Description

The cardiovascular system has a close relationship with the lymphatic system. Like the veins rur ning through the body, the lymphatic system consists of a network of thin-walled vessels called **lymphatic vessels.** Like veins, they contain one-way valves (semilunar valves) that assist in circulating the lymph, which is under very low pressure.

Instead of carrying blood, the lymphatic vessels carry **lymph**—tissue fluid that was filtered from the blood. In the illustration, the gray areas indicate this filtration process. The composition of lymph is similar to plasma—mostly water along with some solutes such as salts.

Lymphatic vessels are connected to lymphatic capillaries and lymph nodes. **Lymphatic capillaries** are structurally similar to blood capillaries. Both are microscopic networks made of a single layer of simple squamous epithelium, but lymphatic capillaries contain flap-like structures that make them more permeable than blood capillaries. **Lymph nodes** are pea-sized structures that act as tiny filters to clean the lymph.

Like an oil filter cleans the motor oil in your car's engine, the lymph nodes filter the debris out of your lymph. These nodes contain macrophages that ingest and destroy pathogens such as bacteria. Lymph enters a lymph node through an **afferent lymphatic vessel** and leaves through an **efferent lymphatic vessel.** In short, "unclean lymph in, clean lymph out." The cleansed lymph is returned to the cardiovascular system via the subclavian veins.

Flow of Lymph

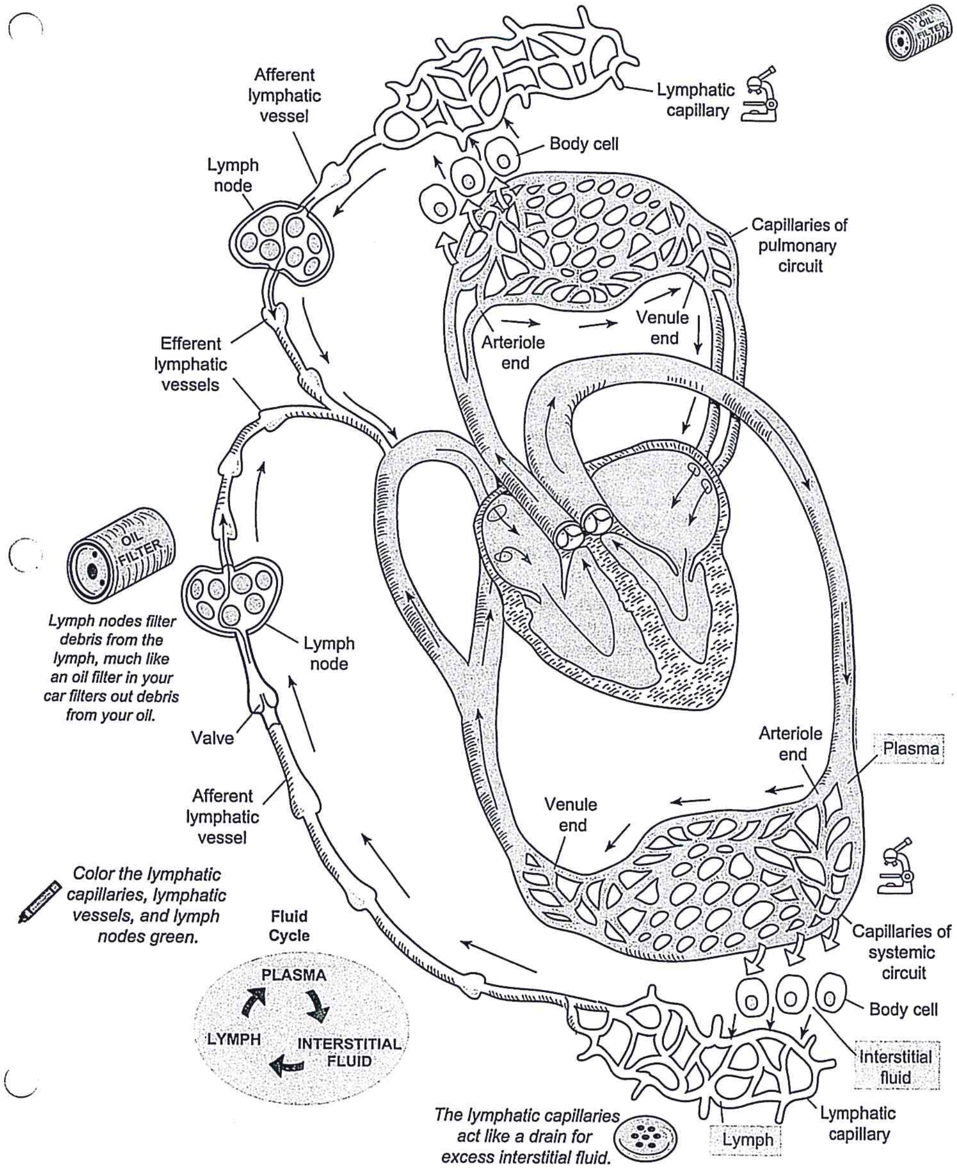
Here is a summary of the flow of lymph through the lymphatic system:

> Lymphatic capillaries → afferent lymphatic vessel → lymph node → efferent lymphatic vessel → subclavian veins

Lymph is really nothing more than filtered blood plasma. All blood capillaries constantly filter the blood as a result of the force of blood pressure (see p. 68). This fluid, called **interstitial fluid,** fills the interstitial spaces between body cells, bathing them in fluid. Filtration occurs at the higher-pressure arteriole end of the capillary. Although some of this fluid is reabsorbed at the venule end, there is still an excess amount. As interstitial fluid pressure builds in the interstitial spaces, it is shunted into the nearby lymphatic capillaries, which act as a drain for the excess fluid. Although this fluid has not changed its chemical composition in any way, once inside the lymphatic capillary, it now is called **lymph.** Think of this fluid cycle as recycling of our plasma. This helps maintain normal fluid levels in the blood. As shown in the illustration: Plasma is filtered to become **interstitial fluid,** which becomes **lymph,** which becomes plasma once again. The cycle is complete!

Study Tip

The terms *afferent* and *efferent* apply to multiple organ systems. Here is a way to distinguish them: Afferent as in Approach; Efferent as in Exit.



Description

This overview of the immune system has a focus on specific resistance. The immune system prote‹ your body against foreign pathogens such as bacteria and viruses, using several lines of defense against these invaders. Think of a pathogenic invasion as an army of invaders attacking another army inside a medieval castle. The first line of defense is the wall around the castle. Similarly, your body has the following physical and chemical barriers as its first line of defense:

1. Physical barriers
   a. Skin: Thick layer of dead cells in the epidermis provides protection.
   b. Mucous membranes: Mucous film on these membranes traps microbes.
2. Chemical barriers
   a. Lysozyme in tears is an antibacterial agent.
   b. Gastric juice in the stomach is highly acidic (pH 2–3), which destroys bacteria.

The second line of defense consists of methods of nonspecific resistance that destroy invaders in a generalized way without targeting specific individuals. For example, if archers along the top of the castle were to shoot arrows into the invading army or if boiling oil were poured on them, this would help kill clusters of enemy soldiers. Similarly, your body has some general defenses for microbes that pass through the first lines of defense. A few examples are the following:

- Phagocytic cells ingest and destroy all microbes that pass into body tissues.
- Inflammation is a normal body response to tissue damage and other stimuli that brings more white blood cells to the site of pathogenic invasion.
- Fever inhibits bacterial growth and increases the rate of tissue repair during an infection.

Specific Resistance

The third line of defense deals with specific resistance, illustrated on the facing page. Think of these defenses like guided missiles that go after a specific target. In the medieval castle, they might be specially trained soldiers who act as assassins to kill the enemy's general. In short, they have a specific mission. Your immune system has "assassin" cells that attack microbes. Unlike in a war in which soldiers in different armies are wearing different uniforms, your immune system has a more difficult time distinguishing its own tissues ("self") from foreign microbes ("non-self"). To make this distinction, it relies on detecting antigens, which are specific substances found in foreign microbes. Most are proteins that serve as the stimulus to produce an immune response. The term "antigen" is coined from "ANTI-body GENerating substances."

The illustration shows the immune response to an antigen. Once the antigen is detected, a dual response is activated by two groups of specialized lymphocytes called T cells and B cells. These cells are able to communicate with each other through chemical signaling. T cells typically are activated first. After they are activated, they can either directly destroy the microbes or use chemical secretions to destroy them. At the same time, T cells stimulate B cells to divide, forming other cells that are able to produce antibodies. These Y-shaped proteins circulate though the bloodstream and bind to specific antigens, thereby attacking microbes.

Details of the mechanisms that T cells and B cells use to attack microbes are examined in subsequent modules. Together, the T cells and B cells provide specific resistance to specific antigens.