

Lec.2

Circulatory System

Main Topic

- What mean circulatory system
- Component of cardiovascular system
- Flow of blood during body
- lymph system and component

The **circulatory system**, also called the **cardiovascular system**, is an organ system that permits blood to circulate and transport nutrients, oxygen, carbon dioxide, hormones, and blood cells to and from cells in the body to nourish it and help to fight diseases, stabilize body temperature and pH, and to maintain homeostasis. The study of blood flow is called hemodynamics.

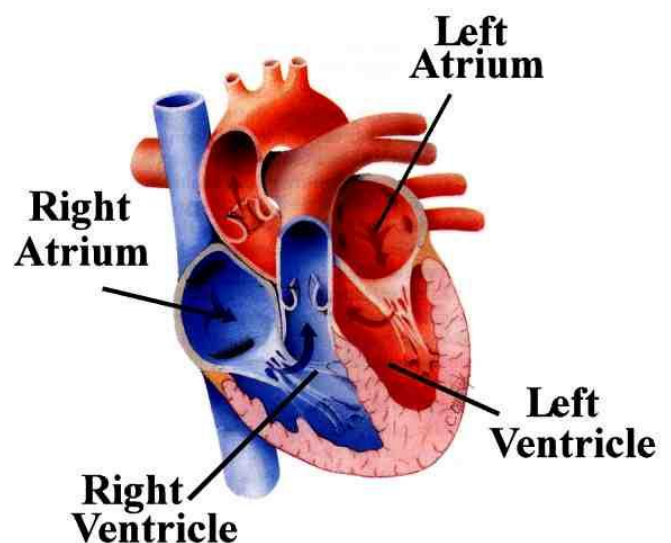
• Cardiovascular System

The cardiovascular system comprises the blood, heart, and blood vessels which distributes blood.

Blood is a fluid consisting of plasma, red blood cells, white blood cells, and platelets that is circulated by the heart through the vertebrate vascular system, carrying oxygen and nutrients to and waste materials away from all body tissues.

▪ The Heart

The heart is a hollow, muscular organ about the size of a fist. It is responsible for pumping blood through the blood vessels by repeated, rhythmic contractions. The heart is composed of cardiac muscle, an involuntary muscle tissue that is found only within this organ. The term "cardiac" (as in cardiology) means "related to the heart" and comes from the Greek word kardia, for "heart."



It has a four-chambered, double pump and is located in the thoracic cavity between the lungs. The cardiac muscle is self-exciting, meaning it has its own conduction system. This is in contrast with skeletal muscle, which requires either conscious or reflex nervous stimuli. The heart's rhythmic contractions occur spontaneously, although the frequency or heart rate can be changed by nervous or hormonal influence such as exercise or the perception of danger.

- **Endocardium**

The endocardium is the inner most lining of the heart which consists of the endothelial cells forming a smooth membrane in places, and a pocked and tribeculated surface in others (mainly the ventricles, or lower pumping chambers).

- **Myocardium**

The myocardium is the muscular tissue of the heart. The myocardium is composed of specialized cardiac muscle cells with an ability not possessed by muscle tissue elsewhere in the body. Cardiac muscle, like other muscles, can contract, but it can also conduct electricity, like nerves. The blood to the myocardium is supplied by the coronary arteries. If these arteries are occluded by atherosclerosis and/or thrombosis, this can lead to angina pectoris or myocardial infarction due to ischemia (lack of oxygen).

- **Epicardium**

The outer most layer next to the myocardium is known as the Epicardium. This is the outer layer after endocardium and myocardium that consists of a thin layer of connective tissue and fat.

- **Pericardium**

The pericardium is the thick, membranous sac that surrounds the heart. It protects and lubricates the heart. There are two layers to the pericardium: the fibrous pericardium and the serous pericardium. The serous pericardium is divided into two layers; in between these two layers there is a space called the pericardial cavity.

- **Heart Chambers**

The heart has four chambers, two atria and two ventricles. The atria are smaller with thin walls, while the ventricles are larger and much stronger.

Atrium

There are two atria on either side of the heart. On the right side is the atrium that contains blood which is poor in oxygen. The left atrium contains blood which has been oxygenated and is ready to be sent to the body. The right atrium receives de-oxygenated blood from the superior vena cava and inferior vena cava. The left atrium receives oxygenated blood from the left and right pulmonary veins. Atria facilitate circulation primarily by allowing uninterrupted venous flow to the heart, preventing the inertia of interrupted venous flow that would otherwise occur at each ventricular systole.

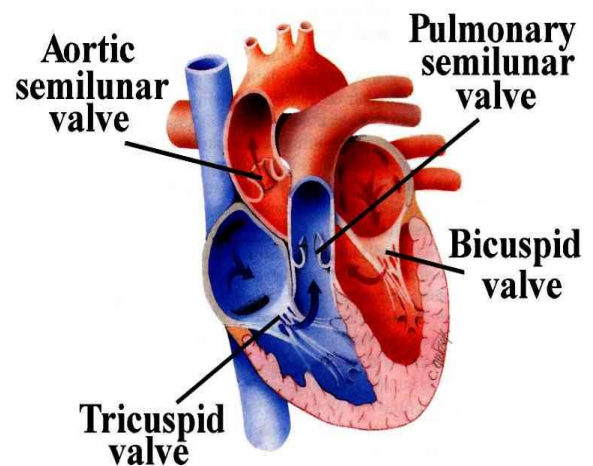
Ventricles

The ventricle is a heart chamber which collects blood from an atrium and pumps it out of the heart. There are two ventricles: the right ventricle pumps blood into the pulmonary circulation for the lungs, and the left ventricle pumps blood into the aorta for systemic circulation to the rest of the body. Ventricles have thicker walls than the atria, and thus can create the higher blood pressure. Comparing the left and right ventricle, the left ventricle has thicker walls because it needs to pump blood to the whole body. This leads to the common misconception that the heart lies on the left side of the body.

Valves

The two atrioventricular (AV) valves are one-way valves that ensure that blood flows from

the atria to the ventricles, and not the other way. The two semilunar (SL) valves are present in the arteries leaving the heart; they prevent blood from flowing back into the ventricles. The sound heard in a heart beat is the heart valves shutting. The right AV valve is also called the tricuspid valve because it has three flaps. It is located between the right atrium and the right ventricle. The tricuspid valve allows blood to flow from the right atrium into the right ventricle when the heart is relaxed during diastole. When the heart begins to contract, the heart enters a phase called systole, and the atrium pushes blood into the ventricle. Then, the ventricle begins to contract and blood pressure inside the heart rises. When the ventricular pressure exceeds the pressure in the atrium, the tricuspid valve snaps shut. The left AV valve is also called the bicuspid valve because it has two flaps. It is also known as the mitral valve due to the resemblance to a bishop's mitre (liturgical headdress). This



valve prevents blood in the left ventricle from flowing into the left atrium. As it is on the left side of the heart,

▪ **Passage of Blood Through the Heart**

While it is convenient to describe the flow of the blood through the right side of the heart and then through the left side, it is important to realize that both atria contract at the same time and that both ventricles contract at the same time. The heart works as two pumps, one on the right and one on the left that works simultaneously. The right pump pumps the blood to the lungs or the pulmonary circulation at the same time that the left pump pumps blood to the rest of the body or the systemic circulation. Venous blood from systemic circulation (deoxygenated) enters the right atrium through the superior and inferior vena cava. The right atrium contracts and forces the blood through the tricuspid valve (right atrioventricular valve) and into the right ventricles. The right ventricles contract and force the blood through the pulmonary semilunar valve into the pulmonary trunk and out the pulmonary artery. This takes the blood to the lungs where the blood releases carbon dioxide and receives a new supply of oxygen. The new blood is carried in the pulmonary veins that take it to the left atrium. The left atrium then contracts and forces blood through the left atrioventricular, bicuspid, or mitral, valve into the left ventricle. The left ventricle contracts forcing blood through the aortic semilunar valve into the ascending aorta. It then branches to arteries carrying oxygen rich blood to all parts of the body.

Blood Flow After the Heart

Aorta-Arteries-Arterioles-Capillaries-Venules-Veins-Vena Cava

▪ **Blood Flow Through Capillaries**

From the arterioles, the blood then enters one or more capillaries. The walls of capillaries are so thin and fragile that blood cells can only pass in single file. Inside the capillaries, exchange of oxygen and carbon dioxide takes place. Red blood cells inside the capillary releases their oxygen which passes through the wall and into the surrounding tissue. The tissue then releases waste, such as carbon dioxide, which then passes through the wall and into the red blood cells.

Arteries

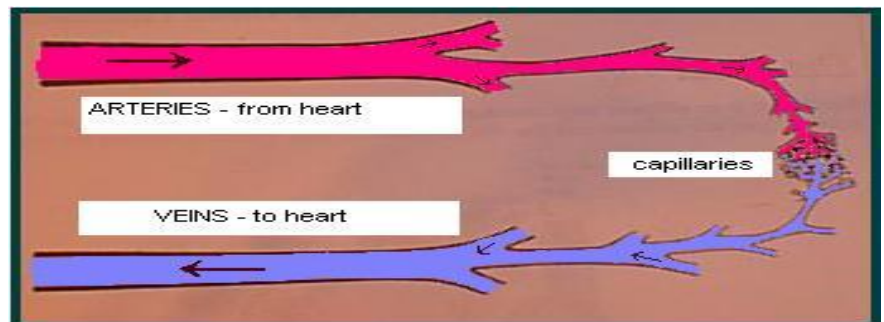
Arteries are muscular blood vessels that carry blood away from the heart, oxygenated and deoxygenated blood. The pulmonary arteries will carry deoxygenated blood to the lungs and the systemic arteries will carry oxygenated blood to the rest of the body. Arteries have a thick wall that consists of three layers. The inside layer is called the endothelium, the middle layer is mostly smooth muscle and the outside layer is connective tissue. The artery walls are thick so that when blood enters under pressure the walls can expand.

Arterioles

An arteriole is a small artery that extends and leads to capillaries. Arterioles have thick smooth muscular walls. These smooth muscles are able to contract (causing vessel constriction) and relax (causing vessel dilation). This contracting and relaxing affects blood pressure; the higher number of vessels dilated, the lower blood pressure will be. Arterioles are just visible to the naked eye.

Capillaries

Capillaries are the smallest of a body's vessels; they connect arteries and veins, and most closely interact with tissues. They are very prevalent in the body; total surface area is about 6,300 square meters. Because of this, no cell is very far from a capillary, no more than 50 micrometers away. The walls of capillaries are composed of a single layer of cells, the endothelium, which is the inner lining of all the vessels. This layer is so thin that molecules such as oxygen, water and lipids can pass through them by diffusion and enter the tissues. Waste products such as carbon dioxide and urea can diffuse back into the blood to be carried away for removal from the body.



Veins

Veins carry blood to the heart. The pulmonary veins will carry oxygenated blood to the heart while the systemic veins will carry deoxygenated to the heart. Most of the blood volume is found in the venous system; about 70% at any given time. The veins outer walls

have the same three layers as the arteries, differing only because there is a lack of smooth muscle in the inner layer and less connective tissue on the outer layer. Veins have low blood pressure compared to arteries and need the help of skeletal muscles to bring blood back to the heart. Most veins have one-way valves called venous valves to prevent backflow caused by gravity. They also have a thick collagen outer layer, which helps maintain blood pressure and stop blood pooling. If a person is standing still for long periods or is bedridden, blood can accumulate in veins and can cause varicose veins. The hollow internal cavity in which the blood flows is called the lumen. A muscular layer allows veins to contract, which puts more blood into circulation. Veins are used medically as points of access to the blood stream, permitting the withdrawal of blood specimens (venipuncture) for testing purposes, and enabling the infusion of fluid, electrolytes, nutrition, and medications (intravenous delivery).

Venules

A venule is a small vein that allows deoxygenated blood to return from the capillary beds to the larger blood veins, except in the pulmonary circuit where the blood is oxygenated. Venules have three layers; they have the same makeup as arteries with less smooth muscle, making them thinner.

• Lymphatic system

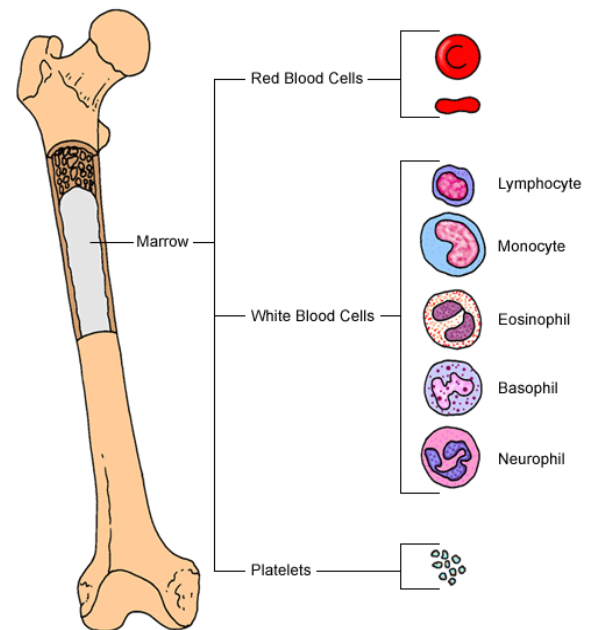
The lymphatic system is a network of tissues and organs that primarily consists of lymph vessels, lymph nodes and lymph . The tonsils, adenoids, spleen and thymus are all part of the lymphatic system .

lymph is a clear fluid (from Latin *lymph* meaning *water*.), contains nutrients, oxygen, hormones, and fatty acids, as well as toxins and cellular waste products, that are transported to and from cellular tissues, Lymph is essentially recycled excess blood plasma after it has been filtered from the interstitial fluid (between cells) and returned to the lymphatic system.

The lymphatic system is also a major part of the immune system. Lymph and lymph nodes contain white blood cells called lymphocytes and antibodies which defend the body against infection. The lymphocytes are made in the bone marrow. When they are mature they are released into the bloodstream and migrate into the lymphatic system.

There are three types of mature lymphocytes:

- B lymphocytes which make antibodies that attack germs (bacteria, viruses, etc).
- T lymphocytes which have various functions including helping the B lymphocytes to make antibodies.
- Natural killer lymphocytes which also help to protect against infection.



Bone marrow

• Functions

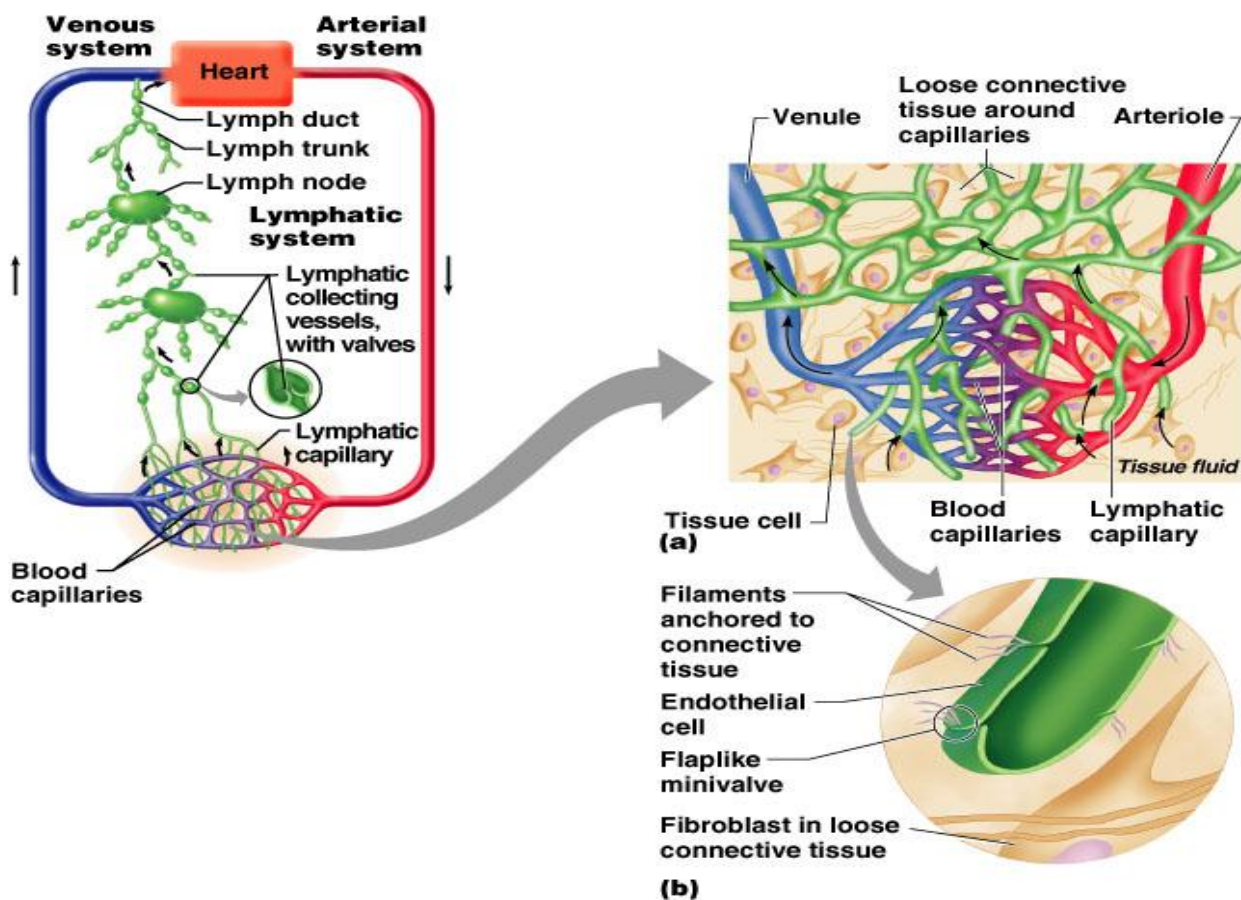
The lymphatic system has multiple interrelated functions:

- It is responsible for the removal of interstitial fluid from tissues
- It absorbs and transports fatty acids and fats as chyle from the digestive system
- It transports white blood cells to and from the lymph nodes into the bones
- The lymph transports antigen-presenting cells (APCs), such as dendritic cells, to the lymph nodes where an immune response is stimulated.

- **Consists of Lymphatic system**

- **lymph nodes**

lymph nodes (often called lymph glands), a network of thin lymphatic channels (similar to thin blood vessels), There are 600 to 700 lymph nodes in the human body that filter the lymph before it returns to the circulatory system. Lymph nodes that are near each other often form into groups or chains. For example, in



the sides of the neck (cervical lymph nodes), the armpits (axillary lymph nodes), and in the groins (inguinal lymph nodes). When bacteria are recognized in the lymph fluid, the lymph nodes make more infection-fighting white blood cells, which can cause swelling. The swollen nodes can sometimes be felt in the neck, underarms and groin.

- **Tonsils** are large clusters of lymphatic cells found in the pharynx.
- **lymph vessels**

lymph vessels (or lymphatic vessels) are thin walled, valved structures that carry lymph. As part of the lymphatic system, lymph vessels are complementary to the cardiovascular

system. Lymph vessels are lined by endothelial cells, and have a thin layer of smooth muscles, and adventitia that bind the lymph vessels to the surrounding tissue.

Lymph vessels are devoted to propulsion of the lymph from the lymph capillaries, which are mainly concerned with absorption of interstitial fluid from the tissues. Lymph capillaries are slightly larger than their counterpart capillaries of the vascular system. Lymph vessels that carry lymph to a lymph node are called the **afferent lymph vessel**, and one that carries it from a lymph node is called the **efferent lymph vessel**, from where the lymph may travel to another lymph node, may be returned to a vein, or may travel to a larger lymph duct. Lymph ducts drain the lymph into one of the subclavian veins and thus return it to general circulation.

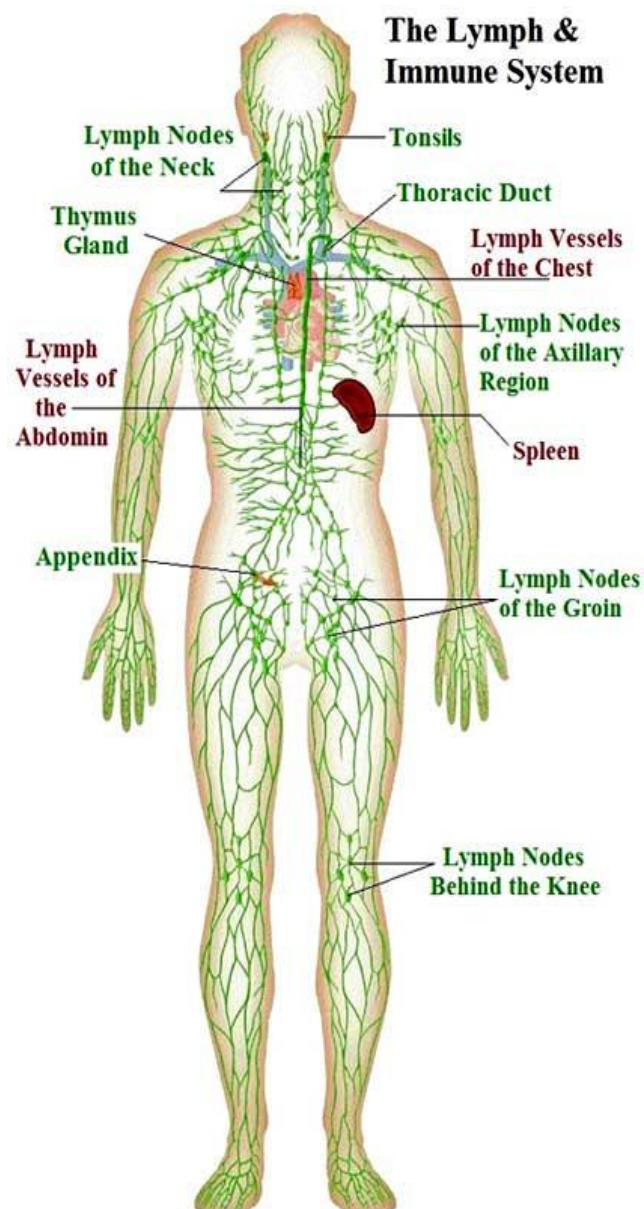
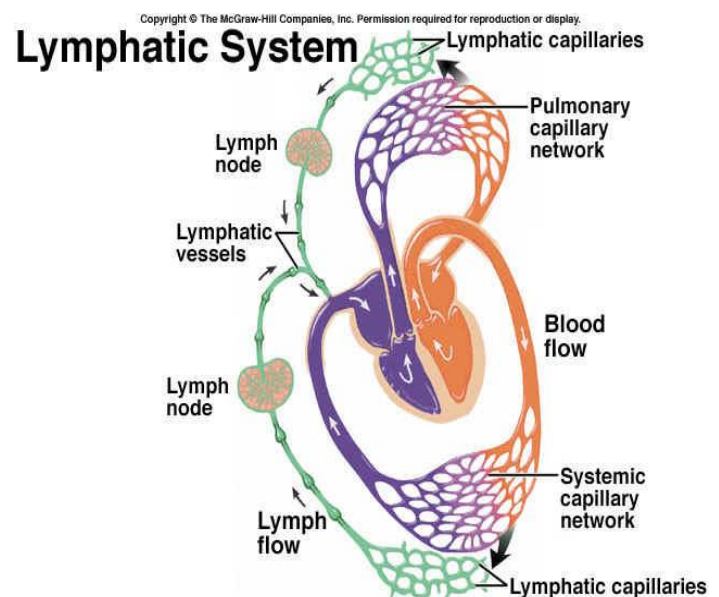
■ Thymus

The thymus is of a pinkish-gray color, soft, and lobulated on its surfaces. is located in the chest just above the heart.

The thymus reaches maximum weight (20 to 37 grams) by the time of puberty is a primary lymphoid organ, the thymus, which stores immature lymphocytes and prepares them to become active T cells.

■ Spleen

The spleen, which is largest lymphatic organ, is located on the left side of the body just above the kidney. Humans can live without a spleen, although people who have lost their spleen to disease or injury are more prone to infections.



Similar in structure to a large lymph node, it acts primarily as a blood filter. The spleen, in healthy adult humans, is approximately 7 centimetres (2.8 in) to 14 centimetres (5.5 in) in length. It usually weighs between 150 grams and 200 grams , synthesizes antibodies in its white pulp and removes antibody-coated bacteria and antibody-coated blood cells by way of blood and lymph node circulation. The spleen is a center of activity of the mononuclear phagocyte system and can be considered analogous to a large lymph node, as its absence causes a predisposition to certain infections.

- **Clinical Significance**

The study of lymphatic drainage of various organs is important in diagnosis, prognosis, and treatment of cancer. The lymphatic system, because of its physical proximity to many tissues of the body, is responsible for carrying cancerous cells between the various parts of the body in a process called metastasis. The intervening lymph nodes can trap the cancer cells. If they are not successful in destroying the cancer cells the nodes may become sites of secondary tumors.

- **Diseases of the lymphatic system**

Diseases and disorders of the lymphatic system are typically treated by immunologists. Vascular surgeons, dermatologists, oncologists and physiatrists also get involved in treatment of various lymphatic ailments. There are also lymphedema therapists who specialize in the manual drainage of the lymphatic system.

- **Lymphedema**

Lymphedema is a chronic swelling of the limbs caused by the accumulation of lymph fluid that occurs if the lymphatic system is damaged or not functioning properly. While the limbs are typically involved, the face, neck and abdomen may also be affected. Many develop the disorder following cancer therapy — particularly breast cancer where the lymph nodes under the arms are removed — recurrent infections, injuries or vascular surgery. Causes are unknown in most cases, but sometimes there is a previous history of severe infection, usually caused by a parasitic disease, such as lymphatic filariasis.

Lymphedema can also occur after surgical removal of cancerous lymph nodes in the armpit (causing the arm to swell due to poor lymphatic drainage) or groin (causing swelling of the leg). Treatment is by massage, and is not permanent

■ Lymphadenopathy

Lymphadenopathy refers to one or more enlarged lymph nodes. Small groups or individually enlarged lymph nodes are generally *reactive* in response to infection or inflammation.

Cancer of the lymphatic system can be primary or secondary. Lymphoma refers to cancer that arises from lymphatic tissue. Lymphoid leukemias and lymphomas are now considered to be tumors of the same type of cell lineage. They are called "leukemia" when in the blood or marrow and "lymphoma" when in lymphatic tissue. They are grouped together under the name "lymphoid malignancy".

