Lecture 7

Immune system & Lymphoid organs

Immune system and Lymphoid organs

Prof. Dr. Marwa Fadhil Alsaffar

Objective:

- **immune system & Lymphoid organs Immune system and Lymphoid organ.**
- **Compare the basic histological organization and main functions of different types of lymphoid tissues (lymph node, thymus and spleen).**

The Immune System

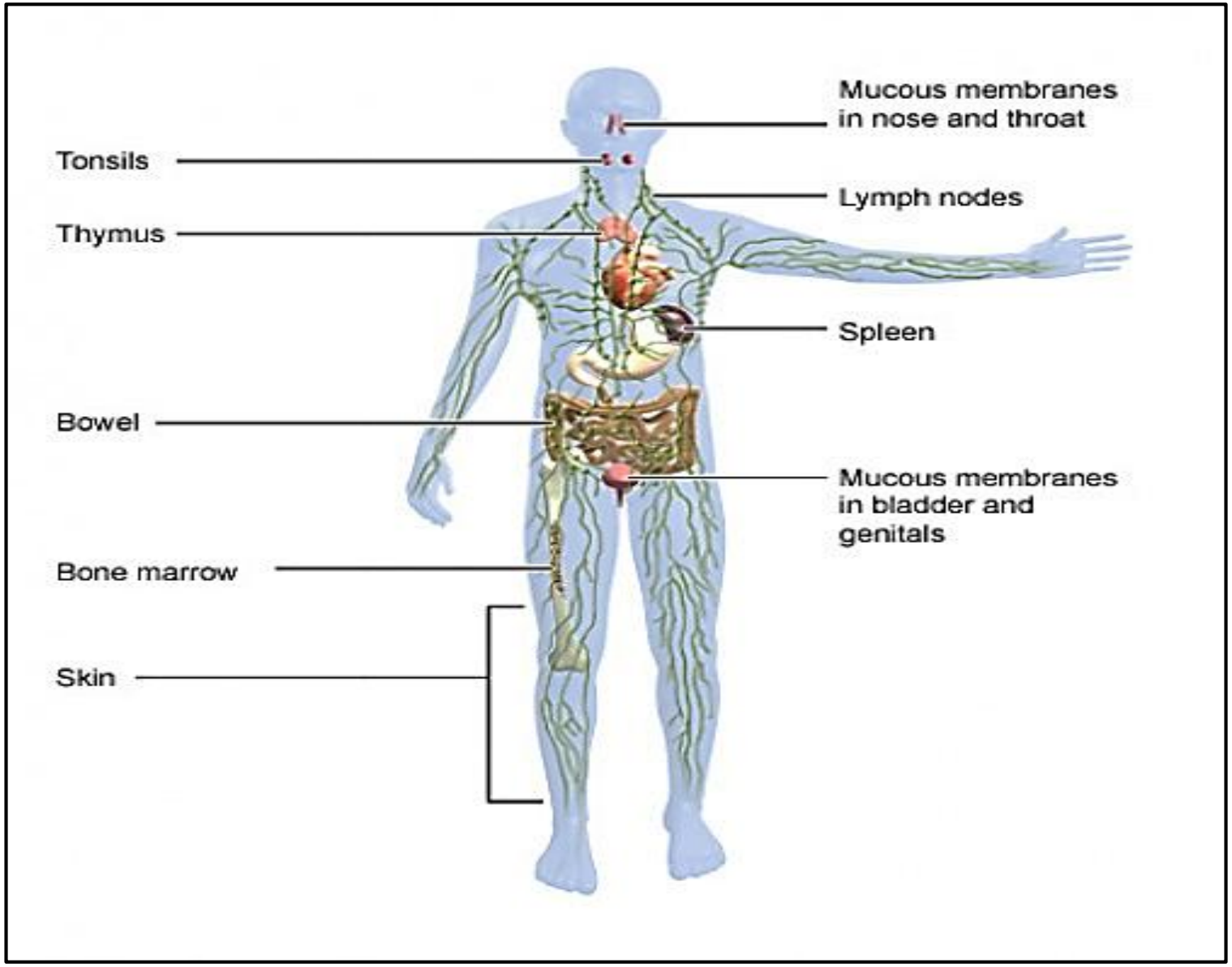
The body has a system of cells—the immune system—that has the ability to distinguish "self" (the organism's own molecules) from "non-self" (foreign substances).

The immune system is a barrier to the pathogens. Our immune system is made up of both **individual cells** and **proteins** as well as **entire organs** and **organ systems** that defends the body against infection. The organs of the immune system include the **skin** and **mucous membranes**, and the **organs of the lymphatic system** too. Normally, the immune system is composed of **primary (or central)** and **secondary (or peripheral)** organs.

The immune system keeps a record of every germ (microbe) it has ever defeated so it can recognise and destroy the microbe quickly if it enters the body again. Abnormalities of the immune system can lead to allergic diseases, immunodeficiencies and autoimmune disorders.

The main parts of the immune system are:

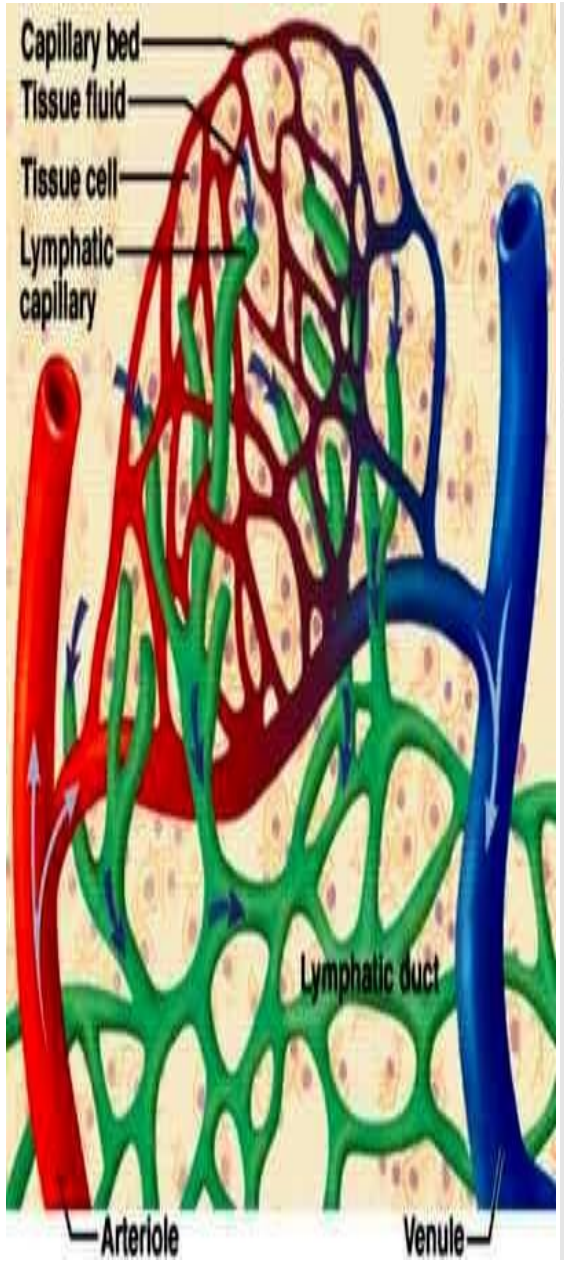
1. Bone marrow.
2. Thymus.
3. Spleen.
4. White blood cells.
5. Antibodies.
6. Complement system.
7. Lymphatic system.

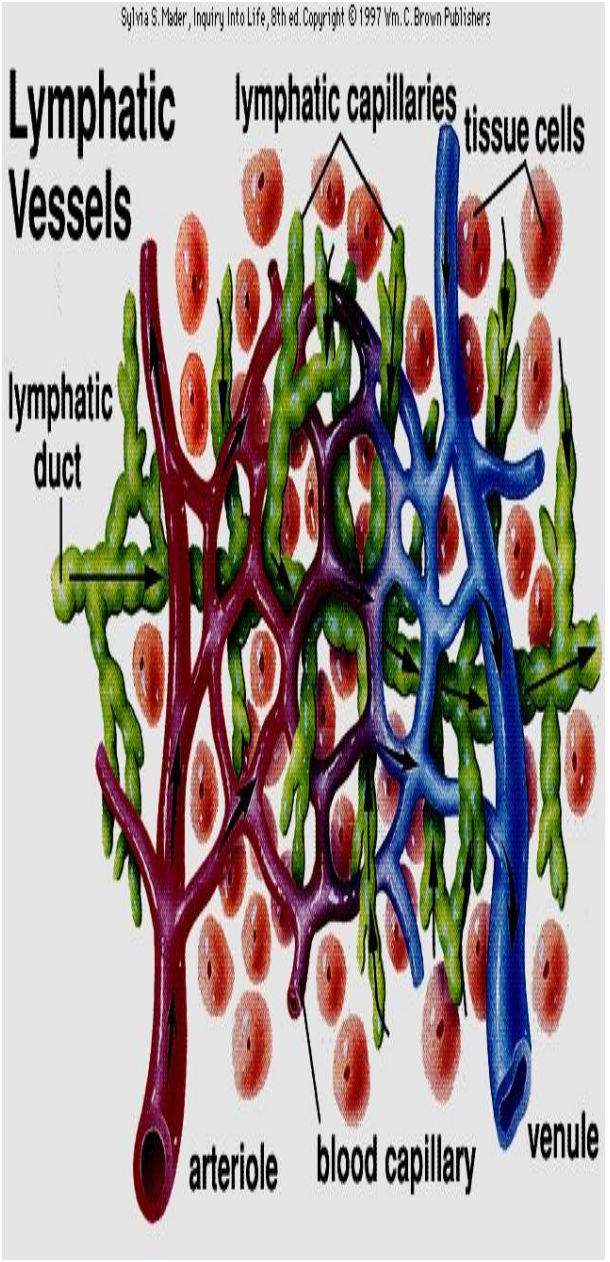


The Lymphatic system

The lymphatic system is a network of delicate tubes throughout the body. **The main roles of the lymphatic system are to:**

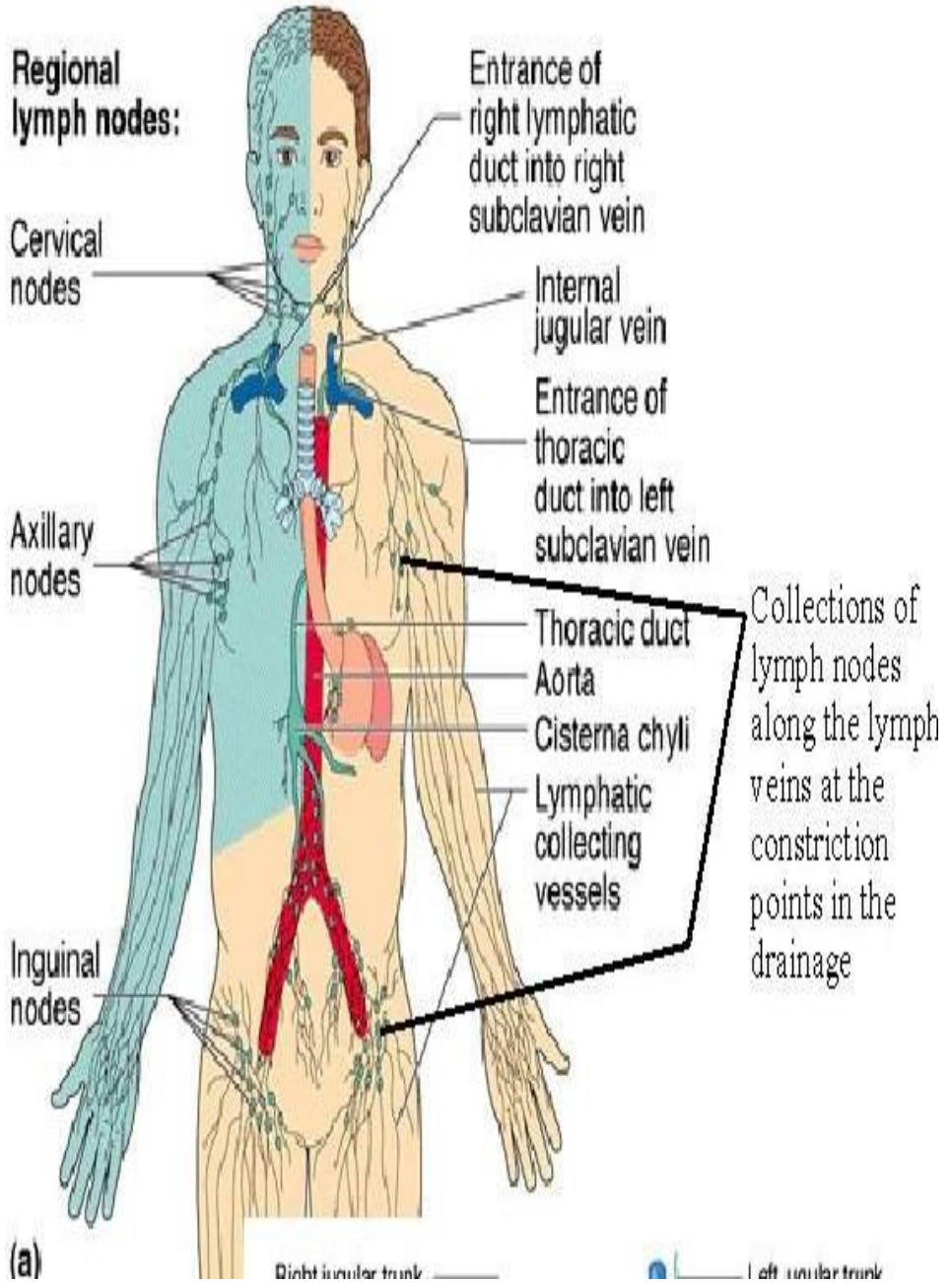
1. Manage the fluid levels in the body.
2. React to bacteria.
3. Deal with cancer cells.
4. Deal with cell products that otherwise would result in disease or disorders
5. Absorb some of the fats in our diet from the intestine.





The lymphatic system is made up of:

1. Lymph nodes (also called lymph glands): which trap microbes.
2. Lymph vessels: tubes that carry the lymph, the colourless fluid that bathes the body's tissues and contains infection-fighting white blood cells.
3. Lymphocytes: which are white blood cells.
4. The Spleen
5. The Bone marrow
6. The Thymus

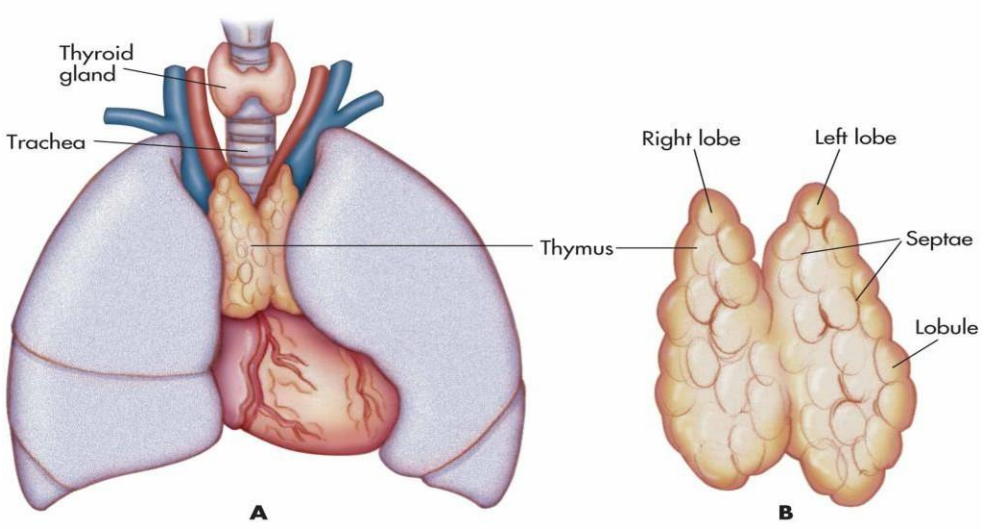


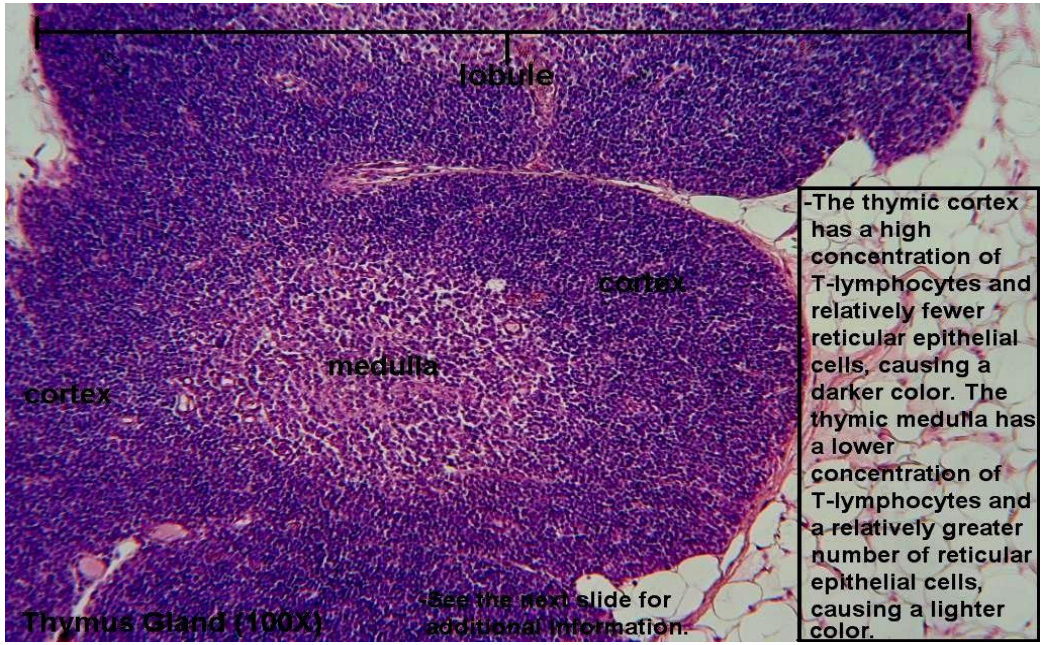
Lymphoid organs

A- Primary lymphoid organs:

These organs include the bone marrow and the thymus. The primary organs enable the performance of functions of the cell and immunoregulation.

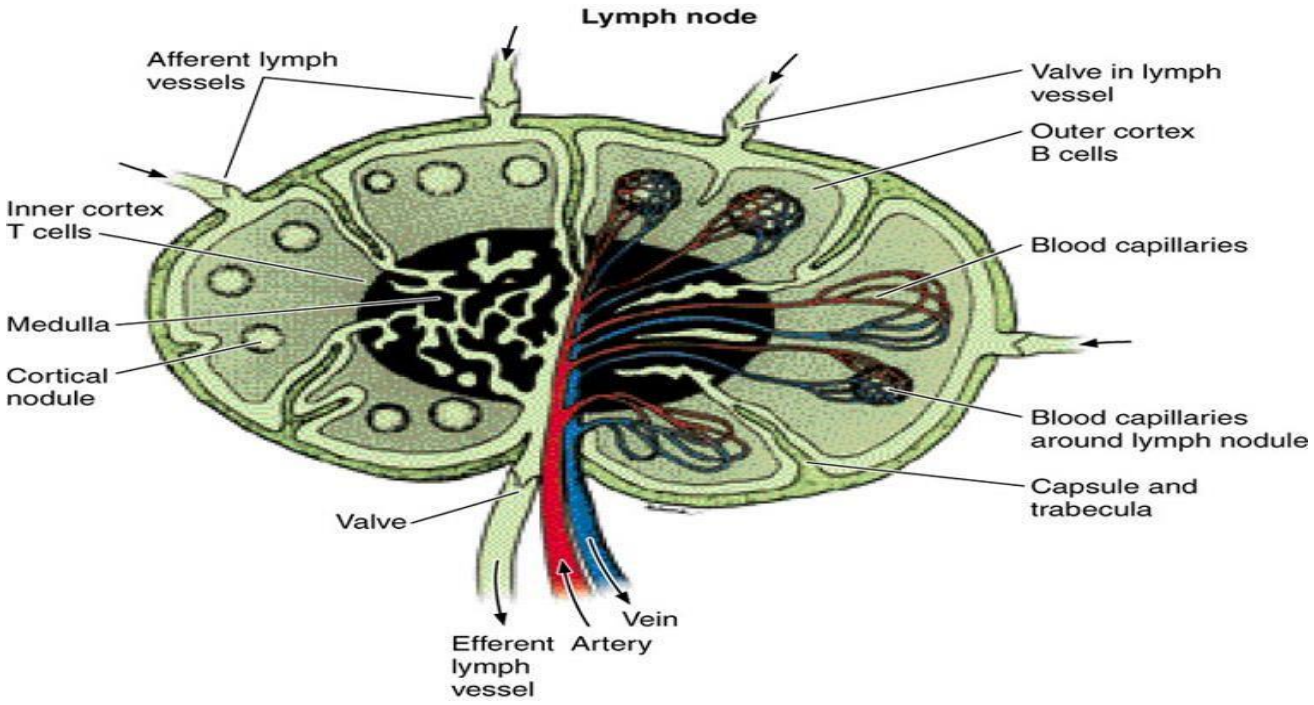
The bone marrow is a primary immune organ and the source of all cell lines used by the immune system and the place of B-cell maturation. Whereas the thymus is a primary immune organ in which thymocytes are differentiated into T cells, and a variety of immunoregulatory substances are produced. They are both create special immune system cells called **lymphocytes**.





B- Secondary lymphoid organs:

These organs include the lymph nodes, spleen, tonsils and certain tissue in various mucous membrane layers in the body (for instance in the bowel). They are these organs where the cells of the immune system do their actual job of fighting off germs and foreign substances.



The primary lymphoid organs

1. Bone marrow

Bone marrow is a sponge-like tissue located inside bones where most immune system cells are produced and multiply. These cells then travel through the bloodstream to other organs and tissues. It contains pluripotent stem cells that can differentiate into various cell types, such as lymphoid stem cells. Blood vessels in the bone marrow form a blood–marrow barrier that prevents immature cells from leaving the marrow.

There are two types of bone marrow:

Red bone marrow: Contains hematopoietic tissue and produces immune system cells.

Yellow bone marrow: Mainly composed of fat cells.

At birth, most bones contain red marrow, but with age, much of it is replaced by yellow (fatty) marrow. In adults, red marrow remains mainly in the ribs, sternum, and pelvis.

Clinically, bone marrow is very important for transplantation in children with primary immunodeficiencies, and bone marrow biopsies are widely used for diagnosing blood disorders.

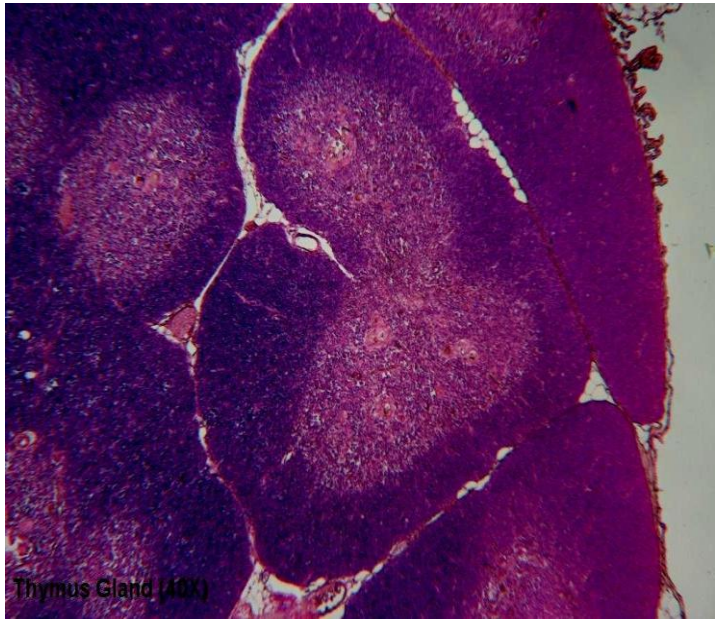
2. Thymus

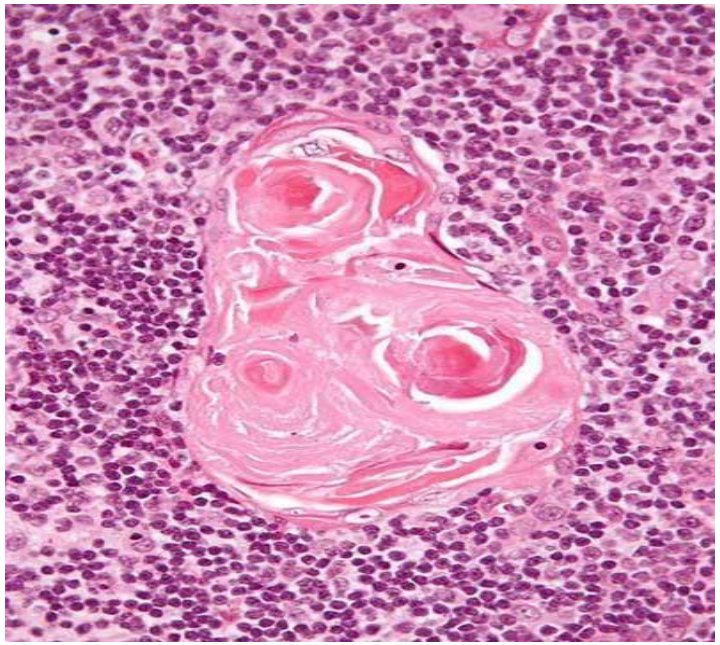
The thymus is a gland-like organ located behind the breastbone and above the heart. It reaches full development during childhood and gradually becomes replaced by fatty tissue with age.

The thymus is the site where T lymphocytes (T cells) mature. These cells play a key role in coordinating both innate and adaptive immune responses and continuously monitor body cells for abnormalities.

Structurally, the thymus is divided into lobules surrounded by a capsule and contains isolated parenchyma with developing T cells (thymocytes), which can pass through the vessel endothelium. It has three main parenchymal zones: subcapsular, cortical, and medullary, corresponding to different stages of T-cell development.

The thymus also produces hormones, neurotransmitters, and immune-related molecules. Clinically, removal of the thymus (thymectomy) in adults does not usually cause immunodeficiency.



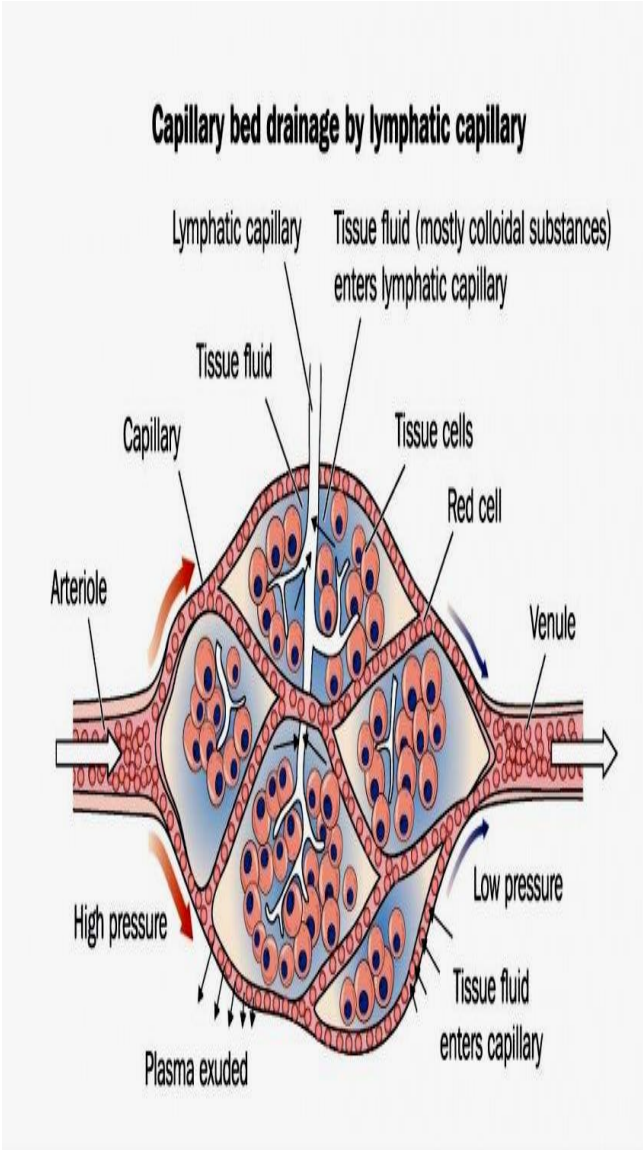


Secondary lymphoid organs

1. Lymph nodes

Lymph nodes are small bean-shaped tissues found along the lymphatic vessels. They act as filters. Various immune system cells trap germs in the lymph nodes and activate the creation of special antibodies in the blood. Swollen or painful lymph nodes are a sign that the immune system is active, for example to fight an infection.

Each lymph node is divided into lymph nodules, which contain a cortical zone of primary follicles with B cells, a paracortical zone of T cells, and a basal part of the nodule in the medulla. The lymph nodes are among the secondary organs of the immune system, widely present in many parts of the body, and have an artery, vein, and afferent and efferent lymphatic vessels. The afferent lymphatics are multiple and wider than efferent vessels, so, cells and molecules can easily enter the lymph nodes.



Conversely, the passage of large cells like macrophages through the efferent vessels is difficult, so that they remain to function within the lymph node.

From the clinical point of view, the lymph nodes have essential clinical significance. They may be enlarged, swollen, and inflamed in many infections, tumors, and even under some non-infectious conditions. The palpation of accessible lymph nodes serves as a suitable means of monitoring for any physician.

2. Spleen

The spleen is one of the secondary organs of the immune system but functions at the systemic level when antigens enter the blood. Thus, the spleen is important in fighting the infections that have invaded the blood. The spleen is located in the left upper abdomen, beneath the diaphragm, and is responsible for different kinds of jobs: it stores various immune system cells. When needed, they move through the blood to other organs.

The spleen contains scavenger cells (phagocytes) that filter germs from the bloodstream. It removes old or damaged red blood cells, stores and breaks down platelets, and produces important immune components such as antibodies and lymphocytes.

The spleen is divided into two main parts:

- **Red pulp:** Responsible for blood filtration, removal of old erythrocytes, storage of extra blood, and hemoglobin metabolism.
- **White pulp:** Contains lymphoid follicles rich in B cells, marginal zones rich in B cells, and periarteriolar lymphoid sheaths rich in T cells.

The white pulp plays a crucial role in immune responses, including B-cell activation, antibody production, removal of antibody-coated microbes, production of properdin (a protein involved in immune defense), and storage of monocytes.

Clinically, splenectomy (removal of the spleen) increases the risk of death from pneumonia and reduces the number of memory B cells. Therefore, vaccination against pneumococci is required before a planned splenectomy.

The spleen has a rich blood supply and very soft tissue, making it prone to rupture during severe injuries, such as accidents. A ruptured spleen can cause life-threatening internal bleeding and usually requires surgical removal. If the spleen is completely removed, other immune organs can partially compensate for its functions.

3. Tonsils

The tonsils are also secondary organs of the immune system part. Because of their location at the throat and palate, they can stop germs entering the body through the mouth or the nose. The tonsils also contain a lot of white blood cells, which are responsible for killing germs.

There is also lymphatic tissue on the side of the throat, which can perform the functions of the palatine tonsils if they are removed.

4. Mucous membranes

The bowel plays a central role in defending the body against germs. More than half of all the body's cells that produce antibodies are found in the bowel wall, especially in the last part of the small intestine and in the appendix. These cells detect the foreign substances, and then mark and destroy them.

The immune system can store information about harmful substances to respond more quickly upon future exposure.

The large intestine contains beneficial bacteria (gut flora) that help prevent harmful germs from spreading and entering the body.

Mucous membranes in areas such as the respiratory tract, urinary tract, and vagina also support the immune system. Immune cells located beneath these membranes prevent bacteria and viruses from attaching and invading.

The skin and mucous membranes form the first line of defense against external germs. They act as a physical barrier and are supported by antibacterial substances that destroy pathogens at an early stage.

A certain **enzyme (lysozyme)** found in the saliva, the airways and tear fluid destroys the cell walls of bacteria. The **mucus** in the bronchi helps trap many of the germs we breathe in, so they can be moved out of the airways by the hair-like structures (the **cilia**). **Stomach acid** stops most of the germs that enter the body in the food we eat. **Harmless bacteria** on our skin and many of the mucous membranes in our body also act as part of the immune system. In addition, **the reflexes** that cause us to **cough** and **sneeze** help to free our airways of germs.

The Cells of the Immune System

These cells are the white blood cells in the human bloodstream, lymphocytes and monocytes or agranulocytes and polymorphonuclear leukocytes (PMN) or granulocytes which are present in the common blood test.

White blood cells are key players in the immune system, produced in the bone marrow and part of the lymphatic system. They patrol the blood and tissues to attack foreign microbes like bacteria, viruses, parasites, and fungi.

T and B lymphocytes: main cells of adaptive immunity.

Innate lymphoid cells (ILCs): crucial for innate immunity, mostly tissue-resident, abundant at mucosal surfaces, and help regulate homeostasis, inflammation, and mucosal immune responses.

The Antibodies

Antibodies help the body to fight microbes or the toxins (poisons) they produce. They do this by recognising substances called **antigens** on the surface of the microbe, or in the chemicals they produce, which mark the microbe or toxin as being foreign. The **antibodies** then mark these antigens for destruction. There are many cells, proteins and chemicals involved in this attack.

The Complement system

The complement system is made up of proteins whose actions complement the work done by antibodies.

The body's other defences against microbes

I- The First Line of Defense

As well as the immune system, the body has several other ways to defend itself against microbes. Barriers that keep out pathogens are the body’s first line of defense. The body's most important nonspecific defense is the **skin**, which acts as a physical barrier to keep pathogens out. Even openings in the skin (such as the mouth and eyes) are protected by saliva, mucus, and tears, which contain an enzyme that breaks down bacterial cell walls. The first line of defense includes mechanical, chemical, and biological barriers.

II- The Second Line of Defense

If a pathogen does make it into the body, there are secondary nonspecific defenses that take place.

1. **The skin**: a waterproof barrier that secretes oil, with bacteria-killing properties.

2. **Lungs**: the mucous (phlegm), cilia wave.

3. **Digestive tract**: the mucous lining contains antibodies, the acid in the stomach can kill most microbes

4. **Other defences:** Body fluids like skin oil, saliva and tears contain anti-bacterial enzymes that help reduce the risk of infection. The constant flushing of the urinary tract and the bowel also helps.

5. **Fever**: is an immune system response, a rise in body temperature, or fever, can happen with some infections. Fever also triggers the body's repair process.