THE RESPIRATORY SYSTEM
Organs of the Respiratory System
Functions of the Respiratory System

1. Gas exchanges between the blood and external environment
   – Occurs in the alveoli of the lungs
2. Passageways to the lungs purify, humidify, and warm the incoming air
Respiratory Zone

- **Structures**
  - Respiratory bronchioles
  - Alveolar ducts
  - Alveolar sacs
  - Alveoli (air sacs)

- **Site of gas exchange** = alveoli only
Respiratory Membrane (Air-Blood Barrier)

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

• 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
Four Events of Respiration

1. Pulmonary ventilation—moving air in and out of the lungs (commonly called breathing)

2. External respiration—gas exchange between pulmonary blood and alveoli
   - Oxygen is loaded into the blood
   - Carbon dioxide is unloaded from the blood

3. Respiratory gas transport—transport of oxygen and carbon dioxide via the bloodstream

4. Internal respiration—gas exchange between blood and tissue cells in systemic capillaries
External Respiration

• Oxygen loaded into the blood
  – The alveoli always have more oxygen than the blood
  – Oxygen moves by diffusion towards the area of lower concentration
  – Pulmonary capillary blood gains oxygen

(a) External respiration in the lungs (pulmonary gas exchange): Oxygen is loaded and carbon dioxide is unloaded.
External Respiration

Carbon dioxide unloaded 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 to be exhaled

Blood leaving the lungs is oxygen-rich and carbon dioxide-poor

(a) External respiration in the lungs (pulmonary gas exchange): Oxygen is loaded and carbon dioxide is unloaded.
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

(b) Internal respiration in the body tissues (systemic capillary gas exchange): Oxygen is unloaded and carbon dioxide is loaded into the blood.
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

Changes in anterior-posterior and superior-inferior dimensions

- Ribs elevated as external intercostals contract
- External intercostal muscles
- Diaphragm moves inferiorly during contraction

Changes in lateral dimensions

- Full inspiration

(a) Inspiration: Air (gases) flows into the lungs
Expiration

Changes in anterior-posterior and superior-inferior dimensions

Ribs depressed as external intercostals relax

External intercostal muscles

Diaphragm moves superiorly as it relaxes

Changes in lateral dimensions

Expiration

(b) Expiration: Air (gases) flows out of the lungs
Respiratory Volumes and Capacities

- **Tidal Volume (TV)** = Normal breathing moves about 500 mL of air with each breath.

- **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 (RV)
  – Air remaining in lung after expiration
  – About 1200 ml

• Vital capacity
  – The total amount of exchangeable air
  – Vital capacity = TV + IRV + ERV

• Functional volume
  – Air that actually reaches the respiratory zone
  – Usually about 350 mL
Respiratory Volumes

- Inspiratory reserve volume: 3100 ml
- Tidal volume: 500 ml
- Expiratory reserve volume: 1200 ml
- Residual volume: 1200 ml

Vital capacity: 4800 ml
Total lung capacity: 6000 ml
Respiratory Sounds

• Sounds are monitored with a stethoscope
• Two recognizable sounds can be heard with a stethoscope
  – Bronchial sounds—produced by air rushing through trachea and bronchi
  – Vesicular breathing sounds—soft sounds of air filling alveoli