

**Respiratory System**

Rita Carey-Nita

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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

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**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

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## 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**

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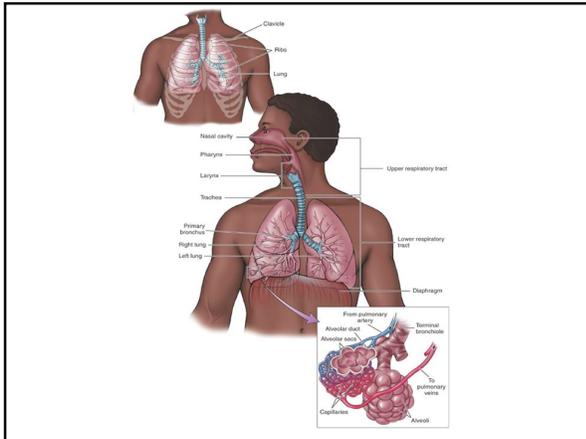
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- Most of the respiratory organs are associated with ventilation; air movement through the respiratory passages
- The aveoli are tiny air sacs at the end of respiratory passages where the exchange of oxygen & carbon dioxide occurs between air & blood

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### 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

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### 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

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### Nose & Nasal Cavities

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

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## Pharynx

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

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## 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

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## 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

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## 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

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## 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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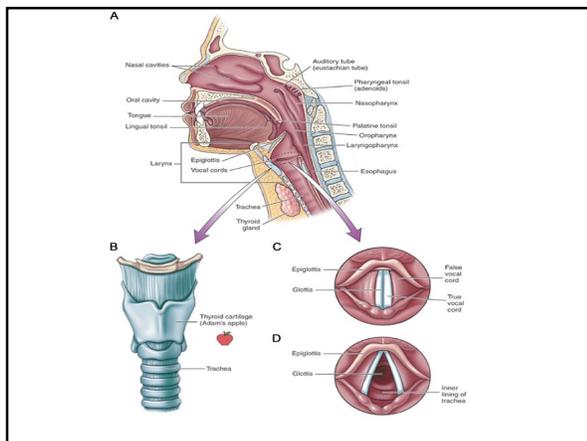
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### Vocal Cords

- 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

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### 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

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### 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

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### 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

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### 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

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### 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

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## 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

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## 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

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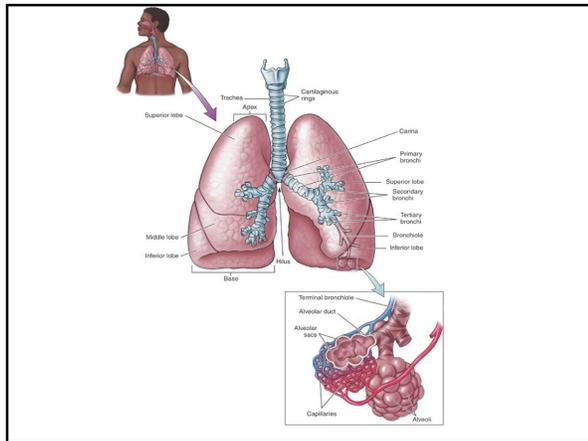
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## Alveoli

- 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

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## 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

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## 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

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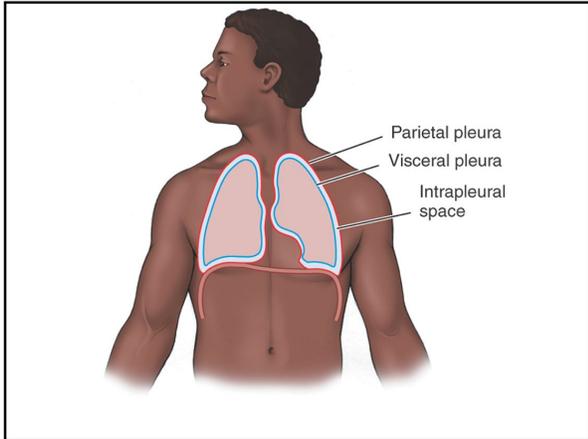
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### Why Lungs Collapse

- 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 un-stretched 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

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### 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

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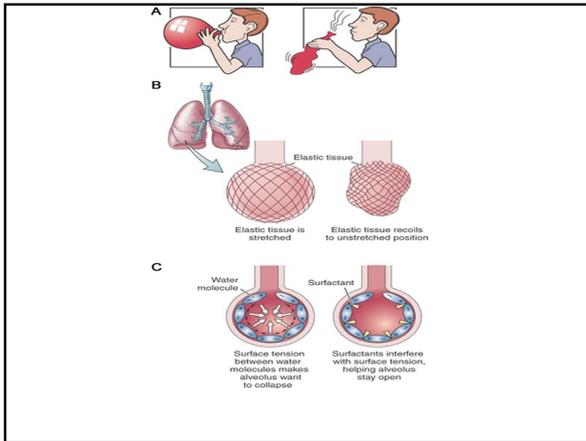
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### Why Lungs Expand

- 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

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### 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

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## Ventilation

Two phases: inhalation & exhalation

- Ventilation occurs in response to Boyle's law
  - Boyle's law states if volume changes then 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

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## 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
- Internal & External intercostal muscles:
  - When the external intercostal contract, the rib cage moves up & out, thereby increasing the width of the thoracic cavity & increasing the thoracic volume

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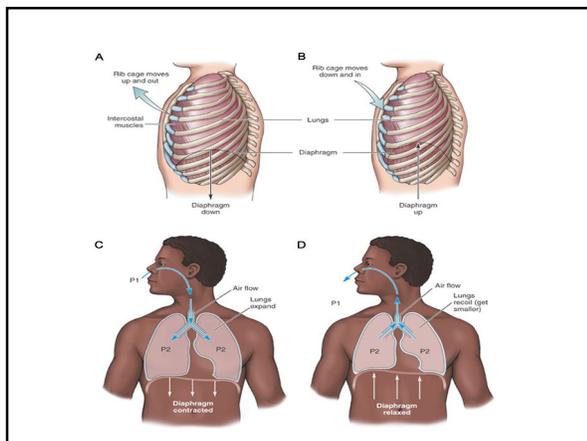
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### Muscles of Respiration

- 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

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### 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

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### 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 intrapulmonic 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 intrapulmonic pressure causing the air to move out of the lung to outside

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### Gas Exchange

- Exchange of Respiratory Gases occurs in two areas by diffusion
  - Within lungs
  - Between cells
- Lungs :
  - Exchange occurs across the membrane of the aveoli & pulmonary capillaries
  - Carbon dioxide leaves blood & enters the aveoli
  - Oxygen leaves the aveoli & enters the blood
- Cells:
  - Oxygen leaves the blood & diffuses into the cells
  - Carbon dioxide diffuses from cells into the blood

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### 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

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### 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

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### 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

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### 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

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### Dead Space

- Anatomical dead space refers to the appox. 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

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### Control of Breathing

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

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### 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

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### 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

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### 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

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### 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

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### 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

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## 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

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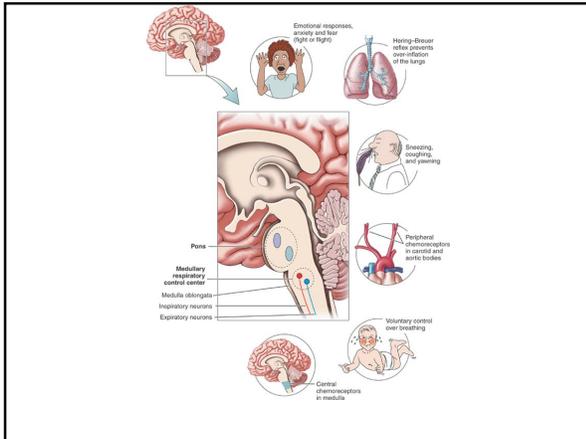
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## Variation in Respiration

- 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

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### 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

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### Key Terms

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

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