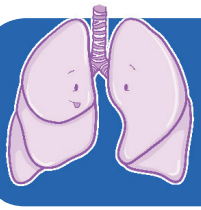

NOTES
ANATOMY & PHYSIOLOGY

RESPIRATORY SYSTEM

osms.it/respiratory-anatomy-physiology

RESPIRATORY SYSTEM

- Upper respiratory tract
  - Nose, pharynx, associated structures
- Lower respiratory tract
  - Larynx, trachea, bronchi, lungs

Respiratory system function

- Gas exchange between blood, atmosphere
- Protection against harmful particles, substances
- pH homeostasis
- Vocalization

Conducting vs. respiratory zone

- Conducting zone
  - Does not participate in gas exchange
  - Nose to terminal bronchioles
  - *Function*: inspire, warm, humidify, filter air before gas exchange
  - Smooth muscle layer contains autonomic nervous system (sympathetic, parasympathetic nerves)
  - Smooth muscle along trachea, first few bronchial branches have beta-2-adrenergic receptors
  - Sympathetic nerves stimulate beta-2-adrenergic receptors → ↑ airway diameter
  - Parasympathetic nerves stimulate muscarinic receptors → ↓ airway diameter
- Respiratory zone
  - Participates in gas exchange
  - Lined with alveoli
  - Terminal bronchioles–alveoli

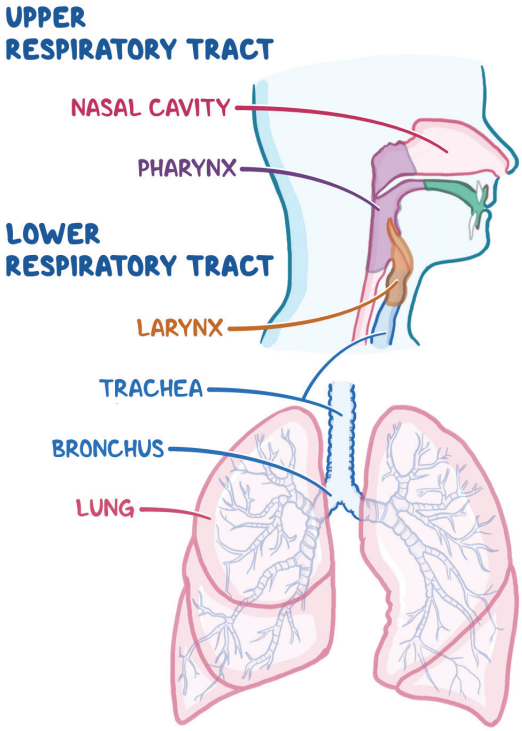

Figure 67.1 Respiratory system overview, categorized into upper, lower respiratory tracts.

RESPIRATORY SYSTEM ANATOMY

Nose

- *Function*: humidifies, warms, filters inspired air; voice resonance chamber; houses olfactory receptors
- Nasal vibrissae (hairs) coated with mucus → traps large particles (e.g. dust, pollen)

Nasal cavity

- Nasal cavity division
  - *Midline nasal septum*: composed of septal cartilage, anteriorly
  - *Vomer bone*: posteriorly
- Four paranasal sinuses (air-filled spaces inside bones) connected to nasal cavity
  - Ethmoid, frontal, sphenoid, maxillary sinuses
  - *Function*: warms, moistens inspired air; amplifies voice; lightens skull
- Roof formed by ethmoid, sphenoid bones
- Floor formed by palate
- Two mucous membrane types
  - *Olfactory mucosa*: olfactory epithelium containing smell receptors
  - *Respiratory mucosa*: pseudostratified ciliated columnar epithelium containing goblet cells; secretes mucus containing lysozyme, defensins
- Nasal conchae
  - Three mucosa-covered projections (superior, middle, inferior nasal conchae) of nasal cavity's lateral wall
  - *Meatus*: groove inferior to each conchae (superior, middle, inferior meatus)
  - *Function*: ↑ turbulence inside cavity to filter, humidify inspired air; reabsorb heat, moisture during nasal expiration

Palate

- Separates nasal cavity from oral cavity
  - *Hard palate*: anterior portion supported by palatine bones
  - *Soft palate*: posterior portion not supported by bones
  - Soft palate, uvula move together; forms valve that closes nasopharynx when swallowing (prevents food from entering nasopharynx)

Pharynx

- AKA throat
- Passageway connecting nasal cavity, larynx, oral cavity, esophagus
- *Nasopharynx*: region connecting nasal cavity to pharynx
  - Posterior to nasal cavity, inferior to sphenoid bone, superior to soft palate
  - Air-only passageway
  - Pharyngeal tonsils (adenoids); located on posterior wall; traps, kills pathogens
  - Pseudostratified ciliated epithelium (part of mucociliary escalator)
- *Oropharynx*: region connecting pharynx to oral cavity
  - Posterior to oral cavity, continuous with isthmus of fauces
  - Soft palate superior, epiglottis inferior
  - Food, air passageway
  - Pseudostratified columnar epithelium of nasopharynx → stratified squamous epithelium
  - Palatine tonsils located on lateral walls
  - Lingual tonsils cover posterior tongue
- *Laryngopharynx*: part of pharynx continuous with larynx (voice box)
  - Food, air passageway
  - Stratified squamous epithelium
  - Epiglottis anterior, esophagus posterior

Larynx

- Cartilage, connective tissue framework
  - Connects pharynx to trachea; houses vocal cords, epiglottis (cartilage flap atop larynx that seals airway off when swallowing—prevents food entering larynx)
- Location
  - Third to sixth cervical vertebra
  - *Superior*: hyoid bone
  - *Inferior*: trachea
- Function
  - Routes food, air into appropriate passageway; voice production
- Histology
  - *Superior portion:* contacts food; stratified squamous epithelium
  - *Inferior portion:* below vocal folds; pseudostratified ciliated columnar epithelium (part of mucociliary escalator)

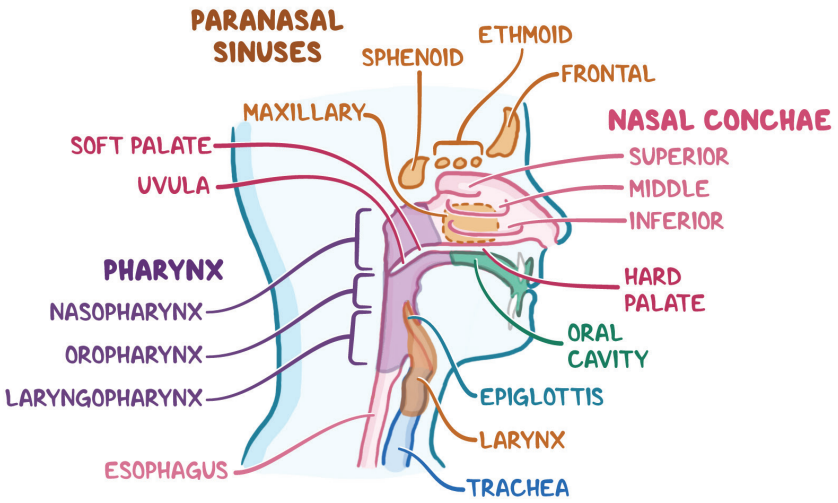

Figure 67.2 Anatomy of upper respiratory tract, surrounding structures.

- Contains nine cartilages
  - *Thyroid cartilage*: large shield-shaped midline cartilage, produces laryngeal prominence ("Adam's apple")
  - *Cricoid* cartilage: ring-shaped cartilage inferior to thyroid cartilage, superior to trachea
  - *Arytenoid, cuneiform, corniculate cartilages*: form posterior, lateral larynx walls (arytenoid cartilages anchor vocal cords)
  - *Epiglottis*: spoon-shaped cartilage is pulled superiorly to cover laryngeal inlet during swallowing (prevents food from passing through larynx)
- Vocal folds/ligaments
  - Attach arytenoid cartilages to thyroid cartilage
  - *True vocal cords*: sound production (function); composed of elastic fibers; core of mucosal folds; appears white (avascularity)
  - *False vocal cords*: superior to true vocal cords; does not participate in sound production; close glottis during swallowing (function)

Trachea

- AKA windpipe
- Mainstem bronchi, airways
- Trachea
  - Tube smooth muscle, connective tissue, C-shaped cartilage (provides support, maintains open passage for air)
  - Connected by trachealis muscle
  - Runs from larynx, divides into two main bronchi inferiorly at carina
- Layers (superficial to deep)
  - *Mucosa*: pseudostratified epithelium with goblet cells; mucociliary escalator
  - *Submucosa*: connective tissue layer (supported by 16–20 C-shaped cartilage rings)
  - *Adventitia*: connective tissue layer encasing cartilage rings

Right & left mainstem bronchus

- Right mainstem bronchus
  - Wider, more vertical
  - Something accidentally inhaled → goes into right lung (more likely)
- Inside lungs
  - Main bronchus subdivides into lobar bronchi → segmental bronchi → terminal bronchioles
- Trachea, first three bronchial generations
  - Wide, supported by cartilage rings
- Large airways lined by ciliated columnar cells, goblet cells (secrete mucus)
  - *Mucociliary escalator*: mucus traps particles → ciliated columnar cells beat rhythmically → moves mucus, trapped particles towards pharynx → spit out/swallowed

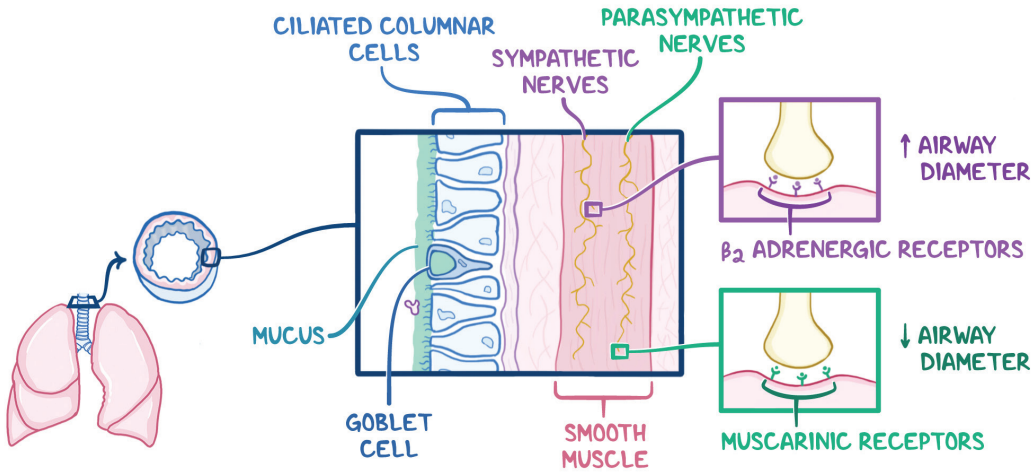

Figure 67.3 Section of tracheal wall showing its histology. Stimulation by sympathetic nerves dilates airways, stimulation by parasympathetic nerves constricts airways.

Histological changes as conducting tubes decrease

- Cartilage
  - Cartilage amount ↓ while elastic fibers ↑ (bronchioles contain no cartilage)
- Epithelium
  - Mucosal epithelium changes from pseudostratified columnar → columnar → cuboidal
  - Goblet cells, cilia ↓ (completely absent in bronchioles)
- Smooth muscle ↑

Bronchioles

- Narrow airways after first three bronchial generations
- *Terminal bronchioles*: last part of terminal bronchioles, end of conducting zone
- *Respiratory bronchioles*: distal to terminal bronchioles, first part of respiratory zone
- Terminal bronchiole → respiratory bronchiole → alveolar ducts → alveolar sac → alveoli

Alveoli

- Alveolar wall
  - Composed of a single simple squamous epithelium layer
- Elastic fibers surround alveoli → allow lung expansion during inspiration, recoil during expiration
  - *Type I pneumocytes*: primary gas exchange site; oxygen–carbon dioxide exchange occurs between alveolar gas, pulmonary capillary blood; thin walls, large alveoli surface-area maximizes gas exchange diffusion capabilities
  - *Type II pneumocytes*: secrete surfactant (↓ surface tension within alveoli → eases expansion, prevents collapsing
- Alveolar macrophages phagocytize particles inside lungs → conducting bronchioles → mucociliary escalator
- Respiratory membrane
  - Capillary, alveolar walls; basement membranes
- Alveolar pores connect adjacent alveoli
- Blood supply
  - Pulmonary capillary networks

Lungs

- Main respiration organs
- Right lung
  - *Three lobes*: upper, middle, lower lobe
- Left lung
  - *Two lobes*: upper, lower lobe
- Base of lungs rest on diaphragm
- *Pleura*: double-layered serosa covering lungs, pleural fluid lining pleural cavity between two layers
  - *Parietal pleura*: outer layer adherent to thoracic wall, superior surface of diaphragm
  - *Visceral pleura*: inner layer adherent to external lung surface

- Pulmonary circulation
  - Pulmonary veins (anterior to main bronchi) bring oxygen-rich blood to lungs from heart
  - Pulmonary arteries bring oxygen-poor systemic venous blood for oxygenation
  - Low-pressure, high-volume circulation
- Bronchial circulation
  - *Bronchial arteries*: provide oxygenated systemic blood to lung tissue
  - *Bronchial veins*: drain deoxygenated venous blood from lungs (with pulmonary veins)
  - High-pressure, low-volume circulation
- Innervation
  - Pulmonary plexus
  - Parasympathetic motor causes bronchoconstriction
  - Sympathetic motor causes bronchodilation
  - Visceral sensory
  - Diaphragm innervated by phrenic nerve

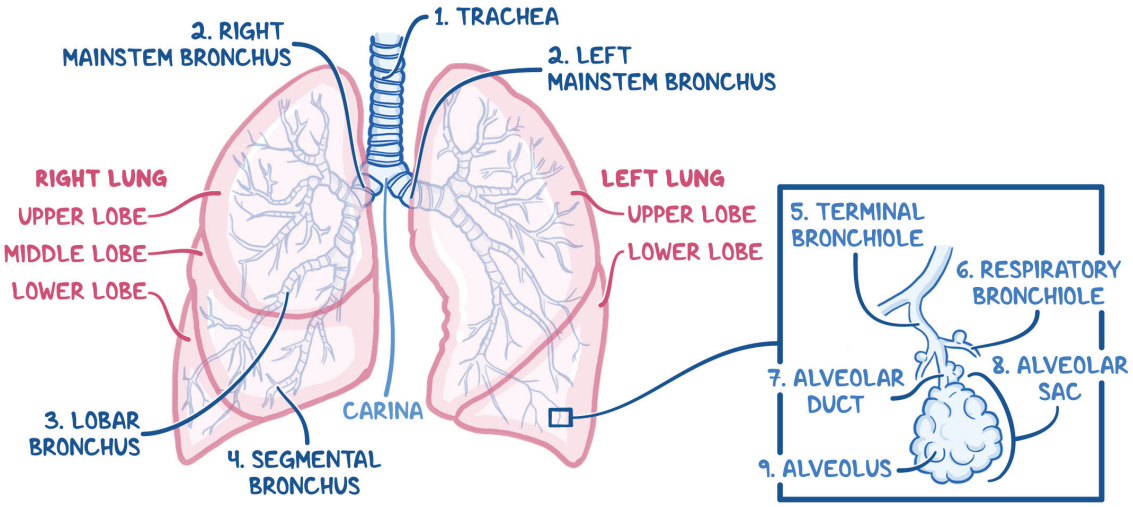

Figure 67.4 Trachea and lung anatomy. Numbered labels show sequence of airflow going into the airways from (trachea to alveoli).

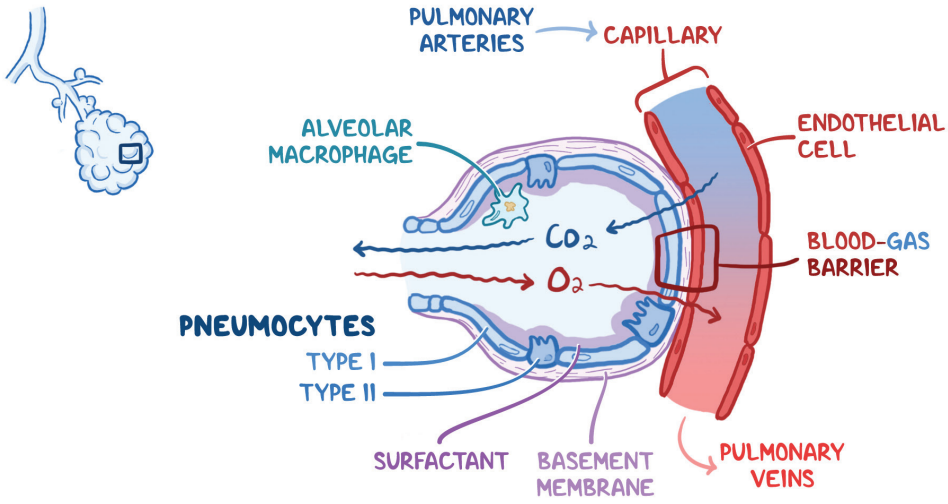

Figure 67.5 Alveolus structure. Gas exchange occurs at the blood-gas barrier. De-oxygenated blood from pulmonary arteries are oxygenated then sent to pulmonary veins.

VENTILATION

- *Ventilation (breathing)*: moving air in, out of lungs
- Oxygen pathway
  - Air inhaled through nostrils → nasal cavity → pharynx → larynx → trachea → mainstem bronchus → conducting bronchioles → terminal bronchioles → respiratory bronchioles → alveolar duct → alveoli → capillary → body
  - Carbon dioxide moves in reverse
- Airflow from atmosphere to lungs
  - Higher pressure → lower pressure
- Muscle movement creates pressure gradient
  - *Primary respiration muscles*: diaphragm, external intercostals, scalenes
  - *Forceful breathing*: other muscles recruited
- *Airflow resistance*: function of respiratory passage diameter
- *Passive inhalation*: negative pressure inside body generated → moves air into lungs
  - Diaphragm contracts downwards, chest muscles pull ribs outward → ↑ intrathoracic volume → ↓ intrathoracic pressure → air moved into lungs (air flows down pressure gradient)
- *Passive exhalation*: ↑ intrathoracic pressure generated → moves air out of lungs
  - Diaphragm relaxes (returns to resting position), external intercostal muscles relax, thoracic cage recoils → elastic lung recoil → ↓ intrathoracic volume → ↑ intrathoracic pressure → air pushed out of lungs