

THE IMMUNE SYSTEM

Overview

The immune system is a complex system that is responsible for protecting us against infections and foreign substances. There are three lines of defense: the first is to keep invaders out (through skin, mucus membranes, etc), the second line of defense consists of non-specific ways to defend against pathogens that have broken through the first line of defense (such as with inflammatory response and fever). The third line of defense is mounted against specific pathogens that are causing disease (B cells produce antibodies against bacteria or viruses in the extracellular fluid, while T cells kill cells that have become infected). The immune system is closely tied to the lymphatic system, with B and T lymphocytes being found primarily within lymph nodes. Tonsils and the thymus gland are also considered lymph organs and are involved in immunity. We often don't realize how effective the immune system is until it fails or malfunctions, such as when the lymphocytes are attacked by HIV in an AIDS patient.

Organs, Tissues and Cells of the Immune System

The immune system consists of a network of lymphatic organs, tissues, and cells. These structures are supported by the reticuloendothelial system: loose connective tissue with a network of reticular fibers. Phagocytic cells, including monocytes and macrophages, are located in the reticular connective tissue. When micro-organisms invade the body, or the body encounters antigens (such as pollen), antigens are transported to the lymph. Lymph is carried through the lymph vessels to regional lymph nodes. In the lymph nodes, the macrophages and dendritic cells phagocytose the antigens, process them, and present the antigens to lymphocytes, which can then start producing antibodies or serve as memory cells. The function of memory cells is to recognize specific antigens in the future.

Primary Lymphatic Organs The primary lymphatic organs are the red bone marrow and the thymus. They are the site of production and maturation of lymphocytes, the type of white blood cell that carries out the most important work of the immune system.

- **Red Bone Marrow** Red bone marrow, the soft, spongy, nutrient rich tissue in the cavities of certain long bones, is the organ that is the site of blood cell production. Some of the white blood cells produced in the marrow are: neutrophils, basophils, eosinophils, monocytes, and lymphocytes. Lymphocytes differentiate into B lymphocytes and T lymphocytes. Red bone marrow is also the site of maturation of B lymphocytes. T lymphocytes mature in the thymus.
- **Thymus Gland** The thymus gland is located in the upper thoracic cavity posterior to the sternum and anterior to the ascending aorta. The

thymus is an organ that is more active in children, and shrinks as we get older. Connective tissue separates the thymus into lobules, which contain lymphocytes. Thymic hormones such as thymosin are produced in the thymus gland. Thymosin is thought to aid in the maturation of T lymphocytes.

The Thymus is critical to the immune system. Without a thymus, a person has no ability to reject foreign substances, blood lymphocyte level is very poor, and the body's response to most antigens is either absent or very weak. Immature T lymphocytes travel from the bone marrow through the bloodstream to reach the thymus. Here they mature and for the most part, stay in the thymus. Only 5% of T lymphocytes ever leave the thymus. They only leave if they are able to pass the test: if they react with "self" cells, they die. If they have the potential to attack a foreign cell, they leave the thymus.

Secondary Lymphatic Organs The secondary lymphatic organs also play an important role in the immune system as they are places where lymphocytes find and bind with antigens. This is followed by the proliferation and activation of lymphocytes. The secondary organs include the spleen, lymph nodes, tonsils, Peyer's patches, and the appendix.

- **The spleen**, The spleen is a ductless, vertebrate gland that is closely associated with the circulatory system, where it functions in the destruction of old red blood cells and in holding a reservoir of blood. Located in the upper left region of the abdominal cavity, it is divided into partial compartments. Each compartment contains tissue known as white pulp and red pulp. The white pulp contains lymphocytes and the red pulp acts in blood filtration. When blood enters the spleen and flows through the sinuses for filtration, lymphocytes react to pathogens, macrophages

engulf debris, and also remove old, worn out red blood cells. A person without a spleen is more susceptible to infections and may need supplementary antibiotic therapy for the rest of their life.

- **Lymph Nodes** are small oval shaped structures located along the lymphatic vessels. They are about 1-25 mm in diameter. Lymph nodes act as filters, with an internal honeycomb of connective tissue filled with lymphocytes that collect and destroy bacteria and viruses. They are divided into compartments, each packed with B lymphocytes and a sinus. As lymph flows through the sinuses, it is filtered by macrophages whose function is to engulf pathogens and debris. Also present in the sinuses are T lymphocytes, whose functions are to fight infections and attack cancer cells. Lymph nodes are in each cavity of the body except the dorsal cavity. Physicians can often detect the body's reaction to infection by feeling for swollen, tender lymph nodes under the arm pits and in the neck, because when the body is fighting an infection, these lymphocytes multiply rapidly and produce a characteristic swelling of the lymph nodes.

- **Tonsils** are often the first organs to encounter pathogens and antigens that come into the body by mouth or nose. There are 3 pairs of tonsils in a ring about the pharynx.