The Respiratory System

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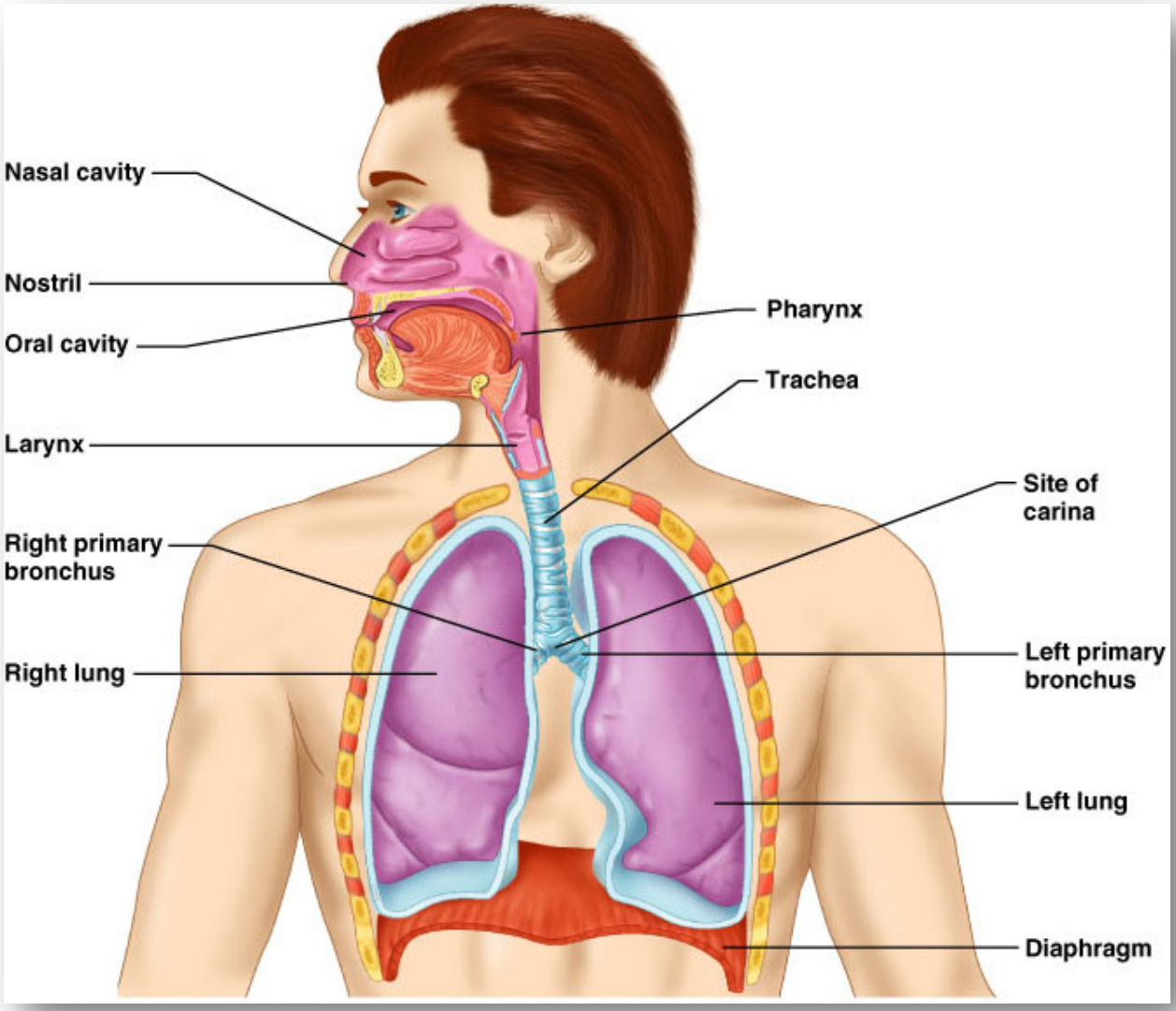


Major Functions of the Respiratory System

- To supply the body with oxygen and dispose of CO2
- Respiration – four distinct processes must happen
    - Pulmonary ventilation – moving air into and out of the lungs
    - External respiration – gas exchange between the lungs and the blood
    - Transport – transport of oxygen and carbon dioxide between the lungs and tissues
    - Internal respiration – gas exchange between systemic blood vessels and tissues

Respiratory System

- Consists of the respiratory and conducting zones
- Respiratory zone
    - Site of gas exchange
    - Consists of bronchioles, alveolar ducts, and alveoli
- Conducting zone
    - Provides rigid conduits for air to reach the sites of gas exchange
    - Includes all other respiratory structures (e.g., nose, nasal cavity, pharynx, trachea)
- Respiratory muscles – diaphragm and other muscles that promote ventilation

Function of the Nose

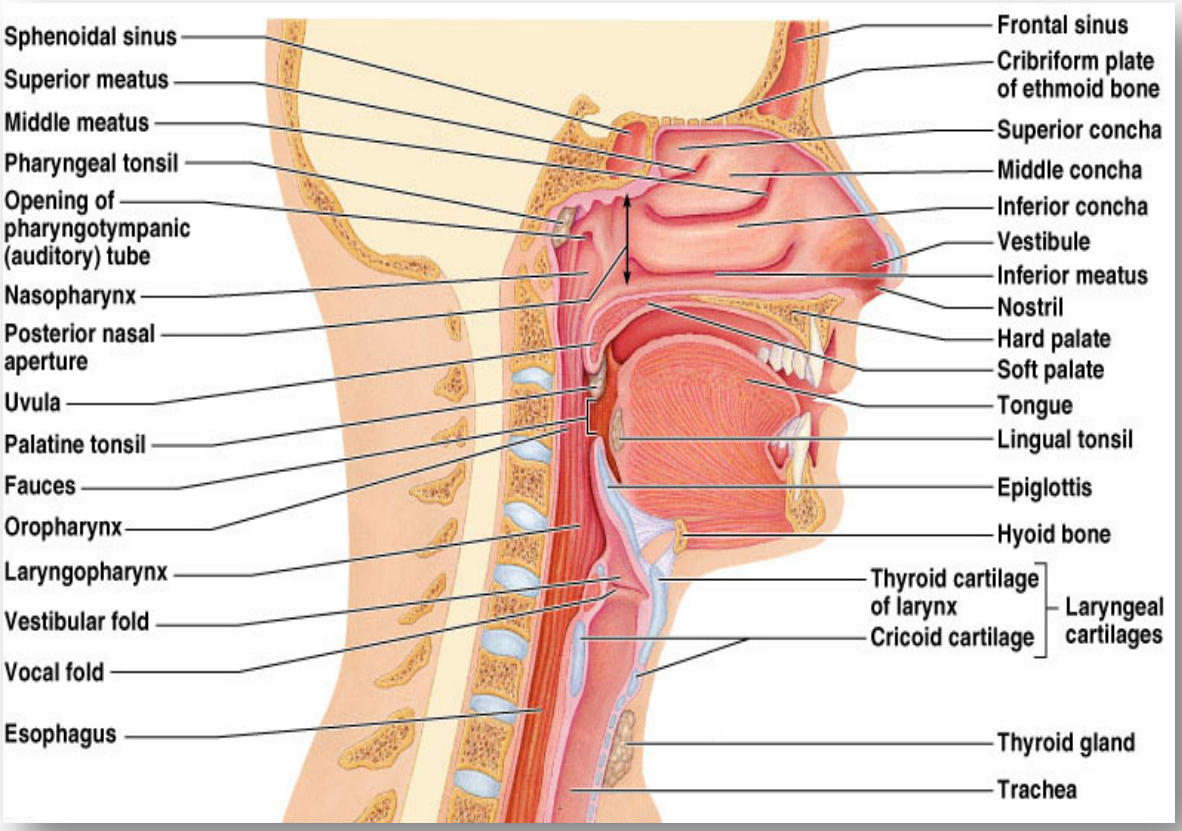
- The only externally visible part of the respiratory system that functions by:
    - Providing an airway for respiration
    - Moistening and warming the entering air
    - Filtering inspired air and cleaning it of foreign matter
    - Serving as a resonating chamber for speech
    - Housing the olfactory receptors

Structure of the Nose

- The nose is divided into two regions
    - The external nose
    - The internal nasal cavity

Nasal Cavity

- Lies in and posterior to the external nose
- Is divided by a midline nasal septum
- Vestibule – nasal cavity superior to the nares
    - Vibrissae – hairs that filter coarse particles from inspired air
- Olfactory mucosa
    - Lines the superior nasal cavity
    - Contains smell receptors
- Respiratory mucosa
    - Lines the balance of the nasal cavity
    - Glands secrete mucus containing lysozyme and defensins to help destroy bacteria



Nasal Cavity

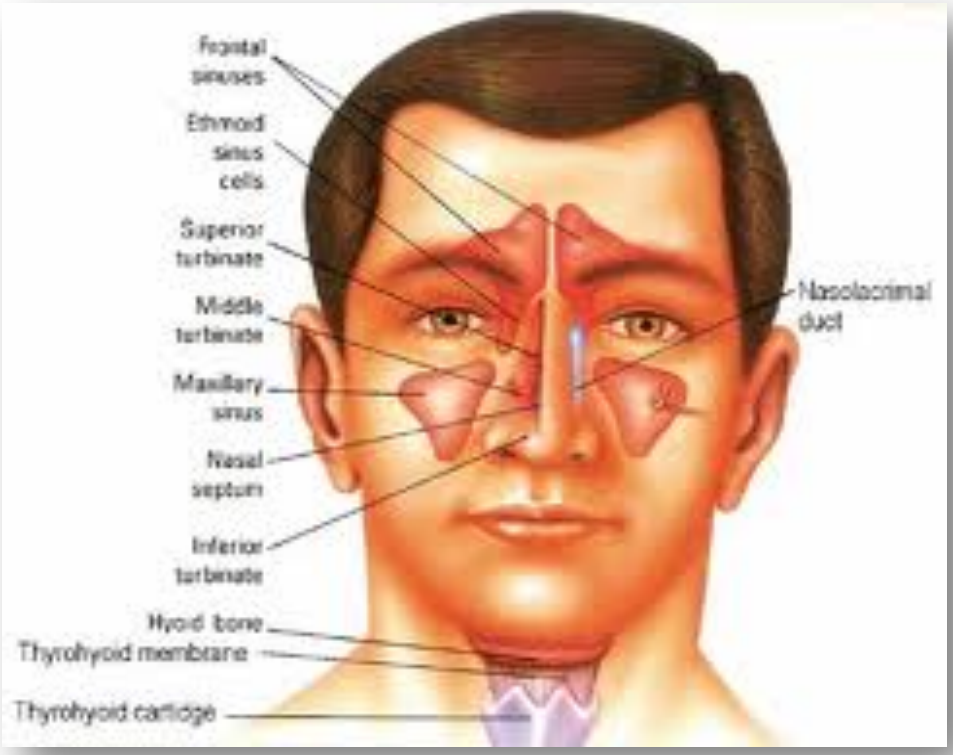
- Inspired air is:
  - Humidified by the high water content in the nasal cavity
  - Warmed by rich plexuses of capillaries
- Ciliated mucosal cells remove contaminated mucus
- Superior, medial, and inferior conchae:
  - Increase mucosal area
  - Enhance air turbulence and help filter air
  - Sensitive mucosa triggers sneezing when stimulated by irritating particles

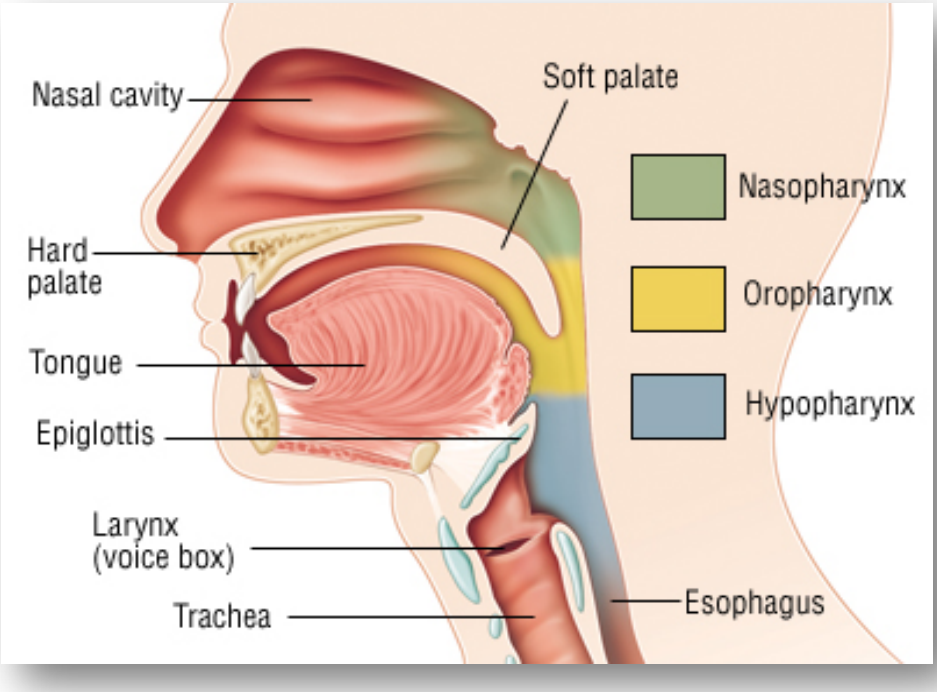
Functions of the Nasal Mucosa and Conchae

- During inhalation the conchae and nasal mucosa:
  - Filter, heat, and moisten air
- During exhalation these structures:
  - Reclaim heat and moisture
  - Minimize heat and moisture loss

Paranasal Sinuses

- Sinuses in bones that surround the nasal cavity
- Sinuses lighten the skull and help to warm and moisten the air


Frontal sinuses
Ethmoid sinus cells
Superior turbinate
Middle turbinate
Maxillary sinus
Nasal septum
Inferior turbinate
Hyoid bone
Thyrohyoid membrane
Thyrohyoid cartilage
Nasolacrimal duct


Nasal cavity
Soft palate
Nasopharynx
Hard palate
Oropharynx
Tongue
Hypopharynx
Epiglottis
Larynx (voice box)
Esophagus
Trachea

Pharynx

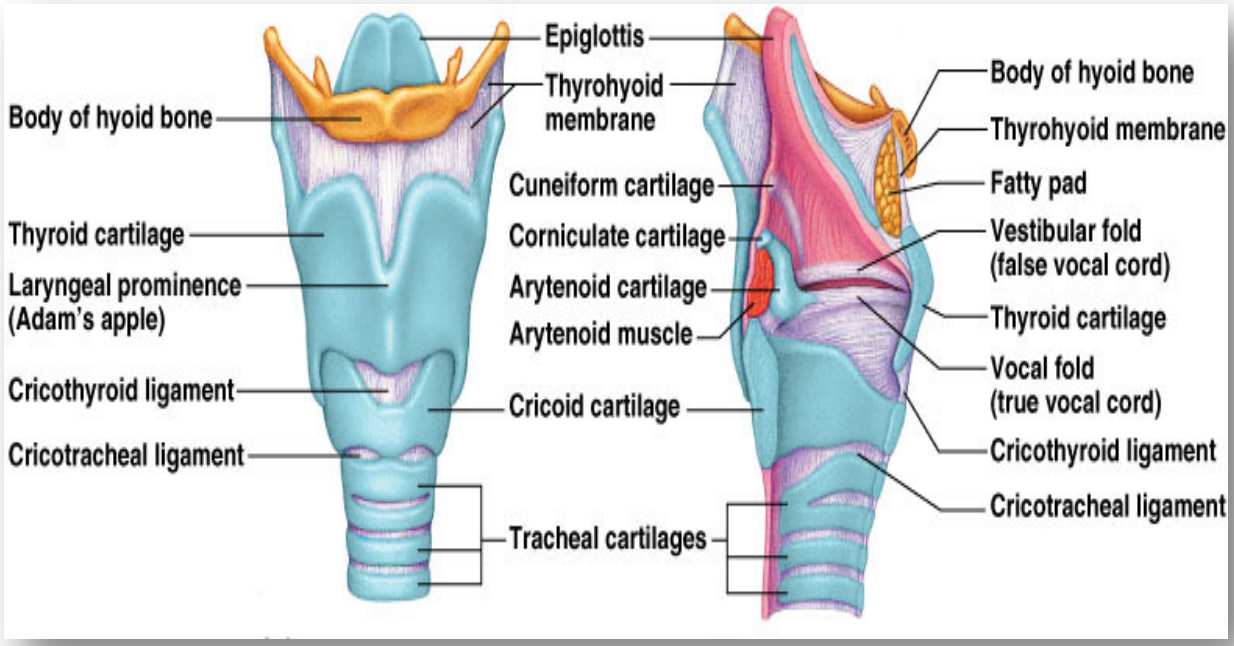
- Funnel-shaped tube of skeletal muscle that connects to the:
  - Nasal cavity and mouth superiorly
  - Larynx and esophagus inferiorly
- Extends from the base of the skull to the level of the sixth cervical vertebra

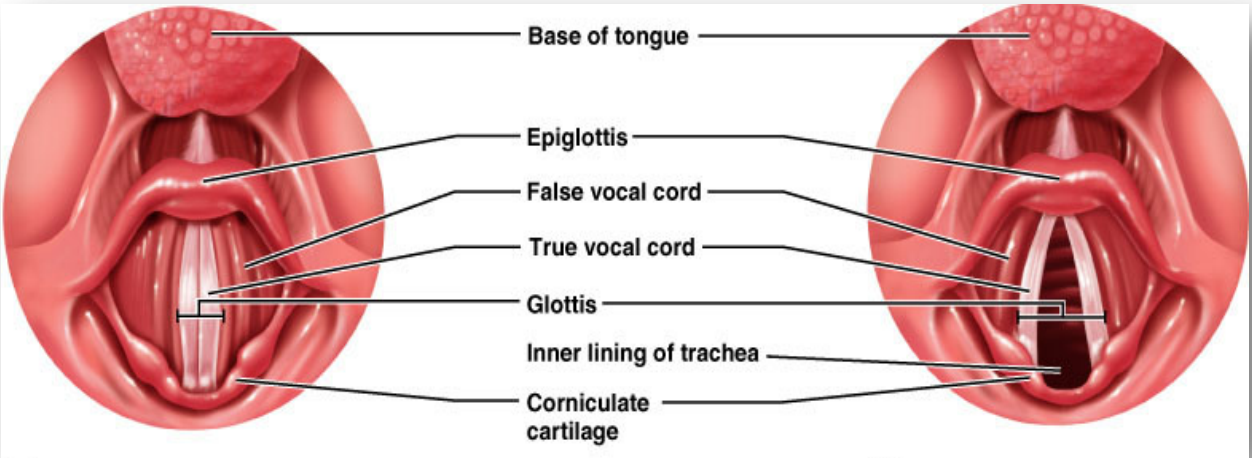
Pharynx – Divided Into Three Regions

- Nasopharynx
  - Strictly an air passageway
  - Closes during swallowing to prevent food from entering the nasal cavity
- Oropharynx
  - Opens to the oral cavity via an archway called the fauces
  - Serves as a common passageway for food and air
- Laryngopharynx
  - Serves as a common passageway for food and air
  - Extends to the larynx, where the respiratory and digestive pathways diverge

Larynx (Voice Box)

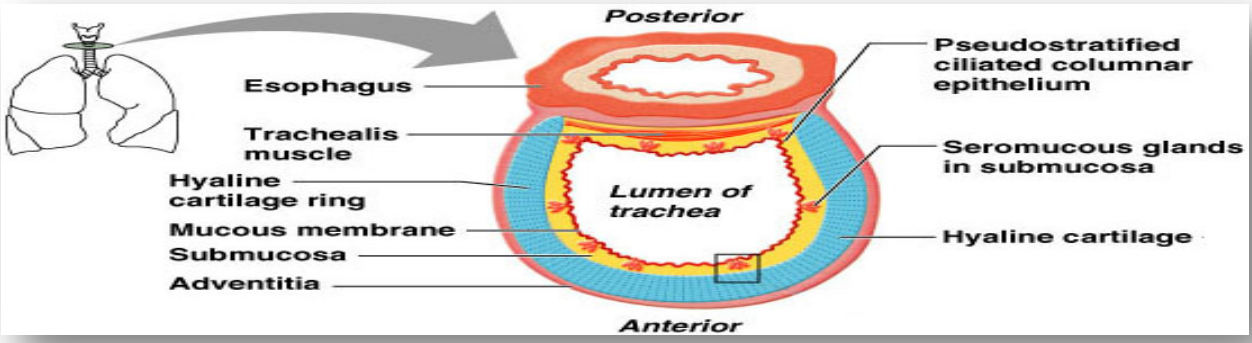
- Superiorly attaches to the hyoid bone. Inferiorly attaches to the trachea
- The three functions of the larynx are:
  - To provide a patent airway
  - To act as a switching mechanism to route air and food into the proper channels
  - To function in voice production
- Epiglottis – elastic cartilage that covers the laryngeal inlet during swallowing





Trachea

- Flexible and mobile tube extending from the larynx into the mediastinum
- Composed of three layers
    - Mucosa – made up of goblet cells and ciliated epithelium
    - Submucosa – connective tissue deep to the mucosa
    - Adventitia – outermost layer made of C-shaped rings of hyaline cartilage

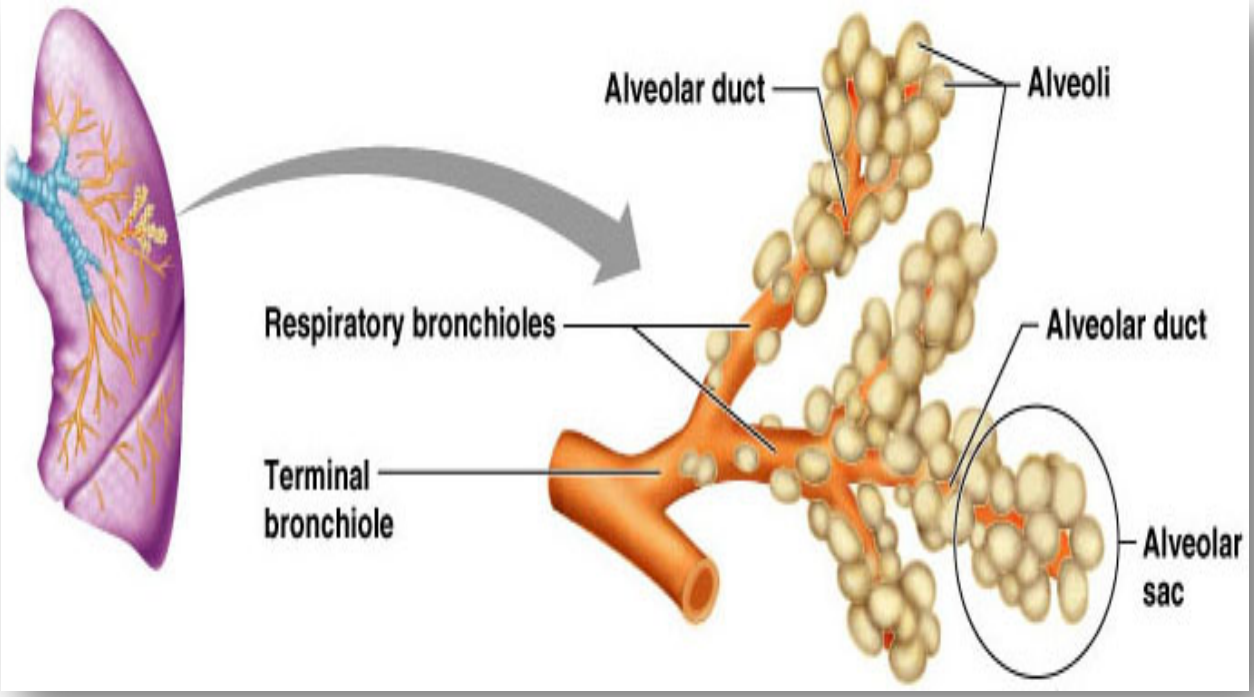


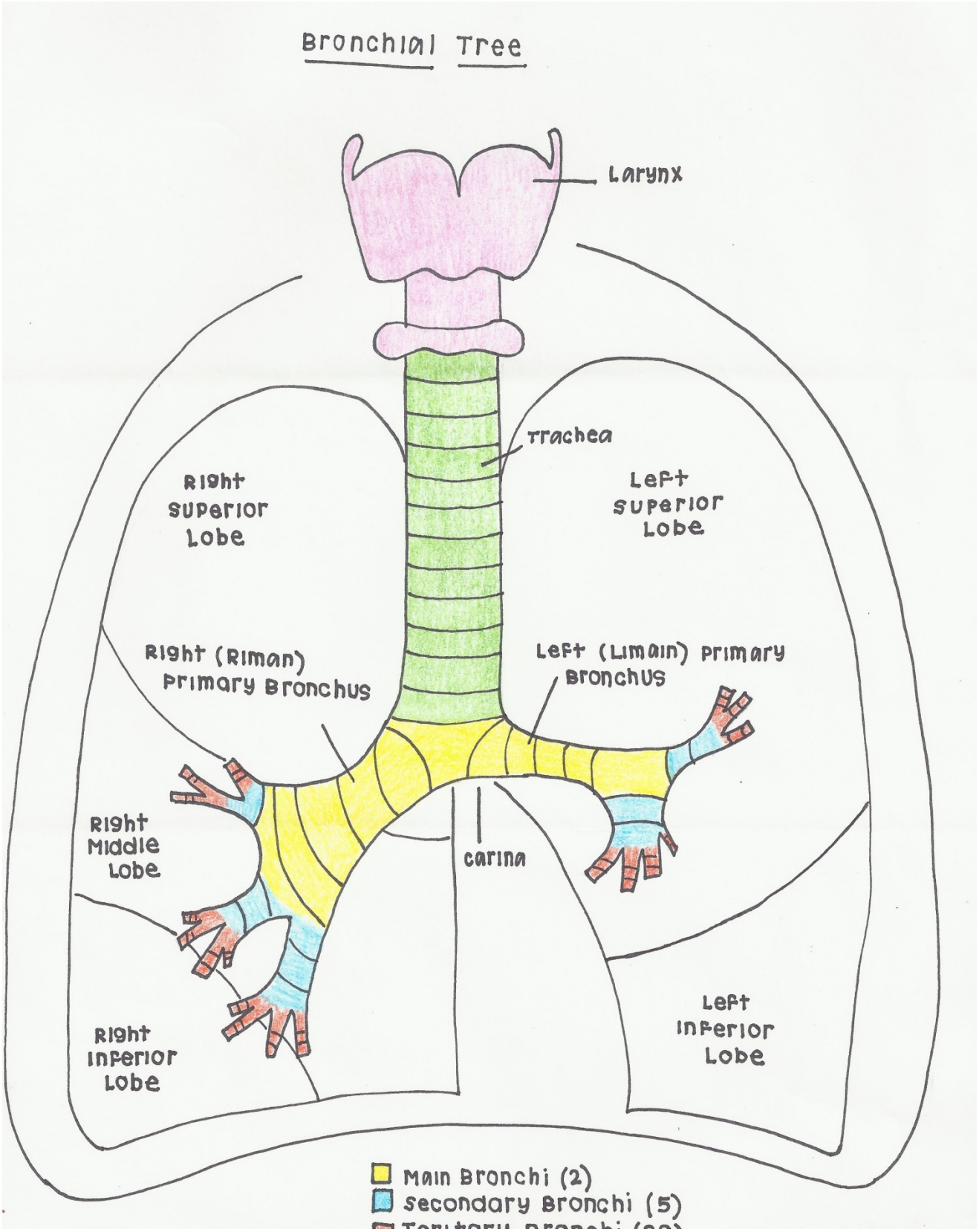
Conducting Zone: Bronchi

- The carina of the last tracheal cartilage marks the end of the trachea and the beginning of the right and left bronchi
- Air reaching the bronchi is:
    - Warm and cleansed of impurities
    - Saturated with water vapor
- Bronchi subdivide into secondary bronchi, each supplying a lobe of the lungs
- Air passages undergo 23 orders of branching in the lungs

Respiratory Zone

- Defined by the presence of alveoli; begins as terminal bronchioles feed into respiratory bronchioles
- Respiratory bronchioles lead to alveolar ducts, then to terminal clusters of alveolar sacs composed of alveoli
- Approximately 300 million alveoli:
    - Account for most of the lungs' volume
    - Provide tremendous surface area for gas exchange





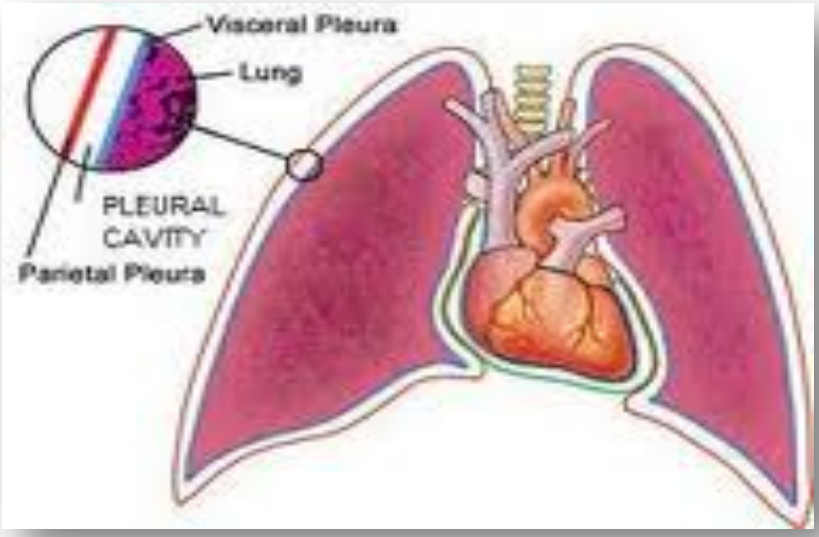
By Kayla Kern – OT Student

Gross Anatomy of the Lungs

- Lungs occupy all of the thoracic cavity except the mediastinum
    - Root – site of vascular and bronchial attachments
    - Costal surface – anterior, lateral, and posterior surfaces in contact with the ribs
    - Apex – narrow superior tip
    - Base – inferior surface that rests on the diaphragm
    - Hilus – indentation that contains pulmonary and systemic blood vessel
    - Cardiac notch (impression) – cavity that accommodates the heart
    - Left lung – separated into upper and lower lobes by the oblique fissure
    - Right lung – separated into three lobes by the oblique and horizontal fissures
    - There are 10 bronchopulmonary segments in each lung

Pleurae

- Thin, double-layered serosa
- Parietal pleura
    - Covers the thoracic wall and superior face of the diaphragm
    - Continues around heart and between lungs
- Visceral, or pulmonary, pleura
    - Covers the external lung surface
    - Divides the thoracic cavity into three chambers
        - The central mediastinum
        - Two lateral compartments, each containing a lung



Breathing

- Breathing, or pulmonary ventilation, consists of two phases
    - Inspiration – air flows into the lungs
    - Expiration – gases exit the lungs

Pressure Relationships in the Thoracic Cavity

- Respiratory pressure is always described relative to atmospheric pressure
- Atmospheric pressure
    - Pressure exerted by the air surrounding the body
- Intrapulmonary pressure – pressure within the alveoli
- Intrapleural pressure – pressure within the pleural cavity
- Two forces act to pull the lungs away from the thoracic wall, promoting lung collapse
    - Elasticity of lungs causes them to assume smallest possible size
    - Surface tension of alveolar fluid draws alveoli to their smallest possible size
- Opposing force – elasticity of the chest wall pulls the thorax outward to enlarge the lungs

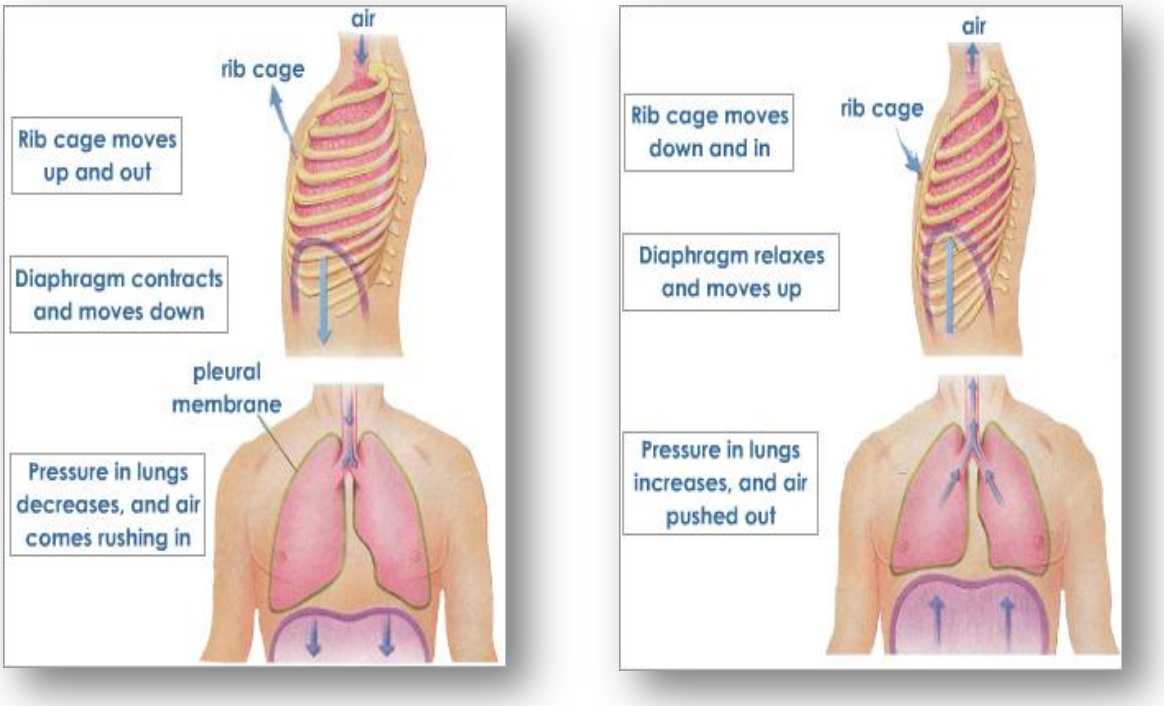
Inspiration

- The diaphragm and intercostal muscles (inspiratory muscles) contract and the rib cage rises
- The lungs are stretched and intrapulmonary volume increases
- Air flows into the lungs

Expiration

- Intercostal muscles relax and the rib cage descends due to gravity
- Thoracic cavity volume decreases
- Elastic lungs recoil passively and intrapulmonary volume decreases
- Gases flow out of the lungs

Inspiration **Expiration**



Airway Resistance

- As airway resistance rises, breathing movements become more strenuous
- Severely constricted or obstructed bronchioles:
    - Can prevent life-sustaining ventilation
    - Can occur during acute asthma attacks which stops ventilation
- Epinephrine release via the sympathetic nervous system dilates bronchioles and reduces air resistance

Alveolar Surface Tension

- Surface tension – the attraction of liquid molecules to one another at a liquid-gas interface
- The liquid coating the alveolar surface is always acting to reduce the alveoli to the smallest possible size
- Surfactant, a detergent-like complex, reduces surface tension and helps keep the alveoli from collapsing

Lung Compliance

- The ease with which lungs can be expanded
- Determined by two main factors
    - Distensibility of the lung tissue and surrounding thoracic cage
    - Surface tension of the alveoli

Factors That Diminish Lung Compliance

- Scar tissue or fibrosis that reduces the natural resilience of the lungs
- Blockage of the smaller respiratory passages with mucus or fluid
- Reduced production of surfactant
- Decreased flexibility of the thoracic cage or its decreased ability to expand
- Examples include:
    - Deformities of thorax
    - Ossification of the costal cartilage
    - Paralysis of intercostal muscles

Respiratory Volumes

- *Tidal volume* - Air that moves into and out of the lungs with each breath (approximately 500 ml)
- *Inspiratory reserve volume* - Air that can be inspired forcibly beyond the tidal volume (2100–3200 ml)
- *Expiratory reserve volume* - Air that can be evacuated from the lungs after a tidal expiration (1000–1200 ml)
- *Residual volume* - Air left in the lungs after strenuous expiration (1200 ml)

Respiratory Capacities

- *Inspiratory capacity* - Total amount of air that can be inspired after a tidal expiration
- *Functional residual capacity* - Amount of air remaining in the lungs after a tidal expiration
- *Vital capacity* - The total amount of exchangeable air
- *Total lung capacity* - Sum of all lung volumes

Surface Area and Thickness of the Respiratory Membrane

- Respiratory membranes:
    - Thicken if lungs become waterlogged and edematous, whereby gas exchange is inadequate and oxygen deprivation results
    - Decrease in surface area with emphysema, when walls of adjacent alveoli break through

Oxygen Transport

- Molecular oxygen is carried in the blood:
- Bound to hemoglobin (Hb) within red blood cells
- Dissolved in plasma

Hypoxia – Low Oxygen to the Tissues

- Anemic hypoxia
    - Poor oxygen delivery from too few RBCs
- Ischemic or stagnant hypoxia
    - Occurs when blood circulation is impaired or blocked
- Histotoxic hypoxia
    - Occurs when body cells are unable to use oxygen

Hypoxia – Low Oxygen to the Tissues - continued

- Hypoxemic hypoxia
    - Seen in reduced oxygen pressure

Carbon Dioxide Transport

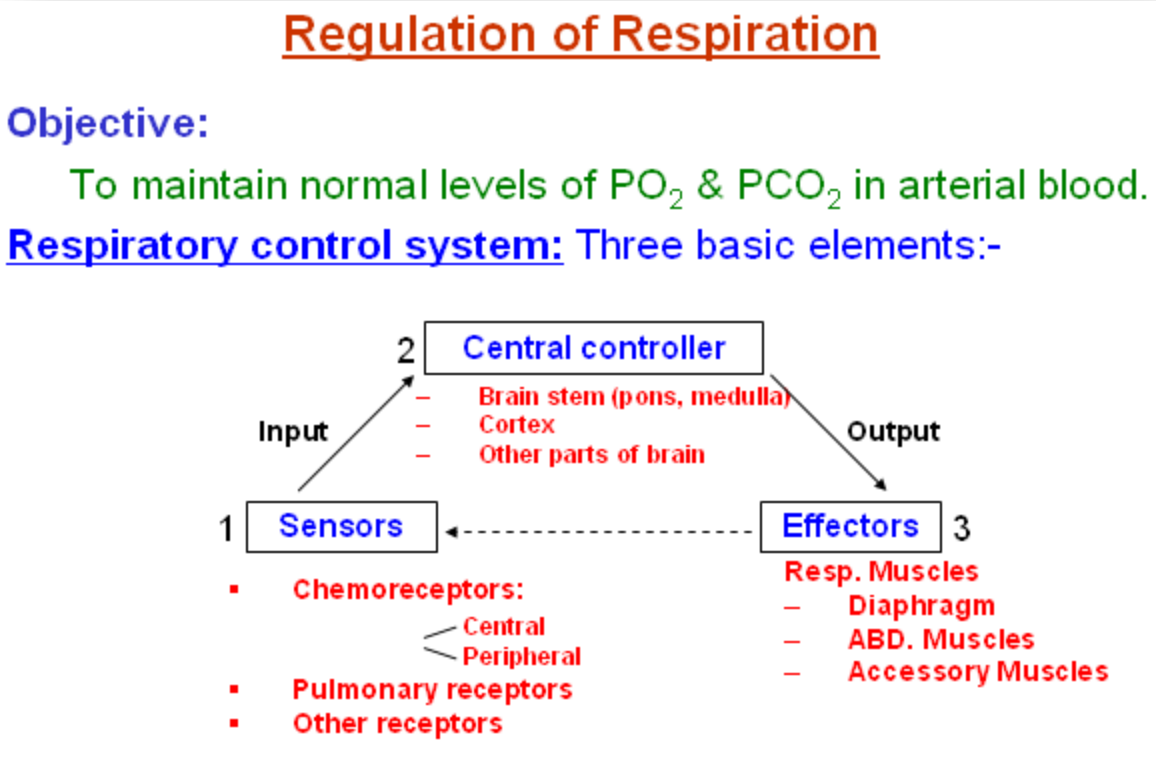
- CO2 is transported in the blood in three forms
    - Dissolved in plasma – 7 to 10%
    - Chemically bound to hemoglobin – 20% is carried in RBCs
    - Bicarbonate ion in plasma – 70% is transported as bicarbonate

Control of Respiration: Medullary Respiratory Centers

- The dorsal respiratory group or inspiratory center
    - Appears to be the pacesetting respiratory center
    - Excites the inspiratory muscles and sets breath rates (12-15 breaths/minute)
    - Becomes dormant during expiration
- The ventral respiratory group is involved in forced inspiration and expiration

Depth and Rate of Breathing: Higher Brain Centers

- Hypothalamic controls act through the limbic system to modify rate and depth of respiration
    - Example: breath holding that occurs in anger
- A rise in body temperature acts to increase respiratory rate
- Cortical controls are direct signals from the cerebral motor cortex that bypass medullary controls
    - Examples: voluntary breath holding, taking a deep breath

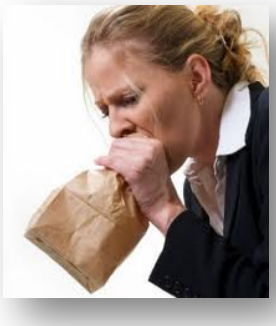


Hyperventilation

- Increase in the rate and depth of breathing that exceeds the bodies need to remove CO2
- Occurs when low CO2 levels in the blood cause cerebral blood vessels to constrict which produces cerebral ischemia

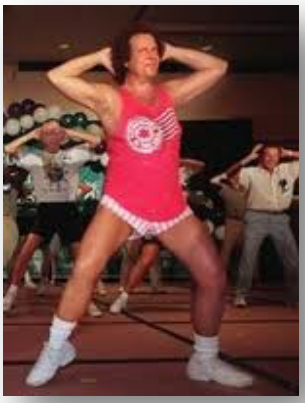
Hypoventilation

- Hypoventilation – slow and shallow breathing due to abnormally low P_{CO2} levels
    - Apnea (breathing cessation) may occur until P_{CO2} levels rise



Respiratory Adjustments: Exercise

- Respiratory adjustments are geared to both the intensity and duration of exercise
- During vigorous exercise:
    - Ventilation can increase 20 fold
    - Breathing becomes deeper and more vigorous, but respiratory rate may not be significantly changed (hyperpnea)
- As exercise begins
    - Ventilation increases abruptly, rises slowly, and reaches a steady state
- When exercise stops
    - Ventilation declines suddenly, then gradually decreases to normal
- Neural factors bring about the above changes, including:
    - Psychic stimuli
    - Cortical motor activation
    - Excitatory impulses from proprioceptors in muscles

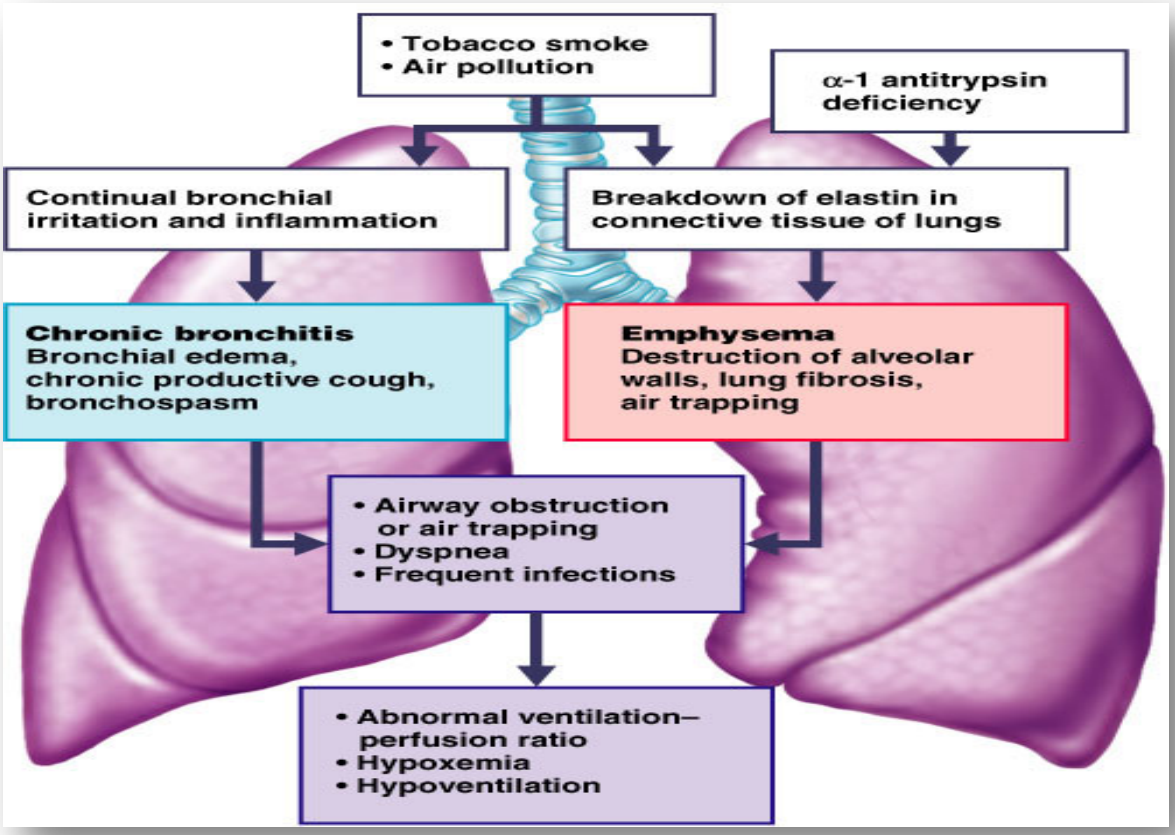


Respiratory Adjustments: High Altitude

- The body responds to quick movement to high altitude (above 8000 ft) with symptoms of acute mountain sickness – headache, shortness of breath, nausea, and dizziness
- Acclimatization – respiratory and hematopoietic adjustments to altitude

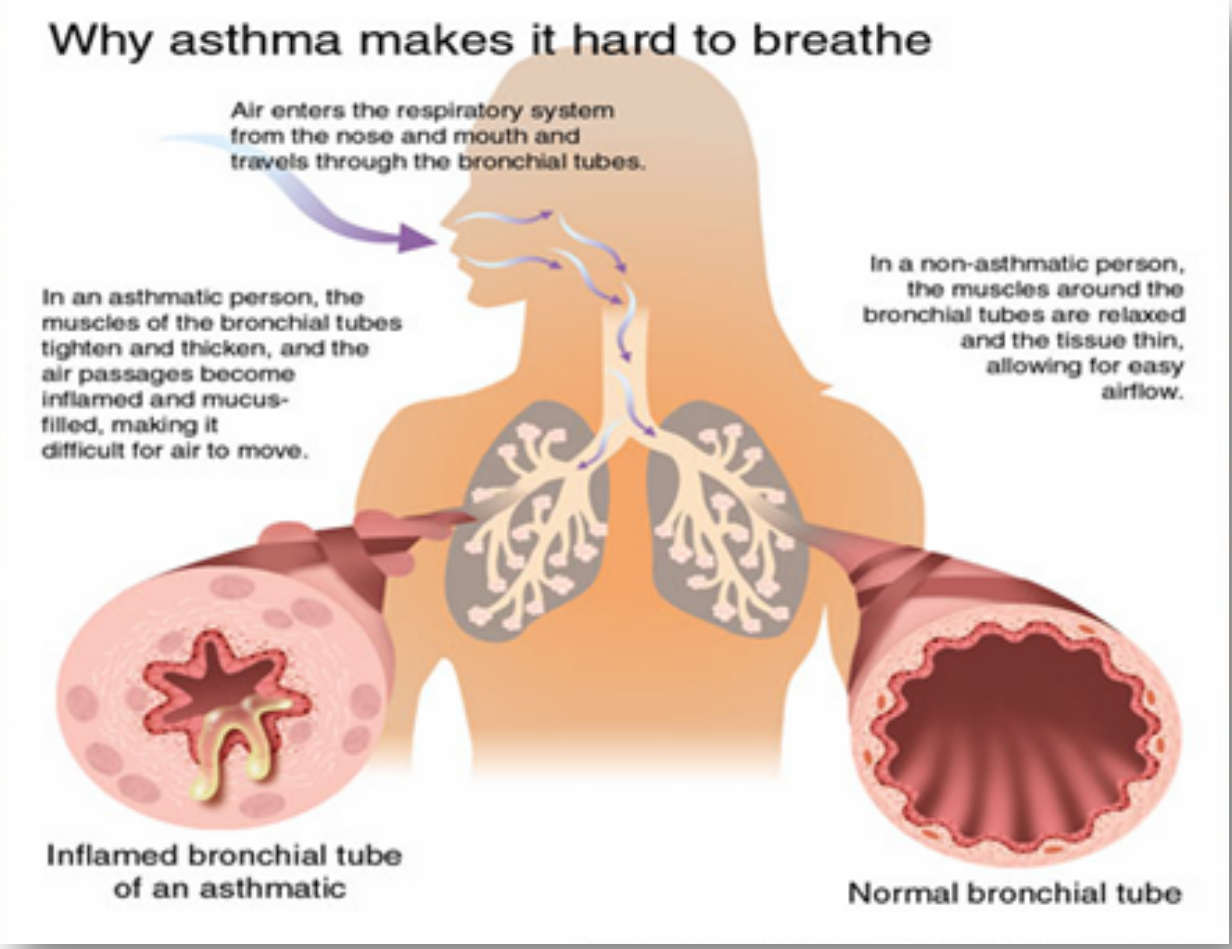
Chronic Obstructive Pulmonary Disease (COPD)

- Exemplified by chronic bronchitis and obstructive emphysema
- Patients have a history of:
    - Smoking
    - Dyspnea, where labored breathing occurs and gets progressively worse
    - Coughing and frequent pulmonary infections
- COPD victims develop respiratory failure accompanied by hypoxemia, carbon dioxide retention, and respiratory acidosis



Asthma

- Characterized by dyspnea, wheezing, and chest tightness
- Active inflammation of the airways precedes bronchospasms
- Airway inflammation is an immune response caused by release of IL-4 and IL-5, which stimulate IgE and recruit inflammatory cells
- Airways thickened with inflammatory exudates magnify the effect of bronchospasms
- Asthma is a process that affects the airways with excessive mucus production, bronchial muscle contraction, and swelling causing obstruction.
- During an asthma attack, spasms in the muscles and bronchi constrict, impeding the outward passage of stale air. Sufferers can get starved for air with coughing, wheezing and chest tightness.
- Recently, asthma has been found to be a chronic inflammatory process with the prior symptoms.
- Most of the research has been aimed at determining what might trigger asthma responses and what to avoid.
- Incidence
    - In the last decade the incidence of asthma has increased by 1/3
    - 20 million people in the US
    - 6 million children and 14 million adults
    - Children under 16 and adults over 65 are more prone


Why asthma makes it hard to breathe
Air enters the respiratory system from the nose and mouth and travels through the bronchial tubes.
In an asthmatic person, the muscles of the bronchial tubes tighten and thicken, and the air passages become inflamed and mucus-filled, making it difficult for air to move.
In a non-asthmatic person, the muscles around the bronchial tubes are relaxed and the tissue thin, allowing for easy airflow.
Inflamed bronchial tube of an asthmatic
Normal bronchial tube


Pollen
Dust mites
Mold
Pet dander
ADAM.

Lung Cancer

- Accounts for 1/3 of all cancer deaths in the U.S.
- 90% of all patients with lung cancer were smokers
- The three most common types are:
    - Squamous cell carcinoma (20-40% of cases) arises in bronchial epithelium
    - Adenocarcinoma (25-35% of cases) originates in peripheral lung area
    - Small cell carcinoma (20-25% of cases) contains lymphocyte-like cells that originate in the primary bronchi and subsequently metastasize

Lifespan Changes

- By the 28th week, a baby born prematurely can breathe on its own
- During fetal life, the lungs are filled with fluid and blood bypasses the lungs
- Gas exchange takes place via the placenta
- At birth, respiratory centers are activated, alveoli inflate, and lungs begin to function
- Respiratory rate is highest in newborns and slows until adulthood
- Lungs continue to mature and more alveoli are formed until young adulthood
- Respiratory efficiency decreases in old age
- Lifespan changes reflect an accumulation of environmental influences and the effects of aging in other organ systems, and may include:
    - The cilia become less active
    - Mucous thickening
    - Swallowing, gagging, and coughing reflexes slowing
    - Macrophages in the lungs lose efficiency
    - An increased susceptibility to respiratory infections
    - A “barrel chest” may develop
    - Bronchial walls thin and collapse
    - Dead space increasing