The Respiratory System

Organs of the Respiratory system

- Nose
- Pharynx
- Larynx
- Trachea
- Bronchi
- Lungs –
  alveoli
- Function of the Respiratory System
- Oversees gas exchanges between the blood and external environment
- Exchange of gasses takes place within the alveoli
- Passageways to the lungs purify, warm, and humidify the incoming air
- The Nose
- The only externally visible part of the respiratory system
- Air enters the nose through the external nares (nostrils)
- The interior of the nose consists of a nasal cavity divided by a nasal septum
- Upper Respiratory Tract
- Anatomy of the Nasal Cavity
- Olfactory receptors are located in the mucosa on the superior surface
- The rest of the cavity is lined with respiratory mucosa
  - Moistens air
  - Traps incoming foreign particles
- Anatomy of the Nasal Cavity
- Lateral walls have projections called conchae
  - Increases surface area
  - Increases air turbulence within the nasal cavity
- The nasal cavity is separated from the oral cavity by the palate
  - Anterior hard palate (bone)
  - Posterior soft palate (muscle)
- Paranasal Sinuses
- Cavities within bones surrounding the nasal cavity

  - Frontal bone
  - Sphenoid bone
  - Ethmoid bone
  - Maxillary bone
- Paranasal Sinuses
- Function of the sinuses
  - Lighten the skull
  - Act as resonance chambers for speech
  - Produce mucus that drains into the nasal cavity Produce mucus that drains into the nasal cavity
- Pharynx (Throat)
- Muscular passage from nasal cavity to larynx
- Three regions of the pharynx
  - Nasopharynx – superior region behind nasal cavity
  - Oropharynx – middle region behind mouth
  - Laryngopharynx – inferior region attached to larynx
- The oropharynx and laryngopharynx are common passageways for air and food
- Structures of the Pharynx
- Auditory tubes enter the nasopharynx
- Tonsils of the pharynx
  - Pharyngeal tonsil (adenoids) in the nasopharynx
  - Palatine tonsils in the oropharynx
  - Lingual tonsils at the base of the tongue
- Larynx (Voice Box)
- Routes air and food into proper channels
- Plays a role in speech
- Made of eight rigid hyaline cartilages and a spoon-shaped flap of elastic cartilage (epiglottis)
- Vocal cords - vibrate with expelled air to create sound (speech)
- Structures of the Larynx
- Thyroid cartilage
  - Largest hyaline cartilage
  - Protrudes anteriorly (Adam’s apple)

- Epiglottis
    - Superior opening of the larynx
    - Routes food to the larynx and air toward the trachea
- Glottis – opening between vocal cords
    - Trachea (Windpipe)
- Connects larynx with bronchi
- Lined with ciliated mucosa
    - Beat continuously in the opposite direction of incoming air
    - Expel mucus loaded with dust and other debris away from lungs
- Walls are reinforced with C-shaped hyaline cartilage
- Primary Bronchi
- Formed by division of the trachea
- Enters the lung at the hilus (medial depression)
- Right bronchus is wider, shorter, and straighter than left
- Bronchi subdivide into smaller and smaller branches

Lungs

- Occupy most of the thoracic cavity
    - Apex is near the clavicle (superior portion)
    - Each lung is divided into lobes by fissures
        - Left lung – two lobes
        - Right lung – three lobes
- Coverings of the Lungs
- Pulmonary (visceral) pleura covers the lung surface
- Parietal pleura lines the walls of the thoracic cavity
- Pleural fluid fills the area between layers of pleura to allow gliding
- Respiratory Tree Divisions
- Primary bronchi
- Secondary bronchi
- Tertiary bronchi
- Bronchioli

- Terminal bronchioli
- Bronchioles
- Smallest branches of the bronchi
- All but the smallest branches have reinforcing cartilage
- Terminal bronchioles end in alveoli

Respiratory Zone

- Structures
  - Respiratory bronchioli
  - Alveolar duct
  - Alveoli
- Site of gas exchange
- Alveoli
- Structure of alveoli
  - Alveolar duct
  - Alveolar sac
  - Alveolus
- Gas exchange takes place within the alveoli in the respiratory membrane
- Squamous epithelial lining alveolar walls
- Covered with pulmonary capillaries on external surfaces
- Respiratory Membrane (Air-Blood Barrier)
- Gas Exchange
- Gas crosses the respiratory membrane by diffusion
  - Oxygen enters the blood
  - Carbon dioxide enters the alveoli
- Macrophages add protection
- **Surfactant coats gas-exposed alveolar surfaces**
- Events of Respiration
- Pulmonary ventilation – moving air in and out of the lungs
- External respiration – gas exchange between pulmonary blood and alveoli
- Events of Respiration
- Respiratory gas transport – transport of oxygen and carbon dioxide via the bloodstream

- Internal respiration – gas exchange between blood and tissue cells in systemic capillaries
- Mechanics of Breathing
(Pulmonary Ventilation)
- Mechanical process
- Depends on volume changes in the thoracic cavity
- Volume changes lead to pressure changes, which lead to equalize pressure of flow of gases
- 2 phases
    - Inspiration – flow of air into lung
    - Expiration – air leaving lung
- Inspiration
- Diaphragm and intercostal muscles contract
- The size of the thoracic cavity increases
- External air is pulled into the lungs due to an increase in intrapulmonary volume
- Expiration
- Passive process dependent up on natural lung elasticity
- As muscles relax, air is pushed out of the lungs
- Forced expiration can occur mostly by contracting internal intercostal muscles to depress the rib cage
- Expiration
- Pressure Differences in the Thoracic Cavity
- Normal pressure within the pleural space is **always negative** (intrapleural pressure)
- Differences in lung and pleural space pressures keep lungs from collapsing
- Nonrespiratory Air Movements
- Caused by reflexes or voluntary actions
- Examples
    - Cough and sneeze – clears lungs of debris
    - Laughing
    - Crying
    - Yawn
    - Hiccup
- Respiratory Volumes and Capacities

- Normal breathing moves about 500 ml of air with each breath - tidal volume (TV)
- Many factors that affect respiratory capacity
  - A person's size
  - Sex
  - Age
  - Physical condition
- Residual volume of air – after exhalation, about 1200 ml of air remains in the lungs
- Respiratory Volumes and Capacities
- Inspiratory reserve volume (IRV)
  - Amount of air that can be taken in forcibly over the tidal volume
  - Usually between 2100 and 3200 ml
- Expiratory reserve volume (ERV)
  - Amount of air that can be forcibly exhaled
  - Approximately 1200 ml
- Residual volume
  - Air remaining in lung after expiration
  - About 1200 ml
- Respiratory Volumes and Capacities
- Functional volume
  - Air that actually reaches the respiratory zone
  - Usually about 350 ml
- Respiratory capacities are measured with a spirometer
- Respiratory Sounds
- Sounds are monitored with a stethoscope
- Bronchial sounds – produced by air rushing through trachea and bronchi
- Vesicular breathing sounds – soft sounds of air filling alveoli
- External Respiration
- Oxygen movement into the blood
  - The alveoli always has more oxygen than the blood
  - Oxygen moves by diffusion towards the area of lower concentration
  - Pulmonary capillary blood gains oxygen
- External Respiration

- Carbon dioxide movement out of the blood
  - Blood returning from tissues has higher concentrations of carbon dioxide than air in the alveoli
  - Pulmonary capillary blood gives up carbon dioxide
- Blood leaving the lungs is oxygen-rich and carbon dioxide-poor
- Gas Transport in the Blood
- Oxygen transport in the blood
  - Inside red blood cells attached to hemoglobin (oxyhemoglobin [HbO_2])
  - A small amount is carried dissolved in the plasma
- Carbon dioxide transport in the blood
  - Most is transported in the plasma as bicarbonate ion (HCO_3–)
  - A small amount is carried inside red blood cells on hemoglobin, but at different binding sites than those of oxygen
- Internal Respiration
- Exchange of gases between blood and body cells
- An opposite reaction to what occurs in the lungs
  - Carbon dioxide diffuses out of tissue to blood
  - Oxygen diffuses from blood into tissue
- Internal Respiration
- Neural Regulation of Respiration
- Activity of respiratory muscles is transmitted to the brain by the phrenic and intercostal nerves
- Neural centers that control rate & depth are located in the medulla
- The pons appears to smooth out respiratory rate
- Normal respiratory rate (eupnea) is 12–15 min.
- Hypernia is increased respiratory rate often due to extra oxygen needs
- Factors Influencing Respiratory Rate and Depth
- Physical factors
  - Increased body temperature
  - Exercise
  - Talking
  - Coughing
- Volition (conscious control)

- Emotional factors
- Factors Influencing Respiratory Rate and Depth
- Chemical factors
    - Carbon dioxide levels
        - Level of carbon dioxide in the blood is the main regulatory chemical for respiration
        - Increased carbon dioxide increases respiration
        - Changes in carbon dioxide act directly on the medulla oblongata

Factors Influencing Respiratory Rate and Depth

- Chemical factors (continued)
    - Oxygen levels
        - Changes in oxygen concentration in the blood are detected by **chemoreceptors** in the aorta and carotid artery
        - Information is sent to the medulla oblongata

Respiratory Disorders:
Chronic Obstructive Pulmonary Disease (COPD)

- Exemplified by chronic bronchitis and emphysema
- Major causes of death and disability in the United States
- Features of these diseases
    - Patients have a history of smoking
    - Labored breathing (dyspnea)
    - Coughing and frequent pulmonary infections
- Respiratory Disorders:
  Chronic Obstructive Pulmonary Disease (COPD)
- Features of these diseases (cont.')
    - Most victims retain carbon dioxide
    - Have hypoxic and respiratory acidosis
    - Those infected will ultimately develop respiratory failure
- Emphysema
- Alveoli enlarge as adjacent chambers break through
- Chronic inflammation promotes lung fibrosis
- Airways collapse during expiration
- Patients use a large amount of energy to exhale

- Over-inflation of the lungs leads to a barrel chest
- Cyanosis appears late in the disease
- Chronic Bronchitis
- Inflammation of the mucosa of the lower respiratory passages
- Mucus production increases
- Pooled mucus impairs ventilation & gas exchange
- Risk of lung infection increases
- Pneumonia is common
- Hypoxia and cyanosis occur early
- Lung Cancer
- Accounts for 1/3 of all cancer deaths in the United States
- Increased incidence associated with smoking
- Three common types
  - Squamous cell carcinoma
  - Adenocarcinoma
  - Small cell carcinoma
- Sudden Infant Death syndrome (SIDS)
- Healthy infant stops breathing and dies during sleep
- Some cases are thought to be a problem of the neural respiratory control center
- 1/3 of cases appear to be due to heart rhythm abnormalities
- Asthma
- Chronic inflammation if the bronchiole passages
- Response to irritants with dyspnea, coughing, and wheezing
- Developmental Aspects of the Respiratory System
- Lungs are filled with fluid in the fetus
- Lungs are not fully inflated with air until two weeks after birth
- Surfactant that lowers alveolar surface tension is not present until late in fetal development and may not be present in premature babies
- Developmental Aspects of the Respiratory System
- Important birth defects
  - Cystic fibrosis – over-secretion of thick mucus clogs the respiratory system
  - Cleft palate

- Aging Effects
- Elasticity of lungs decreases
- Vital capacity decreases
- Blood oxygen levels decrease
- Stimulating effects of carbon dioxide decreases
- More risks of respiratory tract infection
- Respiratory Rate Changes Throughout Life

Respiration rate:

- Newborns – 40 to 80 min.
- Infants – 30 min.
- Age 5 – 25 min.
- Adults – 12 to 18 min
- Rate often increases with old age