# HATAHET ANATOMY

## Respiratory system

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# Lecture 12: Respiratory system

## Introduction to Respiratory system

The respiratory system is the system responsible for gas exchange, reoxygenation of blood, and getting rid of $CO_2$ by the process of Respiration (Inspiration & Expiration)

Classified according to structure and function into:

### ➢ Anatomical (Structural) classification

**1) Upper respiratory tract**

- composed of the respiratory system structures above the vocal cords
- these structures are: Nose, Nasal cavity, and Pharynx

**2) Lower respiratory tract**

- composed of the respiratory system structures below the vocal cords
- these structures are: Larynx, Trachea, Bronchi, and Lungs

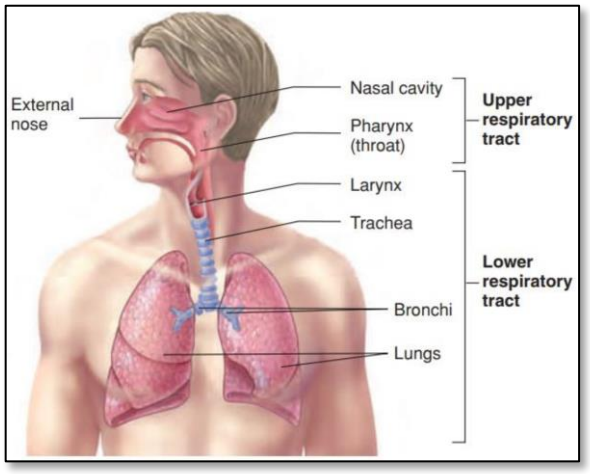
### ➢ Physiological (Functional) classification

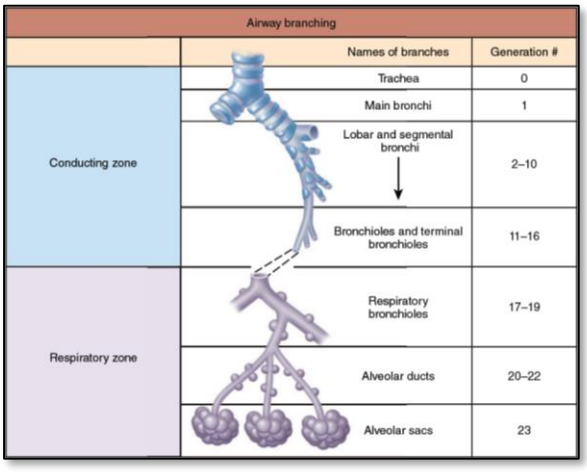
**1) Conducting zone**

- includes the structures that filter, warm, moisten and deliver air to the lungs
- these structures are: Nose, Nasal cavity, Pharynx, Larynx, Trachea, Bronchi, Bronchioles, and Terminal bronchioles

**2) Respiratory zone**

- includes the structures where gas exchange occurs
- these structures are: Respiratory bronchioles, Alveolar ducts, Alveolar sacs, and Alveoli



# Anatomy of Respiratory system

## Nose

The nose is the passageway between the outside and the inner respiratory tract, it is divided into 2 sections:

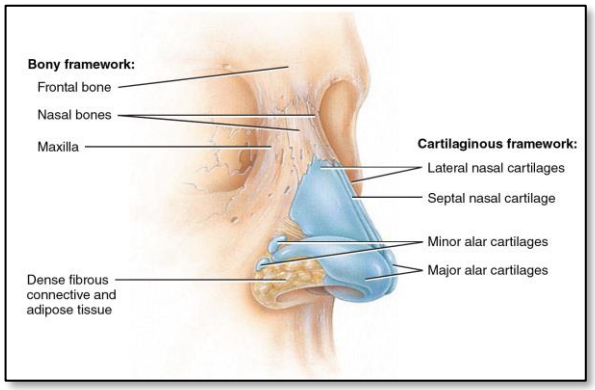
➢ **External nose**, the outer visible portion of the nose, has 2 openings called (External nares - Nostrils), consists of:

❖ **Bones**

- Nasal bones
- Frontal process of Maxilla
- Nasal process of Frontal bone

❖ **Cartilages**

- Lateral nasal cartilage
- Septal nasal cartilage
- Major alar cartilage
- Minor alar cartilage (Lower lateral cartilage)




❖ **Nasal vestibules**, the internal portion of external nose, it contains the nasal hair

## ➢ Nasal cavity (Internal cavity)

- large chamber inside the skull that extends from nostrils to nasopharynx
- it is specialized for warming, moistening, and filtering the air
- it contains the olfactory nerves that receive the olfactory stimuli
- contains the following:

◆ **Floor**, made by the hard palate:

- palatine process of maxilla, anteriorly
- horizontal plate of palatine bone, posteriorly

◆ **Roof**, composed of:

- Cribriform plate of ethmoid bone, houses the olfactory nerve endings
- Body of sphenoid bone
- Frontal bone
- Nasal bones

◆ **Medial wall**, made by Nasal septum:

- Septal cartilage, anteriorly
- bones, posteriorly:

→ Perpendicular plate of ethmoid bone
→ Vomer bone inferiorly

◆ **Lateral wall**

- Conchae, the bony projections of the lateral wall, these are: (superior, middle, inferior)
- Meatuses, shelf-like foldings of the lateral wall mucosa between conchae, these are: (superior, middle, inferior), each meatus has openings for the associated structures:

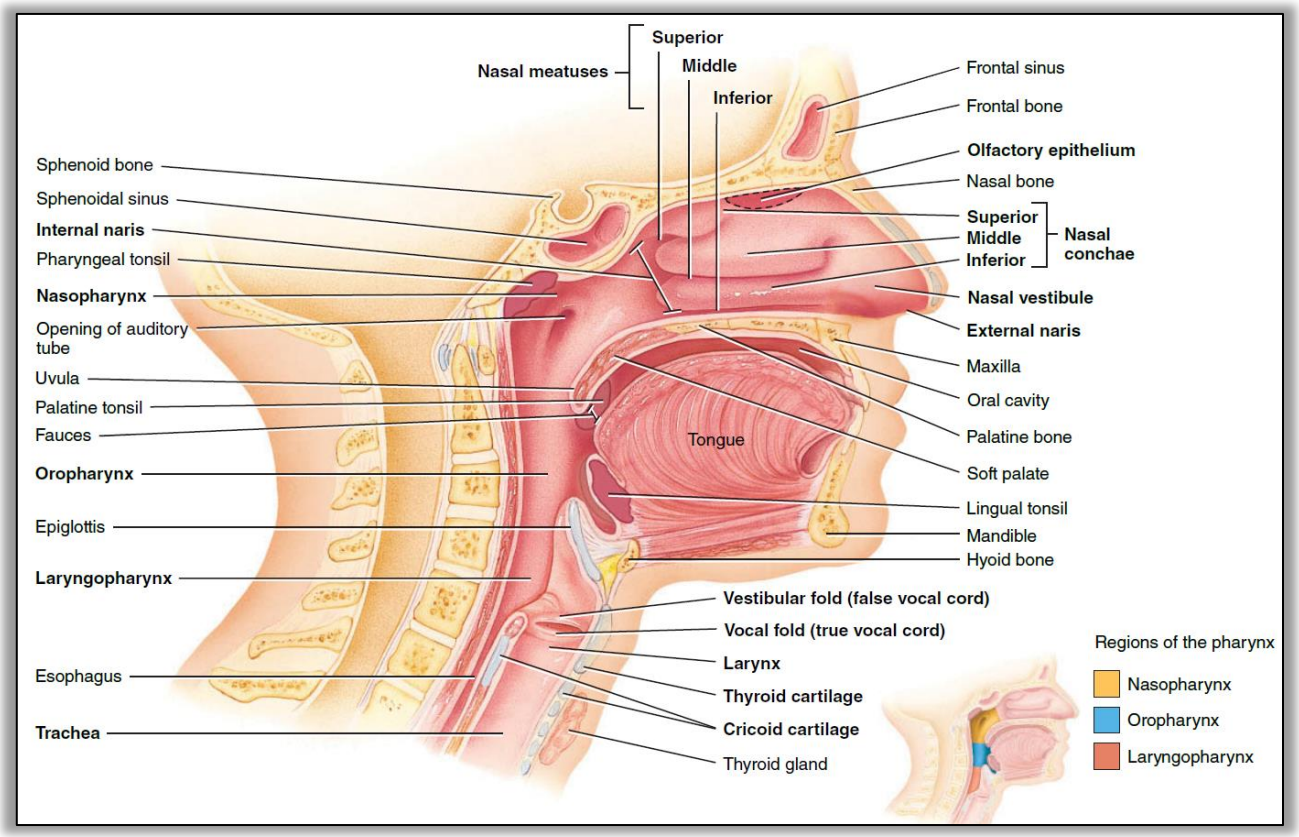
→ **Superior meatus**: (Posterior ethmoid sinuses, Sphenoidal meatus)
→ **Middle meatus**: (Anterior ethmoid sinuses, Middle ethmoid sinuses, Maxillary sinuses, Frontal sinuses)
→ **Inferior meatus**: (Nasolacrimal duct)

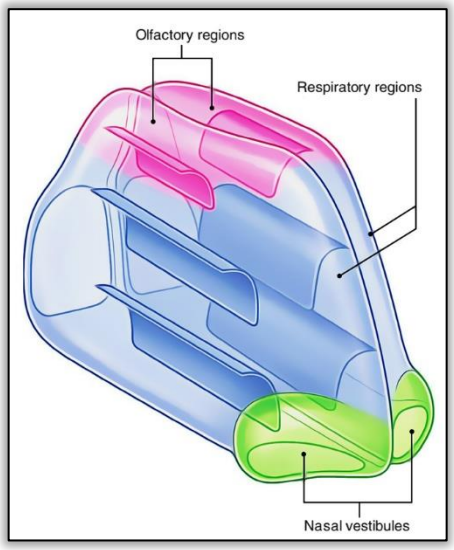
- **Paranasal sinuses**, air-containing spaces within the skull that open into the nasal cavity, these are:

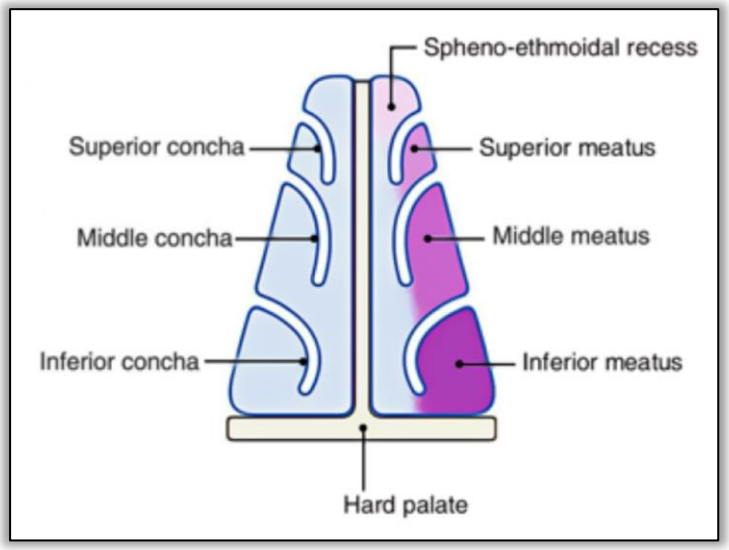
- Maxillary sinuses (x2)
- Sphenoidal sinuses (x2)
- Frontal sinuses (x2)
- Ethmoidal air cells (anterior, middle, posterior)

- **Internal nares (Choanae)**, the posterior openings of the nasal cavity into the pharynx

- **Spheno-ethmoidal recess**, the space between superior concha and sphenoid bone



# Pharynx

- Pharynx is a funnel-shaped fibromuscular tube
- extends from **choanae** (base of the skull) to **C6 vertebra**
- located anterior to cervical vertebrae and posterior to both oral and nasal cavities
- the pharynx is a muscular tube with 6 muscles arranged as the following:

  ❖ **3 Extrinsic circular muscles** (Constrictors - superior, middle, inferior), the successive contraction of these muscles produce the action of **Swallowing** (**Deglutition**)
  ❖ **3 Intrinsic longitudinal muscles**

The pharynx is composed of 3 main anatomical regions, these are:

## ➢ Nasopharynx

- passageway for air only
- located posterior to nasal cavity
- extended from **internal nares** to the **soft palate**
- its walls have several structures (5 Openings + 1 Tonsil):

  - **Choanae** (**Internal nares**), the openings of nasal cavity to nasopharynx
  - **Auditory tube** (**Eustachian tube**) (**Pharyngotympanic tube**), exchanges a small amount of air with the external environment to equalize air pressure between pharynx and middle ear & to prevent stasis of fluids in middle ear
  - **Pharyngeal tonsil** (**Adenoid tonsil**), a singular tonsil located at the posterior wall; adenitis blocks auditory tube
  - **Pharyngeal isthmus**, the inferior opening between nasopharynx & oropharynx

## ➢ Oropharynx

- passageway for air and food
- located posterior to the oral cavity
- extends from the **soft palate** to the level of **hyoid bone**
- the wall of oropharynx contains some structures:

  - **Fauces**, the opening from mouth into oropharynx, it links the oral cavity with the nasal cavity, composed of 2 arches:

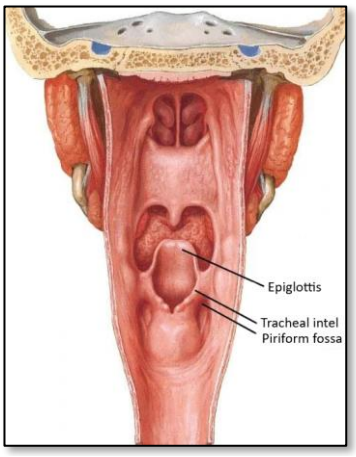
    ◆ **Palatoglossal arch**, the anterior fold, a part of the **oral cavity**
    ◆ **Palatopharyngeal arch**, the posterior fold, a part of the **oropharynx**

  - **Vallecula**, a depression between the posterior $^1/_3$ of the tongue and the epiglottis
  - **Palatine tonsils**, paired set of tonsils located between the anterior & posterior arches of the oropharynx
  - **Lingual tonsil**, a singular tonsil located on the posterior $^1/_3$ of the tongue (Base of tongue)

## ➢ Laryngopharynx

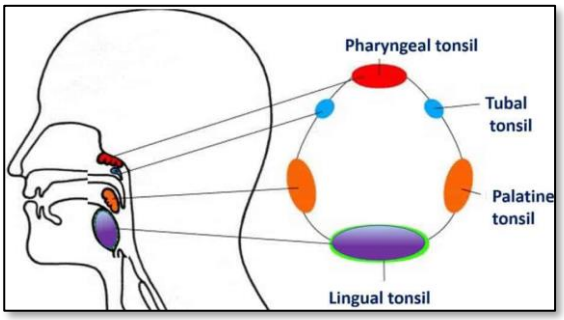
- passageway for air and food
- located posterior to the larynx
- extends from **hyoid bone** to the **C6 vertebra**, and continues as the esophagus
- the laryngopharynx contains some structures:

  - **Laryngeal inlet**, the opening to larynx, positioned posteriorly not superiorly; to protect airways during swallowing
  - **Piriform recesses**, 2 depressions on each side of laryngeal inlet, it functions as a trap for swallowed objects like fishbones to prevent them from damaging the larynx



▪ **Waldeyer's Tonsillar ring**: ring of the lymphatic tissue (tonsils) at the throat, these tonsils are:

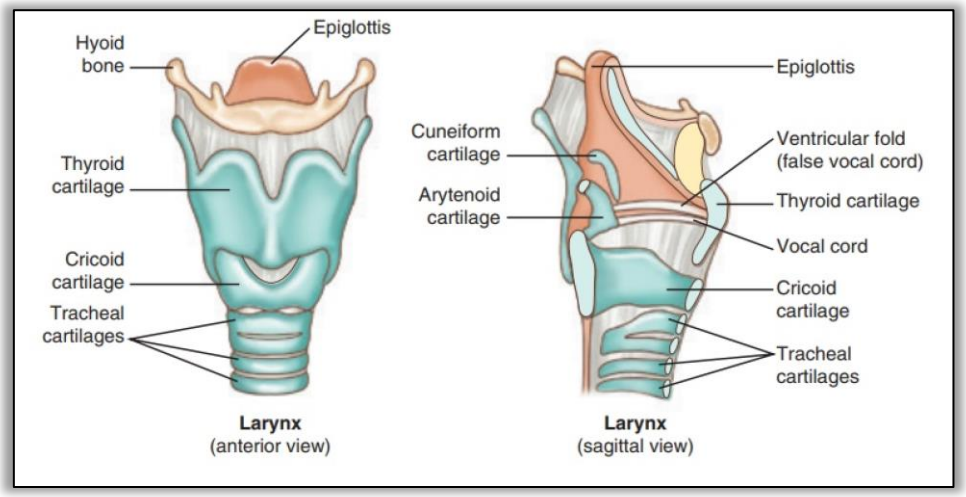
| Tonsil | # of Tonsils | Location |
|---|---|---|
| **Pharyngeal tonsil** | 1 | Nasopharynx |
| **Tubal tonsil** | 2 | Oropharynx |
| **Palatine tonsil** | 2 | Oropharynx |
| **Lingual tonsil** | 1 | Oropharynx |




## Larynx (Voice box)

- Larynx is an air passageway that connects pharynx with trachea
- it extends from the laryngopharynx to the trachea, and it is anterior to (C4 - C6)
- larynx has several functions:

❖ **Main function** → Acting as a protective sphincter for inlet of airways to the lung
❖ **Secondary function** → Production of voice via the vocal cords




- larynx is controlled by 2 groups of muscles:

❖ **Intrinsic muscles** → controls vocal cords; adduction & abduction
❖ **Extrinsic muscles** → elevates and depressed the larynx

- The larynx is busy in structures:

➢ **Cartilages**, attaches to the hyoid bone via the thyrohyoid ligament

✪ **Single**, 3 cartilages:

❶ **Thyroid cartilage (Shield-like)**, the largest cartilage that gives the larynx a triangular shape, composed of:

- 2 laminae (plates) of hyaline cartilage, fuse medially together
- 2 horns posteriorly (superior & inferior)
- 2 notches (superior & inferior)
- Laryngeal prominence (Adam's apple), anteriorly & medially

❷ **Cricoid cartilage (Ring-shaped)**, located inferior to the thyroid cartilage **at level of C6**, composed of:

- Anterior narrow arch
- Posterior wide lamina
- Medial prominent ridge
- Lateral depressions

❸ **Epiglottis (Leaf-shaped)**, it bends when we swallow to close the larynx and prevent food or drinks from entering the lower respiratory tract. Attachments of epiglottis:

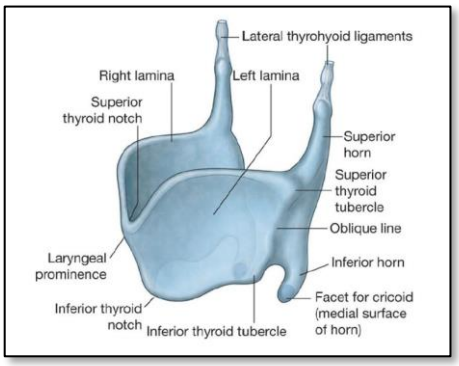
- **Superiorly** (**the leaf**) → Free, not attached to allow bending
- **Inferiorly** (**the stem**) → thyroid cartilage rim via thyro-epiglottic ligament
- **Sides** → arytenoid cartilages via quadrangular membrane

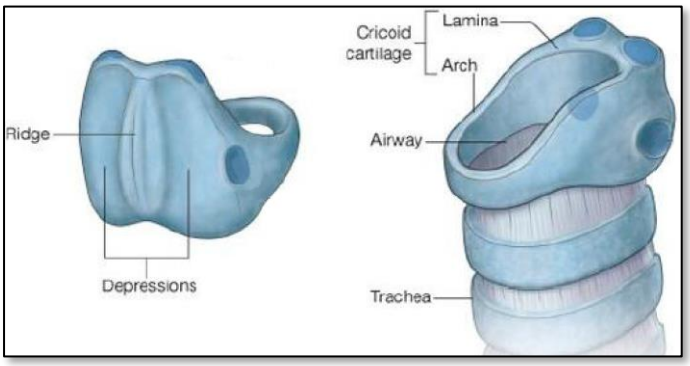
✪ **Paired**, 3 cartilages:

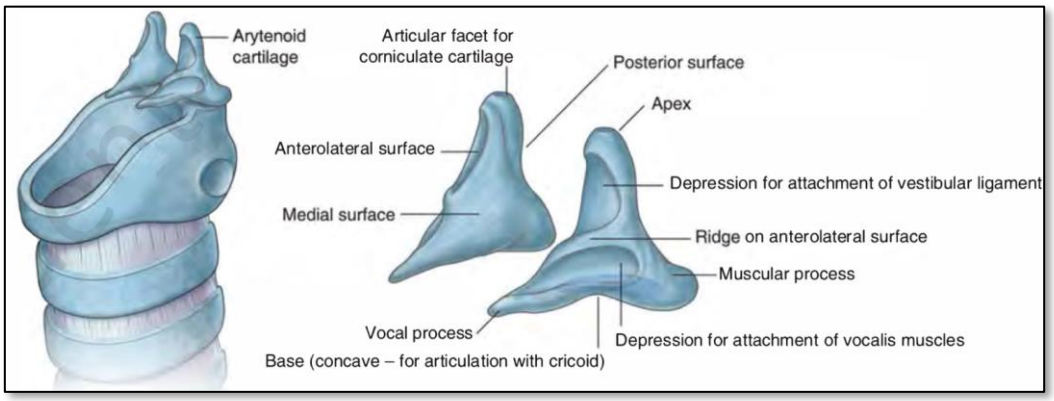
❶ **Arytenoid cartilages (Pyramidal-shaped)** located on each side of cricoid lamina

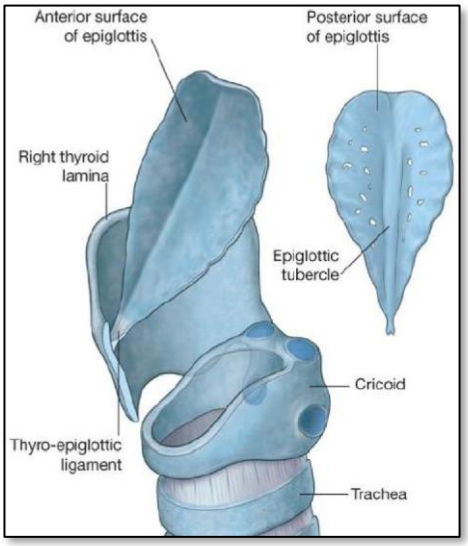
❷ **Corniculate cartilages (horn-shaped)**, located at the apex of arytenoid cartilage

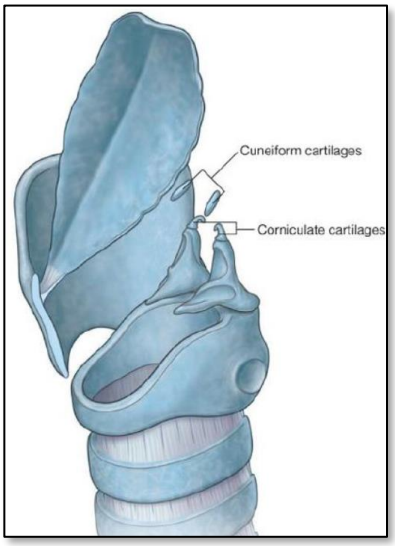
❸ **Cuneiform cartilages (Club-shaped)**, located anterior to each side of corniculate cartilage



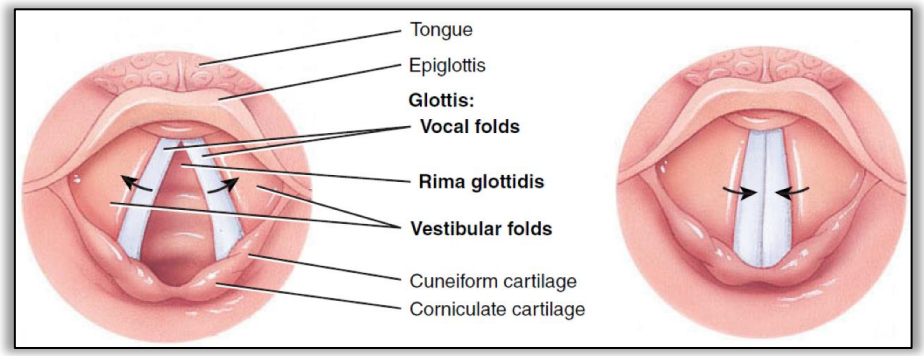
## ➢ Ligaments (Membranes)

✪ **Extrinsic**: (**Thyrohyoid ligament** / **Cricotracheal ligament**)
✪ **Intrinsic**: (**Quadrangular ligament** / **Cricothyroid ligament**)

## ➢ Vocal cords

• **Vestibular folds** (**False vocal cords**) [pink color → vascular], the upper fixed vestibular folds that are formed by the inferior margin of quadrangular ligament, they come together to close the space between them which is called (**Rima vestibularis**)

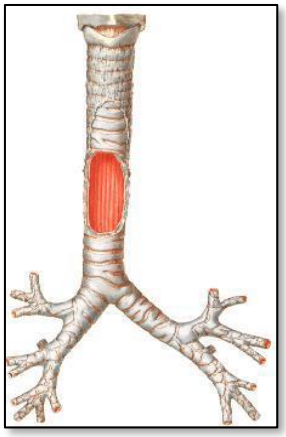
• **Vocal folds** (**True vocal cords**) [white color → avascular], the lower mobile folds that are made by the superior margin of cricothyroid ligament, they can vibrate in response to air to produce sound. The space between them is called (**Rima glottidis**)




***Notes**:

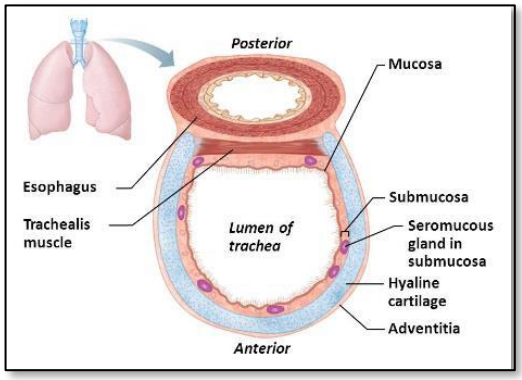
- The cricoid cartilage is the only complete ring in the entire airway
- When we swallow, both pharynx and larynx will rise up:
  - **Pharynx** → widen to receive food and drink
  - **Larynx** → causes the epiglottis to bend posteriorly to close the laryngeal inlet
- Cartilages of the larynx are composed of different CT:
  - **Epiglottis**, **Corniculate cartilage**, and **Cuneiform cartilage** → Elastic cartilages
  - **Thyroid cartilage**, **Cricoid cartilage**, and **Arytenoid cartilage** → Hyaline cartilages
- Arytenoid cartilage influences the positions and tensions of the vocal folds (**True vocal cords**):
  - **Medial rotation of arytenoid cartilage** → adduction of vocal folds
  - **Lateral rotation of arytenoid cartilage** → abduction of vocal folds

## Trachea



• Trachea is a fibrocartilage tube located anterior to the esophagus
• extends between (C6 - T5) where it bifurcates into right and left bronchi at the Carina
• Trachea is composed of:

- **Outer surface:**
  - **16-20 U-shaped hyaline cartilage**, their opened side faces posteriorly; directed to esophagus
  - **Annular ligaments of trachea**, the ligaments between the rings
- **Inner surface:**
  - **Mucosa of trachea**
  - **Trachealis**, a layer of smooth muscles that controls the dilation and constriction of the trachea




▪ **Carina**: an internal structure at the point where the trachea bifurcates to give right and left bronchi, formed by the posteroinferior projection of the last tracheal cartilaginous ring, the carina is a sensitive area so any irritation of that area will produce cough (Cough reflex)

## Trachea

- Bronchi are the subdivisions of the trachea that enter the lung through the Hilum of lungs
- Divisions of the bronchial tree are as the following:

❶ **Primary bronchi**, the first 2 divisions of the trachea, each one will enter a lung

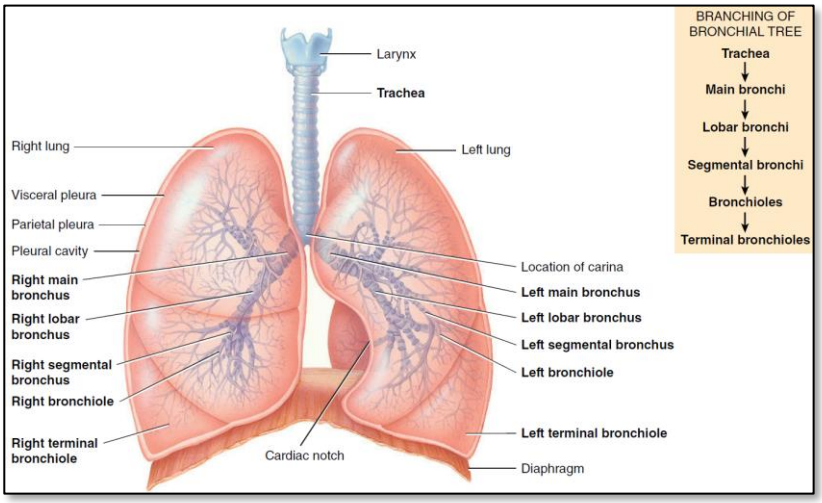
❷ **Secondary bronchi** (**Lobar bronchi**), the subdivisions of each bronchus, each one enters one lobe of the lung

❸ **Tertiary bronchi** (**Segmental bronchi**), the sub-subdivisions secondary bronchi, each lung has 10 tertiary bronchi supplying the 10 bronchopulmonary segments of each lung

❹ **Bronchioles**, the smallest sub-sub-subdivisions of tertiary bronchi that will continue to branch and divide for approximately **17** generations to give the smallest branches called (Terminal Bronchioles)

❺ **Terminal bronchioles**, the last subdivision of the conducting zone. Beyond here, the branches are microscopic

❻ **Respiratory bronchioles**, the last branching of bronchial tree (takes about **23** generations), attaches to **alveolar sacs** which are clusters of outpouching **alveoli** where gas exchange occurs




***Note**: The right primary bronchus is shorter, wider and more vertical than the left one, and that's clinically important; because if someone somehow was choked by food that entered the trachea and, we can predict that the food has passed through the right primary bronchi since it is more prone to aspiration

❖ **Airway branching & Structural changes**, as the bronchi continue to branch more and more, there will be 3 gradual changes in the resulting branches, there changes are:

[1] **The epithelium** starts to change from:

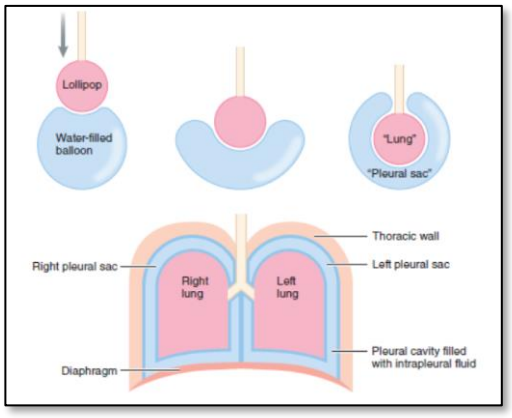
A. ciliated to Non-ciliated
B. Pseudostratified → Columnar → Cuboidal → Squamous

[2] **The C-shaped rings** start to be replaced by smaller cartilaginous plates until they disappear at terminal bronchioles

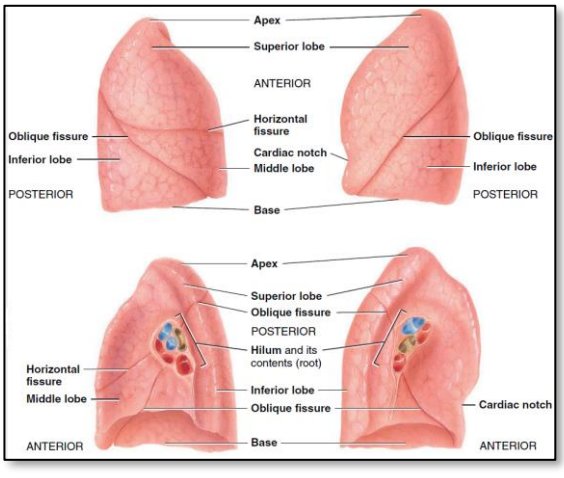
[3] **The amount of smooth muscle tissue** lining the inner wall of the bronchi starts to increase

## Lungs

- **Pleura**: fluid-filled serous membrane that surrounds the lungs without being opened to the outside, as when you push your fist in fluid-filled balloon. Pleura is composed of:
  - **Visceral pleura**, the inner layer that directly covers the lungs and follows their curves
  - **Parietal pleura**, the outer layer that lines thoracic cavity
  - **Pleural cavity**, the potential space between the 2 layers of the pleura which contains fluids; to reduce friction between the 2 layers and allow the gliding of the lungs over the thoracic wall




- Lungs are paired, cone-shaped organs located at the thoracic cavity and separated by the heart and mediastinum
- the lungs extend from the diaphragm inferiorly to just slightly superior to the clavicles (2-3 cm)
- Each lung is composed of:
  - **Apex**, the narrow superior portion of the lungs
  - **Base (Diaphragmatic surface)**, the broad inferior portion of the lungs, lies in the diaphragm
  - **Medial surface** (**Mediastinal surface**)
  - **Lateral surface** (**Costal surface**)
  - **Hilum (Hilus)**, a region at the mediastinal surface of the lungs through which primary bronchi, pulmonary blood vessels, lymphatic vessels and nerves enter and exit lungs. Structures penetrating hilum are called (**Root of lung**)
  - **Lobes & Fissures**:



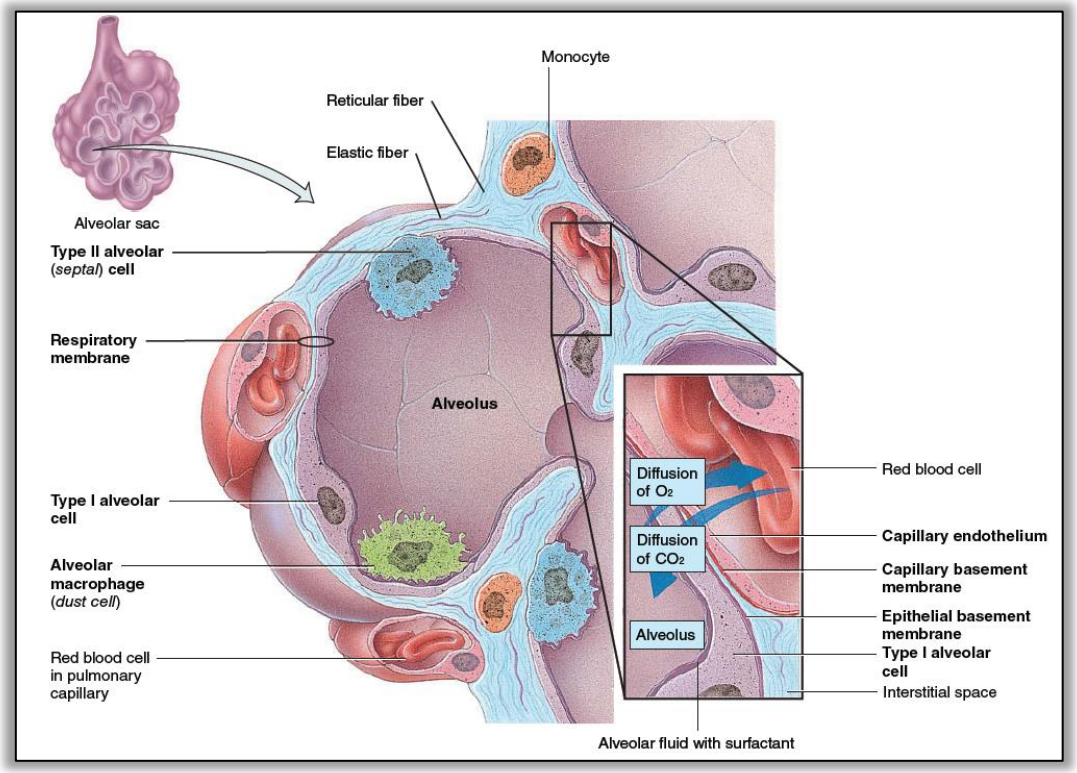

| Differences | Right lung | Left lung |
|---|---|---|
| Size | The right lung is shorter, thicker, bigger and broader than the left lung | |
| # of Lobes | 3: Superior, Middle, Inferior | 2: Superior, Inferior |
| # of Fissures | 2: Oblique, Horizontal | 1: Oblique |

***Note**: The left lung has a notch called the (**Cardiac notch**); because the heart occupies a small space as it develops to the left side. Also, the left lung has a tongue-like process called (**Lingula**)

# Histology of Alveoli

The wall of an alveolus consists of 3 types of cells:

❶ **Type I alveolar cells**, the predominant cells where the gas exchange takes place
❷ **Type II alveolar cells**, larger but fewer epithelial cells that secrete Alveolar surfactant that decreases fluid tension of the alveolus tension; preventing it from collapsing
❸ **Alveolar macrophages (Dust cells)**, these are specialized macrophages that engulf debris, especially $CO_2$ particles




***Note**: Bronchial and pulmonary disorders (tumors or abscesses) that are localized in a particular bronchopulmonary segment may be surgically removed without seriously disrupting the surrounding lung tissue