The Respiratory System

- Ventilation and respiration

Respiratory Membrane (Air-Blood Barrier)

- Thin squamous epithelial layer lines alveolar walls
- Alveolar pores connect neighboring air sacs
- Pulmonary capillaries cover external surfaces of alveoli
- On one side of the membrane is air and on the other side is blood flowing past

Respiratory Membrane (Air-Blood Barrier)

- Gas crosses the respiratory membrane by diffusion
- Oxygen enters the blood
- Carbon dioxide enters the alveoli
- Alveolar macrophages ("dust cells") add protection by picking up bacteria, carbon particles, and other debris
- Surfactant (a lipid molecule) coats gas-exposed alveolar surfaces
Four Events of Respiration

- Pulmonary ventilation—moving air in and out of the lungs (commonly called breathing)
- External respiration—gas exchange between pulmonary blood and alveoli
  - Oxygen is loaded into the blood
  - Carbon dioxide is unloaded from the blood

External 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)

- Completely mechanical process that depends on volume changes in the thoracic cavity
- Volume changes lead to pressure changes, which lead to the flow of gases to equalize pressure
  - Two phases
    - Inspiration = inhalation
      - Flow of air into lungs
    - Expiration = exhalation
      - Air leaving lungs

Inspiration

- Diaphragm and external intercostal muscles contract
- The size of the thoracic cavity increases
- External air is pulled into the lungs due to
  - Increase in intrapulmonary volume
  - Decrease in gas pressure
Expiration

- Largely a passive process which depends on natural lung elasticity
- As muscles relax, air is pushed out of the lungs due to
  - Decrease in intrapulmonary volume
  - Increase in gas pressure
- Forced expiration can occur mostly by contracting internal intercostal muscles to depress the rib cage

Expiration

- Normal pressure within the pleural space is always negative (intrapleural pressure)
- Differences in lung and pleural space pressures keep lungs from collapsing
Nonrespiratory Air (Gas) Movements

- Can be caused by reflexes or voluntary actions
- **Examples:**
  - Cough and sneeze—clears lungs of debris
  - Crying—emotionally induced mechanism
  - Laughing—similar to crying
  - Hiccup—sudden inspirations
  - Yawn—very deep inspiration

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Table 13.1

<table>
<thead>
<tr>
<th>Movement</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cough</td>
<td>Opens chest, clearing lungs of debris</td>
</tr>
<tr>
<td>Sneezing</td>
<td>Similar to cough, clears mucus from nose and throat</td>
</tr>
<tr>
<td>Crying</td>
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</tr>
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Respiratory Volumes and Capacities

- Normal breathing moves about 500 mL of air with each breath
  - This respiratory volume is tidal volume (TV)
- Many factors that affect respiratory capacity
  - A person’s size
  - Sex
  - Age
  - Physical condition

- 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

- Vital capacity
  - The total amount of exchangeable air
  - Vital capacity = TV + IRV + ERV
- Dead space volume
  - Air that remains in conducting zone and never reaches alveoli
  - About 150 mL

- Functional volume
  - Air that actually reaches the respiratory zone
  - Usually about 350 mL
  - Respiratory capacities are measured with a spirometer