# Immune System: Structures, Functions, and Immune Response

THE OVERALL FUNCTION of the immune system is to prevent or limit infection. It is a complex and pervasive system with numerous cell types that either circulate throughout the body or reside in an immune system organ. Each cell type plays a unique role in recognizing problems and protecting the body. The immune system also helps to eliminate toxic or allergenic substances.

## Objectives:

1. Explain the structures and functions of the immune system.
2. Differentiate the types of immunity.

## Key Terms:

adaptive
antibodies
antigens
bone marrow
communicable diseases
immunity
immunization
innate
leukocytes
lymph
lymph nodes
lymphatic system
lymphocytes
macrophages
mast cells
monocytes
mucous membranes
neutrophils
passive
pathogens
phagocytes
toxins
vaccines

## Understanding the Structures, Functions, and Immune Response of the Immune System

The immune system is essential for survival. Without an immune system, the body would be susceptible to attacks from bacteria, viruses, parasites, and more. The immune system is

spread throughout the body and involves many types of cells, organs, and tissues. It is the immune system that keeps a person healthy and fights off disease. It can distinguish good tissue from bad, and recognizes and clears dead and faulty cells.

## STRUCTURES AND FUNCTIONS OF THE IMMUNE SYSTEM

The immune system is made up of a network of structures and processes that work together to protect the body against diseases or other potentially damaging foreign bodies. When functioning properly, the immune system detects and attacks a wide variety of **pathogens** (disease causing microorganisms,) and distinguishes them from healthy tissue.

One of the important components involved in the immune system are **leukocytes** (white blood cells) which are found throughout the body. These cells attack and destroy cells that have been infected by disease-causing organisms or substances. Leukocytes are produced from stem cells in the **bone marrow** (yellow spongy tissue in the center of bones.) Leukocytes circulate throughout the body through lymphatic and blood vessels to monitor the body for germs or substances that might cause problems. They make up approximately 1% of the total blood volume in a healthy adult, and the number of leukocytes in the blood is often an indicator of disease.

There are two basic types of leukocytes: **Lymphocytes** help the body to remember previous invaders and recognize them if they come back to attack again. Lymphocytes are made in the bone marrow. **Phagocytes** are cells also made in the bone marrow that surround and destroy pathogens. There are several types of phagocytes, including:

- **Neutrophils** are the most common type of phagocyte and tend to attack bacteria.
- **Monocytes** are the largest type and destroy pathogens, but they also assist with facilitating healing and repair.
- **Macrophages** patrol for pathogens and remove dead and dying cells.
- **Mast cells** have many roles, but they also defend against pathogens and help to heal wounds.

When **antigens** (foreign substances that invade the body) are detected, several types of leukocytes work together to recognize them and respond. The cells trigger the body to produce **antibodies**, which are specialized proteins that lock onto specific antigens. Antibodies stay in a person's body forever, so that if the immune system encounters that antigen again, the antibodies are already there to do their job. If someone gets sick with any of the **communicable diseases** (diseases capable of being transmitted from person to person,) like measles, that person usually won't contract the disease again. This is also how **vaccines** (substance that helps protect against certain diseases) prevent certain diseases from occurring. Antibodies can also neutralize **toxins** (poisonous or damaging substances) produced by different organisms.

The **lymphatic system** is a system of vessels, cells, and organs that carry excess fluids to the bloodstream, and filters pathogens from the blood. This fluid, or **lymph** (clear fluid that is

derived from blood plasma and originates as interstitial fluid) is returned back to the cardiovascular system. The lymph vessels form a network of branches that reach most of the body's tissues.

**Lymph nodes** are small, bean-shaped organs located throughout the lymphatic system and act as filters or traps for foreign particles. These nodes swell in response to infection due to a build-up of lymph fluid, bacteria, or other organisms and immune system cells. There are about 600 lymph nodes distributed widely throughout the body, including the armpit and stomach, and they are linked by the lymphatic vessels. They are packed tightly with the lymphocytes and macrophages.

Throughout the body are many organs and tissues that play important roles in the immune system. As a group, they are often referred to as lymphoid tissues or organs because they are home to the lymphocytes, those key players in the immune system. The other organs of the immune system include:

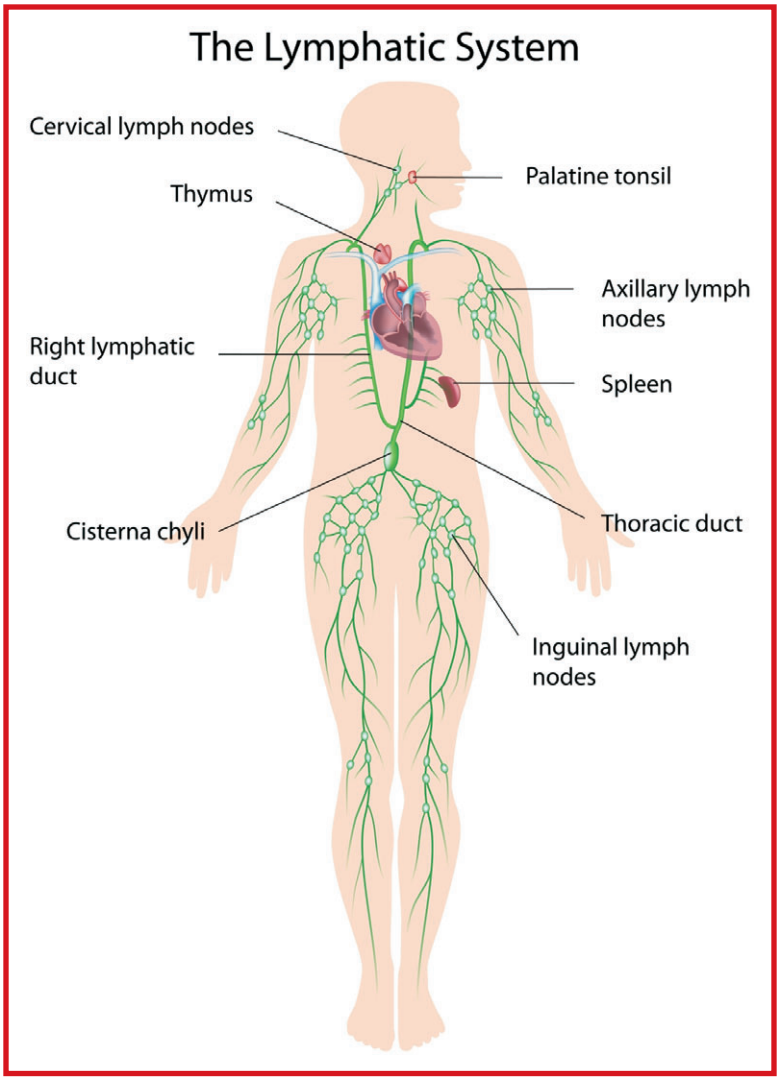


**FIGURE 1. There are lymph vessels throughout the body, in much the same way as the blood vessels.**

- Adenoids trap potential pathogens entering the body through the nose and mouth.
- Appendix monitors potential pathogens in the intestine.
- Bone marrow, the soft tissue in the hollow center of bones, is the ultimate source of all blood cells, including white blood cells destined to become immune cells.
- Lymph nodes are small, bean-shaped lymph nodes that are laced along the lymphatic vessels, with clusters in the neck, armpits, abdomen, and groin. Each lymph node contains specialized compartments where immune cells congregate, and where they can encounter antigens.
- Nasal cavity traps and filters potential pathogens from the air.

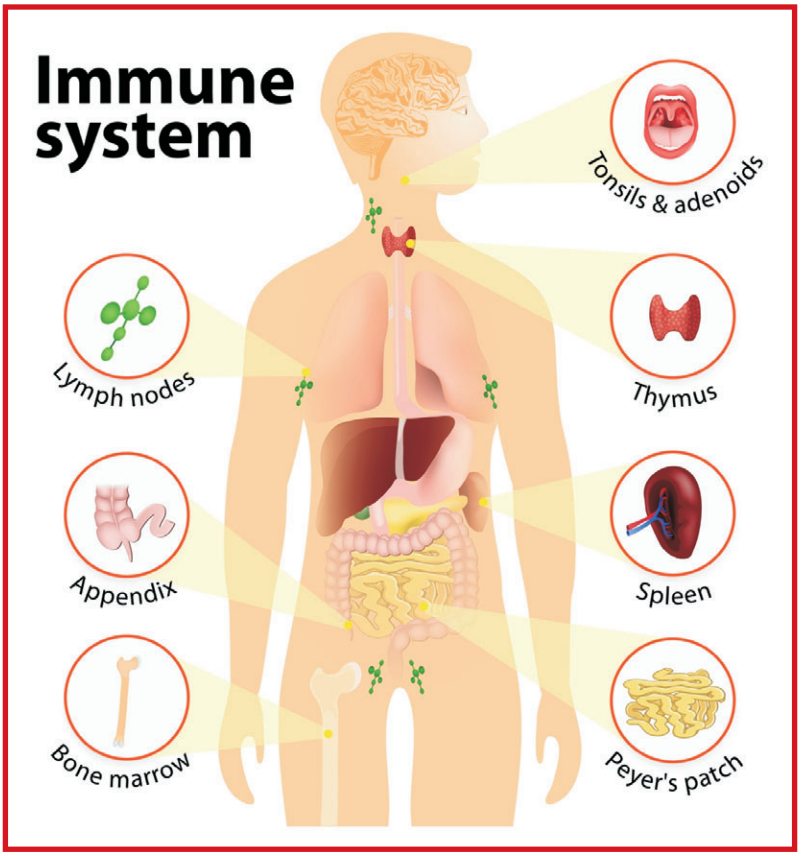


**FIGURE 2. Organs of the immune system are positioned throughout the body.**

- Peyer's patches monitor the intestines to identify potential pathogens.
- Skin serves as a major protective barrier from potential pathogens in the environment. It is considered the body's first line of defense against diseases.
- Spleen destroys defective red blood cells, detects and responds to potential pathogens and acts as a blood reservoir. The spleen is a flattened organ at the upper left of the abdomen. Like the lymph nodes, the spleen contains specialized compartments where immune cells gather and work, and serves as a meeting ground where immune defenses confront antigens.
- Thymus is a small gland located behind the sternum, that is very active from before birth until puberty as it trains lymphocytes to fight infections and cancer, providing immunity that lasts for a lifetime.
- Tonsils trap potential pathogens entering the body through the nose and mouth.

## TYPES OF IMMUNITY

**Immunity** describes a state of having sufficient biological defenses to avoid infection, disease, or any unwanted biological invasion. Everyone's immune system is different, and normally it becomes stronger during adulthood due to multiple exposures to pathogens, and having developed more immunity over the years. That is why teens and adults tend to get sick less

## DIGGING DEEPER...

### UNCOVERING ADDITIONAL FACTS: Allergies

Allergic reactions begin in the immune system. When a harmless substance such as dust, mold, or pollen is encountered by a person who is allergic to that substance, the immune system may over react by producing antibodies that "attack" the allergen. The can cause wheezing, itching, runny nose, watery or itchy eyes, and other symptoms.

Allergies can affect anyone, regardless of age, gender, race, or socioeconomic status. Generally, allergies are more common in children. However, a first-time occurrence can happen at any age, or recur after many years of remission. Hormones, stress, smoke, perfume, or environmental irritants may also play a role in the development or severity of allergies.

Anaphylactic shock is a severe, life-threatening reaction to certain allergens. Body tissues may swell, including tissues in the throat. Anaphylactic shock is also characterized by a sudden drop in blood pressure. An EpiPen containing epinephrine is frequently used to improve breathing, stimulate the heart, raise a dropping blood pressure, and reduce swelling of the face, lips, and throat.

Review John Hopkin's website at https://www.hopkinsmedicine.org/health/conditions-and-diseases/allergies-and-the-immune-system and learn more about the immune system's response to a substance.

often than children. Once an antibody has been produced, a copy remains in the body so that if the same antigen appears again, it can be dealt with quicker.

Humans have three types of immunity: innate, adaptive, and passive.

- **Innate** (natural) immunity is what a person is born with, a type of general protection. Many of the germs that affect other species do not harm humans. For example, the viruses that cause leukemia in cats or distemper in dogs do not affect humans. Innate immunity works both ways because some viruses that make humans ill, such as the virus that causes HIV/AIDS, do not make cats or dogs sick. Innate immunity also includes the external barriers of the body, like the skin and **mucous membranes** (lining of the nose, throat, and gastrointestinal tract,) which are the first line of defense in preventing diseases from entering the body. If this outer defensive wall is broken, the skin attempts to heal the break quickly, and special immune cells on the skin attack invading germs.
- **Adaptive** (able to adjust) immunity is often sub-divided into two major types according to how the immunity was obtained. Naturally acquired immunity occurs through non-deliberate contact with a disease-causing agent, whereas artificially acquired immunity develops through deliberate actions such as vaccination.
- **Passive** immunity is "borrowed" from another source and it lasts for a short time. For example, antibodies in a mother's breast milk give a baby temporary immunity to diseases the mother has been exposed to. This can help protect the baby against infection during the early years of childhood before they can acquire an adaptive immunity or be vaccinated.

Everyone's immune system is different. Some people never seem to get infections, whereas others seem to be sick all the time. As people get older, they usually become immune to more germs as the immune system comes into contact with more and more of them. That's why adults and teens tend to get fewer colds than children. Their bodies have learned to recognize and immediately attack many of the viruses that cause colds.

**Immunization** is the process whereby a person is made immune or resistant to an infectious disease, typically by the administration of a vaccine. Vaccines stimulate the body's own immune system to protect the person against subsequent infection or disease. Immunization is a proven tool for controlling and eliminating life-threatening infectious diseases and is estimated to avert between 2 and 3 million deaths each year.

**FIGURE 3. Immunizations are an example of adaptive immunity.**

## Summary:

The immune system protects the body from possibly harmful substances by recognizing and destroying antigens. The immune system includes white blood cells, antibodies, and several organs working together to keep the body healthy.

There are three types of immunity: Innate, acquired, and passive immunity. Immunization provides an acquired immunity to control and eliminated infectious diseases.

## Checking Your Knowledge:

1. What is the body's first line of defense?
2. Explain the importance of the thymus gland.
3. Summarize the role of the different organs of the immune system.
4. Differentiate the three types of immunity.
5. Explain how immunizations work?

## Expanding Your Knowledge:

Learn more from the National Institute of Health's Immune System Research Frontiers website at https://www.niaid.nih.gov/research/research-frontiers-immune-system. Discover how antibodies are used clinically and are the subject of numerous clinical trials. Genetic engineering is another useful research tool discussed at this website.

## Web Links:

**Immune System**
https://kidshealth.org/en/parents/immune.html.

**How Your Immune System Works**
https://health.howstuffworks.com/human-body/systems/immune/immune-system.htm

**Immune System**
https://www.healio.com/hematology-oncology/learn-immuno-oncology/the-immune-system/components-of-the-immune-system