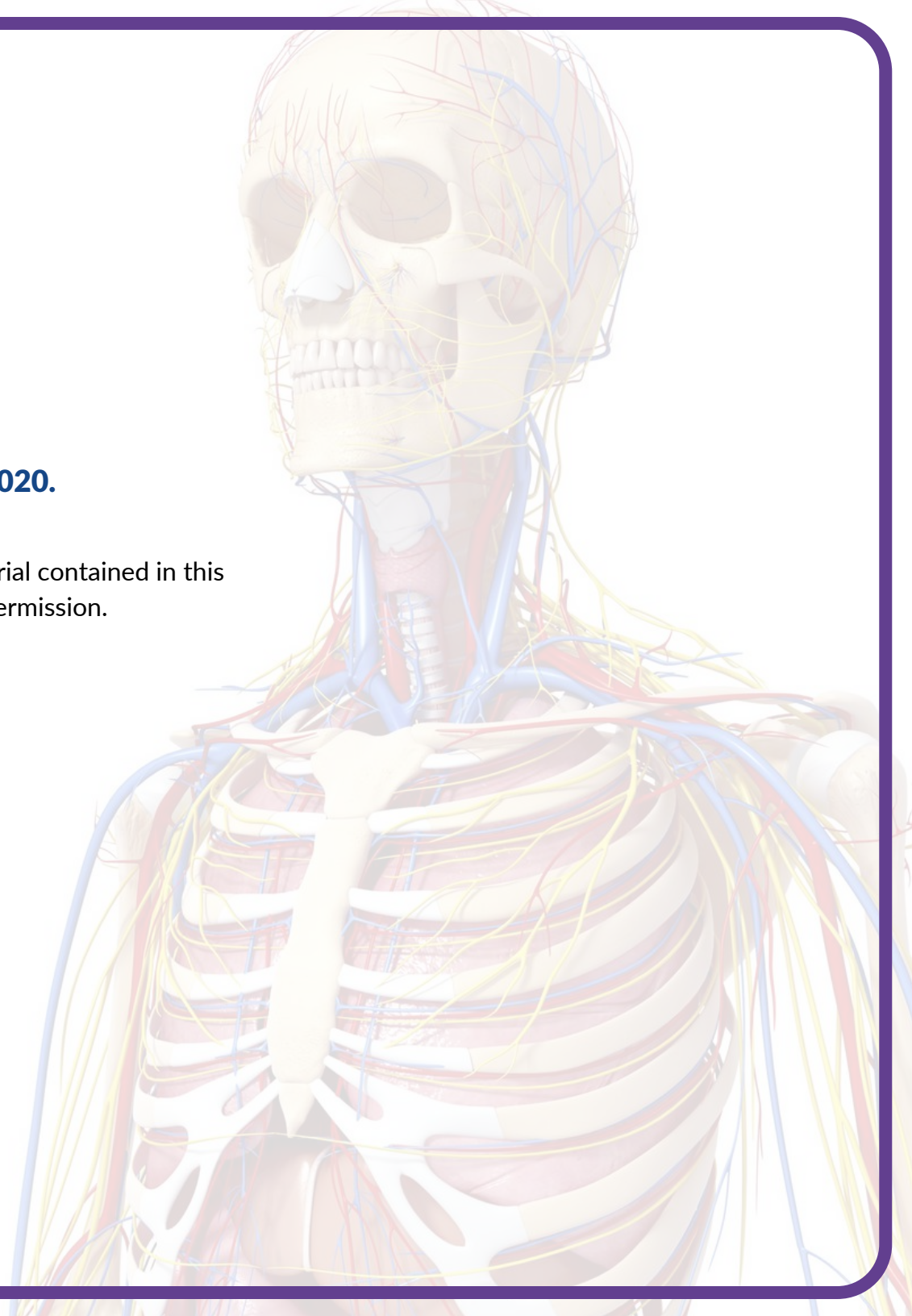


Lymphatic/Immune System Workbook

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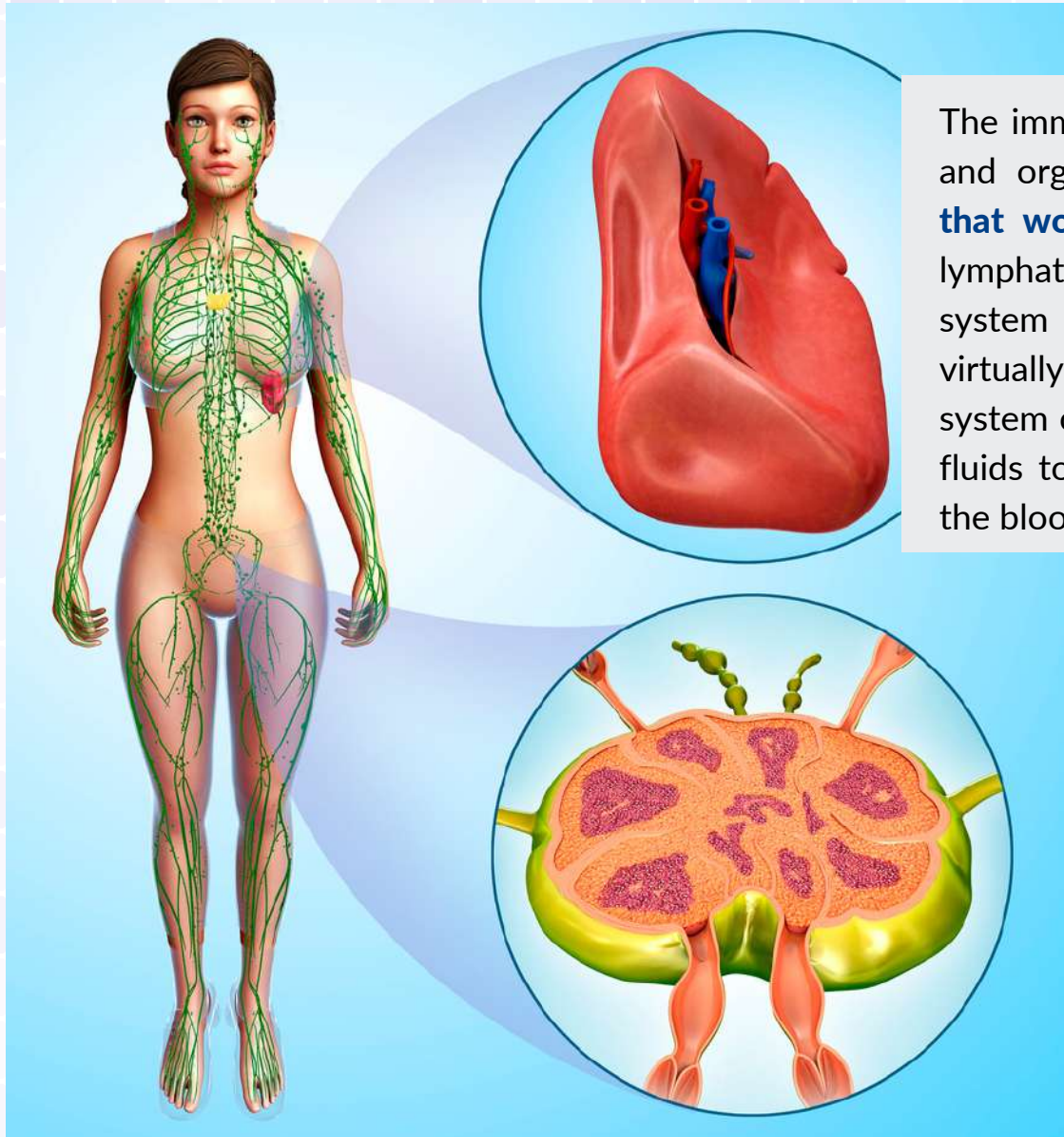
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Learning Objectives

- Describe the function of the lymphatic/immune system and its major components.
- Describe the relationships between the different components of the lymphatic/immune system.
- Explain how the lymphatic/immune system is interdependent with other organ systems.
- Explain how the lymphatic/immune system maintains homeostasis in the body

Lymphatic/Immune System Overview

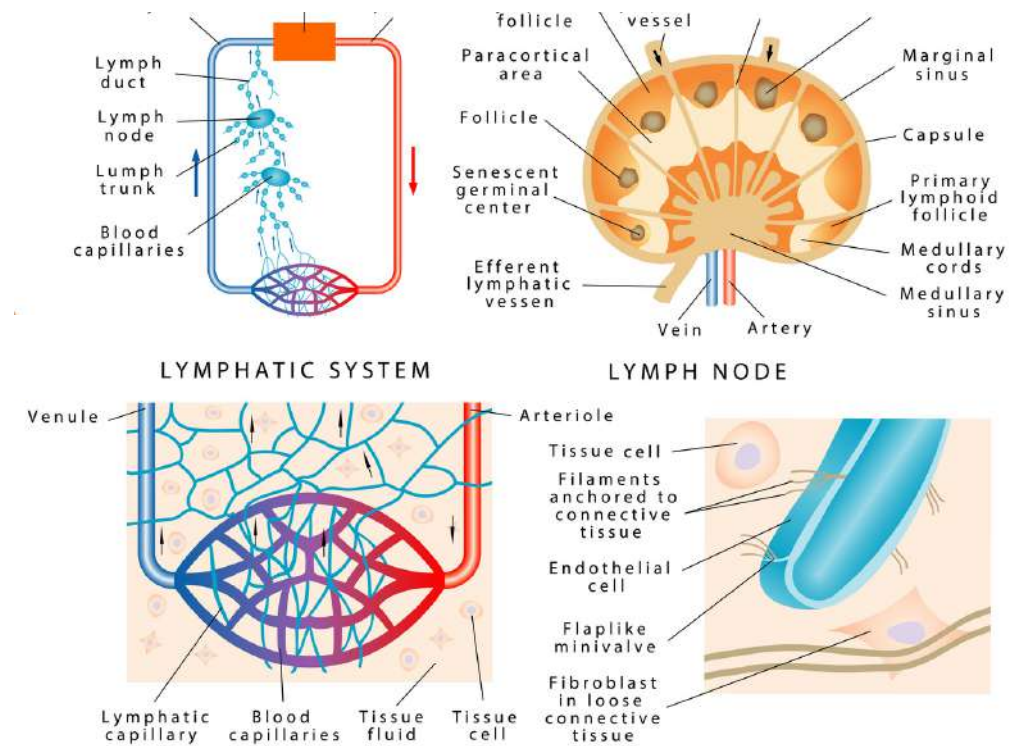
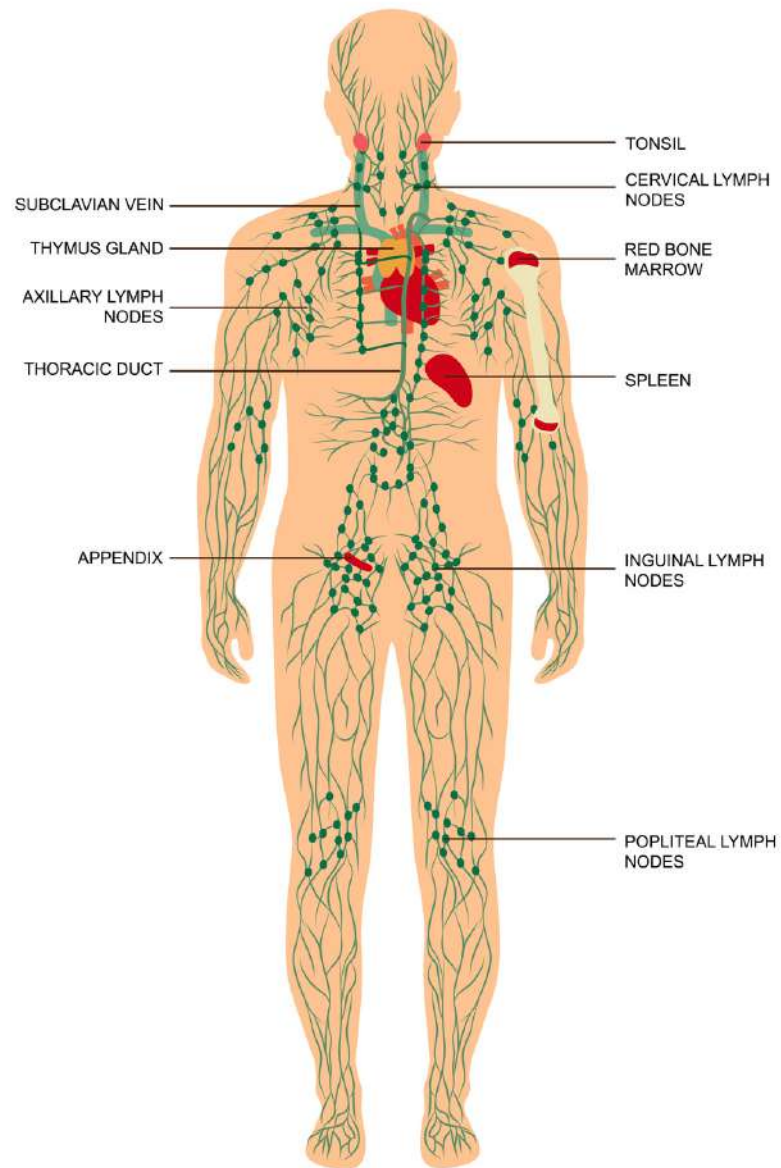


The immune system is the complex collection of cells and organs that destroys or **neutralizes pathogens that would otherwise cause disease or death**. The lymphatic system is associated with the immune system to such a degree that the two systems are virtually indistinguishable. The lymphatic system is the system of vessels, cells, and organs that carries excess fluids to the bloodstream and filters pathogens from the blood.

COMPONENTS

- Thymus Gland
- Spleen
- Lymph Nodes
- Lymph vessels

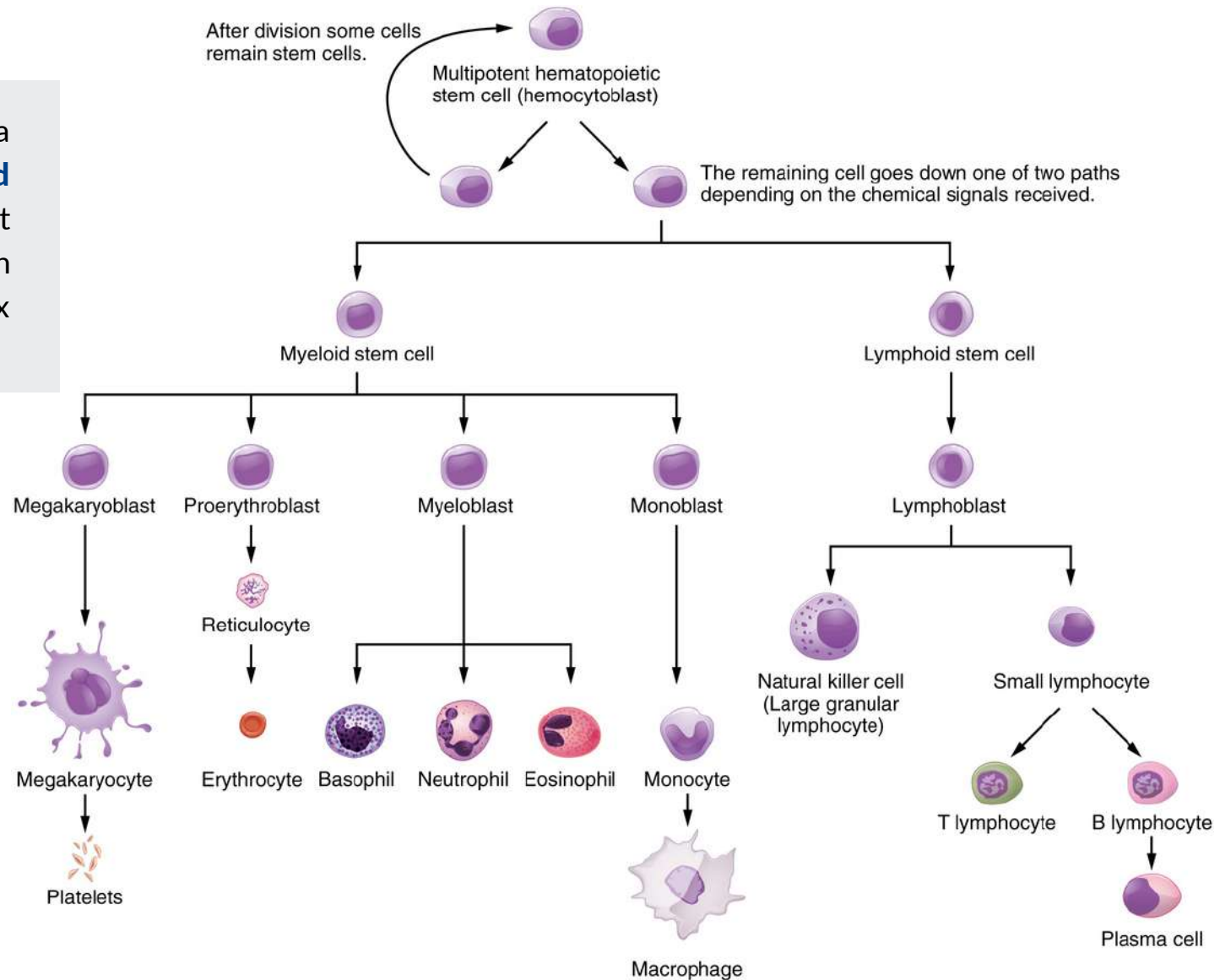
Structure of the Lymphatic System



A major function of the lymphatic system is to **drain body fluids** and return them to the bloodstream. As the vertebrate immune system evolved, the network of lymphatic vessels became convenient avenues for transporting the cells of the immune system. Cells of the immune system not only use **lymphatic vessels** to make their way from interstitial spaces back into the circulation, but they also use **lymph nodes** as major staging areas for the development of critical immune responses.

Organization of Immune Function

The immune system is a collection of **barriers, cells, and soluble proteins** that interact and communicate with each other in extraordinarily complex ways.



Lymphocytes

Lymphocytes are the primary cells of adaptive immune responses. The two basic types of lymphocytes, **B cells** and **T cells**, are identical morphologically with a large central nucleus surrounded by a thin layer of cytoplasm. They are distinguished from each other by their surface protein markers as well as by the molecules they secrete. While **B cells mature in red bone marrow** and **T cells mature in the thymus**, they both initially develop from bone marrow. T cells migrate from bone marrow to the thymus gland where they further mature. B cells and T cells are found in many parts of the body, circulating in the bloodstream and lymph, and residing in secondary lymphoid organs, including the spleen and lymph nodes. The human body contains approximately 10¹² lymphocytes.

B CELLS

B cells are immune cells that function primarily by **producing antibodies**. An antibody is any of the group of proteins that binds specifically to pathogen-associated molecules known as **antigens**. An antigen is a chemical structure on the surface of a pathogen that binds to T or B lymphocyte antigen receptors. Once activated by binding to antigen, B cells differentiate into cells that secrete a soluble form of their surface antibodies. These activated B cells are known as **plasma cells**.

T CELLS

The T cell, on the other hand, does not secrete antibody but performs a variety of functions in the **adaptive immune response**. Different T cell types have the ability to either secrete soluble factors that communicate with other cells of the adaptive immune response or destroy cells infected with intracellular pathogens.

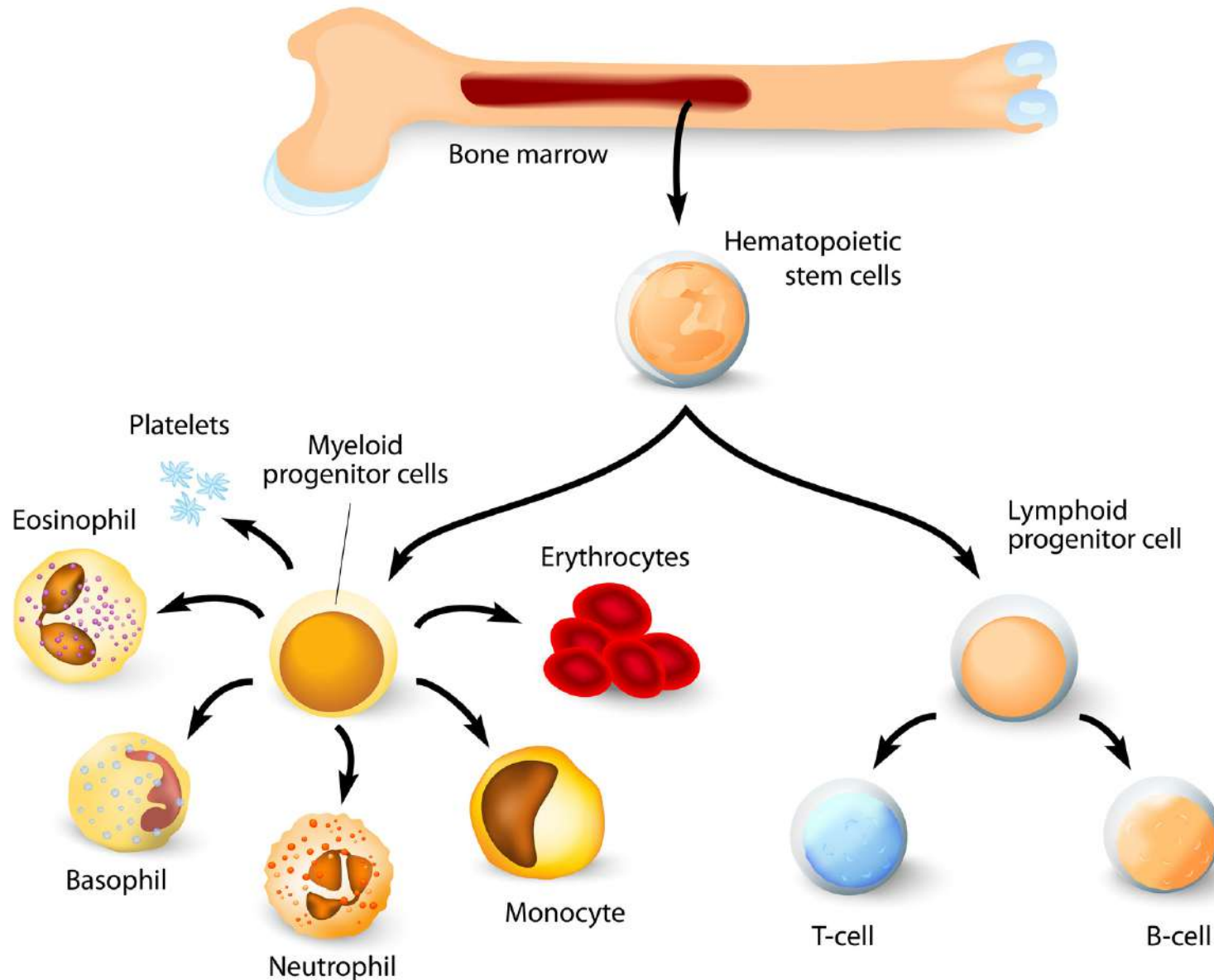
PLASMA CELLS

Another type of lymphocyte of importance is the **plasma cell**. A plasma cell is a B cell that has differentiated in response to antigen binding, and has thereby gained the ability to secrete soluble antibodies. These cells differ in morphology from standard B and T cells in that they contain a large amount of **cytoplasm** packed with the protein-synthesizing machinery known as **rough endoplasmic reticulum**.

NATURAL KILLER CELLS

A fourth important lymphocyte is the natural killer cell, a participant in the **innate immune response**. A natural killer cell (NK) is a circulating blood cell that contains **cytotoxic (cell-killing) granules** in its extensive cytoplasm. It shares this mechanism with the cytotoxic T cells of the adaptive immune response. NK cells are among the body's first lines of defense against viruses and certain types of cancer.

Primary Lymphoid Organs: Bone Marrow

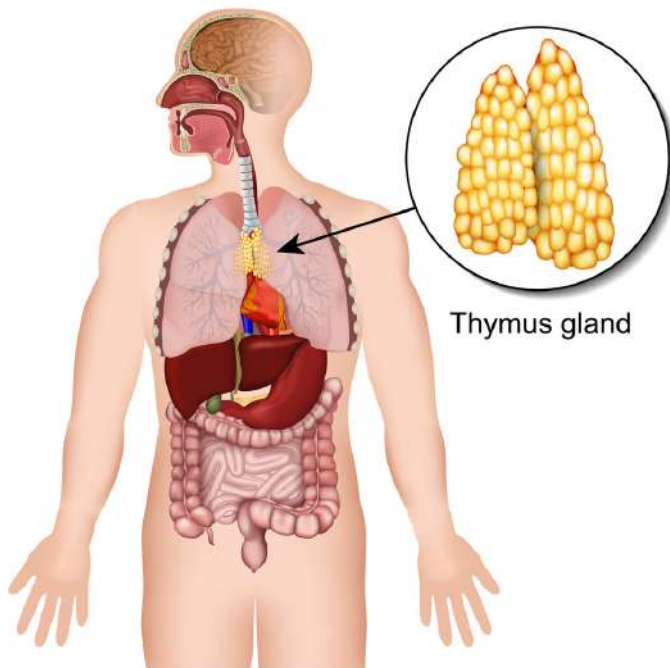
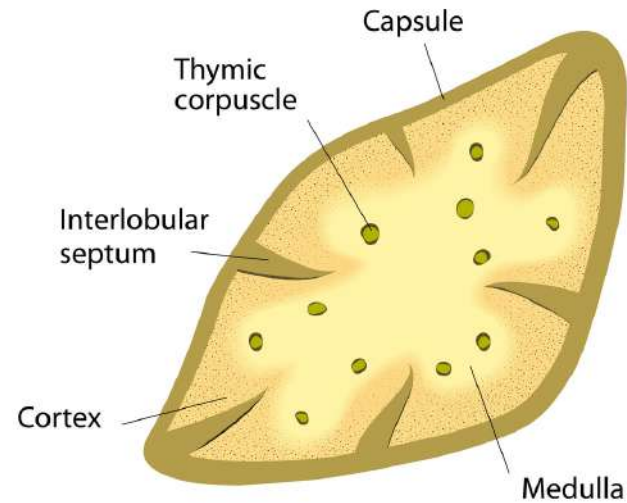


Primary Lymphoid Organs: Thymus Gland

Front view



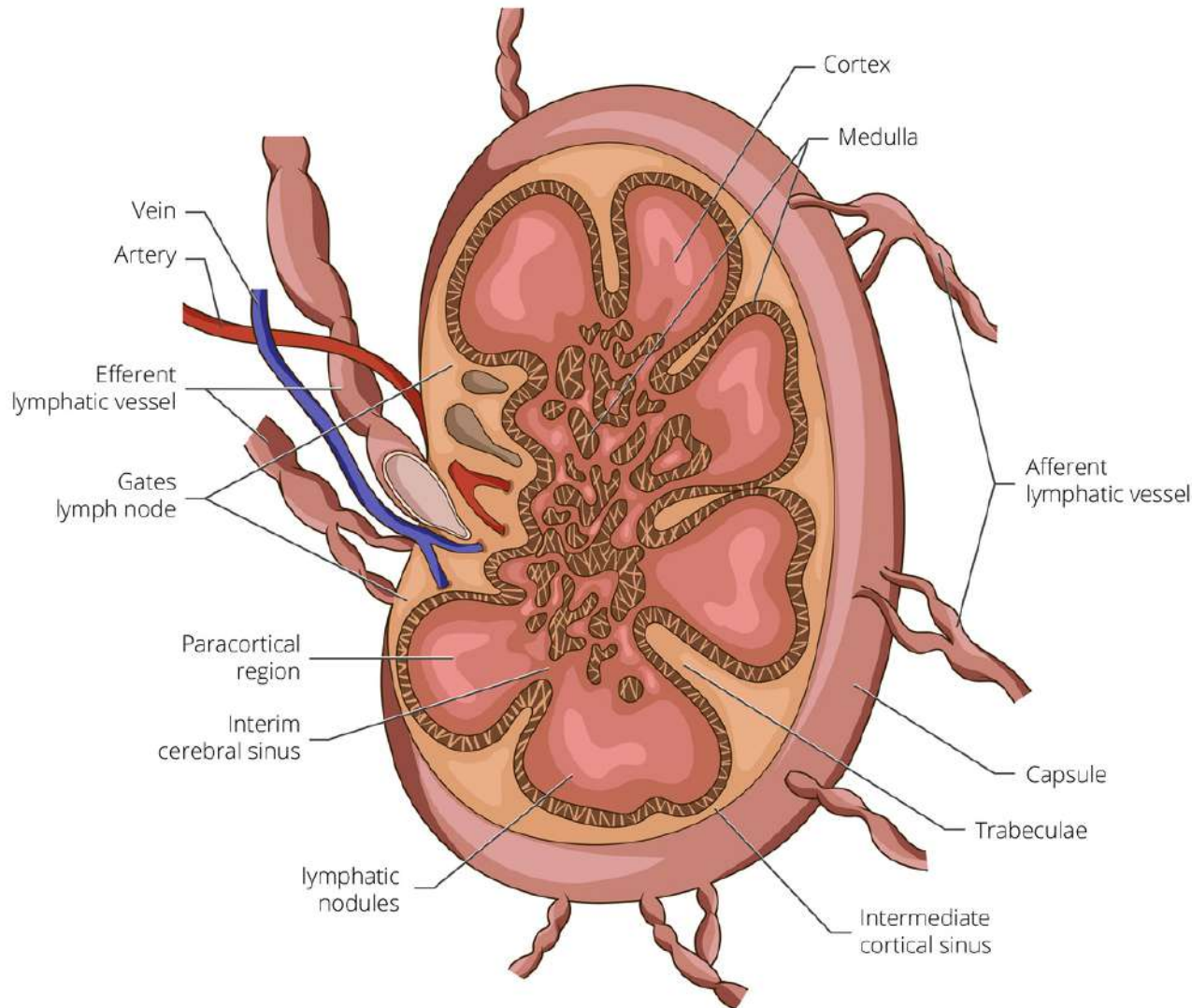
Structure



The **thymus gland** is a bilobed organ found in the space between the **sternum** and the **aorta** of the heart. Connective tissue holds the lobes closely together but also separates them and forms a **capsule**. The connective tissue capsule further divides the thymus into lobules via extensions called **trabeculae**. The outer region of the organ is known as the **cortex** and contains large numbers of **T cells (thymocytes)** with some epithelial cells, macrophages, and dendritic cells (two types of phagocytic cells that are derived from monocytes). The cortex is densely packed so it stains more intensely than the rest of the thymus. The **medulla**, where thymocytes migrate before leaving the thymus, contains a less dense collection of thymocytes, epithelial cells, and dendritic cells.

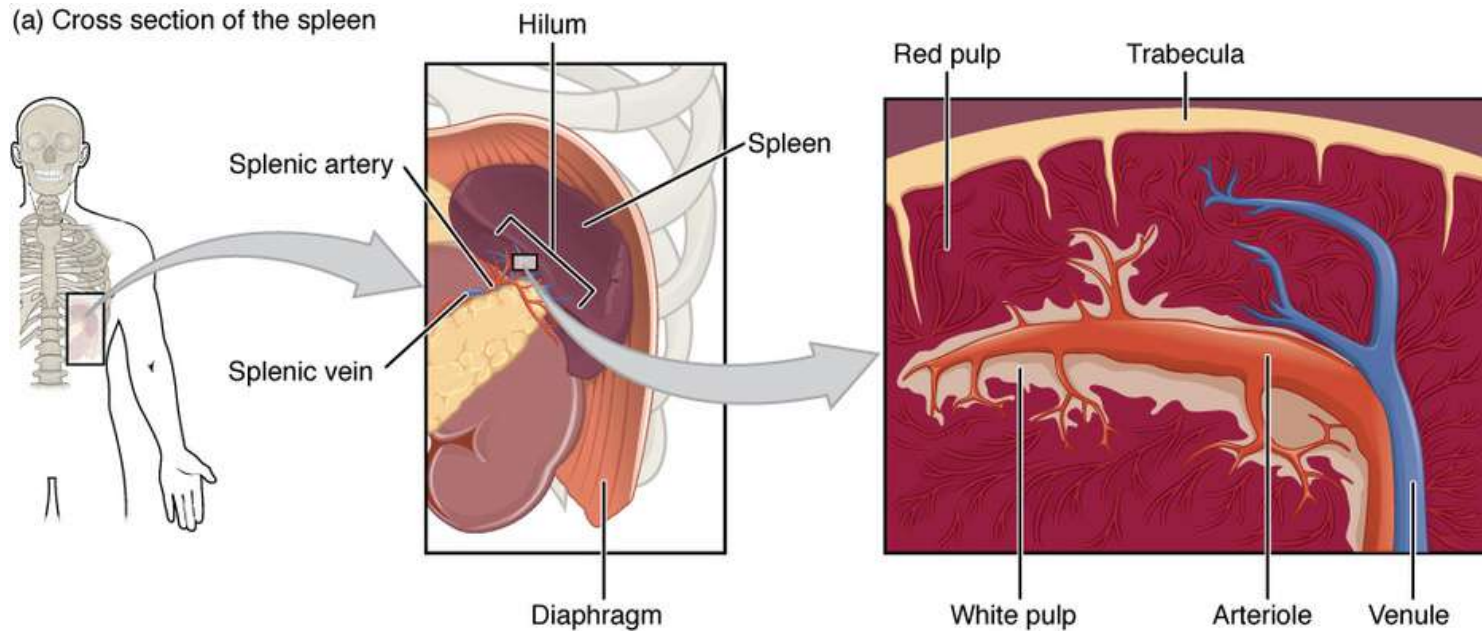
Secondary Lymphoid Organs: Lymph Nodes

Lymph node structure



Lymph nodes function to remove debris and pathogens from the lymph, and are thus sometimes referred to as the “filters of the lymph”. Any bacteria that infect the **interstitial fluid** are taken up by the **lymphatic capillaries** and transported to a **regional lymph node**. **Dendritic cells** and **macrophages** within this organ internalize and kill many of the pathogens that pass through, thereby removing them from the body. The lymph node is also the site of **adaptive immune responses** mediated by **T cells**, **B cells**, and **accessory cells** of the adaptive immune system. Like the thymus, the bean-shaped lymph nodes are surrounded by a tough capsule of connective tissue and are separated into compartments by **trabeculae**, the extensions of the capsule. In addition to the structure provided by the capsule and trabeculae, the structural support of the lymph node is provided by a series of **reticular fibres** laid down by **fibroblasts**.

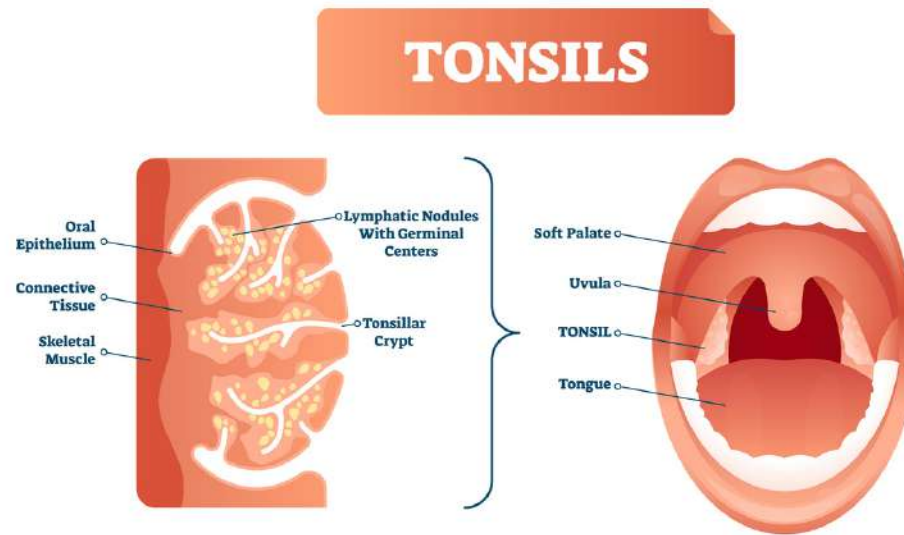
Secondary Lymphoid Organs: Spleen



In addition to the lymph nodes, the **spleen** is a major secondary **lymphoid organ**. It is about 12 cm (5 in) long and is attached to the lateral border of the stomach via the gastrosplenic ligament. The spleen is a fragile organ without a strong **capsule**, and is dark red due to its extensive vascularization. The spleen is sometimes called the “filter of the blood” because of its extensive vascularization and the presence of **macrophages** and **dendritic cells** that remove microbes and other materials from the blood, including dying red blood cells. The spleen also functions as the location of immune responses to blood-borne pathogens.

The spleen is also divided by **trabeculae** of connective tissue, and within each splenic nodule is an area of **red pulp**, consisting of mostly red blood cells, and **white pulp**, which resembles the lymphoid follicles of the lymph nodes. Upon entering the spleen, the **splenic artery** splits into several **arterioles** (surrounded by white pulp) and eventually into **sinusoids**. Blood from the capillaries subsequently collects in the **venous sinuses** and leaves via the **splenic vein**. The red pulp consists of **reticular fibers** with fixed macrophages attached, free macrophages, and all of the other cells typical of the blood, including some lymphocytes. The white pulp surrounds a central arteriole and consists of **germinal centres** of dividing **B cells** surrounded by **T cells** and accessory cells, including macrophages and dendritic cells. Thus, the red pulp primarily functions as a filtration system of the blood, using cells of the relatively nonspecific immune response, and white pulp is where adaptive T and B cell responses are mounted.

Secondary Lymphoid Organs: Lymphoid Nodules



The other lymphoid tissues, the **lymphoid nodules**, have a simpler architecture than the spleen and lymph nodes in that they consist of a dense cluster of **lymphocytes** without a surrounding fibrous capsule. These nodules are located in the respiratory and digestive tracts, areas routinely exposed to environmental pathogens. **Tonsils** are lymphoid nodules located along the inner surface of the pharynx and are important in developing immunity to oral pathogens. The tonsil located at the back of the throat, the **pharyngeal tonsil**, is sometimes referred to as the adenoid when swollen. Such swelling is an indication of an active immune response to infection. Histologically, tonsils do not contain a complete capsule, and the epithelial layer invaginates deeply into the interior of the tonsil to form tonsillar crypts. These structures, which accumulate all sorts of materials taken into the body through eating and breathing, actually “encourage” pathogens to penetrate deep into the tonsillar tissues where they are acted upon by numerous lymphoid follicles and eliminated. This seems to be the major function of tonsils—to help children’s bodies recognize, destroy, and develop immunity to common environmental pathogens so that they will be protected in their later lives. Tonsils are often removed in those children who have recurring throat infections, especially those involving the **palatine tonsils** on either side of the throat, whose swelling may interfere with their breathing and/or swallowing.

Lymphatic System & Other Organ Systems



Cardiovascular system: Circulatory would soon fail without return of fluid and protein by lymphatic system; spleen disposes of expired erythrocytes and recycles iron; lymphatic organs prevent accumulation of debris and pathogens in blood. Lymphatic vessels develop from embryonic veins; arterial pulsation aids flow of lymph in neighbouring lymphatic vessels; leukocytes serve in nonspecific and specific defense; blood transports immune cells, antibodies, complement, interferon, and other immune chemicals; capillary endothelial cells signal areas of tissue injury and stimulate margination and diapedesis of leukocytes; blood clotting restricts spread of pathogens.

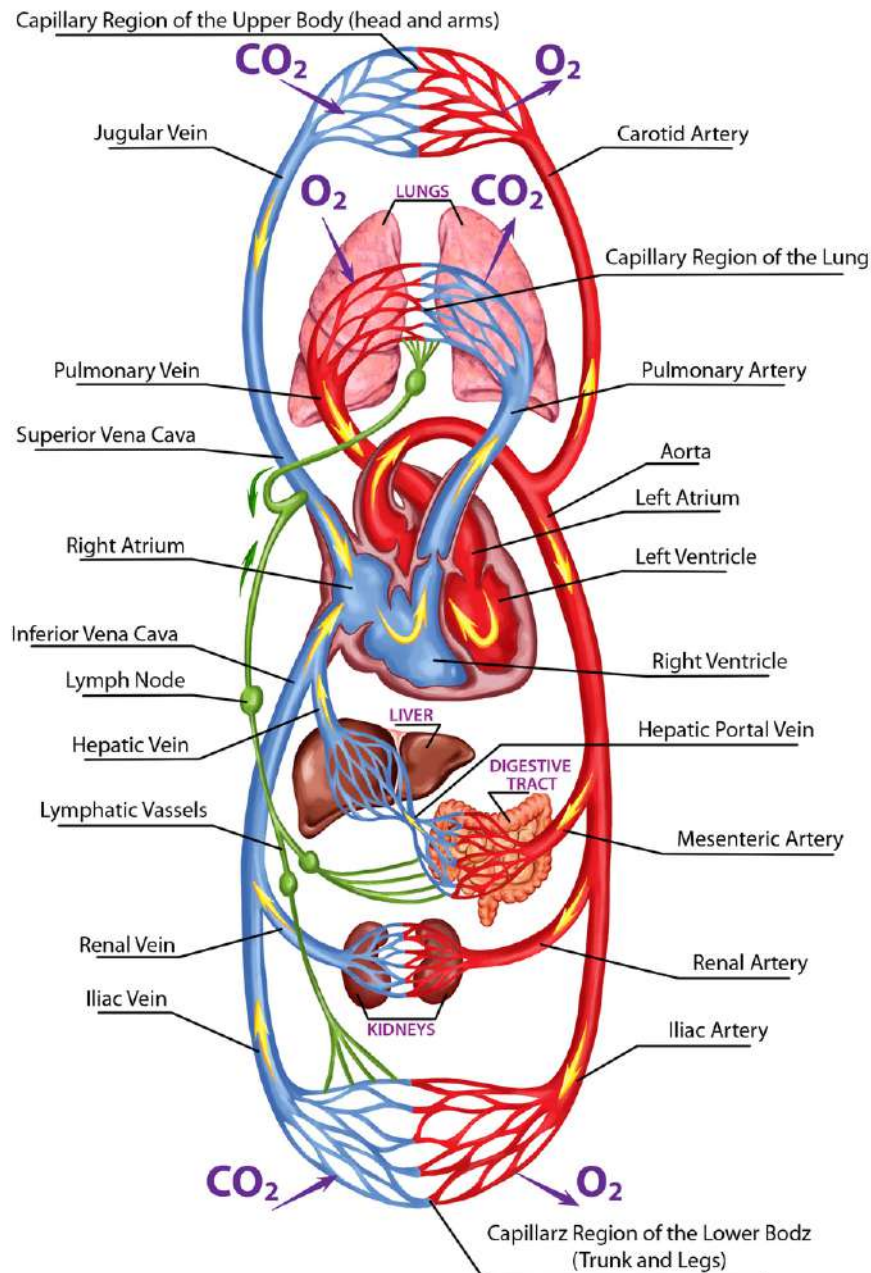


Urinary System: Absorbs fluid and proteins in kidneys, which is essential to enabling kidneys to concentrate the urine and conserve water. Eliminates waste and maintains fluid and electrolyte balance important to lymphatic and immune function; urine flushes some pathogens from body; acidic pH of urine protects against urinary tract infection.



Endocrine System: Lymph transports some hormones. Hormones from thymus stimulate development of lymphatic organs and T cells; stress hormones depress immunity and increase susceptibility to infection and cancer.

Lymphatic System & Homeostasis



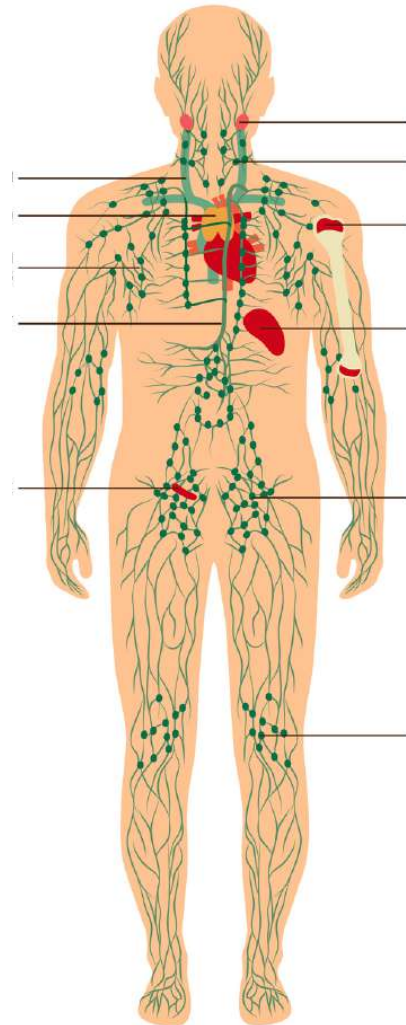
The lymphatic system helps **maintain fluid balance** in the body by collecting excess fluid and particulate matter from tissues and depositing them in the bloodstream.

Review Break

- What is one way the lymphatic/immune system maintains homeostasis within the body?
- What is one way the lymphatic/immune system interacts with other body systems?
- Name one primary lymphoid organ and one secondary lymphoid organ - explain their function.

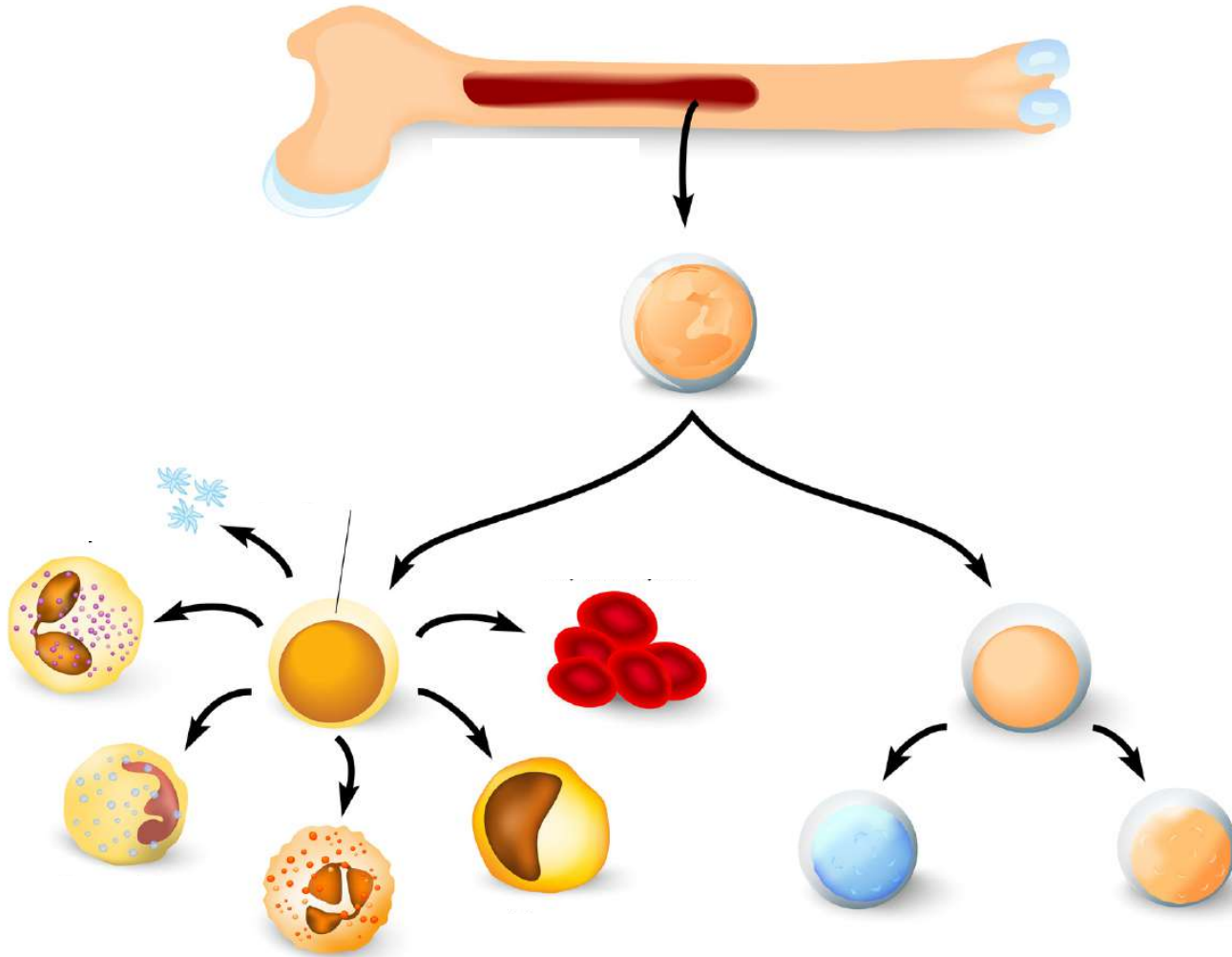
QUIZ!

Without looking back through the workbook label the diagram below



QUIZ!

Without looking back through the workbook label the diagram below



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