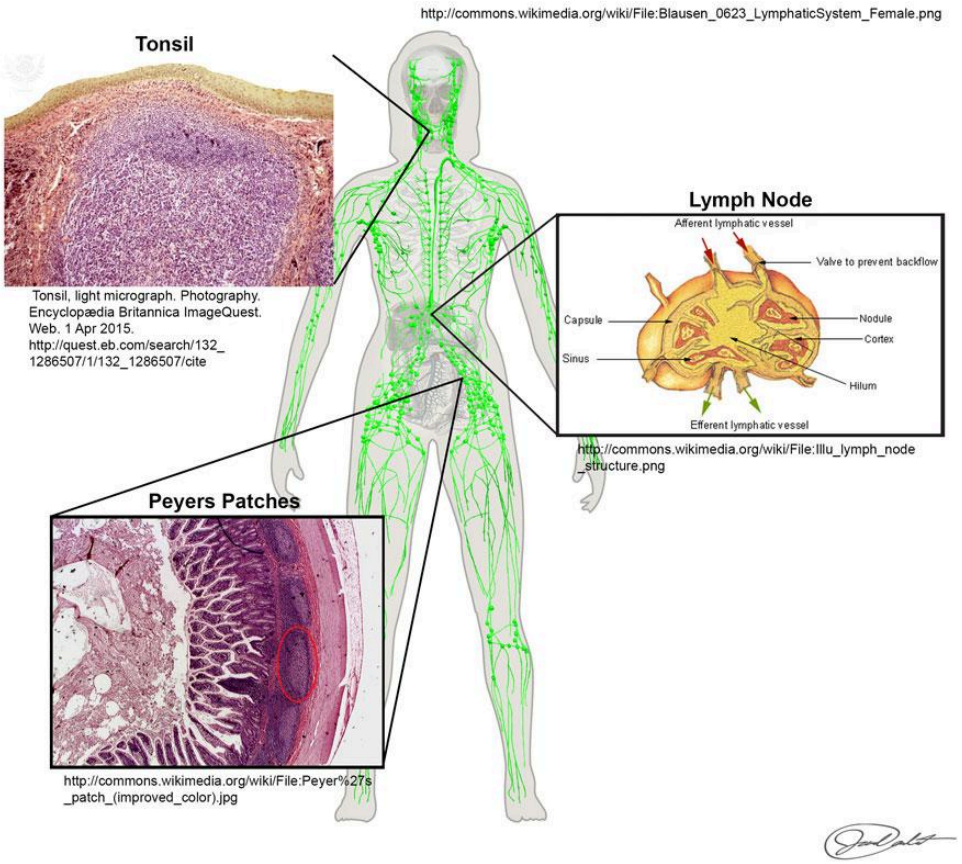
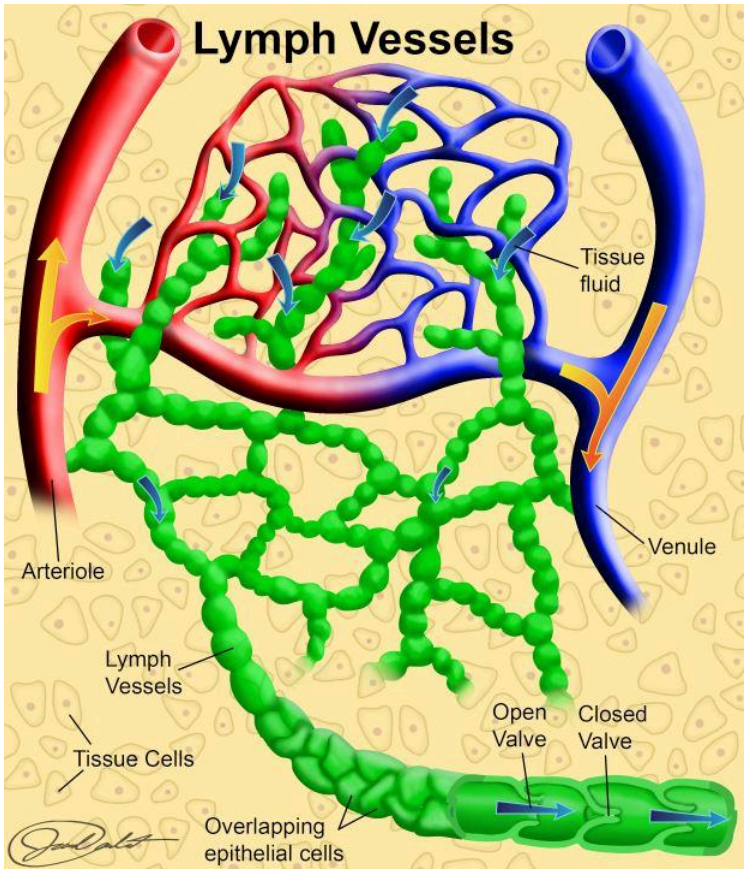
3.1.1

Structure and Function of the Lymphatic System



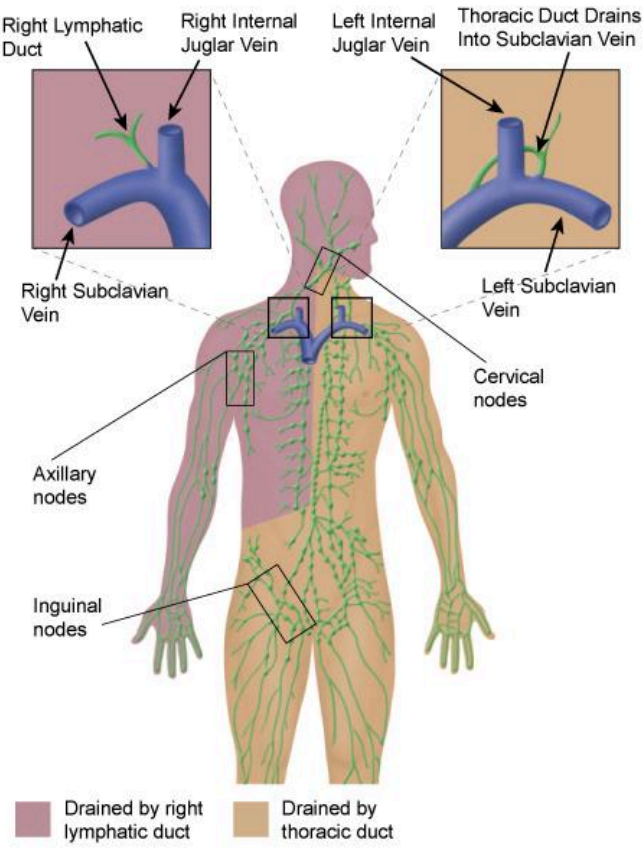
Lymphatic System.

Lymph vessel human: Blausen.com staff. "Blausen gallery 2014". Wikiversity Journal of Medicine.DOI:10.15347/wjm/2014.010.ISSN20018762 Tonsil: Blausen.com staff. "Blausen gallery 2014". Wikiversity Journal of Medicine. DOI:10.15347/wjm/2014.010.ISSN20018762: Creative Commons Attribution 3.0 Unported license.; Lymph Node: Public Domain License. Tonsil: Image Quest. Citation below image.



Lymph Vessels Surrounding Capillary.
BYU-Idaho image, Created Fall 2014

Lymphatic vessels are found in almost every tissue of the body that has blood vessels. The smallest lymphatic vessels are referred to as lymph capillaries. They are composed of simple squamous epithelial cells that slightly overlap each other. The gaps between neighboring cells allow the movement of excess tissue fluid into the lymphatic capillary. Once the fluid is picked up by the lymph capillary, it is called **lymph.** Lymphatic capillaries converge to form lymphatic vessels. These vessels carry the lymph through the lymph nodes to the lymphatic trunk and thoracic duct and then to the left and right subclavian veins where the lymph is dumped into the bloodstream. (You may click on this link to see an image depicting the dumping of lymph fluid back to the large vessels above the hear: lymph dumps into blood stream). The lymph from the upper right side of the body drains into the right subclavian vein via the right lymphatic duct. The lymph from the rest of the body drains into the left subclavian vein via the thoracic duct, which is the largest lymphatic vessel. While blood in the cardiovascular system is circulated due to the pumping of the heart, the lymphatic system depends on contraction of the lymph vessels themselves, as well as muscle pumps and the movements of the body to return the lymph to the heart. As the body moves, the contraction of the skeletal muscles knead and squeeze the lymph vessels pushing the lymph upward. Additionally, the act of breathing and subsequent changes in pressure in the thoracic cavity contributes to drawing the lymph toward the heart. Lymph vessels contain one-way semilunar valves, similar to veins, that prevent lymph from flowing backwards and keep it moving forward until it reaches the heart.

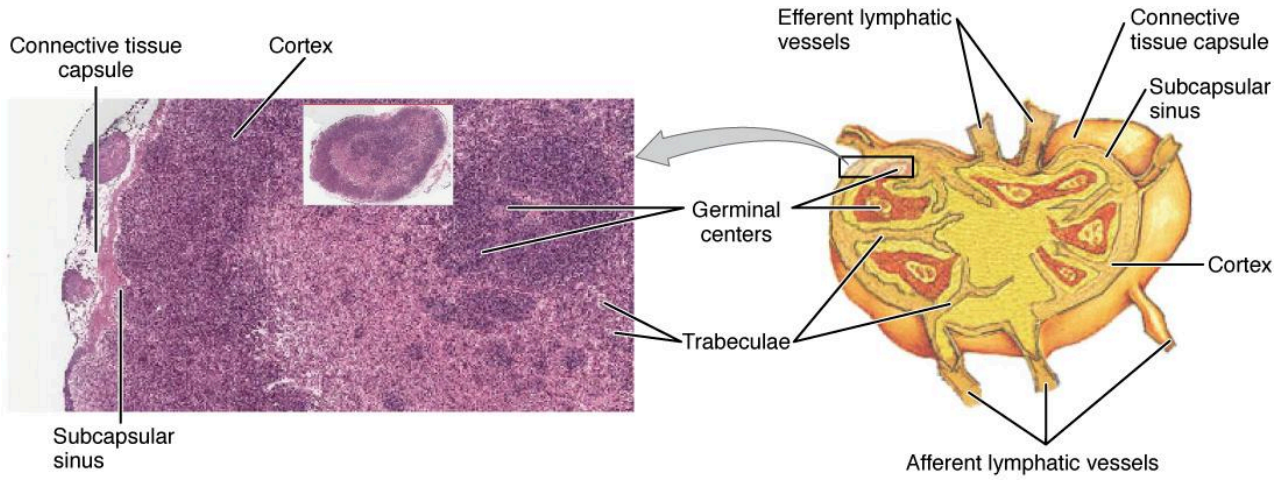


Major Ducts of the Lymphatic System.

Image by BYU-Idaho student Nate Shoemaker, 2017

Lymph Nodes

Lymphatic vessels are connected to many **lymph nodes.** As the lymph is moving toward the bloodstream through the lymphatic vessels, it is filtered through the lymph nodes, removing debris and pathogens. Lymph nodes contain many white blood cells that help defend our bodies from pathogens.



Lymph Nodes.

Author: OpenStax College. License: Creative Commons Attribution 3.0 Unported license Link: https://books.byui.edu/-sorX

The three main types of white blood cells found in the lymph nodes are macrophages, B-cells, and T-cells.

Macrophages are specialized cells that can engulf pathogens or other material found in lymph through endocytosis. Once inside the macrophage, enzymes from lysosomes will digest the material. This process of engulfing and digesting particulate matter is called **phagocytosis** (phago- refers to eating, cyto- means cell, -sis refers to a process; so, phagocytosis is "the process of cell eating"). Once the material has been digested down to simple molecules, it is released from the macrophage through exocytosis and can be used as nutrients for other body cells. B-cells and T-cells can be exposed to pathogens in the lymph nodes and become activated to fight infections. (This process will be discussed in detail later). When the lymph carries larger than normal numbers of pathogens to the lymph nodes, the nodes will become tender and swollen. Therefore, swollen, tender lymph nodes are a sign that there is an infection in the body.

Lymph Nodules

Lymph nodules are accumulations of lymphatic tissue found in close association with the mucous membranes lining the respiratory and digestive tracts. As a result, lymph nodules are commonly referred to as MALT (mucosa-associated lymphoid tissue). The tonsils that surround the opening to the pharynx are large accumulations of lymph nodules. Lymph nodules found around the small intestine are commonly referred to as **Peyer's patches.** Lymph nodules are not connected to the lymphatic vessels and lymph does not flow through them, but they are similar to lymph nodes in that they house macrophages, B-cells, and T-cells. Many potential pathogens gain access to the body through the respiratory and digestive tracts. Having the lymph nodules right at the mucous membranes (major entry sites into the body) allows these white cells to gain rapid access to potential pathogens that enter these systems. This arrangement allows the white blood cells to mount a rapid defense to destroy the pathogens before they can cause serious harm. Similar to lymph nodes, swollen lymph nodules indicate infection. For example, swollen, tender tonsils would indicate that there is an infection in the pharynx. Frequent and reccurring bacterial or viral infections in the pharynx can lead to enlarged tonsils and chronic tonsillitis, which can make it difficult to swallow or even breath while sleeping. If this condition is severe, an option is to have the tonsils surgically removed in a procedure called a tonsillectomy.

Spleen

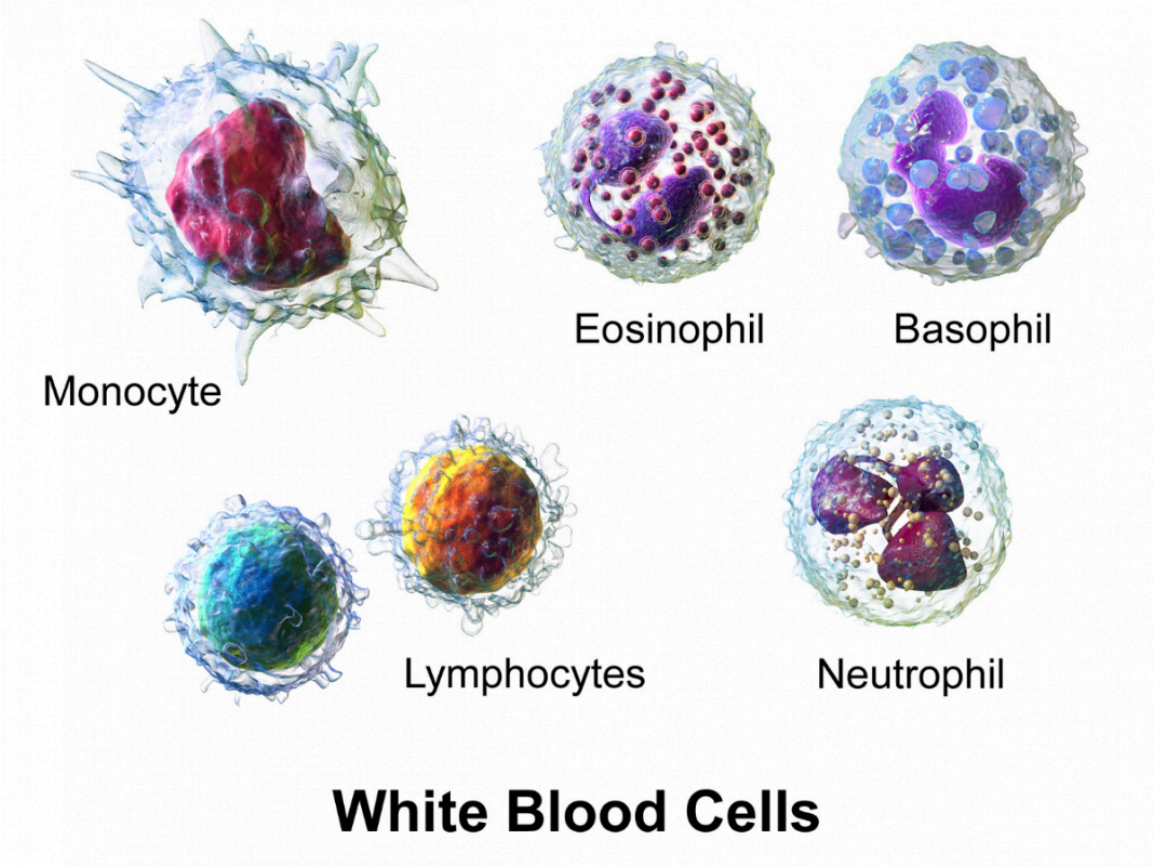
The spleen is a soft, spongy organ that has many small blood vessels and sinuses to store blood. In the event of a traumatic injury the spleen can release this stored blood (roughly the volume of a cup) into the circulatory system to replace blood that was lost. Just as the lymph nodes function to remove any pathogens or cellular debris from the lymph, the spleen carries out this function for the blood. As blood flows through the spleen, macrophages can perform phagocytosis on any bacteria or viruses that have gained access to the blood. Thankfully, infections in the blood are fairly uncommon, so the main function of the macrophages in the spleen is to remove dead or dysfunctional red blood cells. Under normal conditions, millions of red blood cells die each second. Many of the components of these red blood cells can be recycled as they are broken down through phagocytosis and dumped back into the blood by the macrophages in the spleen. If pathogens are found in the blood, B-cells and T-cells in the spleen can become activated to respond to the infection.

Thymus

Located between your lungs and behind your sternum, the thymus gland functions as a training and development center for T-lymphocytes (T-cells). Immature T-cells produced in the red bone marrow are sent to the thymus to be trained to only attack foreign invading cells. They begin first in the cortex of the thymus where immature T-cells come in contact with epithelial cells presenting different antigens. Through a process known as "positive selection" the immature T-cells that respond to the different antigens are selected to survive and migrate to the medulla of the thymus, while the remaining T-cells that didn't' respond to the different antigens die and are broken down by macrophages. In the medulla, the T-cells are tested for "negative selection" and are presented with the body's own antigens. If the T-cells attack the body's own cells (autoimmunity) they are eliminated by apoptosis (self-destruction), resulting in only 2% of immature T-cells reaching maturity. The thymus gland is most active from before birth through puberty as the immune system is actively producing T-cells, and then from puberty on through adulthood the thymus slowly undergoes atrophy (cell death) and is replaced by adipose tissue.

Leukocytes

Leukocytes, or white blood cells, are some of the key players in fighting infection in our bodies. Each leukocyte was given their name based on their appearance when exposed to different pH dyes. Baso = base; basophil granules stain dark blue in basic dye. Eosino = acid; Eosinophil granules stain red or orange in acidic dyes. Neutro = neutral; neutrophils stain a neutral pink in neutral dyes. Lymph = colorless: cyte = cell or vessel; lymphocytes look transparent and will stain pale blue with a dark purple nucleus. Mono = one; monocytes have one large kidney-shaped nucleus inside.



Blausen.com staff (2014). "Medical gallery of Blausen Medical 2014". WikiJournal of Medicine 1 (2). DOI:10.15347/wjm/2014.010. ISSN 2002-4436. (Own work) File: https://books.byui.edu/-idptLicense: [CC BY 3.0 (http://creativecommons.org/licenses/by/3.0)], via Wikimedia Commons

You will be learning more about each of these leukocytes in BIO 265 Lab. Below you will see a chart that briefly describes each of the different leukocytes and their unique characteristics and function.

Formed element	Major subtypes	Numbers present per microliter (μL) and mean (range)	Appearance in a standard blood smear	Summary of functions	Comments

Formed element	Major subtypes	Numbers present per microliter (μL) and mean (range)	Appearance in a standard blood smear	Summary of functions	Comments
Erythrocytes (red blood cells)		5.2 million (4.4–6.0 million)	Flattened biconcave disk; no nucleus; pale red color	Transport oxygen and some carbon dioxide between tissues and lungs	Lifespan of approximately 120 days
Leukocytes (white blood cells)		7000 (5000–10,000)	Obvious dark-staining nucleus	All function in body defenses	Exit capillaries and move into tissues; lifespan of usually a few hours or days
	Granulocytes including neutrophils, eosinophils, and basophils	4360 (1800–9950)	Abundant granules in cytoplasm; nucleus normally lobed	Nonspecific (innate) resistance to disease	Classified according to membrane-bound granules in cytoplasm
	Neutrophils	4150 (1800–7300)	Nuclear lobes increase with age; pale lilac granules	Phagocytic; particularly effective against bacteria. Release cytotoxic chemicals from granules	Most common leukocyte; lifespan of minutes to days
	Eosinophils	165 (0–700)	Nucleus generally two-lobed; bright red-orange granules	Phagocytic cells; particularly effective with antigen- antibody complexes. Release antihistamines. Increase in allergies and parasitic infections	Lifespan of minutes to days
	Basophils	44 (0–150)	Nucleus generally two-lobed but difficult to see due to presence of heavy, dense, dark purple granules	Promotes inflammation	Least common leukocyte; lifespan unknown
	Agranulocytes including lymphocytes and monocytes	2640 (1700–4950)	Lack abundant granules in cytoplasm; have a simple-shaped nucleus that may be indented	Body defenses	Group consists of two major cell types from different lineages
	Lymphocytes	2185 (1500–4000)	Spherical cells with a single often large nucleus occupying much of the cell's volume; stains purple; seen in large (natural killer cells) and small (B and T cells) variants	Primarily specific (adaptive) immunity: T cells directly attack other cells (cellular immunity); B cells release antibodies (humoral immunity); natural killer cells are similar to T cells but nonspecific	Initial cells originate in bone marrow, but secondary production occurs in lymphatic tissue; several distinct subtypes; memory cells form after exposure to a pathogen and rapidly increase responses to subsequent exposure; lifespan of many years
	Monocytes	455 (200–950)	Largest leukocyte with an indented or horseshoe-shaped nucleus	Very effective phagocytic cells engulfing pathogens or worn out cells; also serve as antigen-presenting cells (APCs) for other components of the immune system	Produced in red bone marrow; referred to as macrophages after leaving circulation
Platelets		350,000 (150,000–500,000)	Cellular fragments surrounded by a plasma membrane and containing granules; purple stain	Hemostasis plus release growth factors for repair and healing of tissue	Formed from megakaryocytes that remain in the red bone marrow and shed platelets into circulation

Leukocytes (White Blood Cells) Table.

Author: OpenStax College.Link: https://books.byui.edu/-PyzkLicense: CC BY 3.0 via Wikimedia Commons