The Respiratory System:

Respiration
- Involves both the respiratory and the circulatory systems
- Four processes that supply the body with O_2 and dispose of CO_2

Respiration
- Pulmonary ventilation (breathing): movement of air into and out of the lungs
- External respiration: O_2 and CO_2 exchange between the lungs and the blood
- Transport: O_2 and CO_2 in the blood
- Internal respiration: O_2 and CO_2 exchange between systemic blood vessels and tissues

Respiratory System: Functional Anatomy
- Major organs
  - Nose, nasal cavity, and paranasal sinuses
  - Pharynx
  - Larynx
  - Trachea
  - Bronchi and their branches
  - Lungs and alveoli

Functional Anatomy
- Respiratory zone: site of gas exchange
  - Microscopic structures: respiratory bronchioles, alveolar ducts, and alveoli
- Conducting zone: conduits to gas exchange sites
  - Includes all other respiratory structures
- Respiratory muscles: diaphragm and other muscles that promote ventilation

The Nose
- Functions
  - Provides an airway for respiration
  - Moistens and warms the entering air
  - Filters and cleans inspired air

- Serves as a resonating chamber for speech
- Houses olfactory receptors

The Nose

- Two regions: external nose and nasal cavity
  1. External nose: root, bridge, dorsum nasi, and apex
     - Philtrum: a shallow vertical groove inferior to the apex
     - Nostrils (nares): bounded laterally by the alae

The Nose

  2. Nasal cavity: in and posterior to the external nose
     - Divided by a midline nasal septum
     - Posterior nasal apertures (choanae) open into the nasal pharynx
     - Roof: ethmoid and sphenoid bones
     - Floor: hard and soft palates

Nasal Cavity

- Vestibule: nasal cavity superior to the nostrils
  - Vibrissae filter coarse particles from inspired air
- Olfactory mucosa
  - Lines the superior nasal cavity
  - Contains smell receptors

Nasal Cavity

- Respiratory mucosa
  - Pseudostratified ciliated columnar epithelium
  - Mucous and serous secretions contain lysozyme and defensins
  - Cilia move contaminated mucus posteriorly to throat
  - Inspired air is warmed by plexuses of capillaries and veins
  - Sensory nerve endings triggers sneezing

Nasal Cavity

- Superior, middle, and inferior nasal conchae
  - Protrude from the lateral walls
  - Increase mucosal area
  - Enhance air turbulence

Functions of the Nasal Mucosa and Conchae

- During inhalation, the conchae and nasal mucosa
  - Filter, heat, and moisten air

- During exhalation these structures
  - Reclaim heat and moisture

Paranasal Sinuses
- In frontal, sphenoid, ethmoid, and maxillary bones
- Lighten the skull and help to warm and moisten the air

Pharynx
- Muscular tube that connects to the
  - Nasal cavity and mouth superiorly
  - Larynx and esophagus inferiorly
- From the base of the skull to the level of the sixth cervical vertebra

Nasopharynx
- Air passageway posterior to the nasal cavity
- Lining: pseudostratified columnar epithelium
- Soft palate and uvula close nasopharynx during swallowing
- Pharyngeal tonsil (adenoids) on posterior wall
- Pharyngotympanic (auditory) tubes open into the lateral walls

Oropharynx
- Passageway for food and air from the level of the soft palate to the epiglottis
- Lining of stratified squamous epithelium
- Isthmus of the fauces: opening to the oral cavity
- Palatine tonsils in the lateral walls of fauces
- Lingual tonsil on the posterior surface of the tongue

Laryngopharynx
- Passageway for food and air
- Posterior to the upright epiglottis
- Extends to the larynx, where it is also continuous with the esophagus

Larynx
- Attaches to the hyoid bone and opens into the laryngopharynx
- Continuous with the trachea
- Functions
  1. Provides a patent airway
  2. Routes air and food into proper channels

3. Voice production

Larynx

- Cartilages of the larynx
  - Hyaline cartilage except for the epiglottis
  - Thyroid cartilage with laryngeal prominence (Adam's apple)
  - Ring-shaped cricoid cartilage
  - Paired arytenoid, cuneiform, and corniculate cartilages
- Epiglottis: elastic cartilage; covers the laryngeal inlet during swallowing

Trachea

- Windpipe: from the larynx into the mediastinum
- Wall composed of three layers
  1. Mucosa: ciliated pseudostratified epithelium with goblet cells
  2. Submucosa: connective tissue with seromucous glands
  3. Adventitia: outermost layer made of connective tissue that encases the C-shaped rings of hyaline cartilage

Trachea

- Trachealis muscle
  - Connects posterior parts of cartilage rings
  - Contracts during coughing to expel mucus
- Carina
  - Last tracheal cartilage
  - Point where trachea branches into two bronchi

Bronchi and Subdivisions

- Air passages undergo 23 orders of branching
- Branching pattern called the bronchial (respiratory) tree

Conducting Zone Structures

- Trachea $\rightarrow$ right and left main (primary) bronchi
- Each main bronchus enters the hilum of one lung
  - Right main bronchus is wider, shorter, and more vertical than the left
- Each main bronchus branches into lobar (secondary) bronchi (three right, two left)
  - Each lobar bronchus supplies one lobe

Conducting Zone Structures

- Each lobar bronchus branches into segmental (tertiary) bronchi

    - Segmental bronchi divide repeatedly
- Bronchioles are less than 1 mm in diameter
- Terminal bronchioles are the smallest, less than 0.5 mm diameter

Conducting Zone Structures
- From bronchi through bronchioles, structural changes occur
    - Cartilage rings give way to plates; cartilage is absent from bronchioles
    - Epithelium changes from pseudostratified columnar to cuboidal; cilia and goblet cells become sparse
    - Relative amount of smooth muscle increases

Respiratory Zone
- Respiratory bronchioles, alveolar ducts, alveolar sacs (clusters of alveoli)
- ~300 million alveoli account for most of the lungs' volume and are the main site for gas exchange

Respiratory Membrane
- ~0.5-μm-thick air-blood barrier
- Alveolar and capillary walls and their fused basement membranes
- Alveolar walls
    - Single layer of squamous epithelium (type I cells)
- Scattered type II cuboidal cells secrete surfactant and antimicrobial proteins

Alveoli
- Surrounded by fine elastic fibers
- Contain open pores that
    - Connect adjacent alveoli
    - Allow air pressure throughout the lung to be equalized
- House alveolar macrophages that keep alveolar surfaces sterile

Lungs
- Occupy all of the thoracic cavity except the mediastinum
- Root: site of vascular and bronchial attachments
- Costal surface: anterior, lateral, and posterior surfaces

Lungs
- Apex: superior tip

- Base: inferior surface that rests on the diaphragm
- Hilum: on mediastinal surface; site for attachment of blood vessels, bronchi, lymphatic vessels, and nerves
- Cardiac notch of left lung: concavity that accommodates the heart

Lungs
- Left lung is smaller, separated into two lobes by an oblique fissure
- Right lung has three lobes separated by oblique and horizontal fissures
- Bronchopulmonary segments (10 right, 8–9 left)
- Lobules are the smallest subdivisions; served by bronchioles and their branches

Blood Supply
- Pulmonary circulation (low pressure, high volume)
  - Pulmonary arteries deliver systemic venous blood
    - Branch profusely, along with bronchi
    - Feed into the pulmonary capillary networks
  - Pulmonary veins carry oxygenated blood from respiratory zones to the heart

Blood Supply
- Systemic circulation (high pressure, low volume)
  - Bronchial arteries provide oxygenated blood to lung tissue
    - Arise from aorta and enter the lungs at the hilum
    - Supply all lung tissue except the alveoli
  - Bronchial veins anastomose with pulmonary veins
  - Pulmonary veins carry most venous blood back to the heart

Pleurae
- Thin, double-layered serosa
- Parietal pleura on thoracic wall and superior face of diaphragm
- Visceral pleura on external lung surface
- Pleural fluid fills the slitlike pleural cavity
  - Provides lubrication and surface tension

The Mediastinum
- Is occupied by the mass of tissue between the two pulmonary cavities
- The central compartment of the thoracic cavity
- It is covered by mediastinal pleura

- Contains all of the thoracic viscera except the lungs
- Extends from the superior thoracic aperture to the diaphragm inferiorly
- Also extends from the sternum and costal cartilages anteriorly to the bodies of the thoracic vertebrae posteriorly
- It is divided into superior and inferior parts for purposes of description.

The superior mediastinum

- Exrtends from the superior thoracic aperture to the interverterbal disc of T4 and T5
- It contains the thymus, great vessels with the veins (brachiocephalic veins, SVC) anterior to the arteries (arch of the aorta, roots of tis major branches, the brachiocephalic trunk, left common carotid artery, left subclavian artery), phrenic nerve, vagus nerve, inferior continuation of the cervical viscera, thoracic duct and lymphatic trunks.

The inferior mediastinum:

- is further subdivided by the pericardium into anterior, middle and posterior parts.

The middle mediastinum:

✓ is occupied by the pericardium and its contents (heart and roots of the great
vessels

The Anterior mediastinum:

- Smallest subdivsion
- Consists of loose connective tissue, fat, lymphatic vessels, a few lymph nodes, branches of the internal thoracic vessels
- In children, it contains the inferior part of the thymus.

The Posterior mediastinum:

- Located posterior to the pericardium and diaphragm and between the parietal pleura of the two lungs
- It contains the thoracic aorta, thoracic duct, the lymphatic trunks posterior to mediastinal lymph nodes, azygos and hemiazygos veins, esophagus and esophageal nerve plexus