

Respiratory System

Rita Carey-Nita

Respiratory System

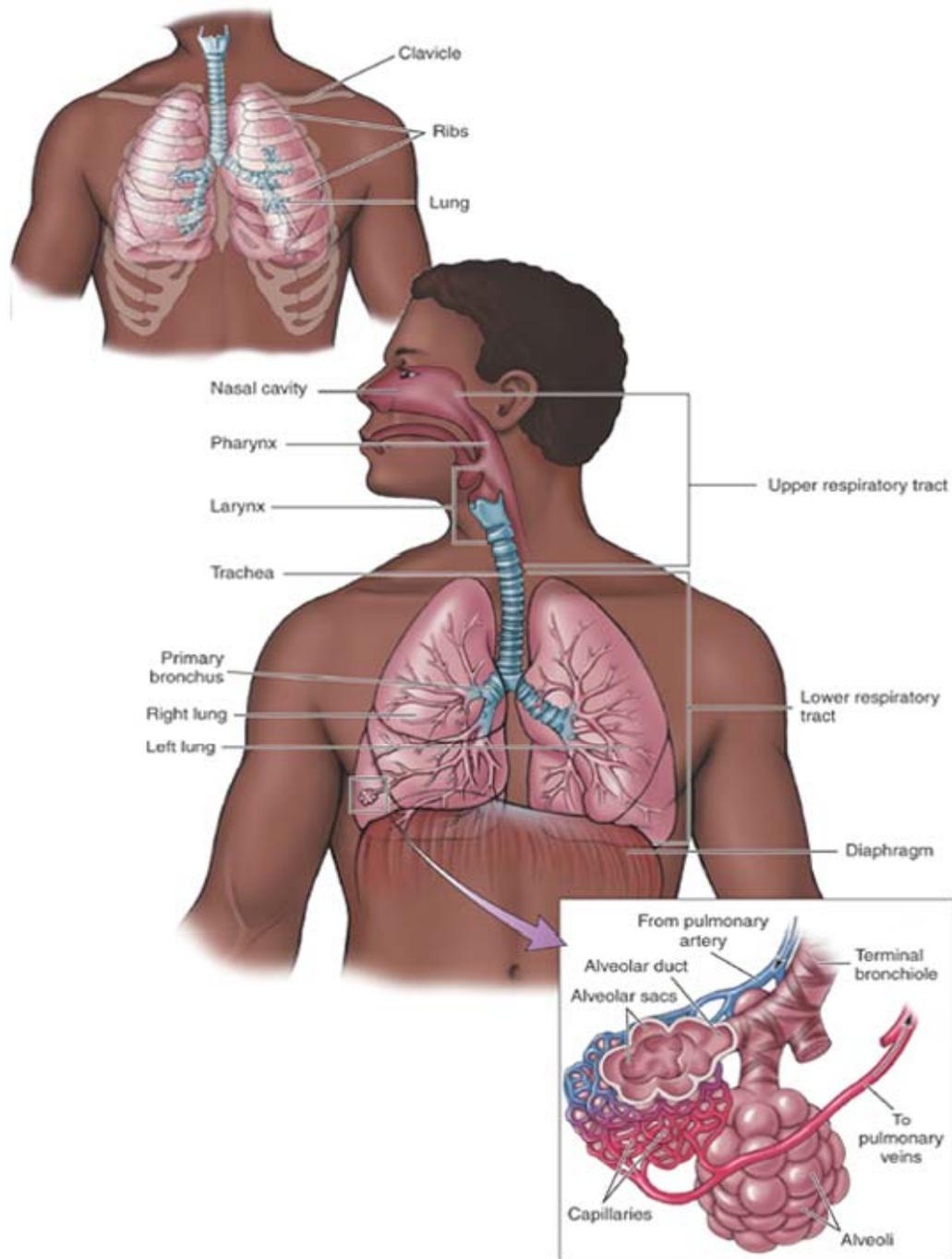
- Respiration includes three steps:
 1. Ventilation: movement of air into & out of lungs
 - respiratory cycle includes 1 inspiration & 1 expiration
 - Inhalation:
 - AKA inspiration
 - Breathing in phase
 - Oxygen rich air moves into the tiny air sacs of lungs
 - Expiration:
 - AKA exhalation
 - Breathing out phase
 - Air rich in carbon dioxide moves out of lung

Respiratory System

- Last two steps in Respiration:
 2. Exchange of oxygen & carbon dioxide from lungs & cells of body
 3. Transport of oxygen & carbon dioxide between the lungs & body cells via blood

Organs of Respiratory System

- Respiratory System consists of the:
 - Upper respiratory tract contains organs located outside the chest cavity: ***nose, nasal cavities, pharynx, larynx & upper trachea***
 - Lower respiratory tract contains organs located in the chest cavity: ***lower trachea, bronchi, bronchioles, aveoli & pleural membranes***



- Most of the respiratory organs are associated with ventilation; air movement through the respiratory passages
- The aveoli are tiny air sacs at the end of respiratory passages where the exchange of oxygen & carbon dioxide occurs between air & blood

Nose & Nasal Cavities

- Nose:
 - external portion that forms part of the face
- Nasal Cavities:
 - internal portion separated into two halves by the nasal septum;
 - contain receptors cells for the sense of smell
- Nasal Septum:
 - bony & cartilage that separates nasal cavities
- Nares or nostrils:
 - two openings where air enters that nasal cavities that are lined with hair that act as filters

Nose & Nasal Cavities

- Nasal conchae:
 - Three bony projections on the lateral walls of the nasal cavities
 - Increase the surface area of nasal cavities
 - Area of ciliated mucous membrane that contains many blood vessels that helps to warm & moisten the air & mucus secreting cells that help to trap dust, pollen & small particles thereby cleansing the air inhaled

Nose & Nasal Cavities

- Paranasal sinuses:
 - Drains the sinus cavities & includes:
 - Maxillary
 - Frontal
 - Ethmoidal
 - Sphenoidal
 - Nasolacrimal ducts also drain into the nasal cavities

Pharynx

- Pharynx:
 - Throat
 - Located behind the oral cavity & between the nasal cavities & larynx
 - Three parts:
 - Nasopharynx: upper portion
 - Oropharynx: middle portion
 - Laryngopharynx: lower section

Pharynx

- The oropharynx & laryngopharynx:
 - are part of both the digestive & respiratory system
 - Function as passageway for both food & air
- The pharynx conducts food to the esophagus to enter the stomach & air to the larynx to enter the lungs
- Pharynx contains two structures:
 - Opening from the eustachian tubes
 - Tonsils

Larynx

- Larynx
 - Also called voicebox because it contains vocal cords
 - Located between the pharynx & trachea
 - Triangle structure made of cartilage, muscles & ligaments
- Three functions:
 - Passageway for air during breathing
 - Produces sound/voice
 - Prevents aspiration of food or foreign objects

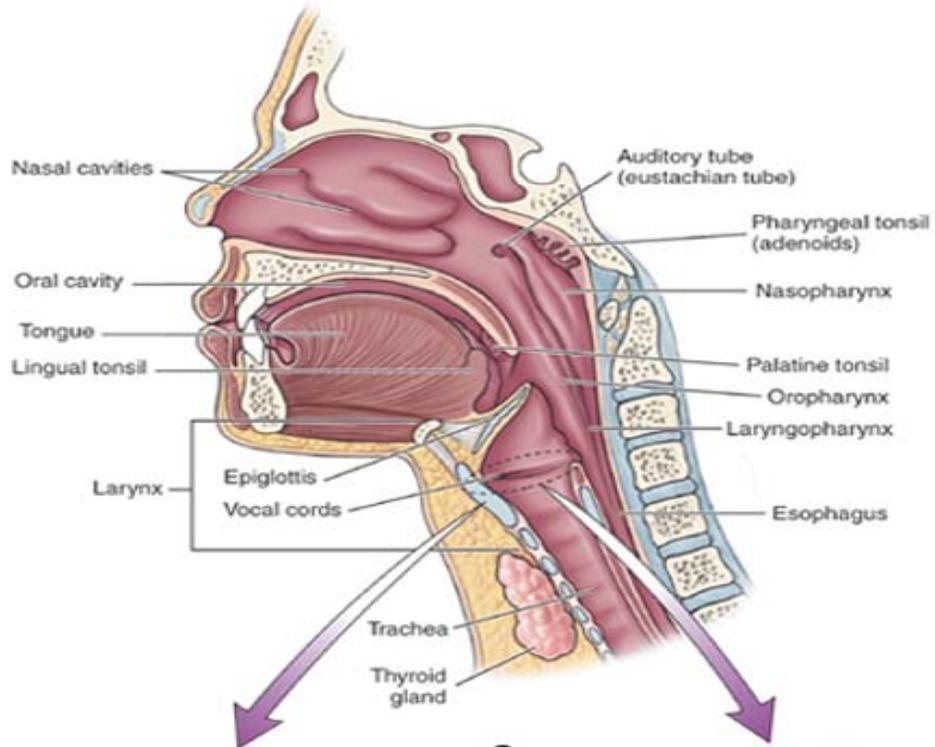
Larynx

- Larynx contains:
 - Thyroid cartilage: tough hyaline cartilage structure that protrudes in the front of the neck; called Adam's apple in men
 - Epiglottis: cartilaginous structure located at the top of the larynx acts as flap covering the glottis (hole at top of larynx) which prevents aspiration
 - Glottis: opening at top of larynx; space between the vocal cords

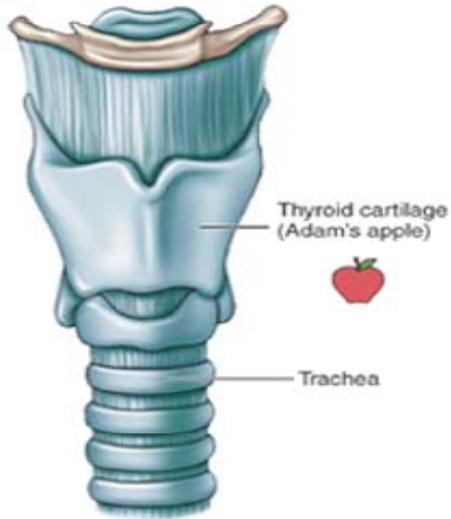
Larynx

- Vocal Cords:
 - Folds of tissue composed of muscle & elastic ligaments & are covered by mucous membrane
 - Stretch across the upper part of the larynx
- Two types:
 - False vocal cords: do not produce sound but help close the airway when swallowing
 - True vocal cords: produce sound

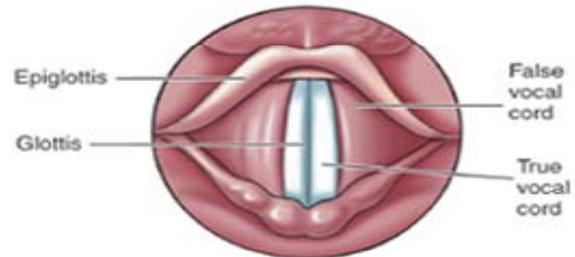
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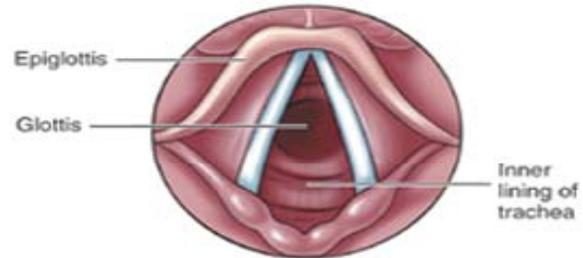
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Vocal Cords

- As air flows from the lungs through the glottis the true vocal cords vibrate producing sound
- The loudness of your voice depends on the force with which the air moves past the true vocal cords
- Pitch depends on tension exerted on the muscles of the true vocal cords

Voice

- You form sound into words with your pharynx, oral cavity, tongue & lip movement
- The nasal cavities, sinuses & pharynx act as resonating chambers, thereby alternating the quality of voice; changes from high to low
- Males larynx enlarge & vocal cords become larger & thicker in response to testosterone which creates a deeper voice

Trachea

- Trachea:
 - AKA windpipe
 - Conducts air to & from lungs
 - Tube 4-5 inches long & 1 inch in diameter
 - Extends from the lower edge of the larynx downward into the thoracic cavity
 - Located in front of the esophagus
 - Splits into right & left bronchi

Trachea

- Trachea:
 - C-shaped rings of cartilage partially surround the trachea to keep it open
 - The rings are open at the backside so that the esophagus can bulge forward as food passes to the stomach

Bronchi

- Bronchi:
 - Right & left primary bronchi are formed as the lower portion of the trachea divides into two tubes
 - The primary bronchi enter the lung at the region called the hilus
 - Then branch into secondary bronchi
 - Secondary branch off into smaller tertiary bronchi

Bronchi

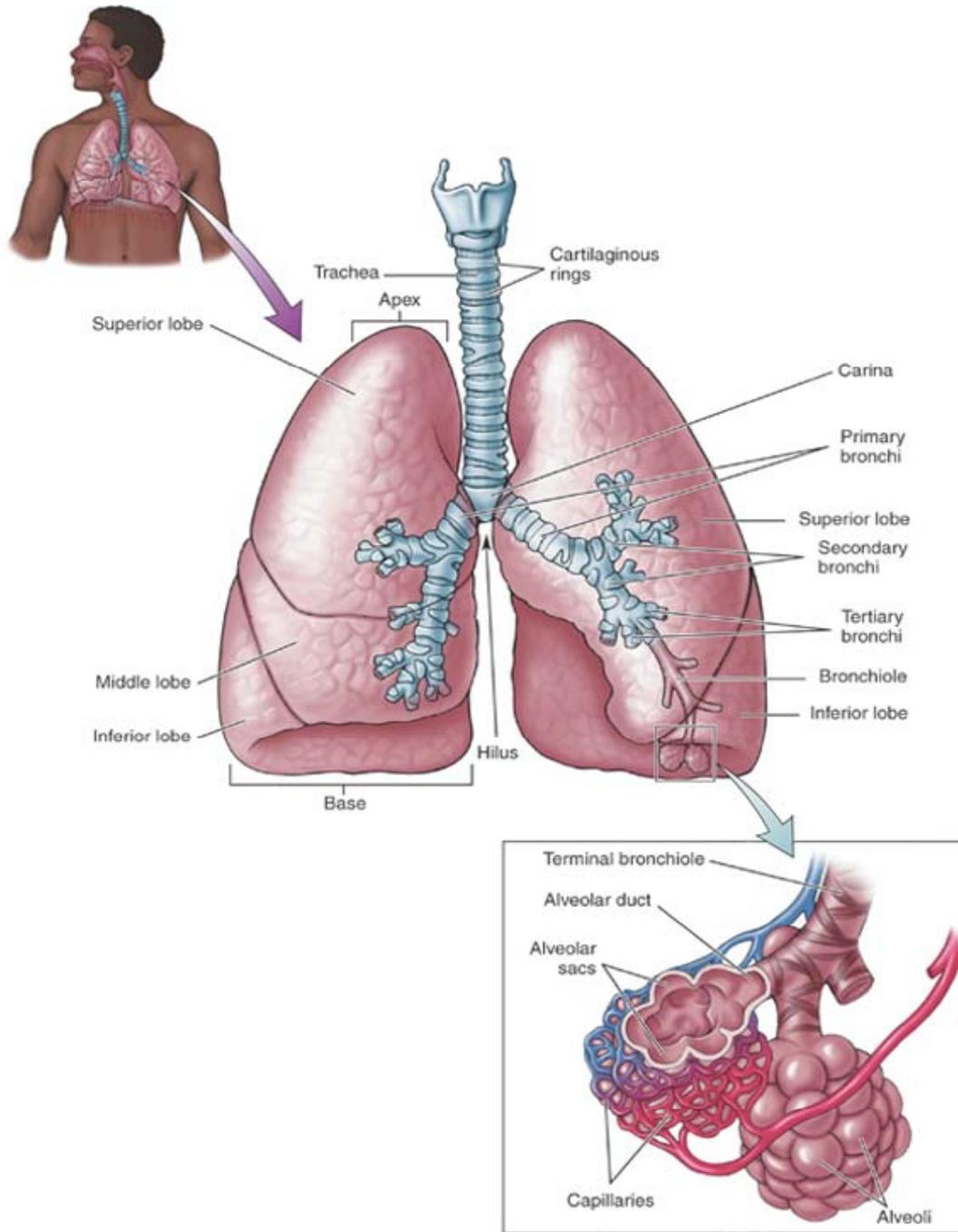
- Left bronchus is narrower & positioned more horizontal due to the position of the heart toward the left side of chest
- Right bronchus is shorter, wider & extends downward in a more vertical position
- Right bronchus is more apt for aspiration because of anatomy
- Upper bronchi contain C-shaped cartilaginous discs that help keep bronchi open
- The amount of cartilage decreases extending down the bronchi; none at distal branches

Bronchioles

- Bronchioles:
 - bronchi divided repeatedly into smaller tubes called bronchioles
 - No cartilage; only smooth muscle
 - Regulate air flow to aveoli
 - Contraction of smooth muscle causes constriction & decreases in lumen & air flow
 - Relaxation of smooth muscles of bronchioles creates opposite effect; increased lumen & air flow

Aveoli

- Aveoli:
 - As bronchioles continue to divide; tiny tube called aveolar ducts form
 - Tiny grape like structures at the end of air passages
 - Surrounded by pulmonary capillaries
 - Function is exchange oxygen & carbon dioxide across the aveolar-pulmonary capillary membrane



Alveoli

- Alveoli:
 - Has large surface area:
 - 350 million/lung
 - Increases the amount of O₂ & CO₂ exchange
 - Thin alveolar walls:
 - simple squamous epithelial cells favor diffusion across membrane
 - Little resistance
 - There is a close relationship between pulmonary capillaries & aveoli:
 - Closeness ensures high rate of diffusion

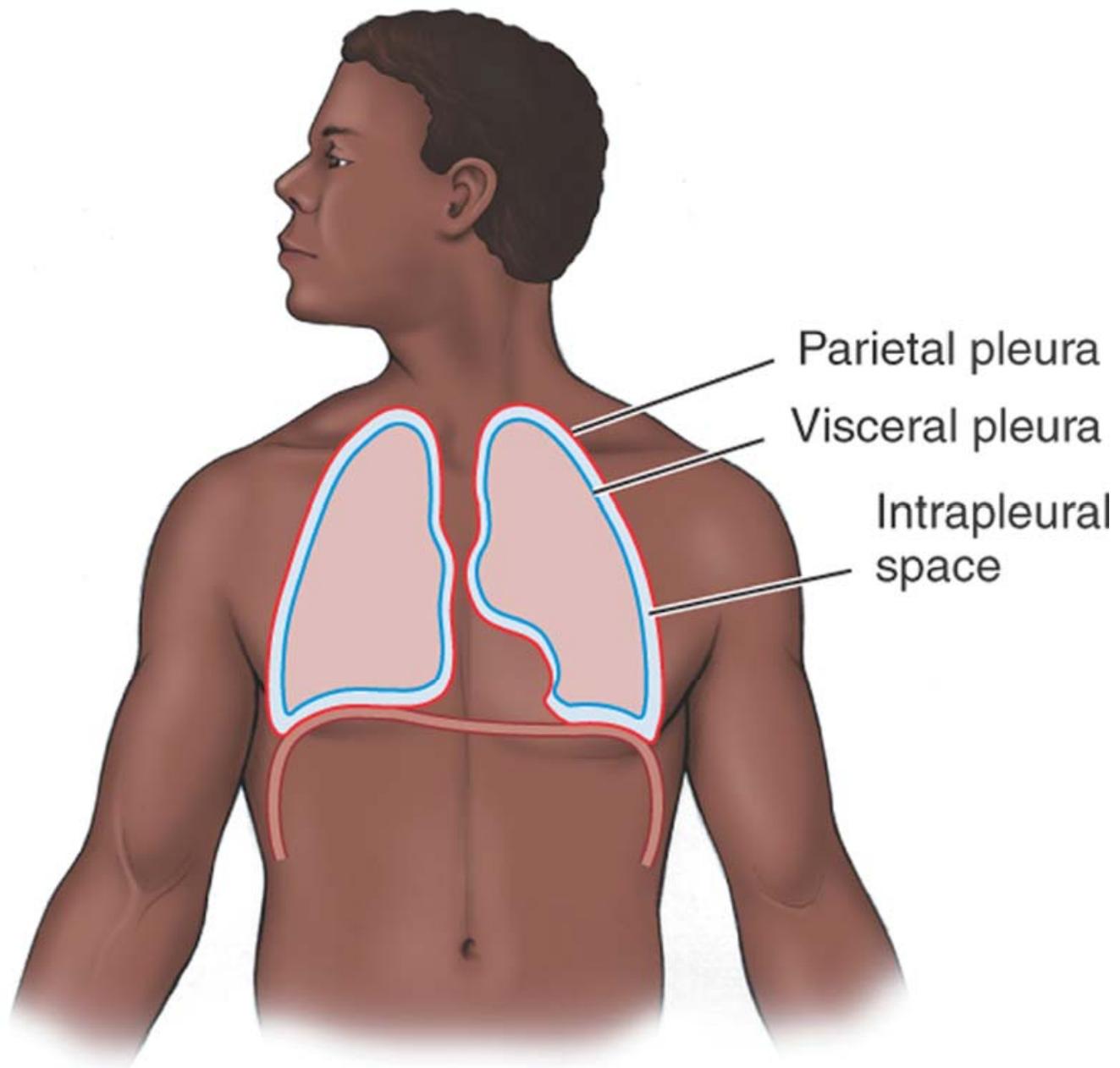
Lungs

- Lungs
 - Located in the thoracic cavity
 - Extending from an area above the clavicle to the diaphragm
 - Soft cone-shaped organs divided into lobes
 - Lobes on left are subdivided into two; superior & inferior
 - Lobes on right are divided into three; superior, inferior, middle
 - Rounded upper part is the apex & lower portion is the base

Pleural Membranes

○Pleural cavity:

- Pleura is a continuous serous membrane that lines each lung & the inner chest wall
 - Visceral pleura cover the outer surface of the lung
 - Parietal pleura lines the chest wall
- Between the visceral pleura & parietal pleura is space called intrapleural space or pleural cavity
- The pleural membranes secrete a thin layer of serous fluid that lubricates the membranes allowing them to slide past one another without friction
- Under abnormal conditions the intrapleural space can accumulate fluid, blood or air



Why Lungs Collapse

○ The lung can collapse due to:

- **Elastic** tissue arrangement of the lung

- if the thoracic cavity is entered the tension is released causing the elastic tissue of the lung to recoil into an unstretched position causing it to deflate or collapse

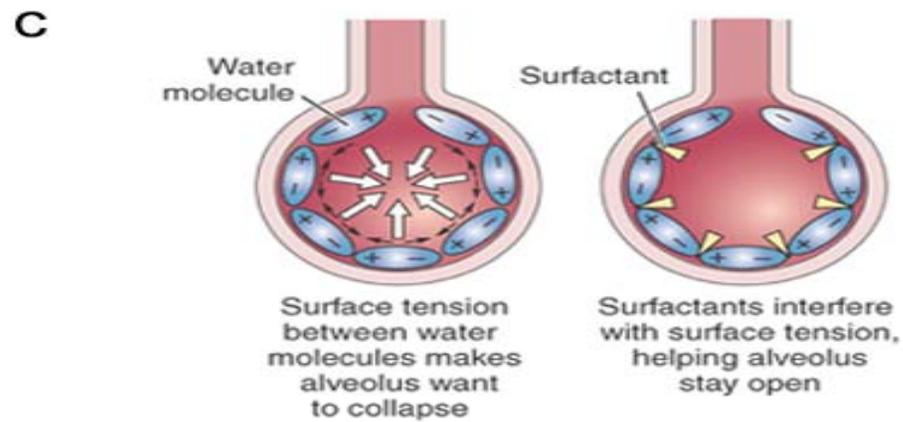
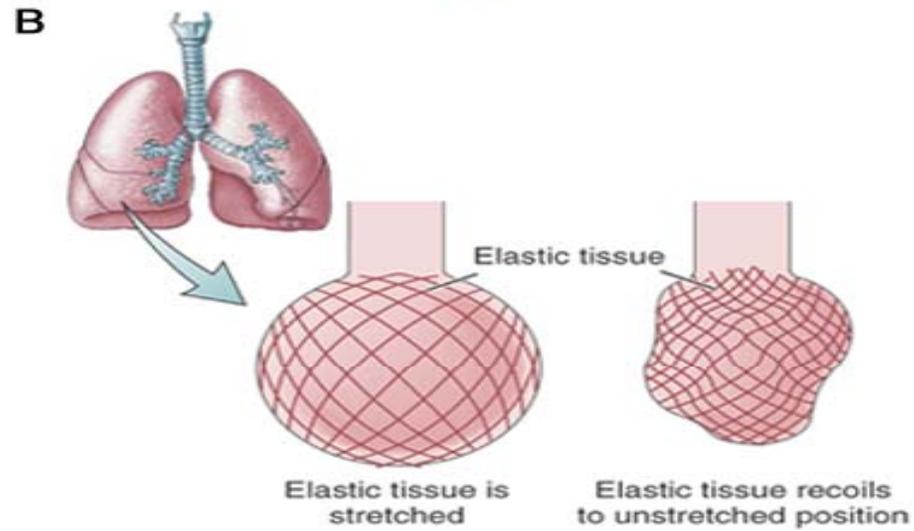
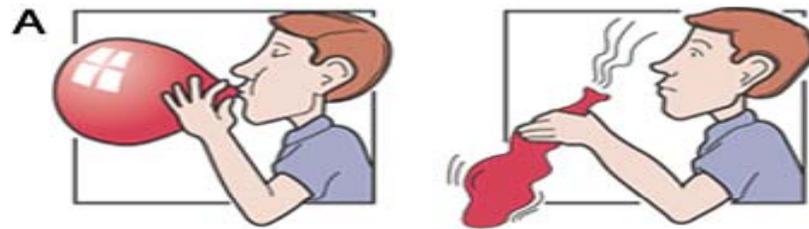
- Surface tension in the lung

- Is the electrical attraction of the water molecules in the aveoli

- As the water molecules pull on each other they collapse the aveoli

Surfactant

- Surfactant
 - Is a lipoprotein secreted by special aveolar cells
 - Decreases the surface tension by interfering with the electrical attraction between water molecules on the inner surface of the aveolus
 - Does not relieve only lowers surface tension just decreases



Why Lungs Expand

- Lung expansion depends on the pressure within the chest cavity
- Three pressure involved:
 - Pressure outside the chest is atmospheric pressure
 - Pressure in the lung is called intrapulmonic pressure
 - Pressure inside in the intrapleural space is intrapleural pressure

Why Lungs Expand

- The lung expands only when the intrapleural pressure is negative
- The atmospheric pressure is greater so it pushes the chest wall inward toward the lung, when they meet the lung is expanded
- If intrapleural pressure is eliminated the lung collapses called pneumothorax

Respiratory Function

- Three steps in respiration:
 - Ventilation
 - Exchange of oxygen & carbon dioxide between:
 - air sacs & blood
 - blood & cells in the body
 - Transport of oxygen & carbon dioxide by blood

Ventilation

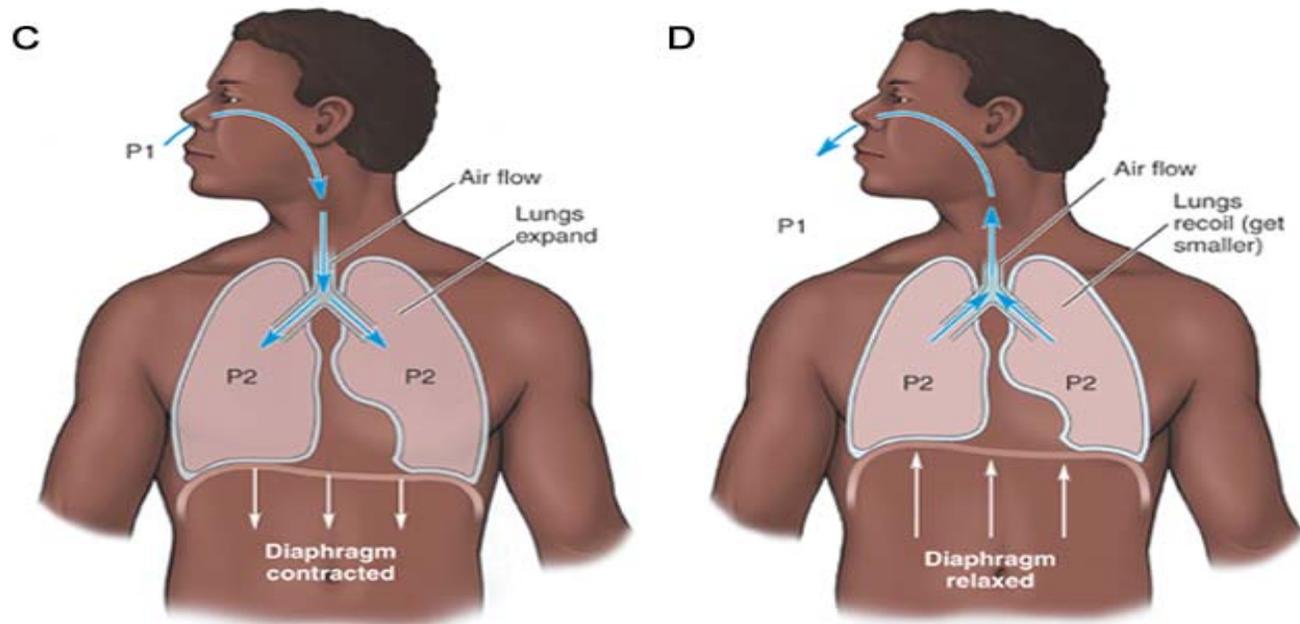
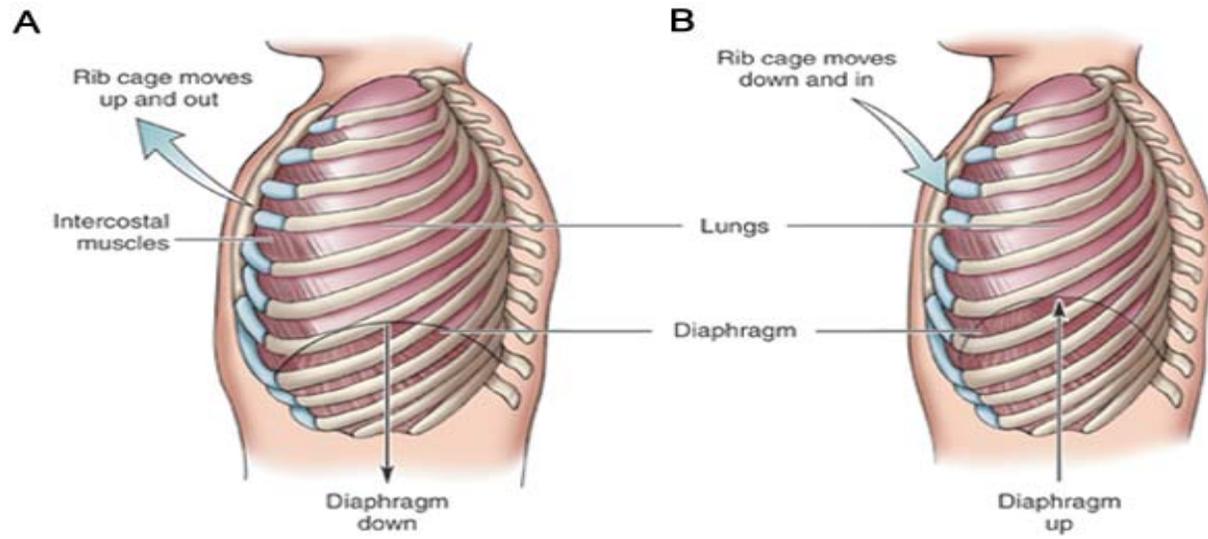
- Ventilation:
- Two phases: inhalation & exhalation
- Ventilation occurs in response to Boyle's law
 - Boyle's law: if volume changes, the pressure changes
 - Upon inhalation, air rushes into the lungs
 - Movement of the rib cage up & out & the diaphragm down increases volume & decreases the intrapulmonic pressure in the lung so atmospheric pressure forces air flow into the lungs
 - Upon exhalation, air leaves the lungs

Muscles of Respiration

- The change in thoracic volume is due to the contraction & relaxation of respiratory muscles
- On inhalation the respiratory muscles, diaphragm & intercostal muscles contract
- Diaphragm is the chief muscle of inspiration
- Contraction of the diaphragm flattens the muscle & pulls it downward increasing the thoracic cavity & thoracic volume

Muscles of Respiration

- Two sets of intercostal muscles:
 - Internal & External
- When the external intercostal contract, the rib cage moves up & out, thereby increasing the width of the thoracic cavity & increasing the thoracic volume
- According to Boyle's law, increase in the volume decreases the pressure in the lungs & as a result air flows into the lungs



Muscles of Respiration

- Accessory Muscles of Respiration:
 - Abdominal muscles
 - Internal intercostal muscles
 - Muscles of the neck
- Used during exertion & forced exhalation or with diseases of the respiratory system, i.e. emphysema

Nerves of Respiratory Muscles

- The respiratory muscles are stimulated by motor nerves to contract
- Nerves include:
 - Phrenic nerve: exits the spinal cord at the level of C4 & travels within the cervical plexus & is distributed to the diaphragm
 - Stimulation of phrenic nerve causes the diaphragm to contract
 - Intercostal nerves supply the intercostal muscles
 - Stimulation of the intercostal nerves contracts the intercostal muscles

Summary of Ventilation

- Starts with nerve stimulation of the phrenic & intercostal nerves causing a contraction of the diaphragm & intercostal muscles
- This contraction flattens the diaphragm & lengthens the thoracic cavity & intercostal muscles contraction widens the thoracic cavity
- Increase volume causes a decrease in pressure causing air to move from outside (where pressure is higher) to inside lung (pressure is lower)
- When the muscles relax, the thoracic cavity

Summary of Ventilation

- During ventilation:
 - Inhalation delivers oxygen-rich air to the aveoli
 - Exhalation removes carbon dioxide from aveoli

Gas Exchange

- Exchange of Respiratory Gases occurs in two areas:
 - In the lungs
 - At the cells
- Lungs :
 - Exchange occurs across the membrane of the aveoli & pulmonary capillaries
- Cells:
 - Oxygen leaves the blood & diffuses into the cells & carbon dioxide diffuses from cells into the blood

Gas Exchange

- Exchange of respiratory gases occurs in the aveoli & pulmonary capillaries
- Gases diffuses from an area of high pressure to an area of low pressure
- Oxygen diffuses from the air in the aveoli into the blood of the pulmonary capillaries
- Carbon dioxide from the pulmonary capillaries to the aveoli

Gas Exchange

- Gas exchange also occurs in cells
- Oxygen diffuses from the capillaries to the cells
- Carbon Dioxide diffuses from the cells into the capillaries

Gas Exchange Summary

- In the lungs between millions of alveoli & capillaries O₂ & CO₂ move across thin walls of alveoli & capillaries into the blood
- Movement occurs by diffusion from an area of high concentration to an area of lower concentration
- When the molecules of gas are high in concentration, pressure is high & then they move

Transport of O₂ & CO₂

- Oxygen transport:
 - Almost all oxygen is transported by hemoglobin
 - As soon as the oxygen enters the blood in the pulmonary capillaries it forms a loose bond with the iron portion of the hemoglobin molecule
 - This new molecule is called oxyhemoglobin
 - As oxygenated blood travels to the cells, the oxygen unloads the hemoglobin molecule & diffuses across the capillary walls of cells

Transport of O₂ & CO₂

- Carbon Dioxide transport:
 - Blood carries carbon dioxide from the metabolizing cells to the lungs where it is exhaled
 - Blood carries it in 3 Ways:
 - 10% is dissolved in plasma
 - 20% combines with hemoglobin to form carbaminohemoglobin
 - 70% is converted to bicarbonate ion

Lung Volumes

- Volume is the amount of air you breath
- 4 types of pulmonary volumes:
 - Tidal volume: is the amount of air moved in & out of the lungs with each breath; average is 500ml
 - Inspiratory reserve volume: after normal inhalation, inhale as much air as you can; usually extra volume is 3,000 ml
 - Expiratory reserve volume: exhale a normal breath, exhale as much as you can; usually 1,100ml
 - Residual volume: air remaining in the lungs after

Lung Capacities

- Pulmonary capacity is a combination of pulmonary volumes
- Vital capacity (4,600ml) refers to the combination of tidal volume(500ml), inspiratory reserve volume(3,000ml) & expiratory reserve volume(1,100ml)
- Vital capacity is the maximal amount of air exhaled after maximal inhalation
- Take deepest breath possible & then exhale all the air possible into spirometer; should be 4,600ml

Dead Space

- Anatomical dead space refers to the approx. 150 ml of air inhaled that never reaches the alveoli for gas exchange
- Remains in the trachea, bronchi & bronchioles
- Slow deep breathes increase the amount of air reaching the alveoli for gas exchange
- Rapid, shallow breathes decreases the quality & amount of air for gas exchange

Control of Breathing

- Breathing is an involuntary process
- Controlled by two mechanism:
 - Nervous
 - Chemical

Control of Breathing

- Nervous:
- Medulla Oblongata
 - Main control center is the medulla called the medullary respiratory control center
 - Controls the breathing rhythm; regular or irregular
 - Inspiratory neurons in the medulla fire sending a nerve impulse along the phrenic & intercostal nerve to muscles of respiration causing contraction of the muscles resulting in inhalation
 - When the expiratory neurons of the medulla fire, the inspiratory neurons are shut down causing the

Control of Breathing

- Pons also plays key role
 - Contains pneumotaxic center & apneustic center
 - Controls breathing pattern; deep or shallow
- Hypothalamus:
 - Processes our emotional response
 - Rapid breathing can be part of fight or flight response
- Cerebral cortex allows us to voluntarily control the depth & rate of breathing
- Vagus nerve sends impulses to the brain stem from lungs
- Hering-Breuer reflex: when lungs are inflated nerve impulses are sent to the brain stem to

Control of Breathing

- Chemicals in the blood also affect breathing
- Chemical include:
 - Carbon dioxide
 - Hydrogen ion
 - Oxygen
- Chemical are detected by chemoreceptors
- Two types:
 - Central chemoreceptors located in the CNS
 - Peripheral chemoreceptors located in PNS

Control of Breathing

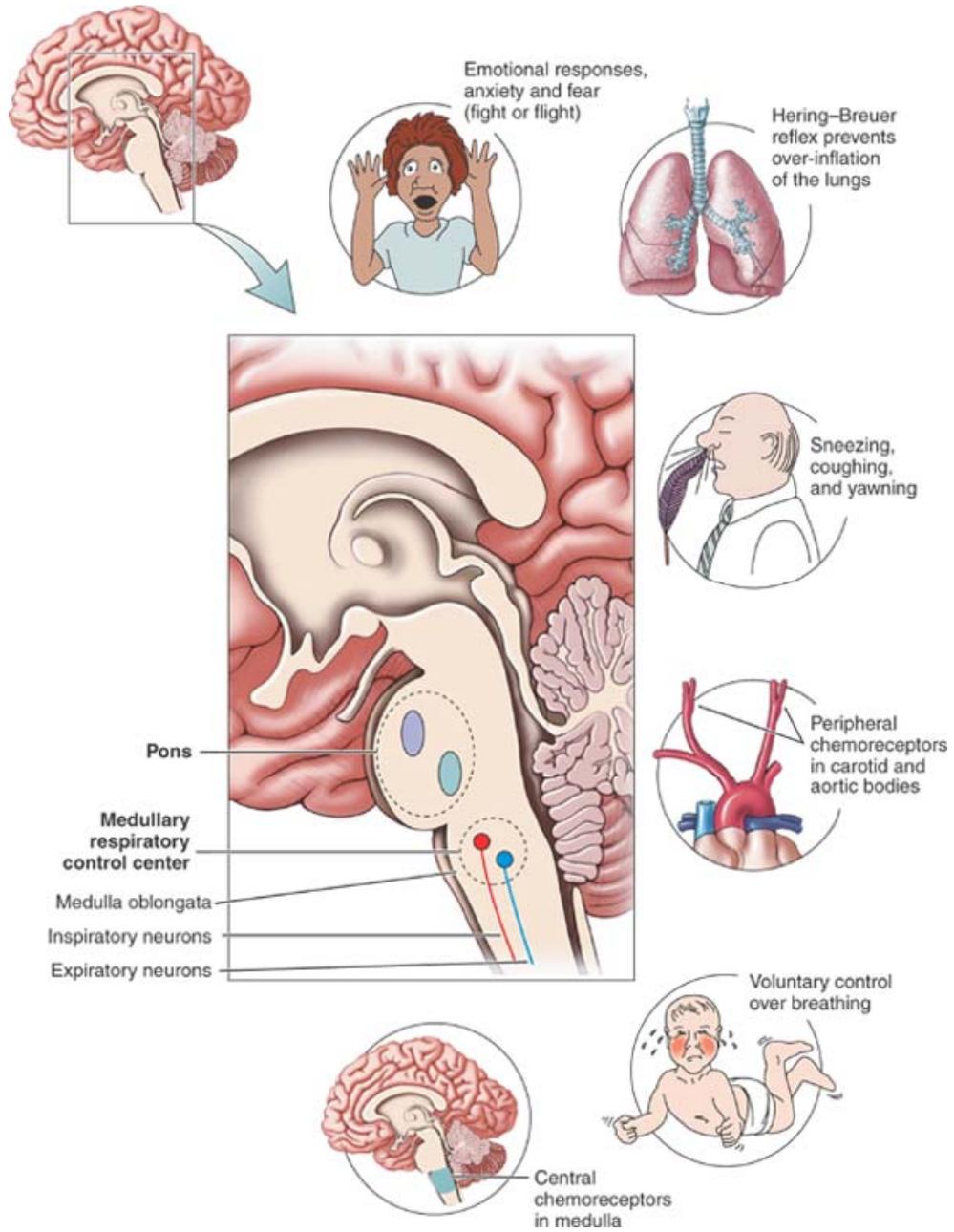
- The central chemoreceptors of the medulla detect changes in the blood concentration of CO₂ & hydrogen ions
- If the CO₂ or hydrogen ion concentration increases, the chemoreceptors signal the respiratory center to increase the rate & rhythm
- With the increase in respiration rate & rhythm, CO₂ is exhaled & blood levels decrease

Control of Breathing

- If the blood levels of CO₂ & hydrogen ions decrease, breathing decreases
- Allows the concentration of CO₂ & hydrogen ions increase
- Breathing is primarily controlled by concentration carbon dioxide & hydrogen ion triggering chemoreceptors

Control of Breathing

- The peripheral chemoreceptors are located in the walls of the carotid arteries & aorta (near neck & chest)
- Sensitive to decrease O₂ concentration & increased hydrogen ion concentration
- Stimulation of receptors stimulates breathing
- O₂ concentration must be very low to trigger peripheral chemoreceptors



Variation in Respiration

- Respiration vary depending on a given situation
- Exercise, fever, medical conditions such as hyperthyroidism acidosis or brain tumor, anxiety increase respirations
- Hypothyroidism, hypothermia, medications (narcotics), brain injury can all decrease respirations

Key Terms

- Hyperventilation: increase in rate & depth of respirations; causes excess exhalation of CO₂ decreasing level in blood (hypocapnia)
- Hypoventilation: decrease in the rate & depth of respirations; causes excess of CO₂ in blood; decrease amount of oxygen to the alveoli

Key Terms

- See chart on p 367
- You are responsible for these terms
- You will hear & use many of these terms in your practice