



# Respiratory System

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# Respiratory System

Respiration includes three steps:

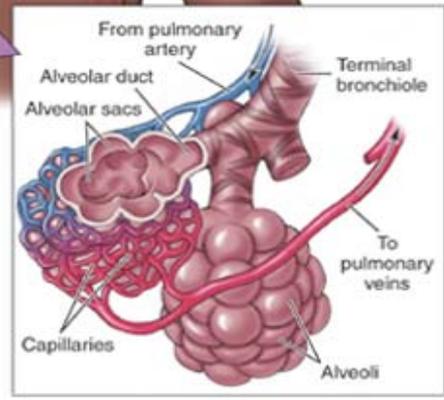
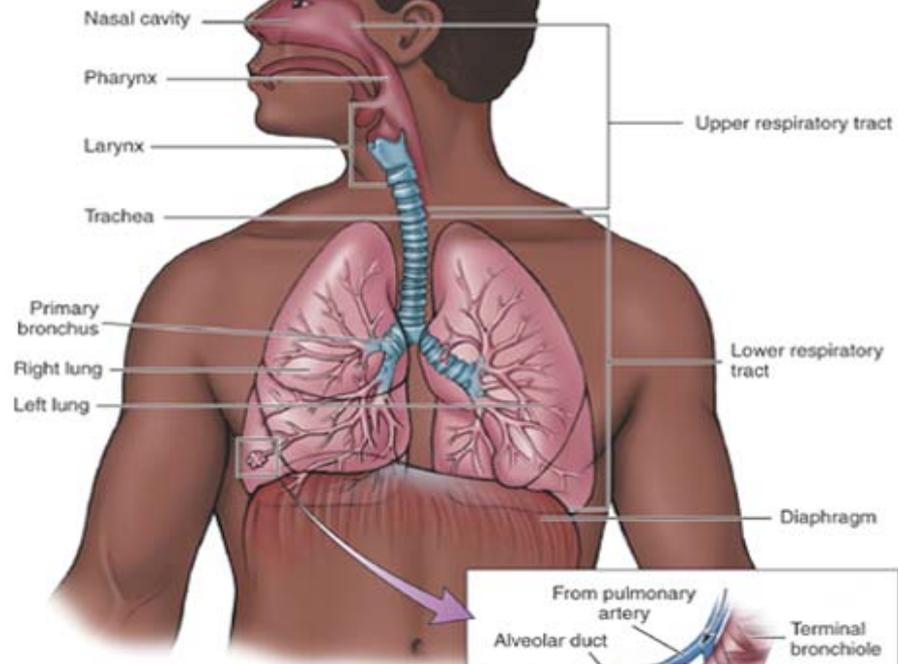
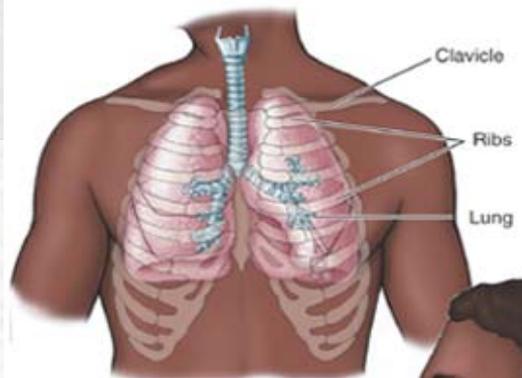
1. Ventilation: movement of air into & out of lungs
  - respiratory cycle includes 1 inspiration & 1 expiration
    - Inhalation:
      - AKA inspiration
      - Breathing in phase
      - Oxygen rich air moves into the tiny air sacs of lungs
    - Expiration:
      - AKA exhalation
      - Breathing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

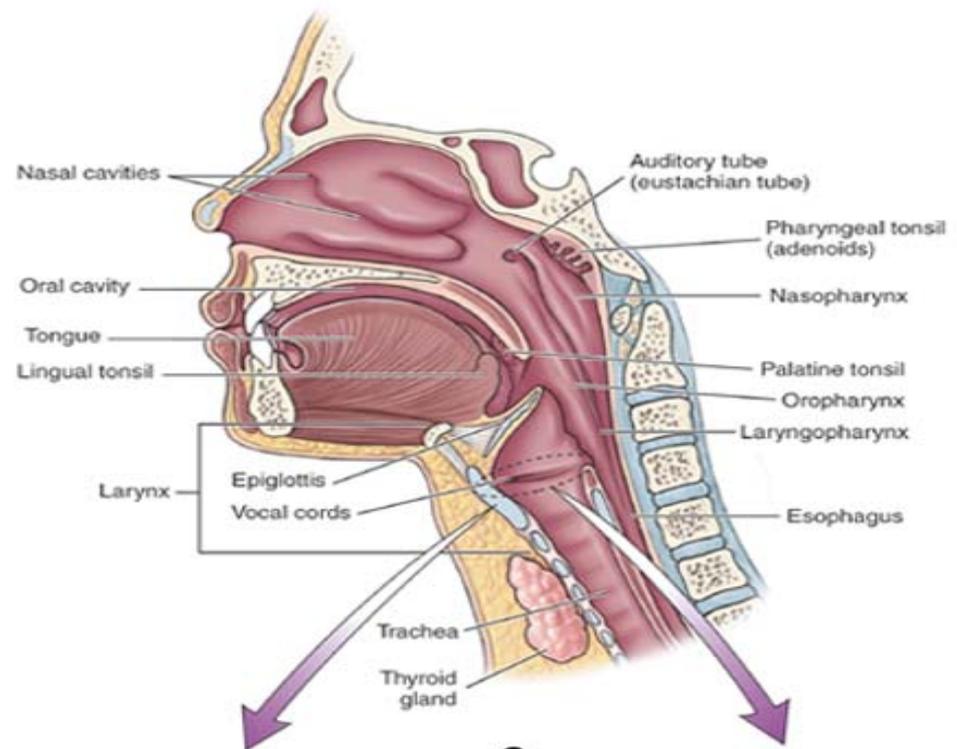
## • Vocal Cords:

- Folds of tissue composed of muscle & elastic ligaments & are covered by mucous membrane
- Stretch across the upper part of the larynx

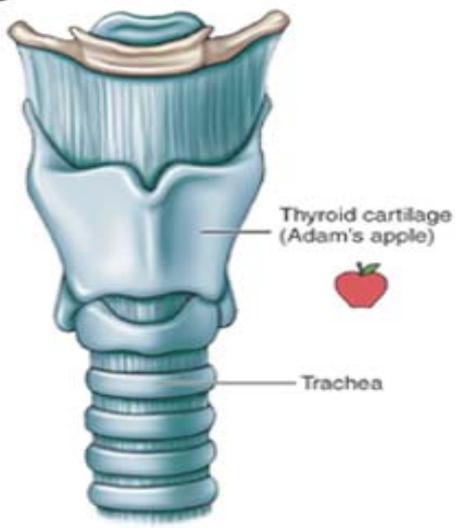
## • Two types:

- False vocal cords: do not produce sound but help close the airway when swallowing
- True vocal cords: produce sound

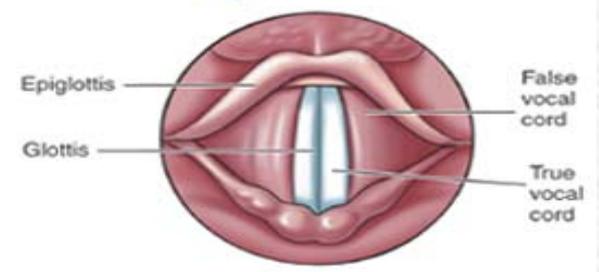
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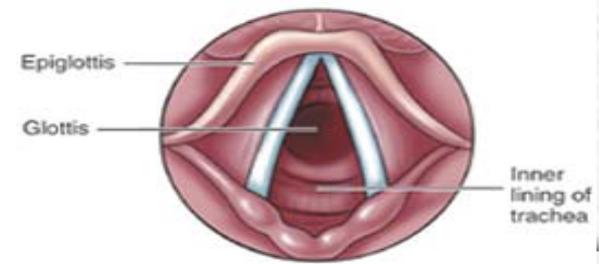
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# Vocal Cords

- 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

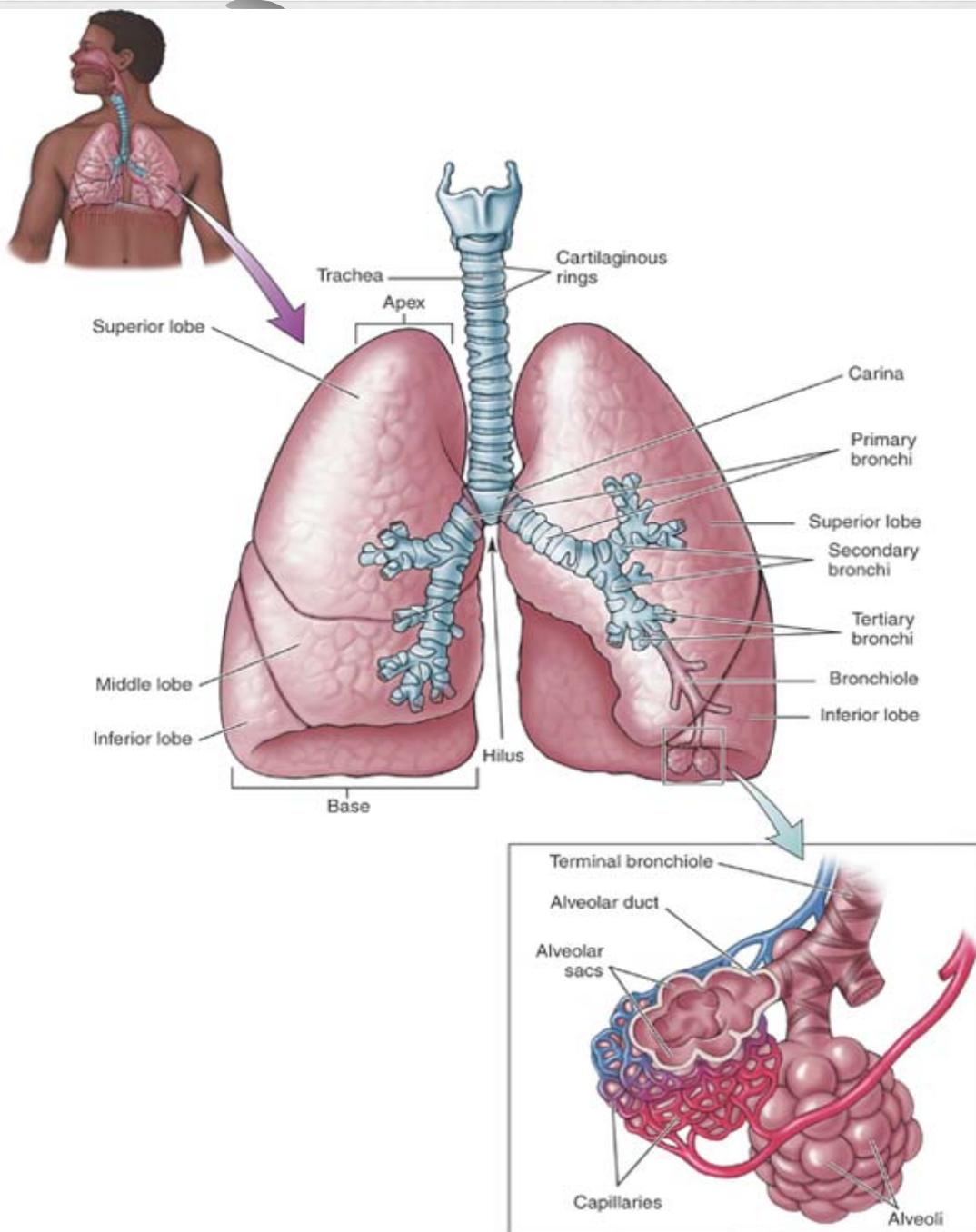
## ■ Bronchioles:

- 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 O<sub>2</sub> & CO<sub>2</sub> exchange
- Thin alveolar walls:
  - simple squamous epithelial cells favor diffusion across membrane
  - Little resistance
- There is a close relationship between pulmonary capillaries & alveoli:
  - Closeness ensures high rate of diffusion

# Lungs

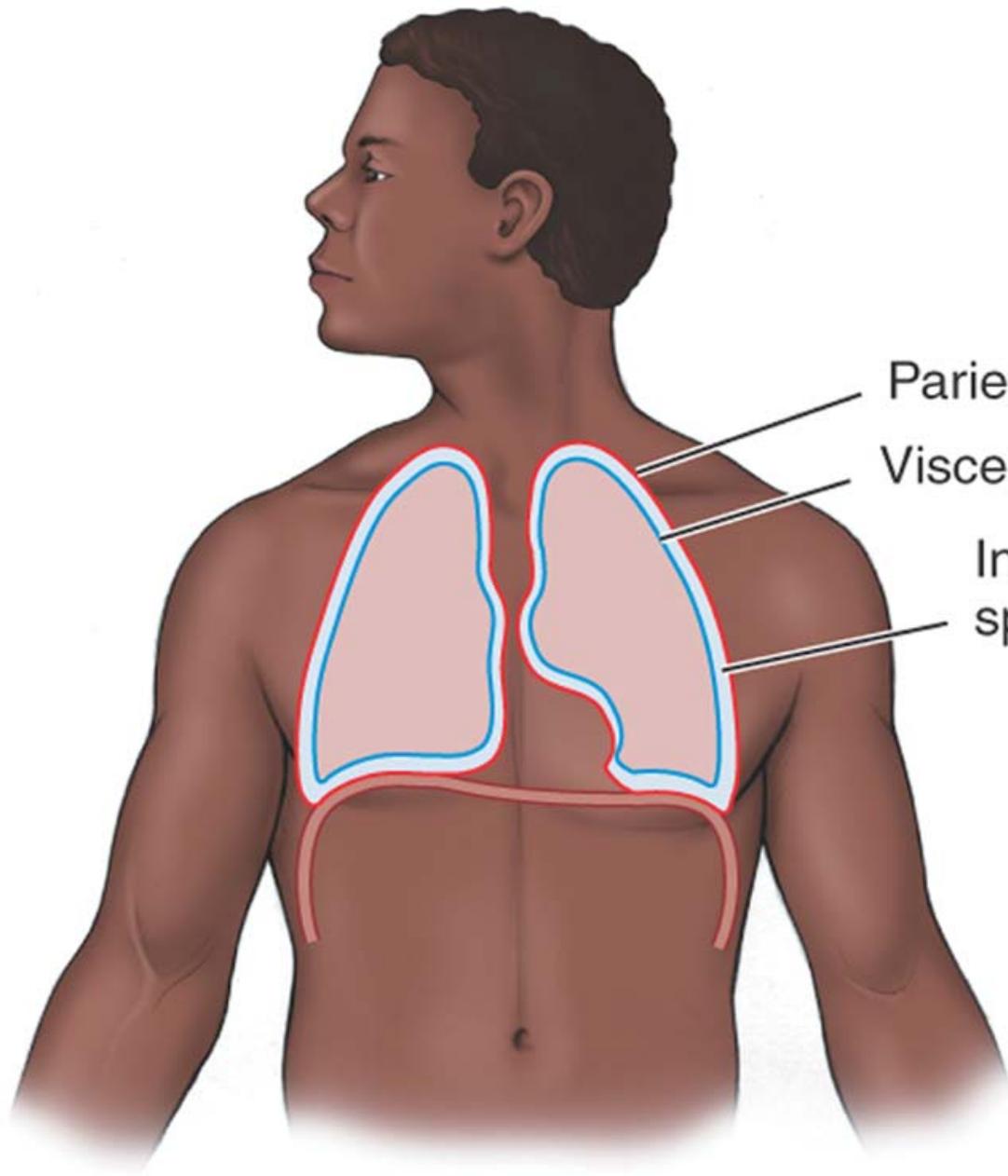
## ☞ Lungs

- 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



Parietal pleura

Visceral pleura

Intrapleural  
space

# Why Lungs Collapse

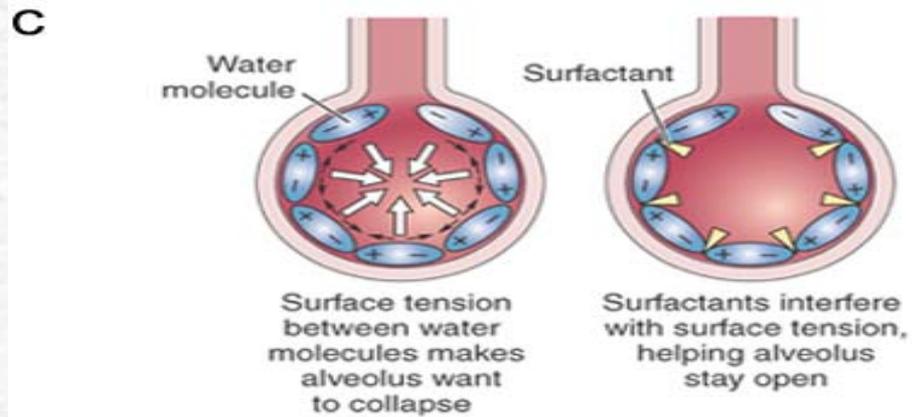
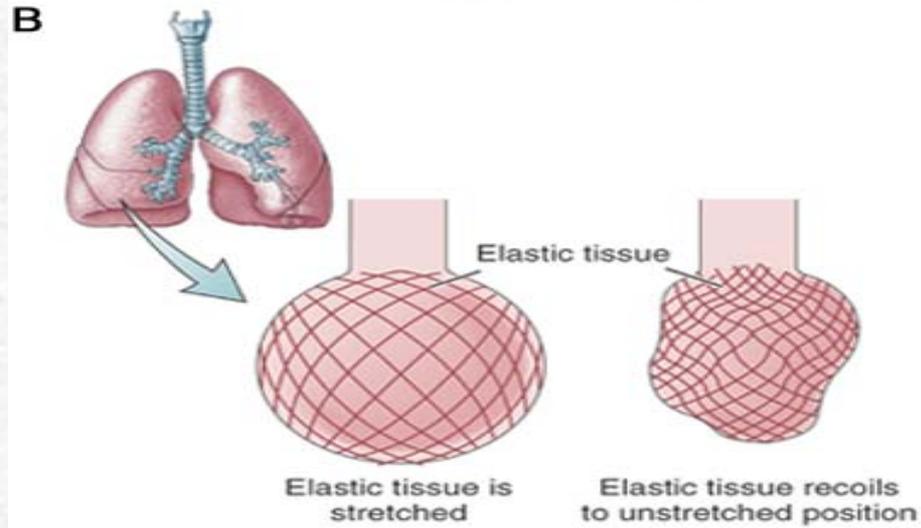
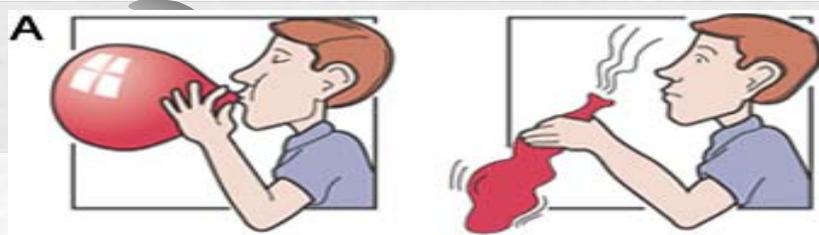
☞ The lung can collapse due to:

- 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
    - the rib cage moves down & in & diaphragm moves up decreasing volume increasing the intrapulmonic pressure in the lungs to increase so forces air flow out of the lungs

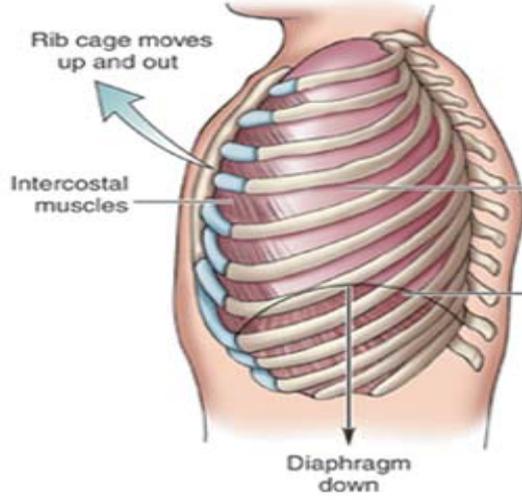
# Muscles of Respiration

- 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

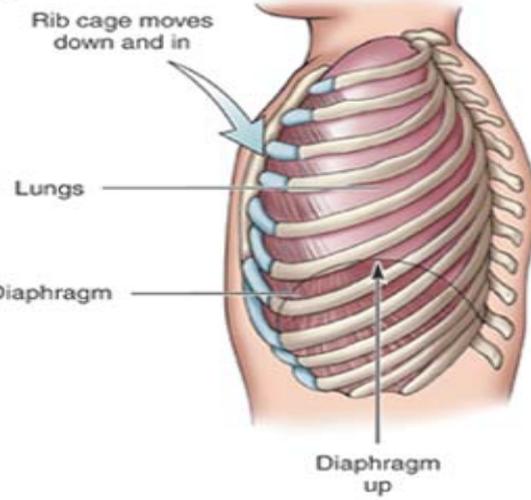
# Muscles of Respiration

- 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

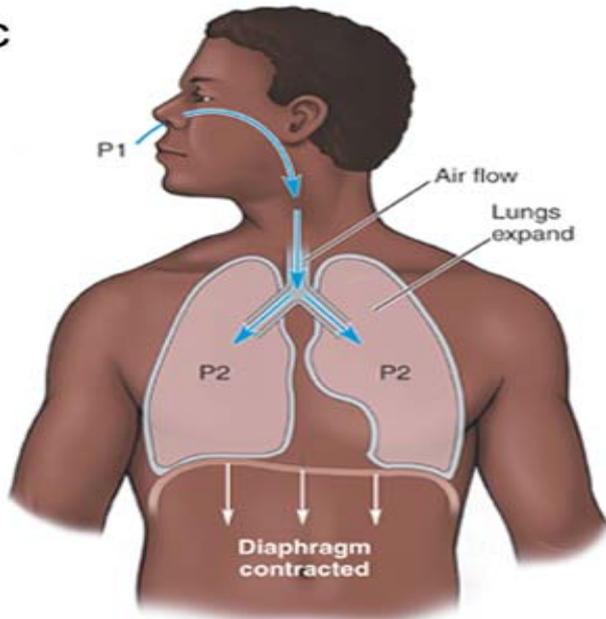
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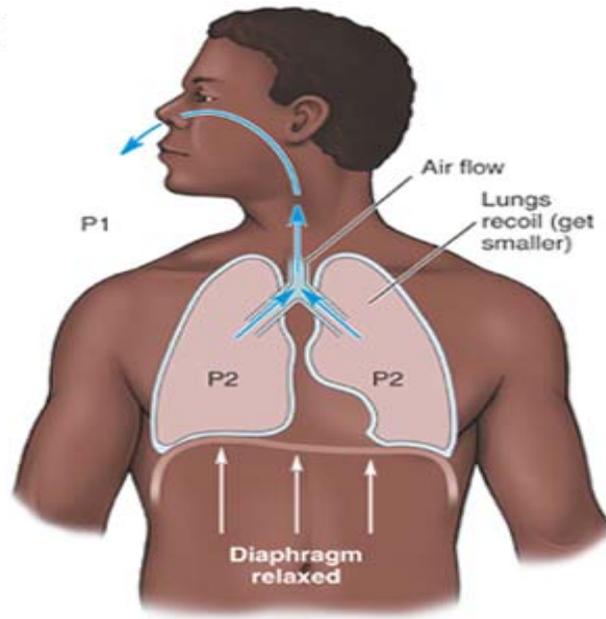
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# Muscles of Respiration

- ☞ 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 space decreases causing decrease in volume which increases pressure causing the air to move out of lung to outside

# 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 O<sub>2</sub> & CO<sub>2</sub> 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 O<sub>2</sub> & CO<sub>2</sub>

## • 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 O<sub>2</sub> & CO<sub>2</sub>

## 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 forced exhalation; usually 1,100ml

# 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
- Common pulmonary function test used to measure function of patients with lung disease

# 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 respiratory muscles to relax causing exhalation

# 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 inhibit inspiratory neurons; protective so lungs do not over-inflate

# 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

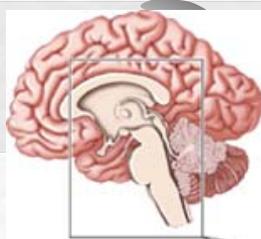
- The central chemoreceptors of the medulla detect changes in the blood concentration of CO<sub>2</sub> & hydrogen ions
- If the CO<sub>2</sub> or hydrogen ion concentration increases, the chemoreceptors signal the respiratory center to increase the rate & rhythm
- With the increase in respiration rate & rhythm, CO<sub>2</sub> is exhaled & blood levels decrease

# Control of Breathing

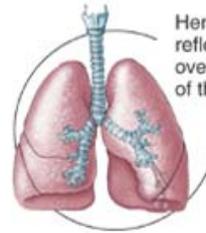
- If the blood levels of CO<sub>2</sub> & hydrogen ions decrease, breathing decreases
- Allows the concentration of CO<sub>2</sub> & hydrogen ions increase
- Breathing is primarily controlled by concentration carbon dioxide & hydrogen ion triggering chemoreceptors

# Control of Breathing

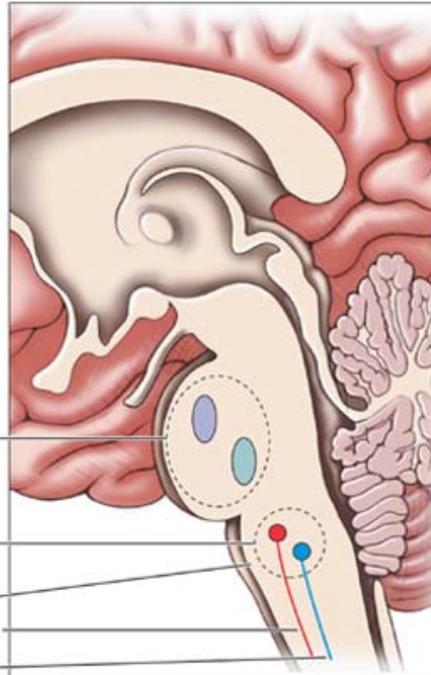
- The peripheral chemoreceptors are located in the walls of the carotid arteries & aorta (near neck & chest)
- Sensitive to decrease O<sub>2</sub> concentration & increased hydrogen ion concentration
- Stimulation of receptors stimulates breathing
- O<sub>2</sub> concentration must be very low to trigger peripheral chemoreceptors



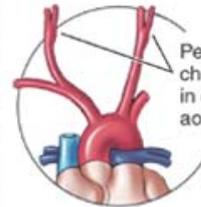
Emotional responses, anxiety and fear (fight or flight)



Hering-Breuer reflex prevents over-inflation of the lungs



Sneezing, coughing, and yawning

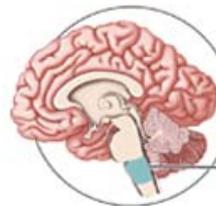


Peripheral chemoreceptors in carotid and aortic bodies

Pons  
Medullary respiratory control center  
Medulla oblongata  
Inspiratory neurons  
Expiratory neurons



Voluntary control over breathing



Central chemoreceptors in medulla

# 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 CO<sub>2</sub> decreasing level in blood (hypocapnia)
- Hypoventilation: decrease in the rate & depth of respirations; causes excess of CO<sub>2</sub> 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