The Respiratory System

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Functions of The Respiratory System

- To allow gases from the environment to enter the bronchial tree through inspiration by expanding the thoracic volume.
- To allow gas exchange to occur at the respiratory membrane, so that oxygen diffuses into the blood while carbon dioxide diffuses into the bronchial tree.
- To permit gases in the lungs to be eliminated through expiration by decreasing the thoracic volume.
General Anatomy of The Respiratory System

1. Consists of a tube that divides into small branching tubes in the lungs: external nares → nasal cavity → nasopharynx → laryngopharynx → larynx → trachea → primary bronchi → lungs (secondary bronchi → tertiary bronchi → bronchioles → alveolar sacs → alveoli).
2. The histology along the respiratory tract changes – from the trachea to the tertiary bronchi, the tract is lined with ciliated pseudostratified columnar epithelium, smooth muscle and cartilage rings; the bronchioles are lined with cuboidal epithelium; and from the alveolar ducts to the alveoli, the tract is lined with simple squamous epithelium.

3. The left lung contains 2 lobes – superior and inferior lobes, while the right lung contains 3 lobes – superior, middle, and inferior lobes. Each lobe is highly vascularized and contains part of the bronchial tree.

4. Inferior to the lungs is a sheet of skeletal muscle under involuntary control, called diaphragm, to facilitate the control of thoracic volume.
(a) Anterior view. The lungs flank mediastinal structures laterally.
Anatomy of Respiratory Organ

1. Nose and nasal cavity:
   • gases in the environment enter the respiratory tract through two openings called external nares which contain hairs to prevent dust particles to come in.
   • the space within the nose, called nasal cavity, is lined with ciliated pseudostratified columnar epithelium to provide a defense mechanism where cilia and mucus (from goblet cells) expel foreign substances.
   • the nasals cavity also contains capillary networks that release body heat into the cavity, so that incoming air can be warmed up to prevent condensation.
2. Larynx (voice box):

- A passageway surrounded by cartilages for gases moving in and out of the trachea.
- Located beneath the nasal pharynx and laryngopharynx.
- A cartilage at the top called epiglottis remains upright when gases are entering or exiting the trachea, through an opening called glottis [during swallowing, a reflex mechanism pulls the epiglottis downward and pushing the larynx upward, resulting in the closure of glottis to push food bolus into the esophagus].
- The glottis is surrounded by another cartilage called thyroid cartilage (where the thyroid gland is attached), which is connected to another cartilage called cricoids cartilage. Between these two structures is a thin layer of connective tissue called cricothyroid membrane.
- Elastic tissues in the larynx also allow different sounds to be generated when air flow passes through the larynx.
(b) Structures of the pharynx and larynx

- Posterior nasal aperture
- **Nasopharynx**
  - Pharyngeal tonsil
  - Opening of pharyngotympanic tube
- **Oropharynx**
  - Palatine tonsil
  - Isthmus of the fauces
- **Laryngopharynx**
- Esophagus
- Trachea

**Larynx**
- Epiglottis
- Vestibular fold
- Thyroid cartilage
- Vocal fold
- Cricoid cartilage
- Thyroid gland

Hard palate
Soft palate
Tongue
Lingual tonsil
Hyoid bone

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(a) Vocal folds in closed position; closed glottis

(b) Vocal folds in open position; open glottis

(b) Anterior view

- Epiglottis
- Vestibular fold (false vocal cord)
- Vocal fold (true vocal cord)
- Glottis
  - Inner lining of trachea
  - Cuneiform cartilage
  - Corniculate cartilage
- Body of hyoid bone
- Thyroid cartilage
- Laryngeal prominence (Adam’s apple)
- Cricothyroid ligament
- Cricoid cartilage
- Cricotracheal ligament
- Tracheal cartilages
3. Trachea: Long, straight tube leading from the larynx to the lungs.

- **Cilia** on its inner wall lining constantly expell foreign substances trapped in mucus back to the nasopharynx and oropharynx.

- Trachea is constantly open because of support by 20 C-shaped cartilage rings, so that gases can pass freely.
4. Bronchial tree

- tree – like branching tubes extended from the trachea. Only the **primary bronchi** are external to the lungs, while the rest of the bronchial tree is embedded in lung tissues.
- diameters of the tubes from primary bronchi to tertiary bronchi are large, so that support with **cartilage** rings is necessary. These tubes contain **columnar cells** which prevent diffusion, so they are only allowing gases to pass.
- diameter at the bronchioles is down to 1 mm where the tubes do not need cartilage rings for support, this structure is composed of **cuboidal cells** where diffusion is also not possible.
- from the alveolar duct to the alveoli, the lining tissue becomes **simple squamous** epithelium where gas exchange is possible. Since there is a much larger surface area at the alveoli, all gas exchange occurs at the alveoli [300 million alveoli provide a total surface area similar to a tennis court!].
Subdivisions of the Bronchial Tree

- Primary bronchi – arises from trachea. Only these bronchi are external to lungs while the rest of bronchial tree is embedded in the lung.
  a. Right and left primary bronchi.
  b. Secondary or lobar bronchi: 3 branches from the right primary bronchus and 2 branches from the left.
     Note: the right lung is larger than left lung and it is divided into 3 parts, called the superior, middle, and inferior lobes. The left lung consist of 2 part, a superior and an inferior lobe.
  c. Tertiary or segmental bronchi: each of these branches supply a portion of lung called a bronchus pulmonary segment (10 segments in the right and 8 segments in the left lung).
  d. Interlobular bronchioles: these small branches of the segmental bronchi enter the basic units of lung – the lobules.
e. Terminal bronchioles: these tubes branch from a bronchiole. Fifty to eighty terminal bronchioles occupy a lobule of the lung.
f. Respiratory bronchioles: 2 or more branch from terminal bronchioles.
g. Alveolar ducts: 2 to 10 mm long, branching alveolar ducts extend from each respiratory bronchiole.
h. Alveolar sac: thin-walled closely packed outpouchings of the alveolar ducts.
i. Alveoli: thin walled, microscopic air sacs that open to an alveolar sac.
(a) Diagrammatic view of capillary-alveoli relationships

Terminal bronchiole
Respiratory bronchiole
Smooth muscle
Elastic fibers
Alveolus
Capillaries
(c) Detailed anatomy of the respiratory membrane

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5. Lungs

- Cone–shaped organs located in the thoracic cavity.
- Thoracic cavity is lined with a body membrane called **parietal pleura**, while the surface of lungs is covered with **visceral pleura**.
- The thin space between the two pleural membranes is called **pleural cavity** which is filled with a clear fluid called **plural fluid** to minimize friction between the tissues and to provide **surface tension** in the pleural cavity [water molecules in the pleural fluid allow the two pleural membranes to adhere to one another, to prevent collapsing of the lungs].
- A chemical substance called **surfactant** secreted by the lungs also facilitate the surface tension.
(a) Anterior view. The lungs flank mediastinal structures laterally.
Clinical Terms

- **COPD**: chronic obstructive pulmonary disease.
  1) emphysema
  2) chronic bronchitis
- **Emphysema**: permanent enlargement and destruction of some alveoli. The lungs lose their elasticity and expiration become an active process.
- **Chronic bronchitis**: chronic excessive mucus production in response to inhaled irritants leading to inflammation and fibrosis of the mucosa. Patients becomes cyanotic known as "blue bloomers".
- **Tuberculosis (TB)**: caused by a bacteria, spread via infected person's cough, causes cavitations of lung.
- **Atelectasis**: collapse of a lung or some portion of it.
- **Lung cancer**: 1/3 of cancer death in the U.S. – smoking is the leading cause.
- **dyspnea**: difficulty in breathing.
- **pneumonia**: infectious inflammation of the lungs, in which fluid accumulates in the alveoli.