The lymphatic system is represented by a network of vessels, tissues, organs and cells by which lymph fluid is able to flow from the tissue spaces back into the bloodstream. Like the cardiovascular system, it is interactive with every organ and directly related to the body's immune function and efficiency.

Fluid that leaves the blood capillaries to supply the body's cells with nutrients is collected by the vessels of the lymphatic system and returned to the blood. By doing so, the lymphatic system maintains the fluid balance in the body. Lymph also carries other substances, such as protein; a higher concentration of white blood cells is found in the lymph fluid of bone marrow, spleen and thymus. The lymphatic system further assists the cardiovascular system in absorbing nutrients and fat from the small intestine.

These vital and necessary actions, however, are only one part of the system's important function—it also serves as the body's internal "garbage collector." The lymphatic system is the main line of defense and responsible for removing and destroying toxic substances and pathogens, therefore resisting the spread of disease throughout the body.

Specialized massage therapy is utilized in manual lymph drainage, and therapists skilled in this type of therapy and knowledge about lymphatic drainage often work with a specialized clientele of patients referred by physicians. Understanding the process of lymph formation is one building block in the development of a lymph-drainage specialty; however, specialized education is required to practice in this area.
Overall health is highly dependent on a sufficient lymphatic system with proper flow and drainage; if its function is impaired, the affected parts of the body that rely on sufficient drainage of fluid, toxins and waste products by the lymphatic system have a tendency to swell and become a breeding ground for infections, which may spread throughout the body.

The smallest vessels, lymphatic capillaries, represent the beginning of the lymphatic drainage system.

**An independent system**

While the lymphatic system is closely associated with the cardiovascular system, it is not directly connected to the heart and relies on its own pumping mechanisms, muscle activity and diaphragmatic breathing to stimulate the flow of lymph back into the bloodstream. Contrary to the cardiovascular system, the lymphatic system is not a closed circulatory system. It is therefore more appropriate to speak of *lymph transport* rather than of *lymph circulation*. The system consists of a network of one-way lymph vessels, also called lymphatics, which transport the watery lymph fluid from the tissues back to the venous part of the blood circulatory system. Throughout all the tissues of the body, the lymph vessels form a complicated, spidery network of fine tubes.

The smallest vessels, called lymphatic capillaries, represent the beginning of the lymphatic drainage system. They originate in close proximity to blood capillaries as closed or dead-end tubes in the interstitial spaces (unlike vessels belonging to the cardiovascular system, which have a closed circuit). The walls of lymphatic capillaries are composed of only a single layer of flattened endothelial cells, which play an important role in a process called lymph formation. Lymph formation describes the absorption of interstitial fluid and other substances from the tissues into the lymphatic capillaries. Once the interstitial fluid enters the lymphatic system, it is called lymph, which is similar to blood plasma but

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contains more white blood cells. (The term lymph originates from the Latin word *lympha*, meaning “clear water.”) Lymph fluid is transported from the lymphatic capillaries to the lymph nodes by larger lymph vessels, called lymph collectors. Lymph nodes serve as filter stations for harmful materials, such as cancer cells and pathogens, and play an important role in the body's immune function through the production of antibodies.

The diameter of lymph collectors varies between 0.1 to 0.6 millimeters; its walls are structured similar to that of veins. Collectors contain valves, which as in venous vessels allow the flow of fluid in one direction only (proximal). The interval between the valves is irregular and varies between 6 and 20 millimeters; in larger collectors, also called lymphatic trunks, the interval can be up to 10 centimeters.

The segment of a collector located between a proximal and distal pair of valves is called lymph angion. Smooth muscles in the wall of lymph angions provide an autonomic contraction frequency of about 10 to 12 contractions per minute at rest.

In healthy lymph collectors, the proximal valve is open during the contraction of the angion while the distal valve is closed; in the relaxation phase, the opposite is the case. This permits directional flow of lymph fluid from distal to proximal angions. Lymph collectors have the ability to react to an increase in volume of lymph fluid with an increase in contraction frequency, therefore preventing the onset of swelling.

Two of the main mechanisms involved in capillary exchange of fluid are filtration and reabsorption.

It can be differentiated between superficial and deep lymph collectors. The vessels belonging to the superficial lymphatic system are embedded in the subcutaneous fatty layer of the skin and follow a fairly straight path toward the lymph nodes, whereas the collectors belonging to the deep and organ systems follow the anatomy of larger blood vessels and organ vessels, respectively.

Following the passage through the lymph nodes, the lymph collectors transport the lymph fluid from the superficial, deep and organ systems to the lymphatic trunks, which then forward the lymph to the venous angles to be returned into the venous bloodstream. During the course of a day, approximately three liters of lymph fluid are returned into the venous angles, which are located behind the collar bone and formed by the internal jugular and subclavian veins.

A constant exchange

To understand lymph formation, it is necessary to understand the processes taking place in the area of blood capillaries, the so-called capillary exchange mechanisms.

The body can be viewed as being composed of two basic fluid compartments: the intravascular and extravascular compartments. The intravascular compartment is comprised of cardiac chambers and blood vessels, which contain blood; the extravascular system represents everything outside of the intravascular compartment and is made up of many subcompartments, such as the interstitial, cellular and lymphatic subcompartments.

A constant exchange of fluids, gases, nutrients and other substances takes place between these compartments; the primary sites of this exchange are the blood capillaries. Some materials are transported across the endothelial membrane of the blood capillaries, but other substances, especially water, also leave through pores in the capillary walls.

Two of the main mechanisms involved in capillary exchange of fluid are filtration and reabsorption, both of which depend on a gradient in pressure between the inside and outside of the blood capillary wall. This passive exchange of water always moves from the area of higher pressure to the area of lower pressure.

The pressure gradient is produced by the blood pressure. The pressure inside blood capillaries is greater than the pressure in the interstitial fluid; under normal conditions the average blood capillary pressure in the arterial end of the capillary is higher than the blood capillary pressure at the venous end of the capillary, which causes water to be filtered out at the arterial end and be reabsorbed back into the blood capillaries at the venous end.

The water leaving the blood via filtration washes over the tissue cells carrying nutrients and other solutes with it. Fluid returning through reabsorption deposits waste products from the cells back into the venous system. This balance in filtration and reabsorption changes frequently by contraction or dilation of the precapillary sphincters, ring-like, smooth muscles located at the begin-
Lymphedema

The proper flow and drainage of the lymphatic system can be severely disturbed if its function is impaired. This is the case in a condition known as lymphedema, which is a common and serious disease affecting at least 3 million Americans.

In the case of lymphedema, the local function of the lymphatic system is impaired to such an extent it is unable to perform its basic function. The fluid that leaves the blood capillaries, as well as proteins, toxins and waste products, cannot be drained sufficiently from the tissues anymore, resulting in swelling of the affected body part.

Lymphedema is most commonly present in the extremities, but may also affect the trunk, abdomen, head and neck and external genitalia. The highest incidence of lymphedema in the U.S. is observed in the upper extremities, following breast cancer surgery with the removal of the axillary lymph nodes.

Massage and lymph

Precapillary sphincters are affected by traditional massage techniques due to the release of histamine from mast cells in skin areas where those techniques are applied. Histamine causes a dilation of the sphincter, resulting in vasodilation (active hyperemia) and an increase of blood capillary pressure with subsequent increase in capillary filtration.

This results in more water and nutrients leaving the blood capillaries into the interstitial spaces, which results in an overall improvement of nutrition and oxygenation of the local tissues. The increase in water content in the interstitial tissues will also stimulate lymph formation and contribute to a gentle increase in lymphatic fluid to be returned to the venous system.

Traditional massage, therefore, positively affects the circulation of blood and lymph fluid, provided the lymphatic system is sufficient and healthy.

Traditional massage therapy, like any therapeutic modality which would lead to vasodilation with a subsequent increase of water content in the already swollen body part, is contraindicated in areas affected by, or at risk for, lymphedema. The therapy of choice to treat this condition is known as manual lymph drainage, a highly specialized form of manual treatment.
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