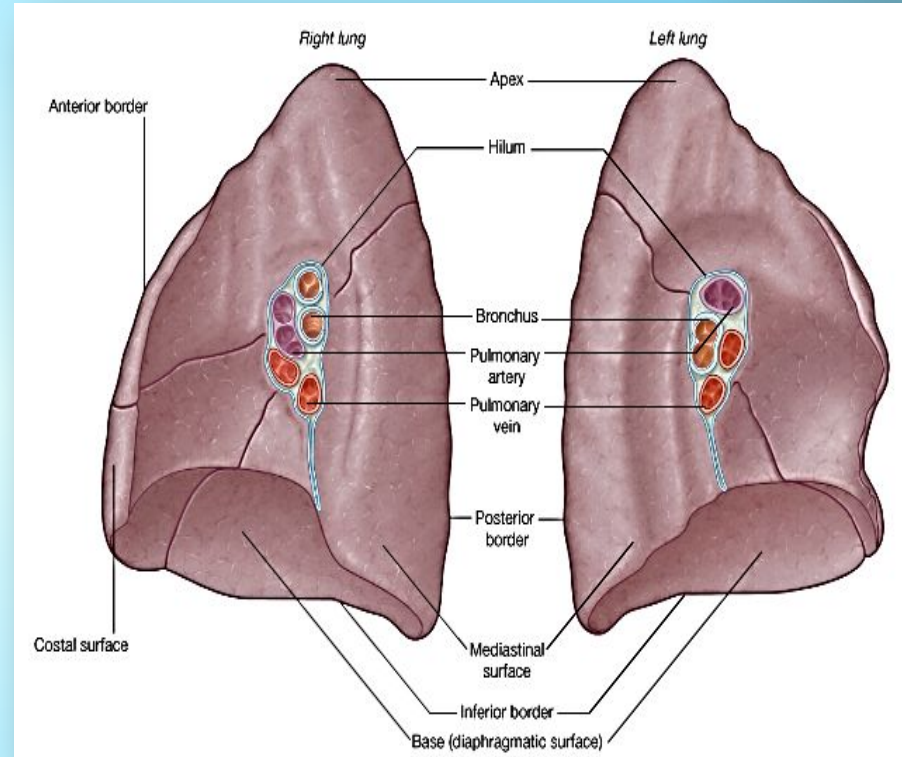
Lungs

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.



Further Reading

- 1) Clinically Oriented Anatomy (Moore). 5th Edition, 2006.
Chapters (1,7,8).
- 2) Gray's Anatomy for Students (Elsevier 2007). Chapters
(3,8).
- 3) Basic Histology. Text and Atlas. 11th Edition, 2007.
Chapter 17.