Have you ever had an allergy? Allergies can cause severe discomfort. A good example is hay fever, with which severe sneezing, watery eyes, sore throat, and coughing may occur. Animals can also have allergies that impact their immune system. How can you recognize it? In this E-unit, you will take a closer look at the immune system.

**Objective:**

Explain the structures and functions of the immune system of animals.

**Key Terms:**

- active immunity
- adaptive immunity
- antibody
- antigen
- B lymphocyte (B-cell)
- dendritic cell
- edema
- eosinophil
- immune system
- immunization
- immunological memory
- inflammatory response (inflammation)
- innate immunity
- interstitial fluid
- lymph
- lymph nodes
- lymphatic capillary
- lymphatic system
- lymphatic vessels
- lymphocyte
- lysozyme
- macrophage
- neutrophil
- passive immunity
- phagocyte
- primary lymphoid organ
- red bone marrow
- secondary lymphoid organ
- spleen
- T lymphocyte (T-cell)
- thymus
The immune system is the set of organs and processes that provide protection from infections, toxins, and foreign bodies. In mammals, it serves as a protector from troublesome invasions to the body, such as bacteria, viral pathogens, airborne toxins, and in some cases, cancer cells.

COMPONENTS OF THE IMMUNE SYSTEM

The immune system is made up of components that work together to keep animals healthy. Scientists continue to study this vast system, since it is the key to combating disease and maintaining homeostasis. Sometimes called the lymphatic-immune system, most of the body’s immunity comes through the cells, lymph, and nodes of the lymphatic system.

The lymphatic system is a group of organs, vessels, and nodes that provide lymph and fluid balance to the bloodstream. This system includes lymphatic vessels, lymph nodes, and associated lymphoid organs (such as the spleen or thymus) that return excess interstitial fluid to the bloodstream and defend the body against disease. Interstitial fluid is the fluid found outside tissue cells and blood vessels. It provides a significant proportion of liquid within the body, and it contains lymph, the part of this system that washes tissue. The lymphatic system also allows the small intestine to absorb fats (called lipoproteins) and transport them to the bloodstream. Finally, it provides sites for the production and distribution of the lymphocytes.

Lymphocytes

A lymphocyte is a small white blood cell that assists in removing toxins, foreign materials, and pathogens from lymph. There are two primary types of lymphocytes needed to carry out the immune system’s defenses. (White blood cells are also called leukocytes.)

B Lymphocytes

A B lymphocyte (B-cell) is a non-thymus leukocyte that is responsible for producing antibodies. It remains in the red bone marrow until maturity, and then it is released into the bloodstream.

T Lymphocytes

In contrast, a T lymphocyte (T-cell) is a leukocyte processed in the thymus that finds foreign invaders, viruses, and pathogens. T-cells send a signal to the B-cell to produce antibodies and can aid in the attack of the infected cells.
**Lymphatic Vessels**

The lymphatic system has a network of lymphatic vessels and lymphatic capillaries. **Lymphatic vessels** are thin-walled tubes (structured like blood vessels) that transport lymph. **Lymph** is a colorless fluid (containing white blood cells) that washes tissue. It flows from the lymphatic system through the vessels and into the bloodstream. A **lymphatic capillary** is an extremely small lymphatic vessel located in the spaces between cells. The capillaries eventually join to form the lymphatic vessels, before they enter lymphatic or thoracic ducts.

---

**FIGURE 1.** Diagram of B-cells and T-cells. This shows the way these lymphocytes work to kill infected cells.
Contractions of skeletal muscles force the lymph through the lymphatic vessels. It cannot flow backward due to one-way valves that keep the fluid moving forward. If too much or not enough lymph is produced, disease may occur and edema may result. **Edema** is a swollen-tissue condition, caused from an accumulation of interstitial fluid. Generally, this stems from the body’s response to a problem within the swollen area (such as an infection or a broken bone).
Lymphoid Organs

The lymphatic system involves several important organs that are essential to its proper function.

Primary Organs

A primary lymphoid organ is an organ in which lymphocytes develop and mature. Bone marrow and the thymus are two such organs. Red bone marrow is a red substance consisting of connective tissue, blood vessels, and the origin cells that make erythrocytes and lymphocytes. Red marrow is found in the bones and uses blood vessels to transport new cells. The thymus is a gland of the thoracic area that produces T-cells.

Secondary Organs

A secondary lymphoid organ is an organ in which lymphocytes are activated by antigens. An antigen is a toxin or foreign invader that corrupts cells and causes illness. Examples of secondary lymphoid organs are the spleen, lymph nodes, and tonsils.

LYMPH NODES

Lymph nodes are extremely small, encapsulated structures that filter lymph from tissue and dwell along the path of lymphatic vessels. They engulf any pathogens or toxins that try to enter the bloodstream. Wherever there are lymphatic organs, there are more than likely to be lymph nodes—further protecting the body from invaders.

Spleen

The spleen is the largest lymphatic organ, is located in the abdomen, and is responsible for filtering blood. It is circular in form, purple in color, and contains red and white pulp that assists in removing old and defective blood cells. It contains lymphocytes to aid in removing antigens from the blood. If the antigens cause a large number of lymphocytes to attack, it can become too enlarged, causing it to burst. Also, if an animal is hit with a crushing abdominal blow, the spleen can rupture.
TYPES OF IMMUNITY

In general, healthy animals have a good immune system that helps them fight most diseases and antigens. This is especially true for those that live in the wild. Since these animals are up against the harshness of the wild while searching for food and shelter, they have developed stronger immunities to bacteria and viruses. Repeated contact with these foreign bodies has strengthened their immune system.

For livestock animals, this isn’t necessarily the case. Livestock animals (as well as companion animals) are domesticated. They generally stay in an environment in which they cannot wander too far away, such as a fenced pasture, a confinement, a stable, or a kennel. Since they have limited contact with outside antigens, their immune systems are challenged in different ways. Their living environment could be an attraction to insects, toxins, and other invaders. Cleanliness and safe, sanitary conditions are the keys to limiting bacterial exposure. Fresh, clean water and feed are important. Habitats must be dry and clear of muck.

Animals, to some extent, do have natural ways of fighting disease, pathogens, and the toxic environments in which they encounter or live in. Their defenses are either innate or adaptive.

Innate Immunity

Innate immunity is a natural, biological aversion or barrier to certain antigens. Within innate immunity, the lymphatic system works continuously to cleanse tissue and remove dead cells. It involves physical barriers, such as skin and the mucous membranes lining the respiratory, digestive, and urinary tract systems. In some animals, the skin secretes oils containing chemicals that weaken and even kill various types of bacteria.

Lysozyme is an enzyme prevalent in saliva, tears, sweat glands, duct milk, and mucus that attacks the cell walls of bacteria. In addition, the pH level in the stomach is generally too acidic for most antigens attached to food.

Innate immunity is most evident when tissues are damaged. This triggers an inflammatory response. An inflammatory response (inflammation) is a series of physiologic processes in response to injuries by antigens or trauma. The inflamed area may be red, hot to the touch, swollen, and painful. This response can also be internal, causing an overreaction of chemicals that repair or protect tissue. This large, cellular response can damage the tissue it is trying to repair.

Adaptive Immunity

In contrast, adaptive immunity is a body’s defense mechanisms for fighting unknown antigens. After exposure to an antigen, defense is mediated by B-cells and T-cells. Receptors in the body are attracted to and surround the antigen. The receptors then work at eliminating the antigen from the bloodstream. This is generally the work of leukocytes. This is why veterinarians look for elevated levels of these blood cells when testing an animal for an infection.
**Antibodies**

An **antibody** is a defensive protein produced to attack specific antigens. Antibodies attach to the antigens and try to eliminate them. They are composed of blood proteins that are Y-shaped. Each end of the “Y” has two arms. The arms are long, polypeptide chains, and the trunk is made of amino acids. The two arms (at each end) form a specific pattern between them, like the tumbler of a lock. This antibody rides on a white blood cell, rolling through antigens like a locked weapon seeking the right key. If the antigen’s “key” fits an antibody’s “lock,” the leukocytes become the weapon—multiplying and raining down a stream of antibodies that attach to and kill the antigens. (This is called the antigen-antibody complex.)

**Immunological Memory**

Interestingly, adaptive immunity contains lymphocytes that are able to remember the antigen and the body’s response to that antigen. Scientists call this the immune’s system **immunological memory**, the cellular ability to recall previous antigen encounters. An animal’s adaptive abilities will depend on its DNA structure. Some antigens will invade and be attacked so many times that their memory lasts a lifetime, but what about lasting through generations? Scientists debate this point. Were genetic markers of a certain bloodline that is immune to an antigen bred into a species, or did an ancestor’s adaptive immunity force the DNA to remember how to fight it? Most believe that it is a genetic predisposition rather than immunological memory, but as you know, science is always evolving. Read an interesting article on DNA-encoded fears in animals by Aaron Kase on the Reset.me website at [http://reset.me/story/science-proving-memories-passed-ancestors/](http://reset.me/story/science-proving-memories-passed-ancestors/).

**Phagocytes and Natural Killer Cells**

There are several types of leukocytes, and they all have specific roles. A **dendritic cell** is a specialized cell that presents antigen information to the other cells, and regulates T-cell and B-cell growth and behavior. Dendritic cells are messengers that deliver key antigen information for both innate and adaptive immune systems. A **phagocyte** is a leukocyte that can engulf and digest viruses and bacteria. A **neutrophil** is a phagocyte that attaches to the walls of the blood vessel. Neutrophils attack antigens and prevent their entry into the bloodstream. An **eosinophil** is a leukocyte that responds to allergic
reactions and attacks parasites (such as worms) by releasing toxins. A **macrophage** is a phagocyte within body tissue.

**Active and Passive Immunity**

Generally, antibodies are introduced into the immune system through active or passive means. These means can be natural (from the body) or artificial (from a vaccine).

**Active Immunity**

**Active immunity** is the creation of antibodies in response to an exposure to an antigen. For example, when a kitten catches a cold, its body produces T-cell and B-cell responses that eventually remove the viruses from its body. However, the antigen can also be introduced in an artificial manner through vaccination, resulting in the creation of antibodies.

**Passive Immunity**

**Passive immunity** is the presence of antibodies without exposure to an antigen. These antibodies can be acquired naturally by the transfer from one individual to another, such as from mother to offspring. For example, a mother cat passes her immune responses and antibodies across the placenta to the kittens before they are born. However, after a few months, the antibodies slowly wear off, and vaccinations are needed to promote antibody production. These antibodies can also be introduced through a booster, artificially.

**Immunization**

**Immunization** is the act of providing an immunity to specific antigens, artificially. Generally, this includes exposure to an antigen in order to promote the production of antibodies—through a vaccine.

A **vaccine** is an artificially-produced, antigen-based substance designed for the body’s production of antibodies and immunity to a disease. Usually, the antigen within the vaccine is in a weakened form. It is strong enough for the animal to produce antibodies, but not strong enough to cause the harmful effects of the disease. Vaccines are given in the form of a shot. Vaccines are an active (artificial) immunity, because the antibodies are produced as a response to an antigen.

Conversely, immunity boosters, such as antibiotics, are used to boost the immune system by introducing antibodies. They can be used to aid in the current fight of a disease, or as a preventive measure. Interestingly, the antibodies can be reproduced by the body years later. B-cells and T-cells remember these antibodies, just as they do antigen attacks. Antibiotics and immunity boosters are a passive (artificial) immunity, because the antibodies are introduced without a response to an antigen. [Booster shots are different from an antibiotic or immune booster. They are the same vaccine previously injected (or a stronger version of the antigen). This is to further prepare and strengthen the immune system against an attack. In animals, an example would be the rabies vaccine. In Illinois, it is required for a puppy at four months, then the first booster is given a year later. After
that, Illinois law says it should be given in intervals recommended by the USDA concerning the specific drug being used. Generally, it is every one to three years.]

Summary:

The immune system serves as a protector from troublesome invasions to the body, such as bacteria, viral pathogens, toxins, and cancer. The lymphatic system (lymphatic-immune system) includes lymphatic vessels, lymph nodes, and lymphoid organs that return excess interstitial fluid to the bloodstream and defend the body against disease. Two primary types of lymphocytes needed to carry out the immune system’s defenses are B-cells and T-cells.

Innate immunity is a natural defense to unwanted antigens. Animals have innate physical barriers to combat invaders, such as skin and mucous membranes. In contrast, adaptive immunity results from exposure to unknown antigens. Active immunity is the production of antibodies in response to an antigen. Passive immunity is the production of antibodies without the introduction of an antigen. Vaccines aid active immunity by introducing an antigen to teach the body how to respond. Antibiotics and immunity boosters aid passive immunity by adding antibodies into the bloodstream.

Understanding how the immune system works will help you to better care for the animals under your watch.
Expanding Your Knowledge:

Think about your immune system. When you catch a cold, your body is fighting to keep antigens at bay. In most cases, a cold only lasts a few days. Without an immune system, what would happen?

Watch the YouTube video, “Introduction to the Immune System,” on the Osmosis channel at https://www.youtube.com/watch?v=Xc_Ljc5ycfM. As the video plays, check your notes to be sure you understand the primary differences between innate and adaptive immunity.

Checking Your Knowledge:

Part One: Matching

Instructions: Match the word with the correct definition.

a. antigen  e. lymph nodes
b. innate immunity  f. B lymphocyte (B-cell)
c. lymph  g. inflammatory response (inflammation)
d. adaptive immunity  h. red bone marrow

1. _______ a red substance consisting of connective tissue, blood vessels, and the origin cells that make erythrocytes and lymphocytes
2. _______ extremely small, encapsulated structures that filter lymph from tissue and dwell along the path of lymphatic vessels
3. _______ a colorless fluid (containing white blood cells) that washes tissue
4. _______ a natural, biological aversion or barrier to certain antigens
5. _______ a toxin or foreign invader that corrupts cells and causes illness
6. _______ a body’s defense mechanisms for fighting unknown antigens
7. _______ a series of physiologic processes in response to injuries by antigens or trauma
8. _______ a non-thymus leukocyte that is responsible for producing antibodies

Part Two: Completion

Instructions: Complete the following statements.

1. ___________________________ can attack the infected cells or send a signal to the B-cell to produce antibodies.

2. ___________________________ is an enzyme prevalent in saliva, tears, sweat glands, duct milk, and mucus that attacks the cell walls of bacteria.
3. A/an _________________________ is a leukocyte that can engulf and digest viruses and bacteria.

4. _________________________ provides a significant proportion of liquid within the body.

5. _________________________ transport lymph throughout the body.

6. A swollen foot may indicate _________________________.

7. A/an _________________________ is a specialized cell that presents antigen information to the other cells, and regulates T-cell and B-cell growth and behavior.

8. The gland of the thoracic area that produces T-cells is the _________________________.

---

**Part Three: True/False**

*Instructions: Write T for true or F for false.*

1. Neutrophils are white blood cells that respond to allergic reactions and release toxins to kill parasites (such as worms).

2. The spleen is a secondary lymphatic organ that is located in the abdomen.

3. Antibodies are composed of blood proteins that are Y-shaped.

4. The thymus is a secondary lymphatic organ.

5. The immune system protects animals from invaders, such as pathogens and bacteria.

6. Lymphatic capillaries are extremely small vessels found throughout the animal’s body.

7. Organs do not produce the lymphocytes.

8. The red bone marrow only produces white blood cells.

9. The lymphatic system allows the small intestine to absorb fats in the form of lipoproteins and transport them to the bloodstream.

10. Lymph nodes are beneficial, because they cause edema.