Chapter 22 The Respiratory System
Incomplete Outline Key

I. Anatomy of the Respiratory System
  A. Organs and Divisions
    1. Principle Organs: nose, pharynx, larynx, trachea, bronchi, and lungs
    2. Conducting Division: from the nostrils through the major bronchioles
    3. Respiratory Division: the alveoli and other gas-exchange regions
    4. Upper Respiratory Tract: from the nose to the larynx
    5. Lower respiratory Tract: regions from the trachea through the lungs
  B. The Nose
    1. Functions:
      a. warms, cleanses and humidifies air
      b. detects odors
      c. resonating chamber that amplifies the voice
    2. Anatomy:
      a. Facial part of the nose is shaped by bone and hyaline cartilage
      b. Nasal cavity: internal chamber of the nose divided into two halves…
        i Nasal fossae: right and left halves of the nasal cavity
        ii Nasal septum: the dividing wall of the nasal cavity
      c. Vestibule: small dilated chamber just inside the nostril
        iii Bordered with guard hairs that block insects and debris
      d. Nasal Conchae: three folds of tissue in the nasal cavity
        iv Superior, middle, and inferior
      e. Meatus: air passage found beneath each concha
      f. Respiratory epithelium: lines a majority of the respiratory system that has cilia to move mucus
  C. The Pharynx: tube from the conchae to the larynx (three regions)
    1. Nasopharynx: receives the auditory tubes, houses the pharyngeal tonsil, inhaled air turns 90 degrees downward as it passes through
    2. Oropharynx: contains the palatine tonsils
    3. Laryngopharynx: passes only air and is lined by pseudostratified columnar epithelium
  D. The Larynx: voice box
    1. Function is to keep food and drink out of the airway
    2. Epiglottis: flap of tissue that guards the opening of the larynx
    3. Thyroid cartilage
      a. Laryngeal prominence: anterior peak known as the Adam's apple found in males
    4. Vestibular folds: close the larynx during swallowing
    5. Vocal cords: produce sound when air passes between them
  E. The Trachea: windpipe anterior to the esophagus
    1. Supported by 16-20 C shaped rings of hyaline cartilage
    2. Mucociliary escalator: mechanism of debris removal
  F. Lungs and Bronchial Tree
    1. Lung: two conical organs that rest on the diaphragm
    2. Hilum: through which the lungs receives the main bronchus, blood vessels, lymphatics, and nerves
    3. Lobes: the right lung has three lobes and the left has two

4. Bronchial Tree: branching system of air tubes
    a. Right main (primary) bronchus: arises from the fork of the trachea and is slightly wider and more vertical than the left resulting in more lodged objects
        v Gives of three branches called the lobar bronchi
    b. Left main bronchus: more narrow and horizontal with only two lobar bronchi
    c. Bronchioles: continuations of the airway that lack supportive cartilage
    d. Path of Airflow: nasal cavity -> pharynx -> trachea -> main bronchus -> lobar bronchus -> segmental bronchus -> bronchiole -> terminal bronchiole -> respiratory bronchiole -> alveolar duct -> atrium -> alveolus
5. Alveoli: sacs that serve as the site of gas exchange
    a. Squamous and cuboidal great alveolar cells and alveolar macrophages

G. The Pleurae
1. Visceral pleura: surface of the lung that extends into the fissures
2. Parietal pleura: adheres to the mediastinum, inner surface of the rib cage, and diaphragm
3. Pleural cavity: space between the parietal and visceral pleurae
4. Pleural functions: reduce friction, create pressure gradient, and compartmentalize

II. Pulmonary Ventilation

A. Respiration Cycle: one complete inspiration and expiration
1. Quiet respiration: breathing at rest
2. Forced respiration: deep or rapid breathing

B. Respiratory Muscles
1. Diaphragm: prime mover of respiration
    a. When relaxed, the lungs are at their minimum volume
    b. When contracted, the lungs are at their maximum volume
2. Internal and external intercostal muscles: synergists of the diaphragm found between the ribs

C. Neural Control of Breathing
1. Brainstem Respiratory Centers: automatic, unconscious cycle of breathing
    a. Ventral respiratory group: primary generator of the respiratory rhythm
        vi Inspiratory and expiratory neurons: two webs of neurons found in the medulla that form a reverberating circuit
        vii Output from the spinal centers travel by way of the phrenic and intercostal nerves
    b. Dorsal respiratory group: receives input from several sources and issues output to the VRG that modifies the respiratory rhythm
    c. Pontine respiratory group: receives input from higher brain centers and adapt breathing to sleep, exercise, vocalization, and emotional responses
2. Voluntary Control of Breathing: originates in the motor cortex
    a. There are limits to voluntary control, automatic controls override one's will

D. Pressure, Resistance, and Airflow
1. Pressure and Airflow
    a. Atmospheric pressure: the weight of the air above us
    b. Intrapulmonary pressure: pressure from the lungs
    c. Boyle's Law: the pressure of a given quantity of gas is inversely proportional to its volume
        viii If the intrapulmonary pressure drops lower than the atmospheric pressure surrounding the body, then air tends to flow down its pressure gradient into the lungs. Conversely, if intrapulmonary pressure rises above atmospheric pressure, air flows out of the lungs.

2. Inspiration: during inspiration, the lungs expand and as they increase in volume the internal pressure drops and air flows in
3. Expiration: a passive process that compresses the lungs as the diaphragm raises up and raises the intrapulmonary pressure, thus expelling air
4. Resistance to Airflow
    a. Diameter of bronchioles
        ix Bronchconstriction: the more constricted the diameter, the less air that is able to pass through
        x Bronchodilation: the more widened the diameter, the more air that is able to pass through
    b. Pulmonary compliance: the ease with which the lungs expand
    c. Surface tension of the alveoli and distal bronchioles
        xi Surfactant: an agent that disrupts the hydrogen bonds water and reduces surface tension
            ➢ Premature infants often have a deficiency of pulmonary surfactant and experience great difficulty breathing

III. Gas Exchange and Transport
A. Alveolar Gas Exchange: back-and-forth traffic of O2 loading and CO2 unloading across the respiratory membrane
    1. The reason that O2 can diffuse in one direction and CO2 in the other is that each gas diffuses down its own pressure gradient
    2. Both O2 loading and CO2 unloading involve RBCs, the efficiency of these processes therefore depends on how long an RBC spends in an alveolar capillary
B. Systemic Gas Exchange: the unloading of O2 and loading of CO2 at the systemic capillaries
C. Blood Gases and the Respiratory Rhythm: the most potent stimulus for breathing is pH, followed by CO2, and lastly O2
    1. Hydrogen Ions
        a. Acidosis: a blood pH lower than 7.35
        b. Alkalosis: a blood pH greater than 7.45
        c. The PCO2 of arterial blood normally ranges from 37 to 43mmHg
            xii Hypocapnia: PCO2 less than 37mmHg
            xiii Hypercapnia: PCO2 greater than 43mmHg
        d. Carbonic acid levels determine the levels of pH
            xiv As CO2 levels increase, carbonic acid levels increase thus lowering the pH
                ➢ Aka respiratory acidosis
                ➢ Corrective response: hyperventilation to release more CO2
            xv As CO2 levels decrease, carbonic acid levels decrease thus raising the pH
                ➢ Aka respiratory alkalosis
                ➢ Corrective response: hypoventilation or breathing into a bag to retain more CO2
    2. Carbon Dioxide: has an indirect effect on pH
    3. Oxygen: usually has little effect on respiration
        a. A moderate drop in PO2 does stimulate the peripheral chemoreceptors
            xvi Long term hypoxia: drives respiration more than CO2 or pH
            xvii Also occurs in situations such as emphysema, pneumonia, and mountain climbing

IV. Respiratory Disorders
A. Oxygen Imbalances
    1. Hypoxia: a deficiency of oxygen in a tissue
        a. Hypoxemic hypoxia: inadequate pulmonary gas exchange

b. Ischemic hypoxia: inadequate circulation of the blood
c. Anemic hypoxia: due to anemia (inability of the blood to carry adequate oxygen)
d. Histotoxic hypoxia: poison
e. Cyanosis: symptom of hypoxia resulting in blueness of the skin
xviii Primary effect is necrosis

2. Oxygen toxicity: when pure oxygen is breathed
   a. Generates hydrogen peroxide and free radicals that destroy enzymes and nervous tissue
   xix Thus leading to seizures, coma and death

B. Chronic Obstructive Pulmonary Diseases: long-term obstruction of airflow
   1. Major COPDs: asthma, emphysema, and chronic bronchitis
      a. Chronic bronchitis: cilia are immobilized, while goblet cells enlarge and produce excess mucus
      b. Emphysema: lungs become fibrotic and less elastic
      xx Lungs tend to collapse and obstruct during expiration
      c. COPD tends to cause hypoxemia, hypercapnia, respiratory acidosis, and cardiomegaly