

Lymphatic System

The adult human body each day loses approximately 4–8 L of fluid from capillaries to the surrounding tissues. There is also some leakage of blood proteins from capillaries, even though the capillary wall is not very permeable to large molecules. The lost fluid and proteins return to the blood via the lymphatic system, which includes a network of tiny vessels intermingled among capillaries of the cardiovascular system, as well as larger vessels into which small vessels empty.

Lymph nodes are organs that produce phagocytic white blood cells and filter lymph - an important role in the body's defense. Thus, lymphatic system also aids in body defense.

Lymph does not include red blood cells.

Lymph is circulated in the body by the aid of smooth muscles surrounding lymph vessels and daily skeletal muscle movements (no pump).

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- Lymphatic system has 3 main functions:
- a. collecting excess water and proteins from interstitial fluid
- b. immune functions
- c. lipid and vitamin transport from intestine to bloodstream

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Blood Composition and Function

- Blood consists of several kinds of blood cells suspended in a liquid matrix called plasma.
- The cellular elements: red blood cells, white blood cells, and platelets occupy about 45% of the volume of blood.

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Plasma

- Blood plasma is about 90% water. Among its solutes are inorganic salts in the form of dissolved ions, sometimes called electrolytes.
- Another important class of solutes is the plasma proteins, which influence blood pH, osmotic pressure, and viscosity. Various plasma proteins function in lipid transport, immunity, and blood clotting.
- Plasma transports nutrients, gases, and cell waste.

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Cellular Elements

- Suspended in blood there are 2 types of cells:
 - Red blood cells rbc = *erythrocytes*, transport *oxygen*.
 - White blood cells wbc = *leukocytes*, function in *defense*.
- *Platelets* (thrombocytes) are fragments of cells that are involved in *blood clotting*.

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Erythrocytes - Oxygen Transport

- Red blood cells, or erythrocytes, are by far the *most numerous blood cells*.
- They transport oxygen throughout the body.
- They contain hemoglobin, the iron-containing protein that transports oxygen.

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Leukocytes - Defense

- There are 5 major types of white blood cells, or **leukocytes**: monocytes, neutrophils, basophils, eosinophils, and lymphocytes.
- They function in defense by phagocytizing bacteria and debris or by producing antibodies.
- They can be found both in and outside of the circulatory system.

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Platelets - Blood Clotting

- Platelets are fragments of cells and function in blood clotting.
- When the endothelium of a blood vessel is damaged, the clotting mechanism begins.
- A cascade of complex reactions converts fibrinogen to fibrin, forming a clot. *A blood clot formed within a blood vessel is called a thrombus and can block blood flow.*

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Gas exchange

- **Gas exchange** supplies oxygen for cellular respiration and disposes of carbon dioxide. Gases diffuse down pressure gradients in the lungs and other organs as a result of **differences in partial pressure**.
- ***Partial pressure** is the pressure exerted by a particular gas in a mixture of gases. A gas diffuses from a region of higher partial pressure to a region of lower partial pressure: $H \rightarrow L$*
- In the lungs and tissues, O_2 and CO_2 diffuse from where their partial pressures are higher to where they are lower.

Respiratory Media

- Animals can use air or water as a source of O_2 , or respiratory medium.
- In a given volume, there is less O_2 available in water than in air. Obtaining O_2 from water requires greater efficiency than air breathing.

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Tracheal Systems in Insects

- The tracheal system of insects consists of tiny branching tubes that penetrate the body. These tubes are called *tracheal tubes*. They supply O_2 directly to body cells.
- *The respiratory and circulatory systems are separate.*

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Lungs = Infoldings of the body surface

- The circulatory system (open or closed) transports gases between the lungs and the rest of the body.
- Lungs are localized respiratory organs. Since the respiratory surface of a lung is not in direct contact with all other parts of the body, the gap must be bridged by the circulatory system, which transports gases between the lungs and the rest of the body.
- Representing an infolding of the body surface, they are typically subdivided into numerous pockets to increase efficiency. The size and complexity of lungs correlate with an animal's metabolic rate.

Respiratory Pigments

- Respiratory pigments = proteins that transport O₂, which greatly increase the amount of oxygen that blood can carry.
- Arthropods and many molluscs have hemocyanin with copper as the oxygen-binding component.
- Most vertebrates and some invertebrates use hemoglobin with iron = O₂-binding component contained within erythrocytes.

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Hemoglobin

- A single hemoglobin molecule can carry four molecules of O_2
- *CO_2 produced during cellular respiration lowers blood pH and decreases the affinity of hemoglobin for O_2*
- This is called the *Bohr shift*.

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Carbon Dioxide Transport

- Hemoglobin also helps to transport CO₂ and assists in buffering.
- CO₂ from respiring cells diffuses into the blood and is transported either in blood plasma or bound to hemoglobin as bicarbonate ions = HCO₃⁻.

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