



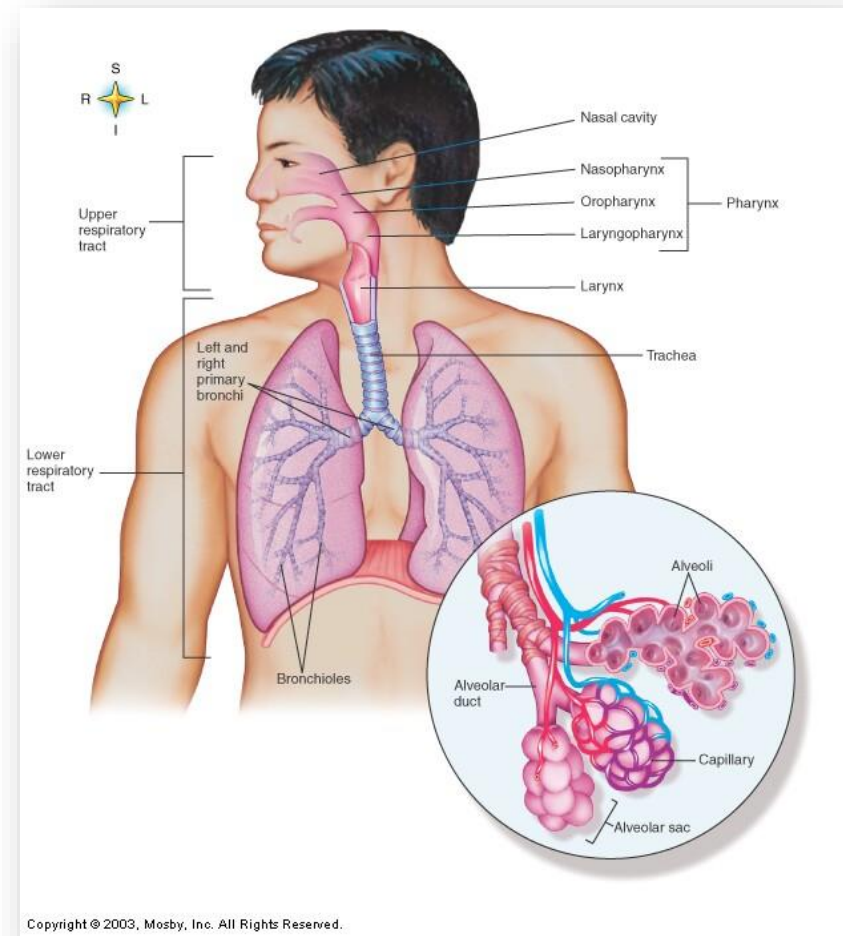
RESPIRATORY ANATOMY

DND Primary Care Paramedicine

Module: 03

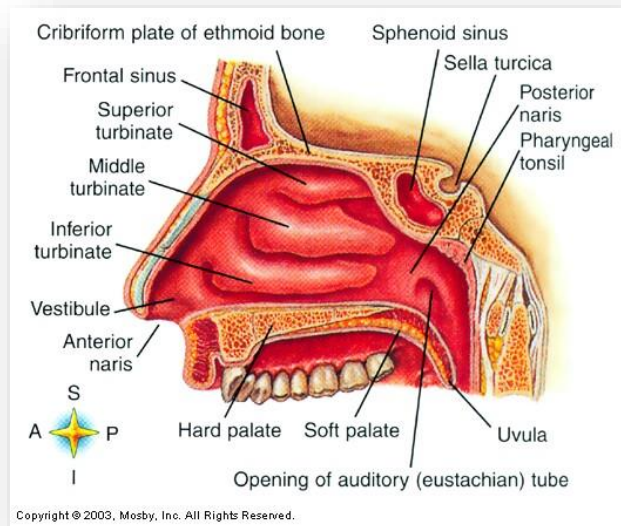
Section: 01

- Divided into two sections:
 - Upper Airway
 - Lower Airway



- Nasal cavity
- Oral Cavity
- Pharynx
 - Nasopharynx
 - Oropharynx
 - Laryngopharynx
- Larynx

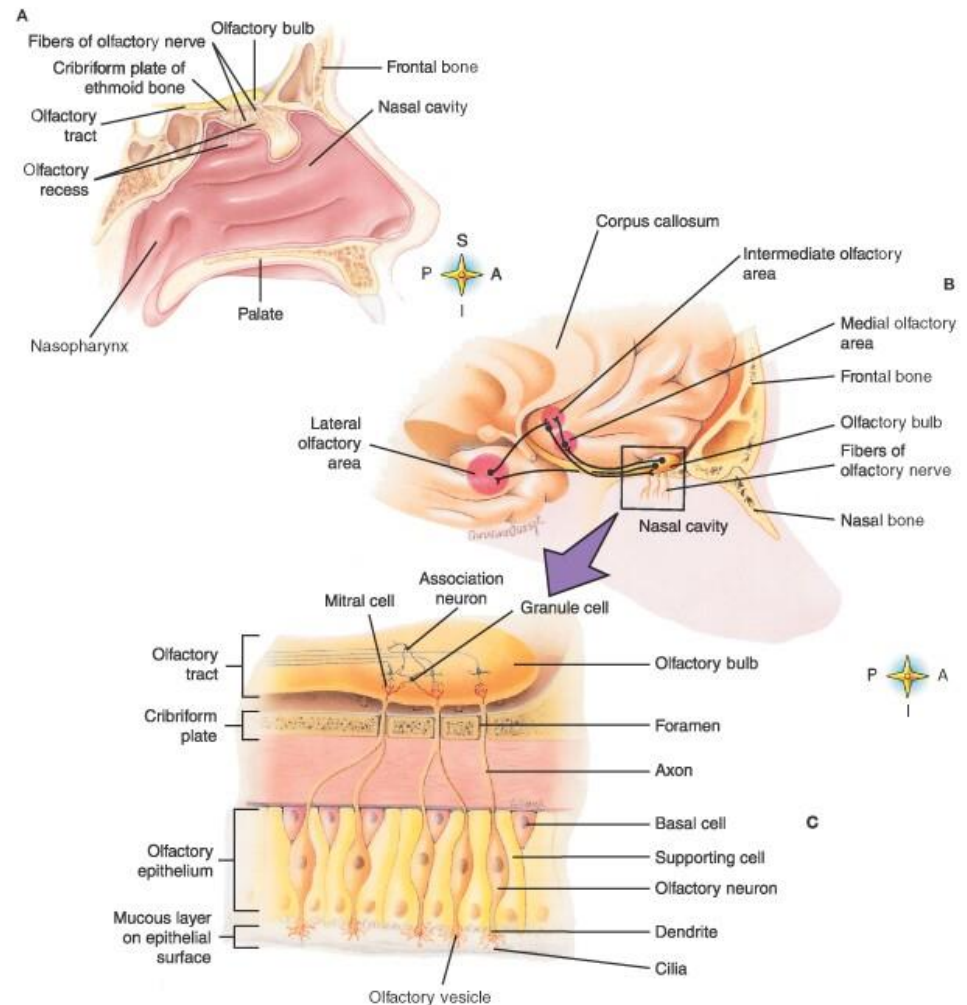
- Anatomy
 - Anterior (external) nares
 - Nasal septum
 - Vestibule
 - Turbinates (conchae)
 - Inferior, middle and superior
 - Internal (posterior) nares

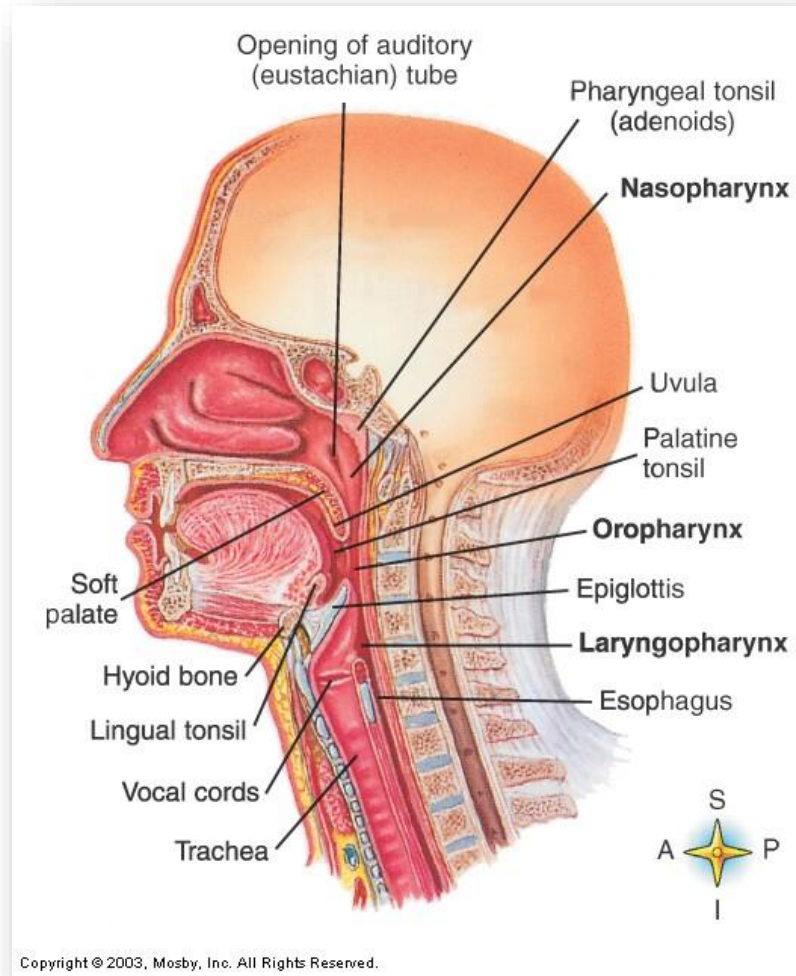


- Function
 - Nasal mucosa
 - Ciliated columnar epithelium
 - Rich in goblet cells
 - Rich in vasculature
 - Heat air as it enters the system
 - Cilia trap foreign materials
 - Goblet cells “package” for excretion
 - Roof of nose (above superior turbinate)
 - Olfactory epithelium

- Air containing spaces in the bones of the face that open and drain into the nasal cavity
 - Four pairs named for the bone they occupy
 - Frontal
 - Maxillary
 - Ethmoid
 - Sphenoid
 - Lined with respiratory mucosa
- Help trap particulates and moisten air as it enters the system
- Provide resonating chambers for speech
- Lighten the weight of the bones

- Air redirected by middle and superior turbinates are examined by the olfactory sense
- Looks for chemically irritating substances as a defense
- Gives us our sense of smell





- **Anatomy**

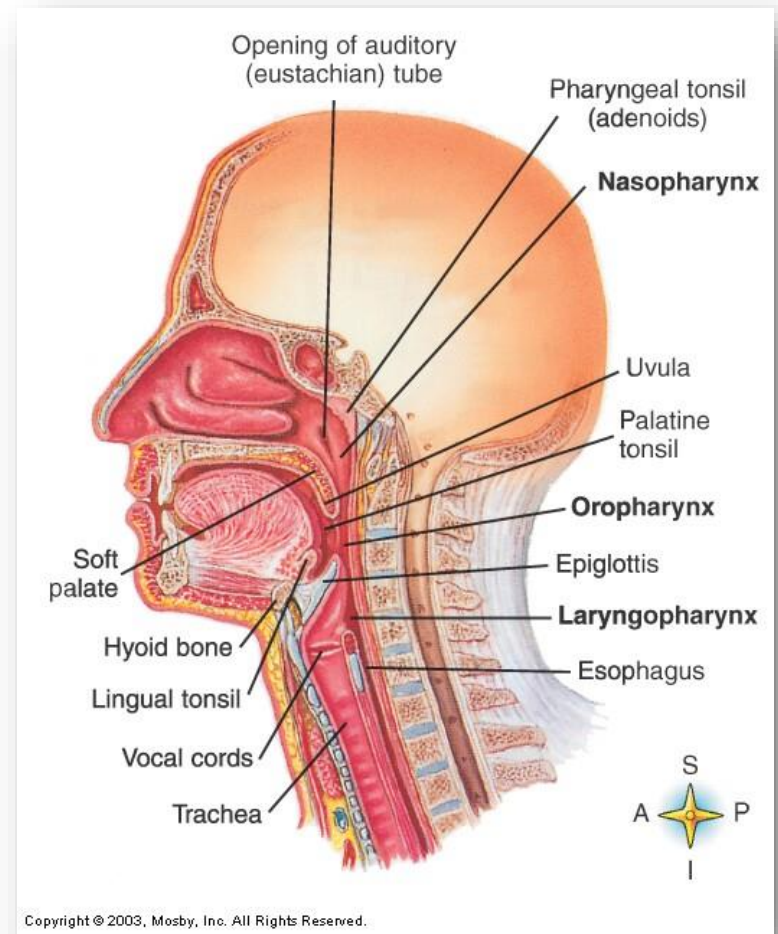
- Entrance of nutrients and liquid

- Lips
- Teeth
- Tongue
- Hard palate
- Soft palate
- Uvula

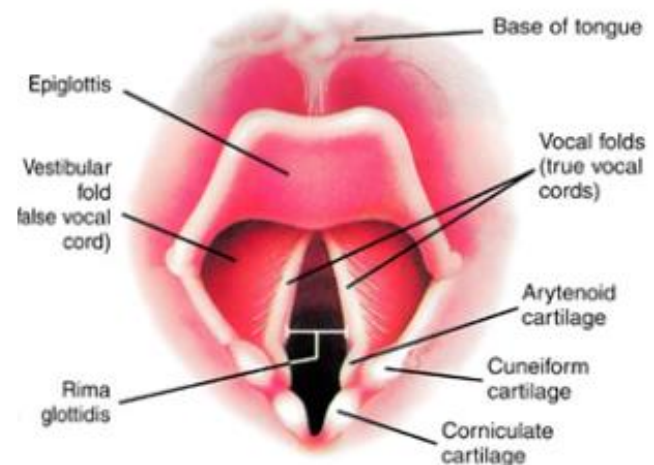
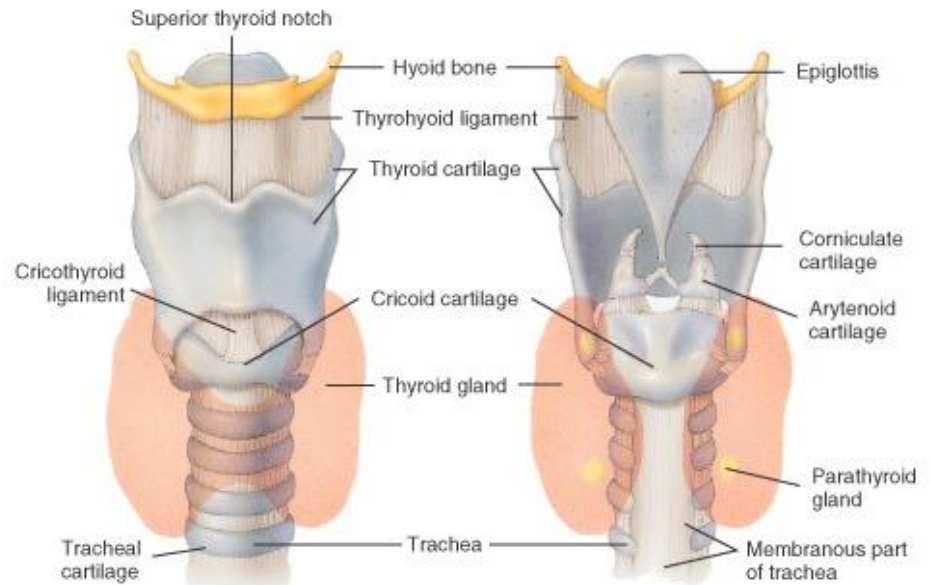
- **Function**

- Acts as a secondary respiratory tract if nasal cavity blocked
- Direct food and liquid down towards the esophagus

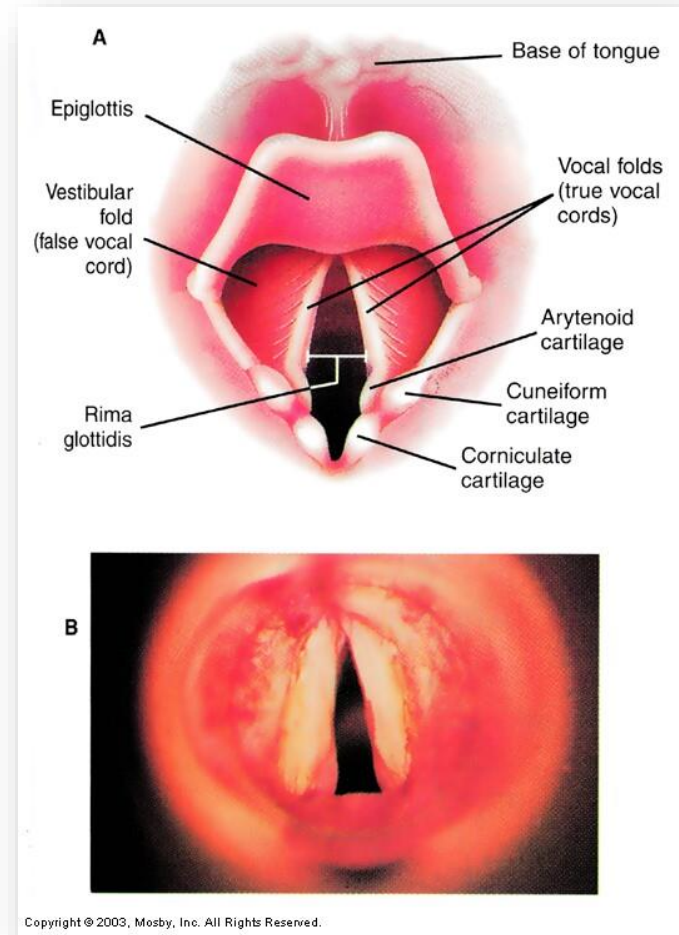
- Extends from the base of the skull to the esophagus
- Divided into 3 sections:
 - Nasopharynx
 - Pharyngeal tonsils (adenoids if enlarged)
 - Does not collapse
 - Oropharynx
 - Palatine tonsils (at the fauces)
 - Lingual tonsils (base of the tongue)
 - Laryngopharynx
- Muscular with a mucous membrane
- Ciliated



- Comprised of 9 Cartilages
 - Thyroid Cartilage
 - Cricoid Cartilage
 - Epiglottis
 - Corniculate (X 2)
 - Cuneiform (X 2)
 - Arytenoid (X 2)
- Extends from the root of the tongue to the trachea
- Lined with ciliated mucous membrane
- This membrane forms two pairs of folds

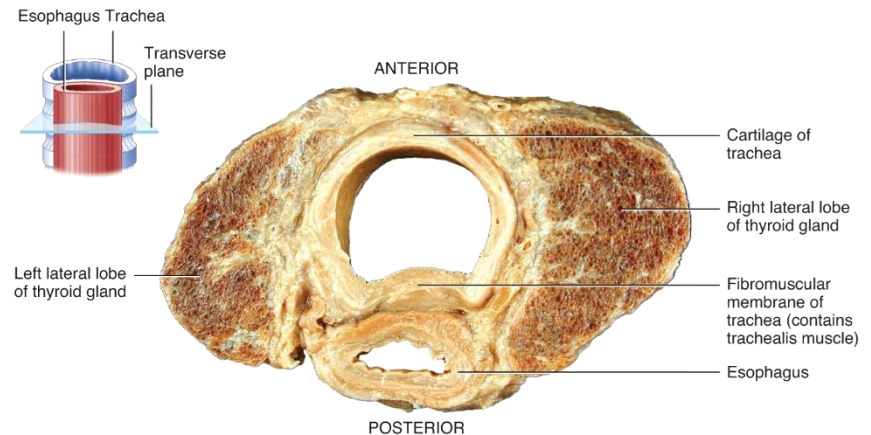
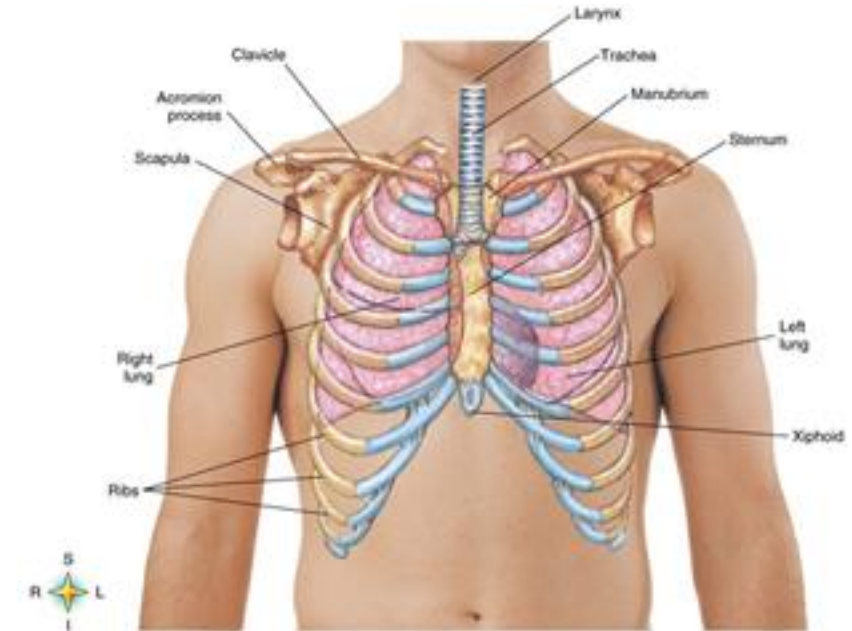


- Upper pair
 - Vestibular fold (false vocal cords)
 - Play no part in pronunciation
- Lower pair
 - Vocal folds (true vocal cords)

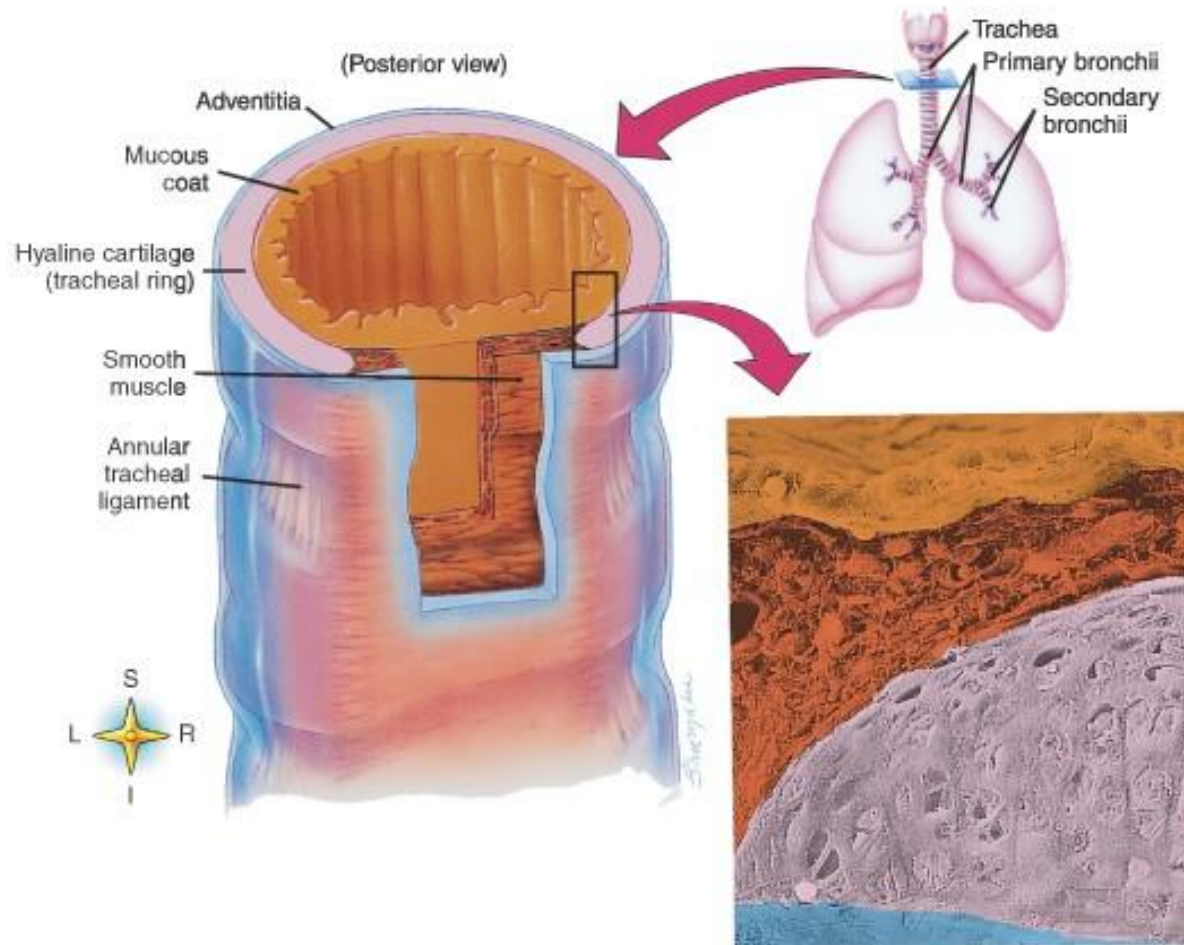


- Trachea
- Bronchi
- Alveoli

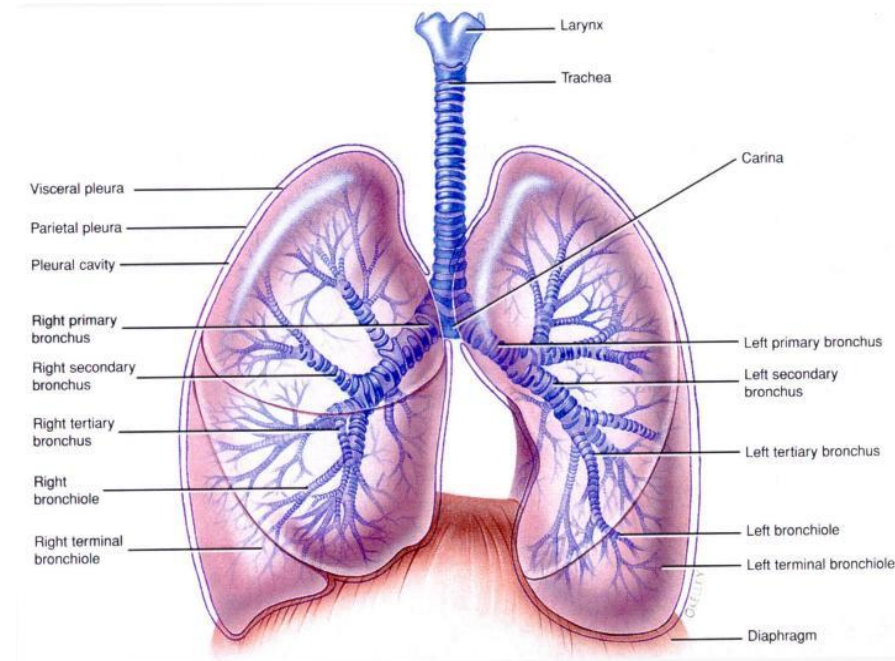
- Approx. 12 cm long
 - Extends from the larynx to the primary bronchi
 - Is approx. 2.5 cm in diameter
- C-shaped cartilage
- Has ciliated epithelium cells

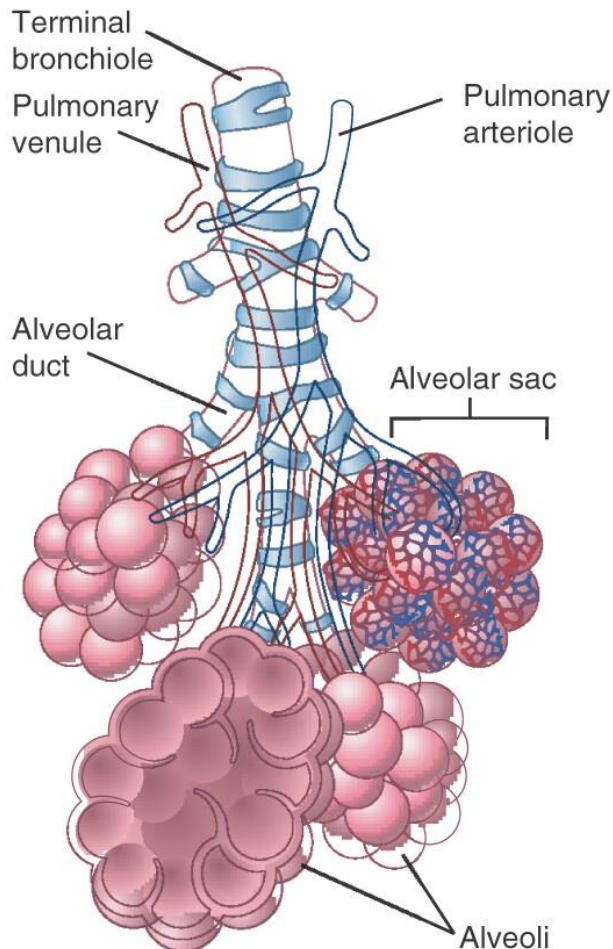


Superior view of transverse section of thyroid gland, trachea, and esophagus



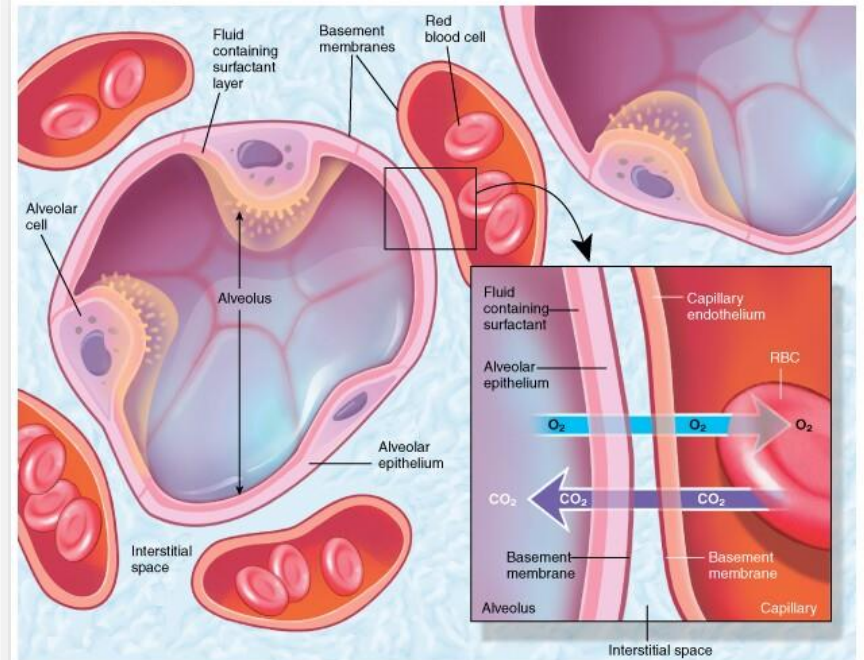
- Anatomy
 - Carina
 - Ciliated membranes
 - Primary bronchi (right and left mainstem)
 - Still C-shaped
 - Secondary bronchi (complete rings)
 - Tertiary bronchi (complete rings)
 - Bronchioles (no cartilage, muscular)
- Function
 - Distribution of air to the alveoli



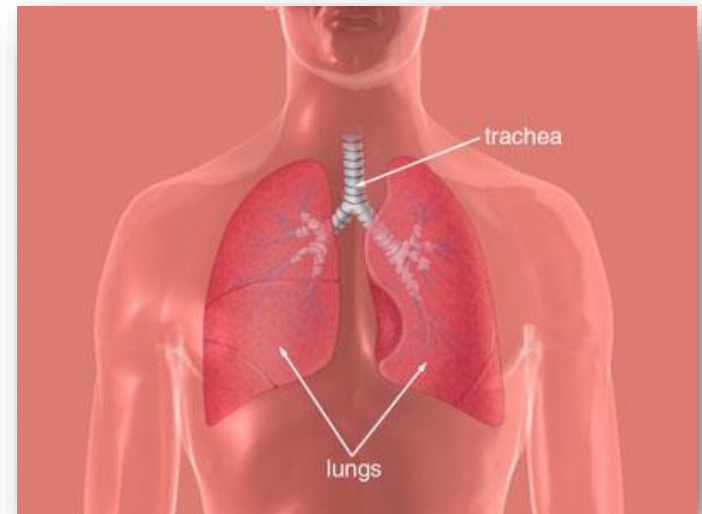


- Anatomy
 - Alveolar ducts
 - Alveoli
 - Capillary abundant on outer surface
 - Surfactant
 - Lipid derivative that helps reduce surface tension
 - Produced by Type II Alveolar cells
 - Prevents collapse of the lung
 - Single layer of epithelial tissue (respiratory membrane)
- Function
 - Location of gas exchange

- Respiratory Membrane
- Surfactant
 - Reduce surface tension

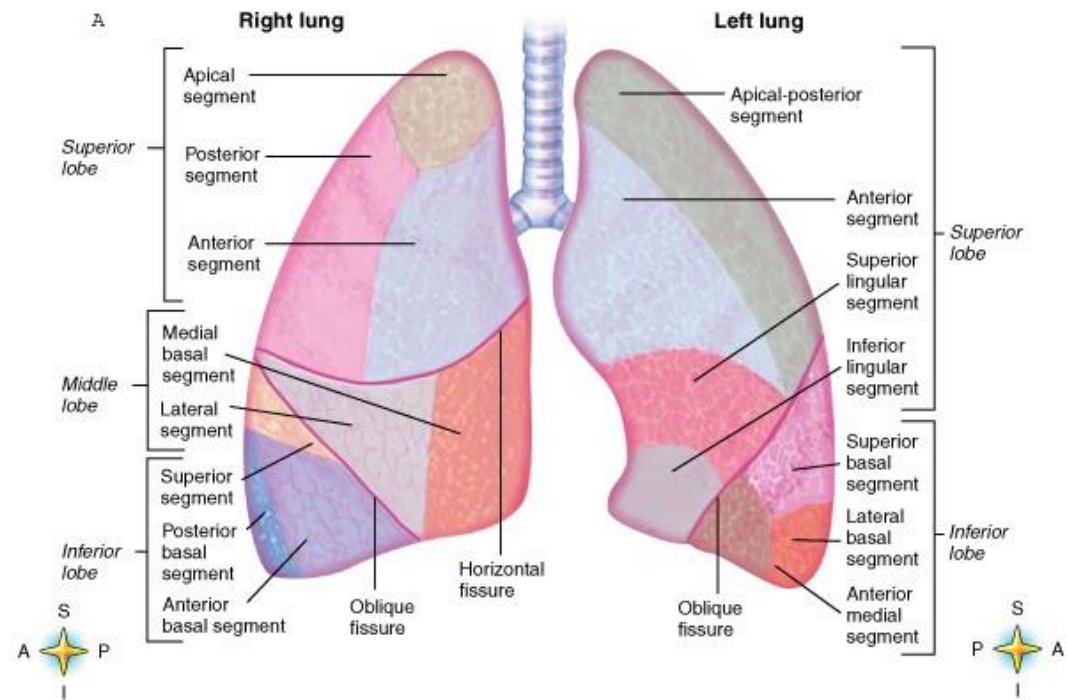


- Cone shaped
- Base
 - Rests on the diaphragm
- Apex
- Costal surface
 - Lies against the rib cage
- Only point of attachment is the hilum
- Right and left lungs are separated by the mediastinum



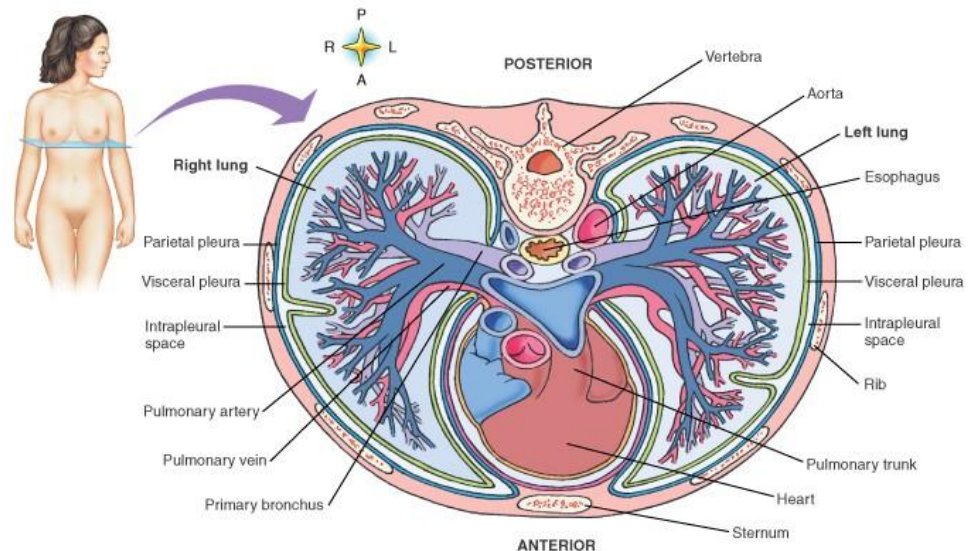
- Right
 - 3 lobes
 - URL, MRL, LRL (superior, middle and inferior)
 - Divided by oblique and horizontal fissures

- Left
 - 2 lobes (cardiac notch)
 - ULL, LLL (superior and inferior)
 - Divided by oblique fissure



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- Each lung covered with pleura
 - Visceral
 - Firmly attached to the surface of the lung
 - Parietal
 - Lines the wall of the thorax
- Potential space in between is called the pleural cavity
- This contains a serous fluid that acts as a lubricant to reduce friction



Respiratory Anatomy

PHYSIOLOGY

- Gas exchange:
 - The body needs a continuous supply of O_2 for the metabolic processes that sustain life
 - Works with the circulatory system to provide O_2 and to remove the waste products of metabolism (CO_2)
- Regulation:
 - Helps in regulating the pH of the blood
 - Body temperature

- Respiration results in the exchange of O₂ and CO₂ between the atmosphere and the tissue
- Ventilation is stimulated by nerve impulses

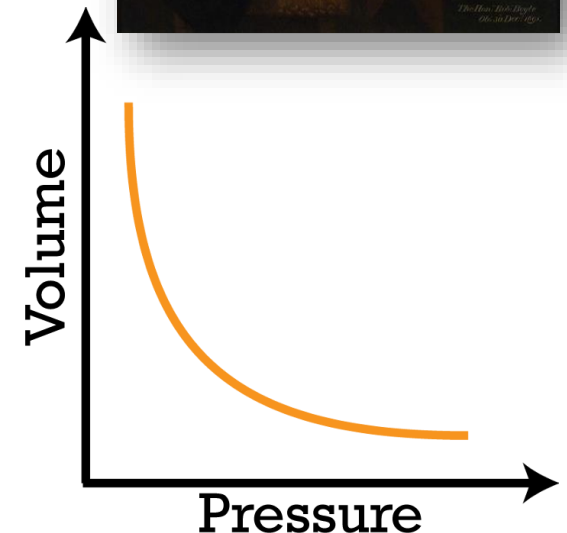
- External respiration
 - Exchange of gases between the lungs and the blood
- Internal respiration
 - Exchange of gases between the blood and the tissues
- Cellular respiration
 - Cells utilize the O₂ for metabolism

- Defined as the movement of air through the conducting passages between the atmosphere and the lungs
- Conducting Passages
 - Upper Respiratory Tract
 - Nose, pharynx and larynx
 - Lower Respiratory Tract
 - Trachea, bronchial tree and lungs

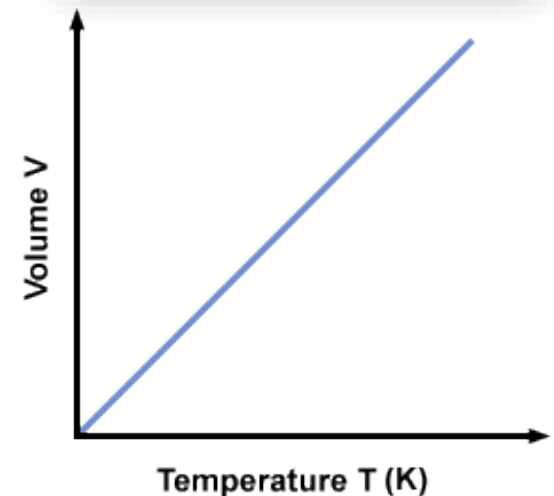
- Terms used to describe the process of breathing
 - Inspiration: moves air into the system
 - Expiration: moves air out of the system
- Air moves based on the same principles as fluid
 - Movement down a pressure gradient

- In order to appreciate the function of the respiratory system you should be familiar with the basic gas laws:
 - Boyle's Law
 - Charles' Law
 - Dalton's Law
 - Henry's Law

- The volume of a gas is inversely proportional to its pressure.
 - If the pressure is increased the volume will decrease
 - May be written in the form of an expression: $P_1V_1=P_2V_2$
- Pressures in ventilation
 - Atmospheric pressure
 - Intra-alveolar (intrapulmonary) pressure
 - Intra-pleural pressure



- Volume is directly proportional to the temperature as long as the pressure is constant
 - So as air is heated within the respiratory system it will expand





John Dalton

- Dalton surmises that the total partial pressure of a gas is the sum of all the partial pressures of its components.

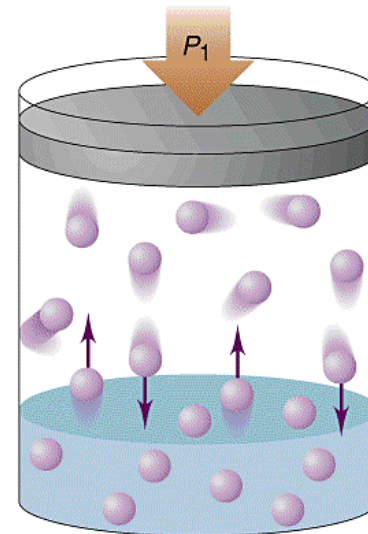
$$p_{\text{Total}} = p_{\text{gas1}} + p_{\text{gas2}} + p_{\text{gas3}} + p_{\text{gas4}}$$

$$p(\text{air}) = p(\text{N}_2) + p(\text{O}_2) + p(\text{CO}_2) + \dots$$

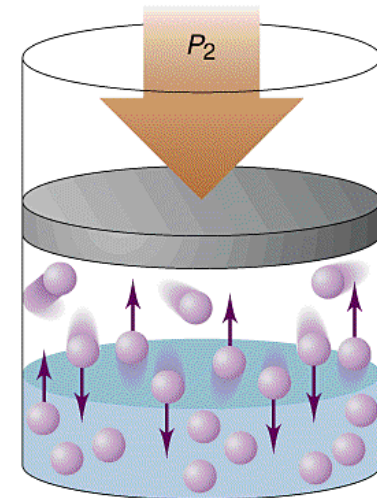
$$760 \text{ mmHg} = 592.8 \text{ mmHg} + 159.6 \text{ mmHg} + 0.2 \text{ mmHg} + \dots$$

$$100 \% = 76 \% + 21 \% + 0.03 \% + \dots$$

- The concentration of a gas in a solution depends on the partial pressure of the gas and its' solubility (as long as the temperature stays constant)
 - The higher the solubility, the more gas will dissolve
 - The higher the pressure the more gas will dissolve

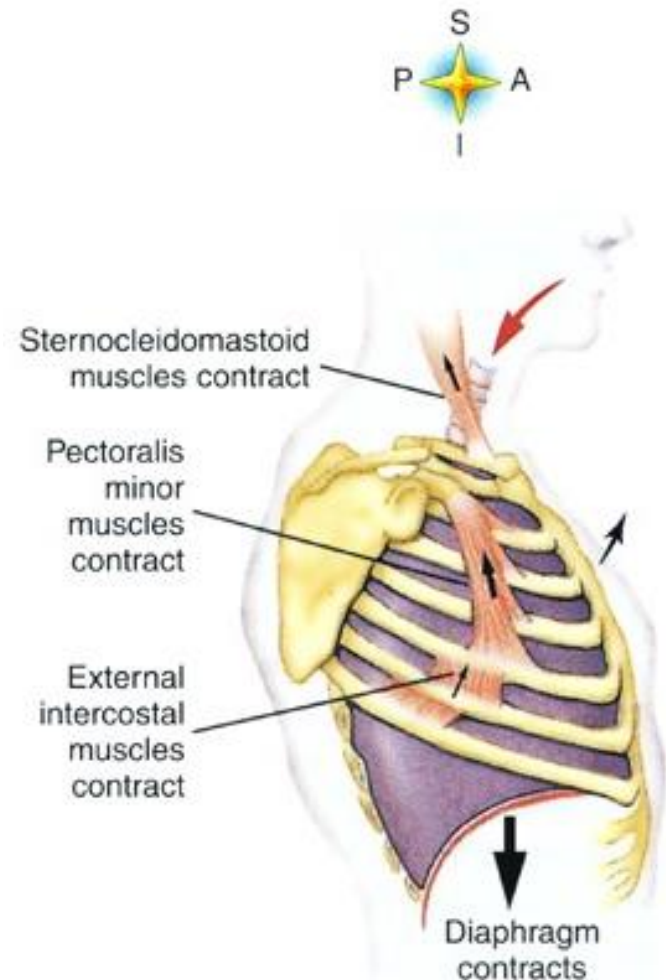


A



B

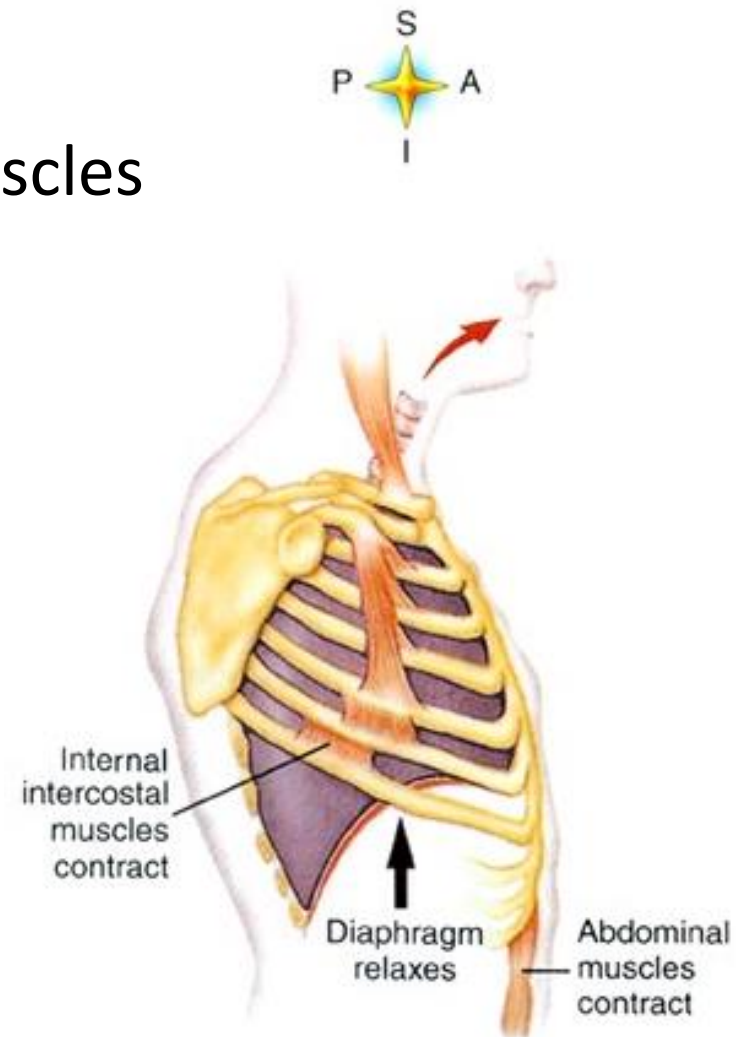
- Quiet Inspiration
 - Diaphragm
 - External intercostals
- Forceful Inspiration
 - Sternocleidomastoid
 - Pectoralis minor
 - Serratus anterior (scapula)



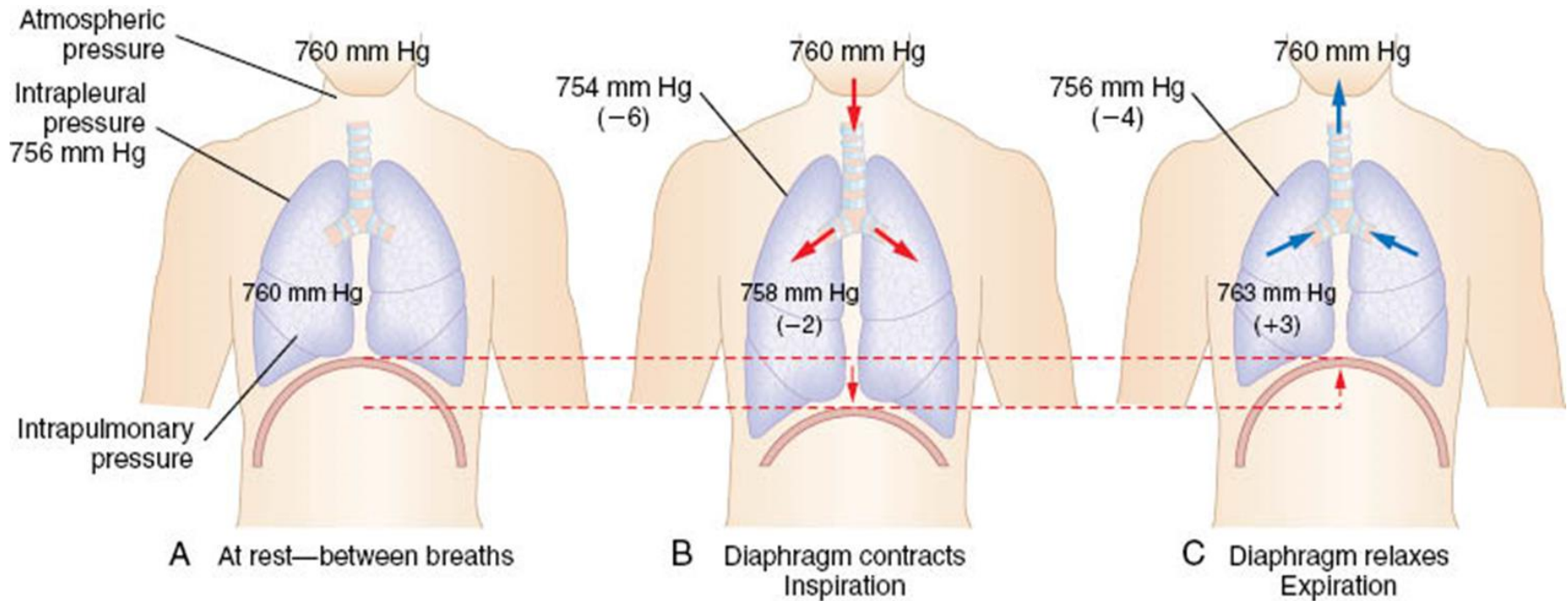
- At rest:
 - Atmospheric pressure = 760 mmHg
 - Intrapleural pressure = 756 mmHg
 - Intrapulmonary pressure = 760 mmHg
 - This pressure difference helps create surface tension with surfactant to overcome “the collapse tendency of the lungs”

- As thoracic cavity increases in size
 - Cohesion between parietal and visceral layers allows the lungs to be “pulled”
 - This change in cavity size changes the pressures of the cavity
 - Atmospheric pressure = 760 mmHg
 - Intrapleural pressure = 754 mmHg (-6)
 - Intrapulmonary pressure = 758 mmHg (-2)

- Quiet Expiration (Passive)
 - Relaxation of inspiration muscles
 - Diaphragm
 - Internal intercostals
- Forceful Expiration
 - Abdominal Muscles



- As thoracic cavity decreases in size
 - This change in cavity size changes the pressures of the cavity
 - Atmospheric pressure = 760 mmHg
 - Intrapleural pressure = 756 mmHg (-4)
 - Intrapulmonary pressure = 763 mmHg (+3)



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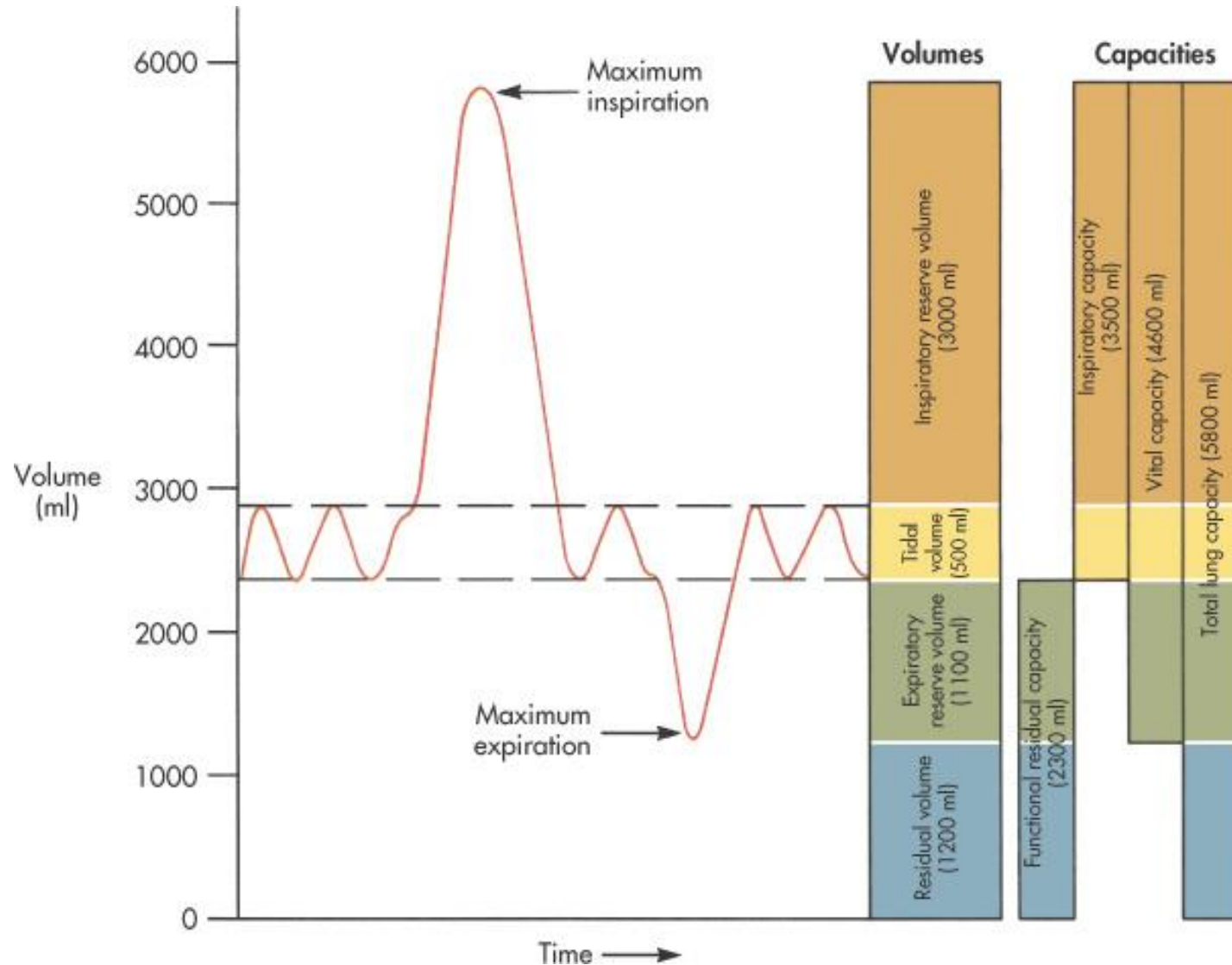
- (A) Illustrates the lungs at rest
- In inspiration (B), the intrapulmonary pressure is less than atmospheric pressure and air flows into the lungs.
- In expiration (C), intrapulmonary pressure is greater than atmospheric pressure and air flows out of the lungs. Intrapleural pressure is always less than either intrapulmonary or atmospheric pressure.

- Elastic Recoil:
 - The tendency for the lungs and thorax to return to their pre-inspiration state
 - Disease states may require forceful expirations even at rest
- Compliance:
 - The ability for the lungs and thorax to stretch is essential for respiration
 - Disease states may make inspiration more difficult

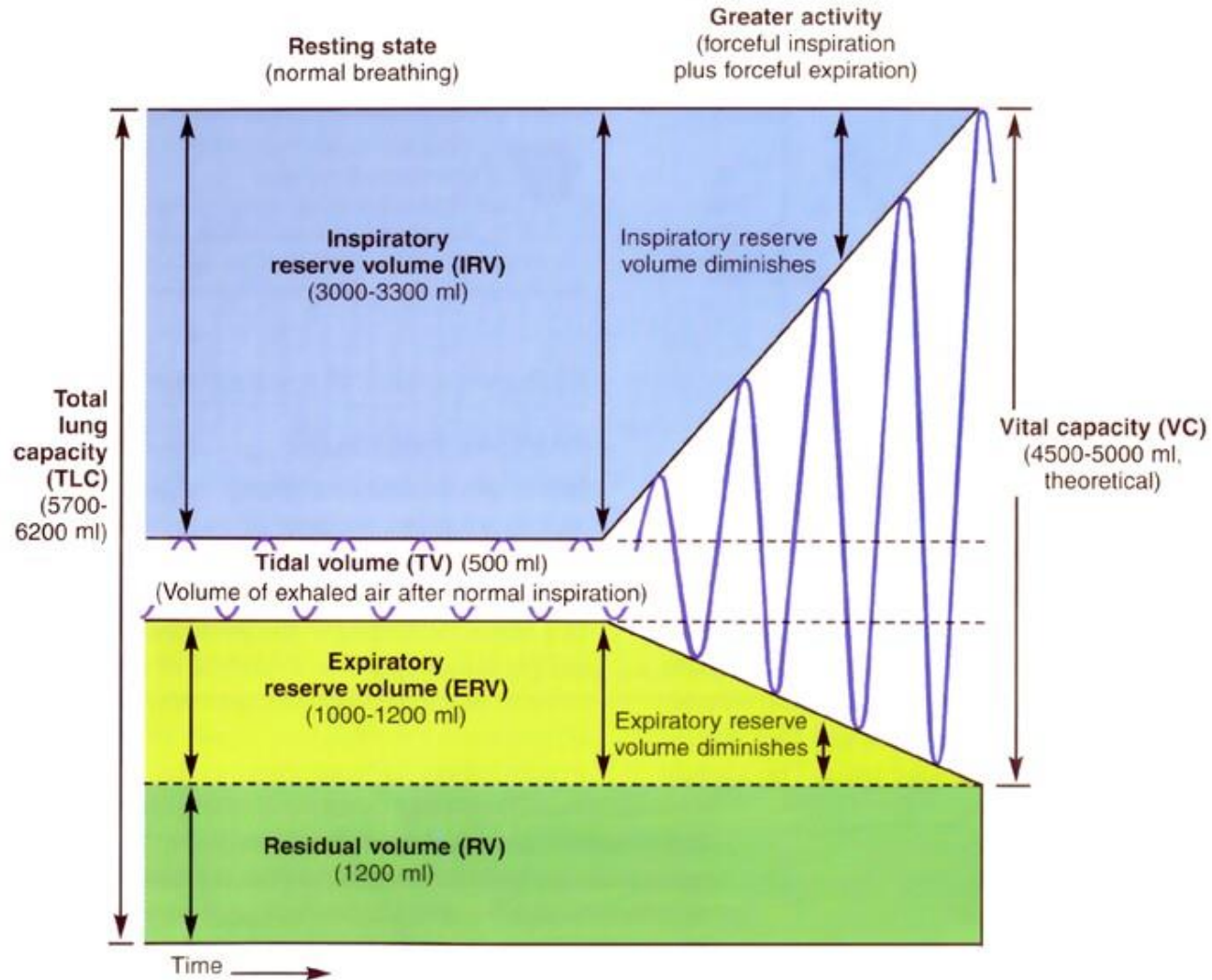
- Four respiratory volumes
 - Tidal volume (TV)
 - Amount of air exhaled after an inspiration
 - Inspiratory reserve volume (IRV)
 - Max amount that can be forcefully inhaled after TV
 - Expiratory reserve volume (ERV)
 - Max amount that can be forcefully exhaled after TV
 - Residual volume (RV)
 - Amount remaining after max expiration

- Respiratory capacities
 - Vital Capacity (VC)
 - Max amount of air that can be exhaled after max inspiration (TV+IRV+ERV)
 - Inspiratory Capacity (IC)
 - Max amount of air inhaled (TV+IRV)
 - Functional residual capacity (FRC)
 - Amount remaining after tidal expiration (RV+ERV)
 - Total Lung capacity (TLC)
 - Total amount of air the lung can hold (RV+TV+IRV+ERV)
 - Minute Volume
 - Total volume of inspired air per respiration times the respiratory rate

Volumes and Capacities



Volumes and Capacities

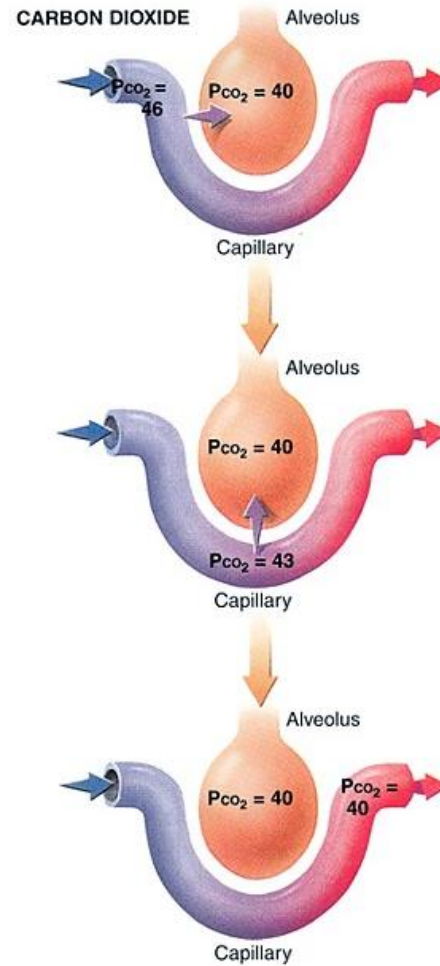
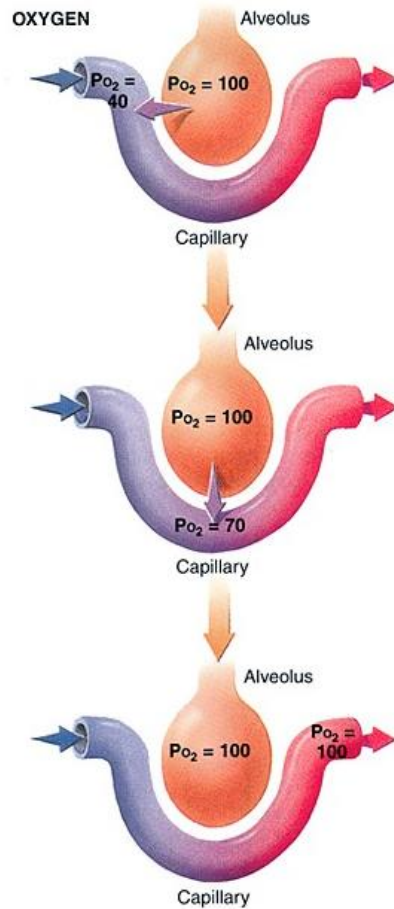


- The volume of inspired air that reaches the alveoli
- Only air that takes part in exchange of gases

- Volume of air which is inhaled, but does not take part in gas exchange either because it remains in the conducting airways or in alveoli that are poorly perfused
 - Anatomic Dead Space
 - Portion of the airways which conduct gas to the alveoli
 - Alveolar Dead Space
 - Sum of the volumes of those alveoli that are ventilated but not perfused
 - Physiological Dead Space
 - Anatomical Dead Space + Alveolar Dead Space

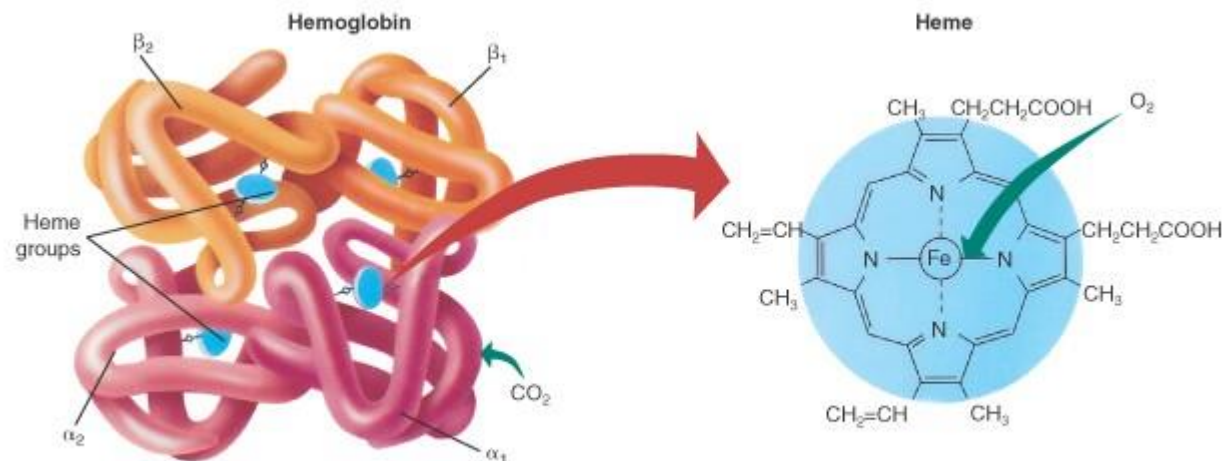
- Gas exchange occurs between the lungs and the blood at the capillary level
- Gases move in both directions through the respiratory membrane
- Occurs due to pressure differentials in the system

- Amount of oxygen diffusion depends on many factors:
 - O₂ pressure gradient between alveoli and blood (Altitudes)
 - Total functional surface area of the membrane (Pneumothorax)
 - Minute volume (Morphine)
 - Alveolar ventilation (COPD)

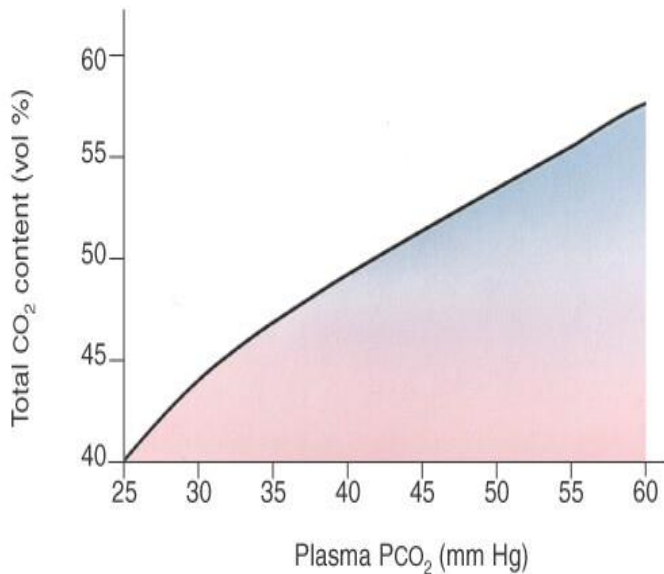


- Blood transports O₂ and CO₂ as either solutes or combined with other chemicals
- As they enter the blood stream they are dissolved in plasma
- Since plasma can only hold small amounts of gas they combine chemically with another molecule
 - Hemoglobin, plasma proteins or water
- As they combine with the molecules, plasma concentrations decrease providing more space for in the plasma

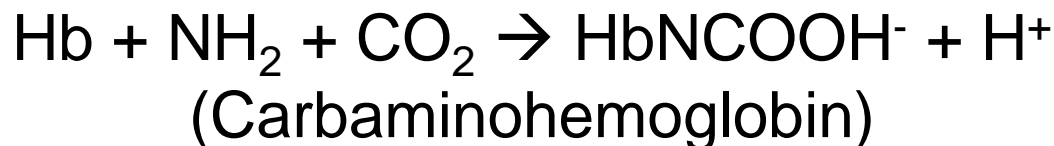
- Remember that hemoglobin:
 - Contain four polypeptide chains
 - Each chain has a heme group (contains iron)
 - O_2 can combine with the Fe
 - CO_2 can be absorbed in the chains



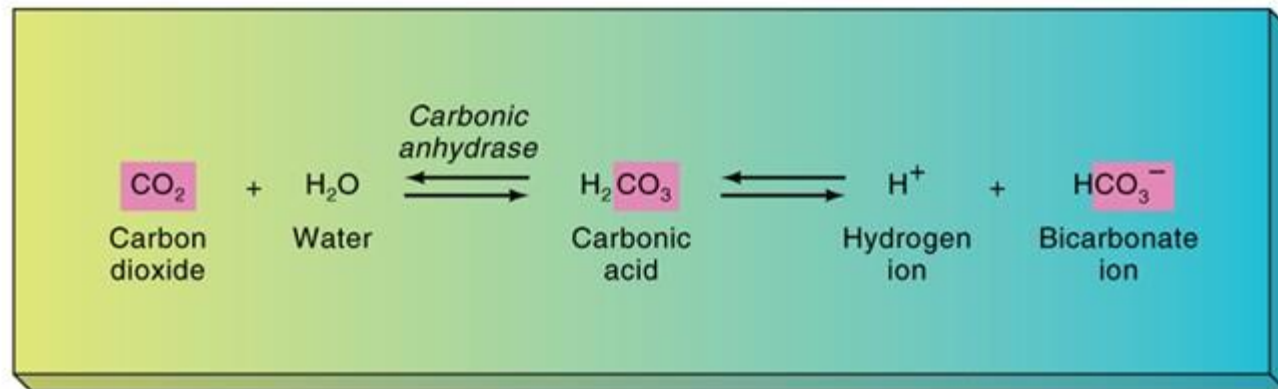
- Oxygen transport
 - 3% stays in plasma
 - Remainder combines with hemoglobin in the RBC
 - Loading (In the lungs)
 - $\text{Hb} + \text{O}_2 \rightarrow \text{HbO}_2$
 - Unloading (In the tissues)
 - $\text{HbO}_2 \rightarrow \text{Hb} + \text{O}_2$
 - Temperature, O_2 & CO_2 levels and pH affect loading and unloading



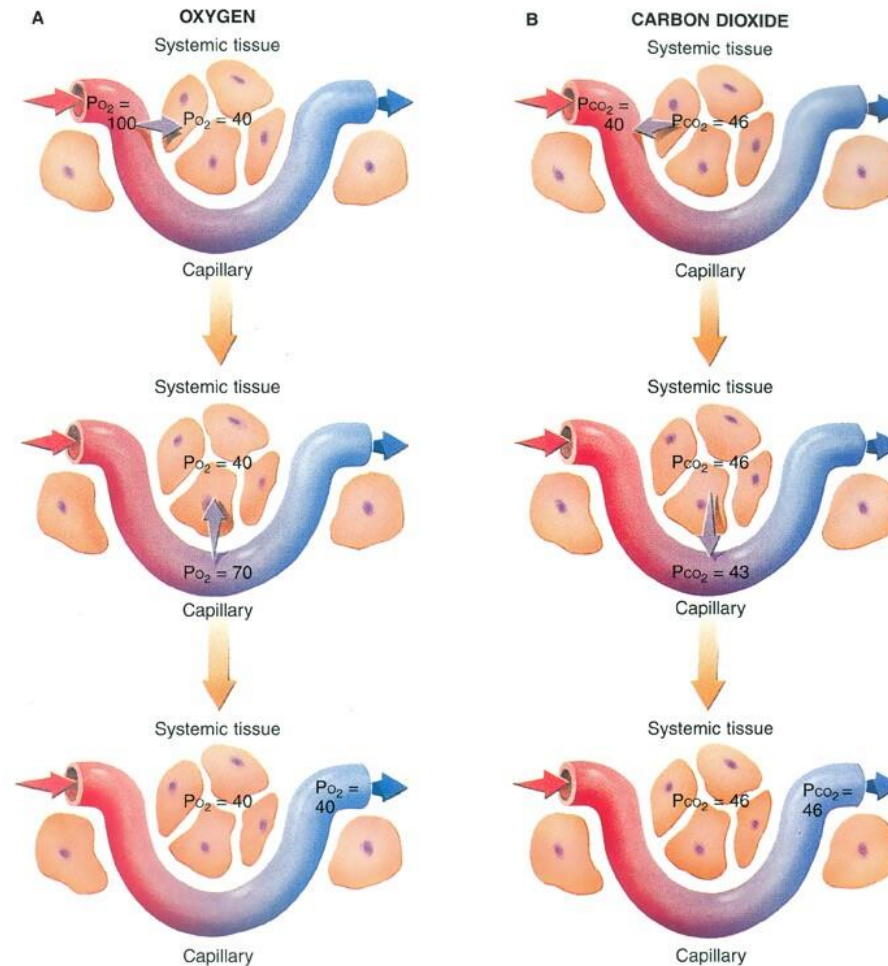
- Carbon Dioxide transport
 - Dissolved in plasma (7 – 10 %)
 - Combine with amine (NH₂) groups which combine with hemoglobin in the RBC (20 - 23%)



- Carbon Dioxide transport
 - As part of bicarbonate ions (70%)
 - Dissolved in H₂O (Blood plasma) to make carbonic acid, sped up by carbonic anhydrase enzyme and dissociates into bicarb and hydrogen

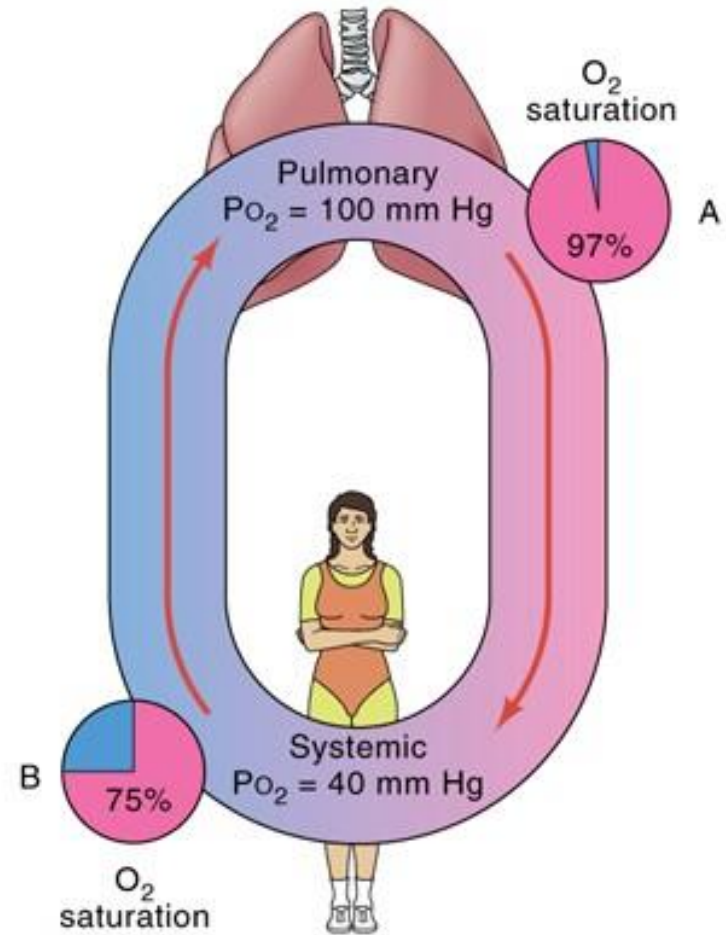
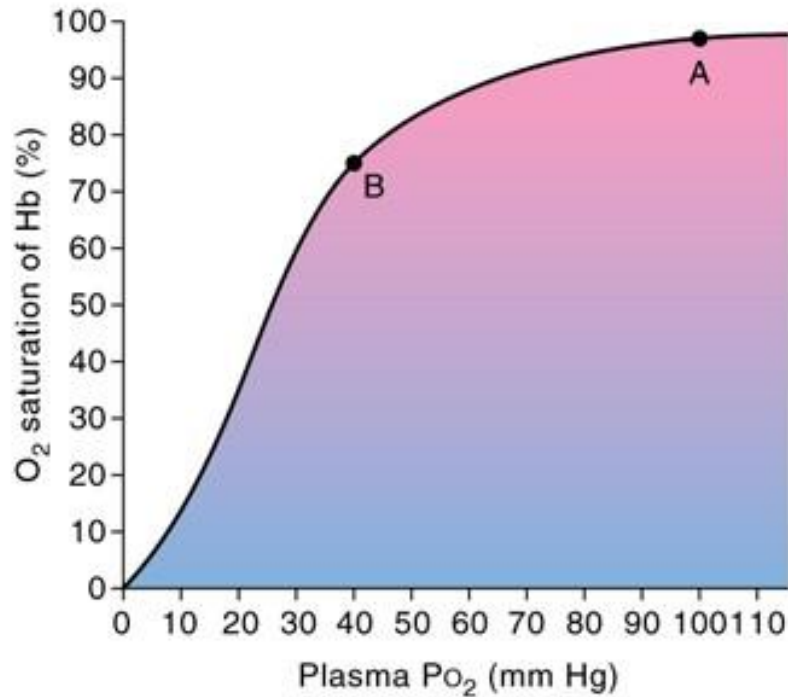


Systemic Gas Exchange



- A non-linear graph showing the relationship between pO_2 of plasma with the Hb Saturation (%)
- Is the difference between hypoxia and hypoxemia
 - Many factors can influence how rapidly hemoglobin can associate or dissociate with oxygen in the system
 - An increasing blood pO_2 accelerates association of Hb with O_2
 - A decreasing blood pO_2 accelerates dissociation of Hb with O_2

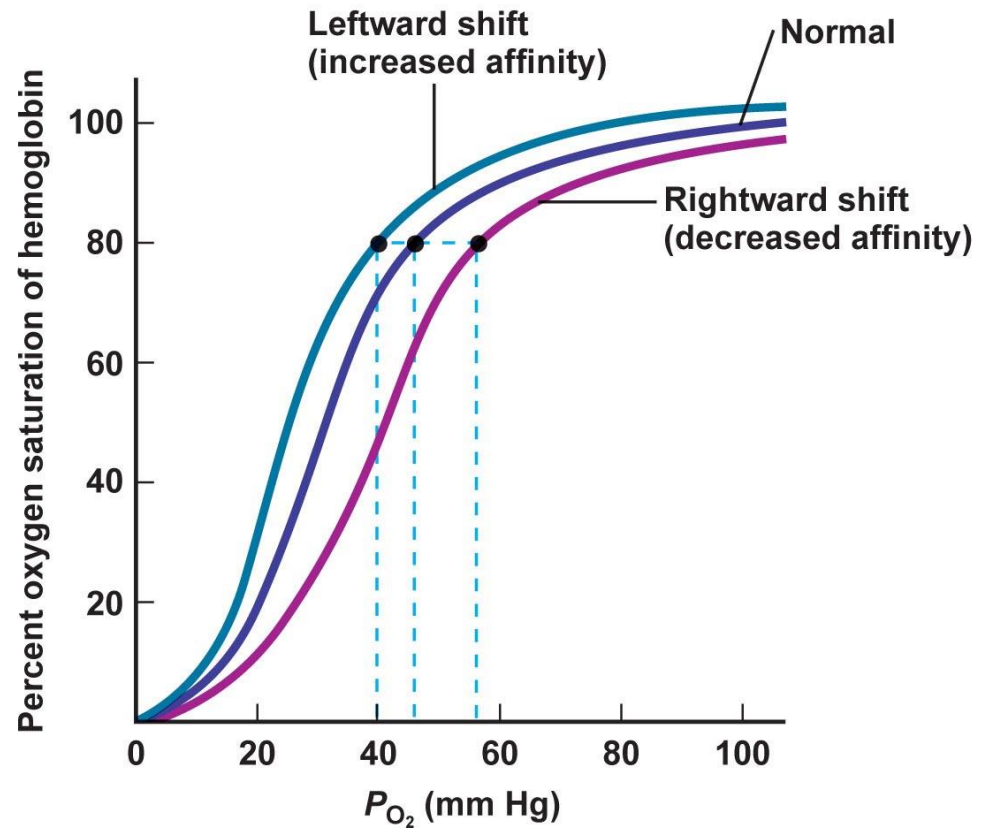
Oxyhemoglobin Dissociation Curve



- Influencing factors:
 - Acidity
 - Hb affinity for oxygen is lower and oxygen dissociates easily from the Hb
 - Too acidic will result in no affinity of Hb to oxygen
 - Partial Pressure of CO₂
 - As pCO₂ increases hemoglobin releases O₂ more readily
 - The increase in pCO₂ may result in a large amount of bicarbonate and hydrogen ions in the blood, thus decreasing the pH

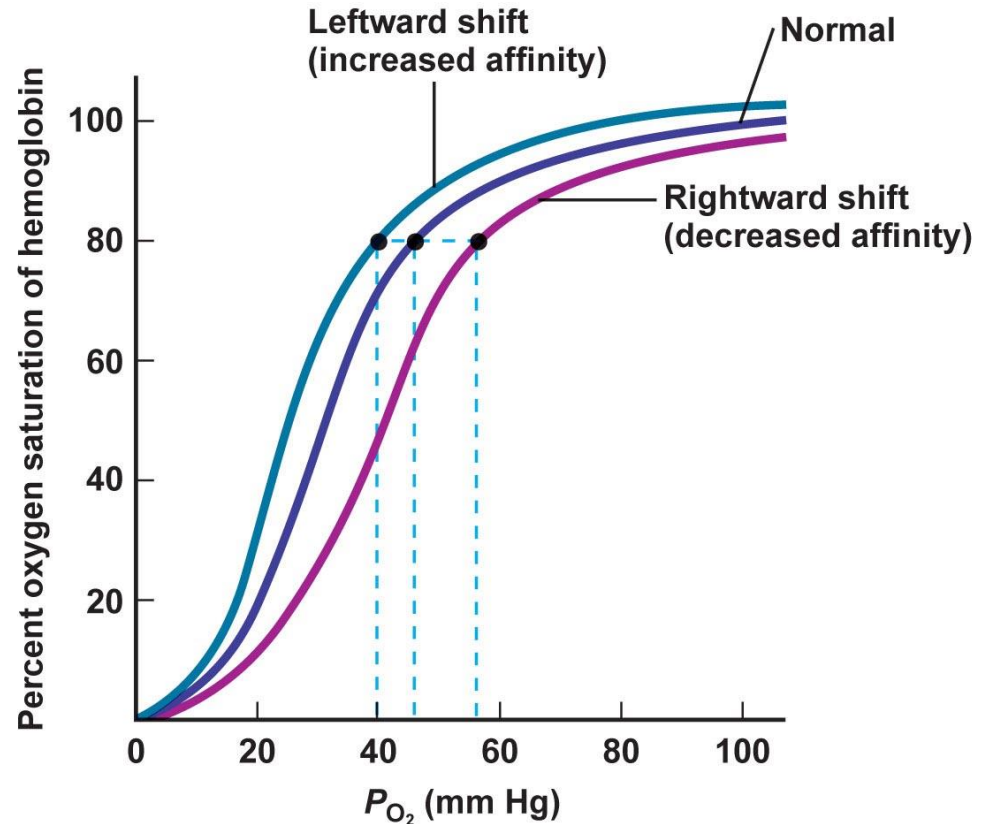
- Influencing factors:
 - Temperature
 - 2, 3 biphosphoglycerate (2, 3 BPG)
 - Formed in the RBC's when glucose is broken down during glycolysis
 - BPG decreases the Hb affinity
 - When BPG combines with Hb, oxygen is easily dissociated and more oxygen can be delivered to the tissues
 - Certain hormones can increase BPG content such as epi, nor-epi and testosterone
 - High altitudes can affect BPG as well

- Right Shift (Bohr Effect)
 - An decrease in oxygen's affinity to Hb
 - Weaker bonds (more dissociation)
 - Results in a right shift in the curve
 - Causes:
 - Decreased pH (acidosis)
 - Increased CO₂
 - Increased temperature
 - Increased BPG
 - COPD, CHF



- Left Shift (Haldane Effect)

- An increase in oxygen's affinity to Hb
 - Stronger bonds (less dissociation)
 - Results in a left shift in the curve
- Causes:
 - Increased pH (alkalosis)
 - Decreased CO_2
 - Decreased temperature
 - Decreased BPG
 - Septic shock

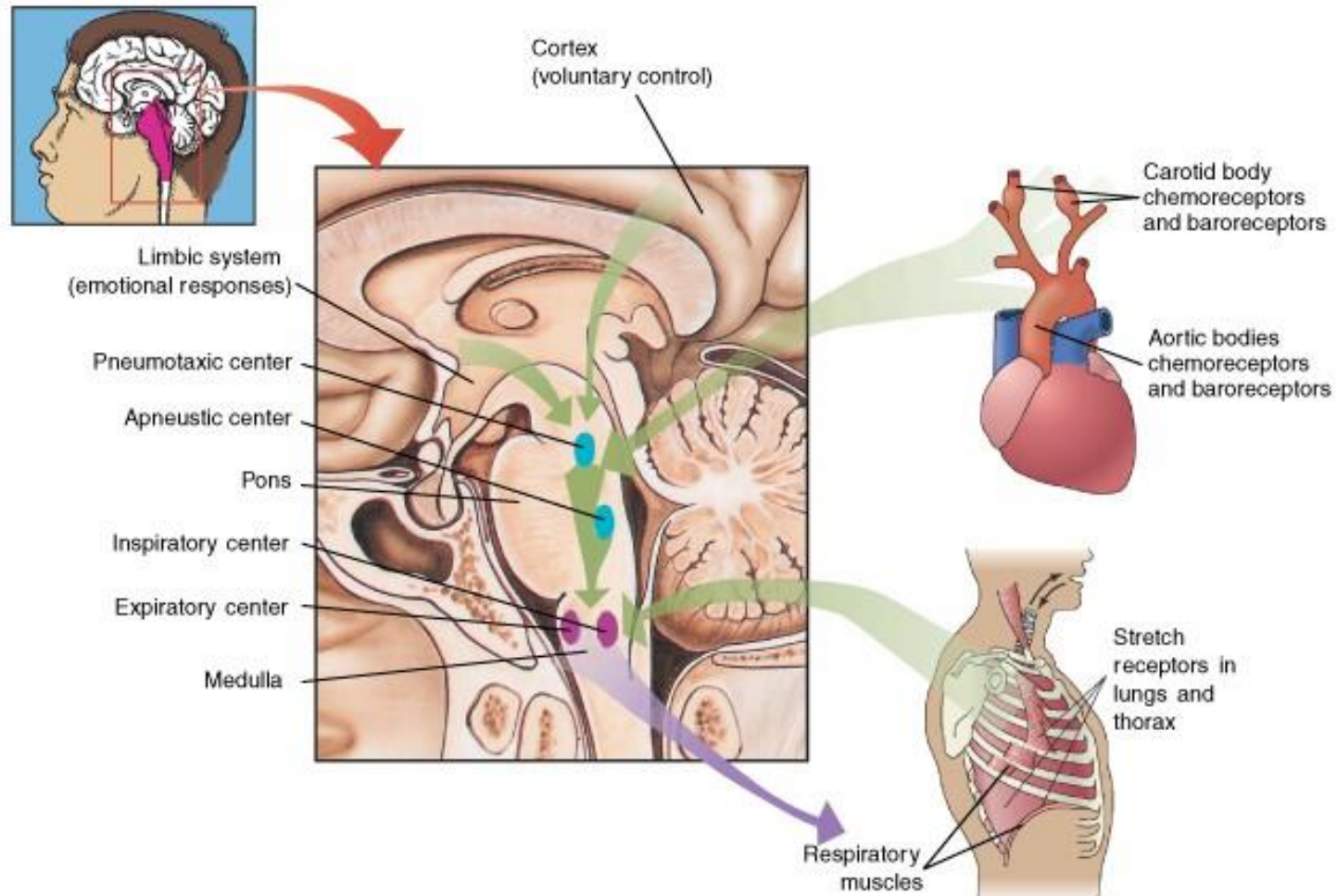


- Medulla and pons form the Respiratory center in brainstem
 - Inspiratory phase send signals down phrenic nerve to the diaphragm
 - Also to intercostal nerves for deep breath
 - Expiration occurs when the impulse stop

- Medulla
 - The main integrators that control the nerves that affect respiration are located in the brainstem (respiratory centers)
 - Medullary Rhythmicity Area
 - Consists of:
 - Inspiratory center (primary respiratory pacemaker)
 - Expiratory center
 - » Typically is only active for forceful expiration

- Pons
 - Apneustic center
 - Stimulates the inspiratory center to increase length and depth of inspiration
 - Pneumotaxic center
 - Inhibits both the apneustic center and the inspiratory center
 - Helps prevent over inflation of the lungs

Factors that influence breathing



- A complex control system exists to control
 - pH
 - $p\text{CO}_2$
 - $p\text{O}_2$
- $p\text{O}_2$ must be controlled to ensure all tissues receive O_2
- $p\text{CO}_2$ must be controlled to keep pH near 7.4
- pH must be controlled to keep
 - enzymes functioning normally
 - membrane and other proteins functioning normally
 - biological processes functioning that depend on pH
- Minute Volume
 - Is altered to keep $p\text{O}_2$ high and $p\text{CO}_2$ near 40 mmHg
 - Caused by changes in respiratory rate and tidal volume

- Control Systems in regulating pH and pO₂
 - Mechanical control system
 - Chemically mediated control system
 - Nonspecific respiratory drives
- Each of these alter the respiratory centers to alter breathing as required

- Mechanical Control
 - Hering-Breuer Reflex
 - Large lung inflations cause
 - Deflation
 - Decrease in rate of breathing
 - Large deflations of the lung cause
 - Inspiration
 - Increased rate of breathing
- Receptors for mechanical control
 - Stretch receptors
 - Airway smooth muscle in trachea, bronchi and bronchioles
 - Sensory information is carried to medulla via Vagus nerve
 - Efferent information is carried by Motor neurons to respiratory muscles
 - Phrenic (innervates the diaphragm)
 - External and internal intercostal motor neurons

- Chemical
 - Chemoreceptors
 - Are sensitive to changes in CO_2 and pH
 - Central: medulla oblongata
 - » Recognizes slight changes in pCO_2
 - Peripheral: carotid bodies and aorta
 - » Recognize large changes in pCO_2
 - Increase in pCO_2 results in faster breathing with greater volume
 - Decrease in pCO_2 results in inhibition of chemoreceptors and slows breathing rates
 - May note a change in pO_2 if the levels drop below 70 mmHg as an emergency respiratory control mechanism
 - \downarrow pH will result in \uparrow minute volume

- Stretch receptors of the lungs
 - Initiates the Hering-Breuer Reflex to prevent overinflation
- Cerebral cortex
 - Stimulus from higher brain centers
 - Involuntary or voluntary
 - Catecholamine releases
- Temperature
 - Increase in temp increases respiratory rate
 - Sudden cold stimuli may cause reflex apnea

- Pain
 - Sudden painful stimulation will cause reflex apnea
 - Continued pain will increase rate and depth of respirations
- Stimulation of pharynx or larynx
 - By chemicals or touch may cause a temporary apnea
 - A protective measure against aspiration

- Reflexes, voluntary and emotions
 - Coughing
 - Stimulated by foreign material in trachea or bronchi
 - Epiglottis and glottis close and the expiratory muscles contract to force them open and a gush of air up
 - Sneezing
 - Contaminants in the nasal cavity
 - Sighing
 - Hiccup
 - Spasmodic contraction of the diaphragm followed by a sudden closure of the glottis
 - Crying
 - Laughing
 - Yawning