Respiration

Chapter 33

Learning Objectives:

- Understand the basis of gas exchange and factors that influence diffusion of gases in and out of tissues
- Compare and contrast different respiratory systems among animals
- Learn the anatomy and function of the different components of the human respiratory system
33.1 The Nature of Respiration

- All animals must supply their cells with oxygen and rid their body of carbon dioxide

**Respiration**
- The physiological process by which an animal exchanges oxygen and carbon dioxide with its environment
- Respiration depends on diffusion of gaseous oxygen \( \text{O}_2 \) and carbon dioxide \( \text{CO}_2 \) down their concentration gradients

Diffusion of Gases

- Requirements to facilitate diffusion of gases across a respiratory surface:
  - Moisture (cells membranes moist)
  - Thin respiratory surfaces
  - High surface-to-volume ratio
  - High ventilation rate (movement of air or water across the respiratory surface)
Respiratory Proteins

- **Respiratory proteins** contain one or more metal ions that reversibly bind to oxygen atoms
  - **Hemoglobin:** An iron-containing respiratory protein found in vertebrate red blood cells
  - **Myoglobin:** A respiratory protein found in muscles of vertebrates and some invertebrates

Invertebrate Respiration

- **Integumentary exchange**
  - Some invertebrates that live in aquatic or damp environments have no respiratory organs; gases diffuse across the skin
Invertebrate Respiration

- **Gills**
  - Filamentous respiratory organs that increase surface area for gas exchange in water
  - Amphibians
  - Mollusks
  - Crustacians

**Tracheal system**

Insects and spiders with a hard integument have branching tracheal tubes that open to the surface through spiracles (no respiratory protein required)
Insect respiratory system:

- **Spiracles**: pores in exoskeleton
- **Trachea**: connect to spiracles, carry oxygen to the body cells
Honey bee disease: Tracheal mites

Closure contact among bees permits passage of female mites from infected bee to young uninoculated bees.

Life Cycle of Tracheal Mites

3-4 Days Larvae in trachea
up to 14 eggs in trachea

Male
Female
Mated female migrates out of spiracle and attaches to tip of hair.

Some spiders also have thin sheets of respiratory tissue that exchange oxygen with a respiratory pigment (hemocyanin) in blood.

Book lungs

air-filled space
blood-filled space

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Vertebrate gills: Countercurrent Flow

Fishes use gills to extract oxygen from water. **Countercurrent flow** aids exchange (blood flows through gills in opposite direction of water flow).

- **Fig. 39-10 (b-c), p. 686**

Vertebrate gills: Countercurrent Flow

![Diagram](image)

- **B** Two gill arches with filaments
- **C** Countercurrent flow of water and blood

Fig. 39-10 (b-c), p. 686
Frog Respiration

Amphibians exchange gases across their skin, and at respiratory surfaces of paired lungs.

Vertebrate Respiration

- Reptiles, birds and mammals exchange gases through paired lungs, ventilated by chest muscles.
- Birds have the most efficient vertebrate lungs
  - Air sacs allow oxygen-rich air to pass respiratory surfaces on both inhalation and exhalation.
A Inhalation 1
Muscles expand chest cavity, drawing air in through nostrils. Some of the air goes to lungs and some goes to posterior air sacs.

B Exhalation 1
Anterior air sacs empty. Air from posterior air sacs moves into lungs.

C Inhalation 2
Air in lungs moves to anterior air sacs and is replaced by newly inhaled air.

D Exhalation 2
Air in anterior air sacs moves out of the body and air from posterior sacs flows into the lungs.

Fig. 39-12, p. 687

Human Respiratory System

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Fig. 39-13a, p. 688
Air enters through nose or mouth, flows through the **pharynx** (throat) and the **larynx** (voice box)

The **epiglottis** protects the **trachea**, which branches into two **bronchi**, one to each lung

**Alveoli** are small sacs, one cell thick, where gases are exchanged with pulmonary capillaries
Gas Exchange in the Lungs

from the pulmonary artery

capillary
alveolar membrane
respiratory membrane
surfactant fluid

Oxygen diffuses into the red blood cells
Carbon dioxide diffuses into the alveolus

Gas Exchange in the Lungs

Oxygen diffuses into the red blood cells
Carbon dioxide diffuses into the alveolus

Fig. 33-9

Oxygen Transport

(a) O₂ transport from the lungs to the tissues

Fig. 33-10a
Functions of Circulatory System

1. Transport of $O_2$ from lungs $\rightarrow$ tissues; transport of $CO_2$ from tissues $\rightarrow$ lungs

2. Transport nutrients digestive system $\rightarrow$ body cells

3. Transport waste products and toxic substances $\rightarrow$ liver and kidneys for excretion

4. Distribution of hormones from glands and organs where produced (e.g., gastrin from stomach or insulin from pancreas) to other tissues

Learning Objectives: Circulatory System

- Understand the movement of blood through the heart
- Differentiate between the pulmonary and systemic circulation
- Identify the four chambers of the heart
- Identify where the blood is oxygenated and where it isn't.
Functions of Circulatory System

5. Maintenance of homeostasis:
   - Body temperature Regulation: adjustments in blood flow
   - pH Maintenance via buffers contained in blood

6. Wound healing and blood clotting to prevent blood loss

7. Protection against disease by circulating white blood cells and antibodies (week 9)

Vertebrate circulatory systems

- a) Fish Heart: One Atrium, One Ventricle, "Single Circulation"
  - gill capillaries
  - atrium
  - body capillaries
  - ventricle

- b) Reptile/Amphibian Heart: Two Atria, One Ventricle (both oxygenated and deoxygenated blood are mixed), "Double Circulation"
  - lung capillaries
  - atria
  - body capillaries
  - ventricle

- c) Mammalian Heart: Two Atria, Two Ventricles (oxygenated and deoxygenated blood separate), "Double Circulation"
  - lung capillaries
  - atria
  - heart chambers
  - body capillaries
Vessels of Circulatory System

Arteries

Away from the heart

Veins

Toward the heart

Figure 9.12. Sections through an artery, capillary, and vein. At any given moment, about 30% of the blood in your systemic circulation will be found in the arteries, 51% in the capillaries, and 65% in the veins.
Always
- arteries = away from the heart
- veins = towards the heart

Activity: on scrap paper

Systemic and Pulmonary Oxygen
and blood flow in heart
About the heart

- Thicker muscle
- Larger ventricle
- Apex points to the bottom of the left side
- Bicuspid valve
- Larger ventricle
- Thicker muscle

Fetal heart

- foramen ovale
  (hole between the right & left atrium)
- ductus arteriosus
  (joins pulmonary trunk to the aorta)

Two mechanisms to by-pass the lungs
Vert Anatomy II: Circulatory

Remember: it goes through 2 capillary beds