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Understanding the Equine Immune System

The immune system is critical to maintaining life in any species. It protects when foreign invaders, such as viruses, parasites, or bacteria, breach your physical barriers—such as skin and mucous membranes—and enter the body. Naturally, this important system is extremely complex.

Amanda Adams, PhD, equine immunologist at the University of Kentucky's Gluck Equine Research Center, presented an overview of the immune system at the Role of Immunology in Equine Health Symposium, held Nov. 21 in Lexington. She started with some of the basics: What is immunity?

"Immunity is a state of having sufficient biological defenses to avoid infection, disease, or other unwanted biological invasion," Adams began.

There are three types of immunity: Natural acquired immunity, artificial acquired immunity (induced when vaccines are administered), and passive acquired immunity (that which horses acquire via their dam's colostrum at birth). There are also two types of immune response that are both critical to fighting infection—innate and adaptive—which Adams described in detail.

The Innate Immune Response
When a pathogen, or disease-causing organism, breaks through the body's natural protective barriers, the innate immune system is activated as the first line of defense. This is the body's built-in immunity to resist infection, said Adams. The innate immune response is present from birth, not specific for any particular microbial substance (it doesn't matter if the invader is a virus, parasite, or bacteria, the immune system will kick in), and has no memory.

One of the purposes of the innate immune response is to "slow the growth of infectious agents until the adaptive (more pathogen-specific) immune response kicks in," said Adams. It does this by binding immune cells called phagocytes to the offending microbes. These phagocytes then internalize and eventually kill the microbes through a process called phagocytosis.

Specific phagocytes include:

- **Neutrophils**—These are the most abundant immune cells in the blood and the first cells to the site of an infection. "They're on high alert for pathogens in the body," said Adams. After engulfing and killing microbes, the neutrophil will die; an accumulation of dead neutrophils eventually leads to what we know as pus—a sign of infection.
- **Monocytes**—These innate immune cells also uptake invading microorganisms, but they can do so repeatedly without dying. Further, they're not just present in blood, but can circulate and scavenge throughout bodily tissues, in which they become macrophages, Adams explained.
- **Dendritic cells**—These are the messengers between the innate and adaptive immune systems. We'll get to their function in a minute.

When pathogens break through the epithelial barrier (skin), epithelial cells release small proteins called chemokines and cytokines, which are "critical in creating a trail or signal to activate the innate immune response," said Adams. They are directly responsible for immune cell-to-cell communication.

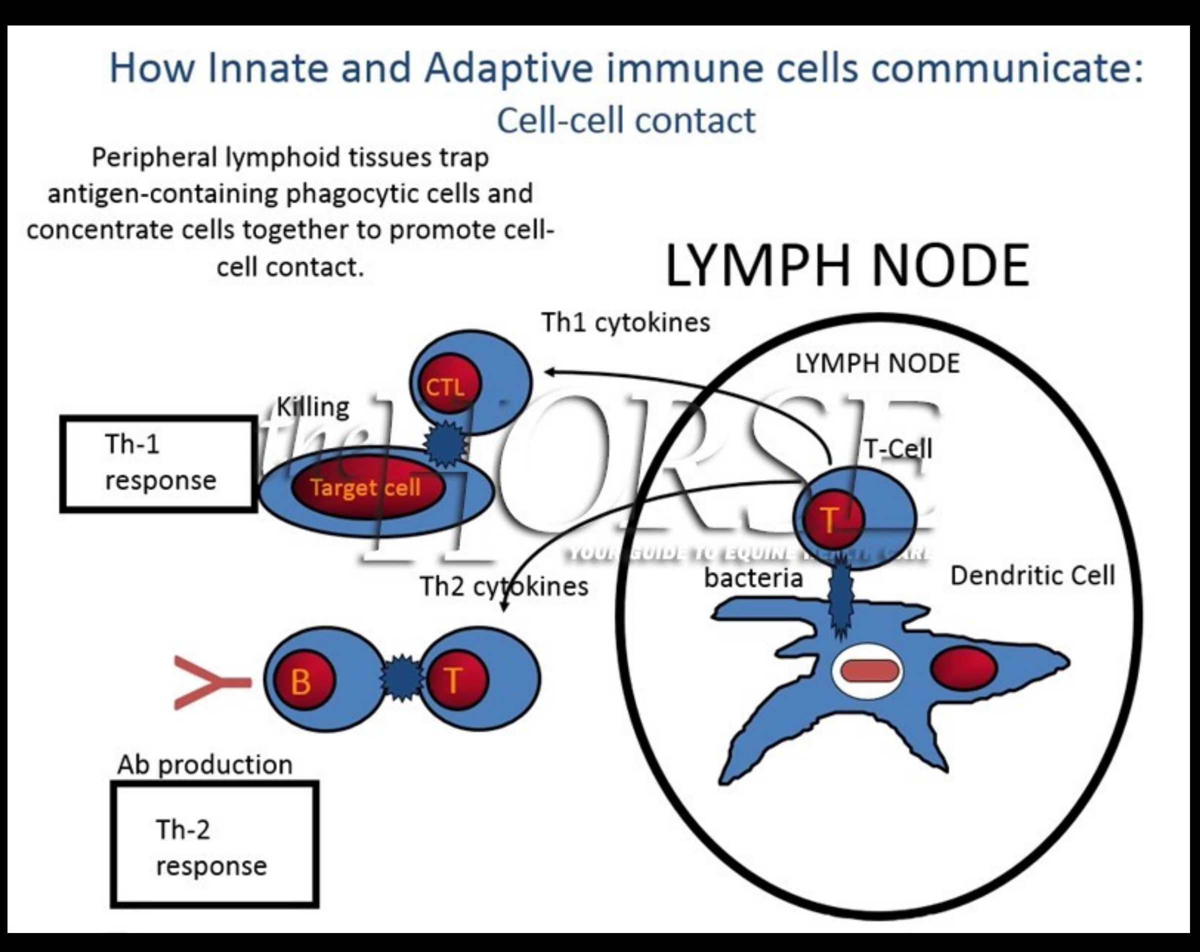
When cytokines are produced, they also trigger the inflammatory process characterized by heat, swelling, redness, and pain. This acute inflammation is actually good, said Adams, because the resulting vasodilation of the endothelial cells attracts and allows for more phagocytes at the site of infection.

This entire innate immune response can happen in seconds and continue for minutes to days, she said.

So, to recap:

1. A pathogen breaks through the skin via a laceration , for instance, and enters the body;
2. This activates the epithelial cells, which produce cytokines and chemokines;
3. Cytokines and chemokines cause inflammation and vasodilation, which attract the phagocytes;
4. Inflammation then allows phagocytes to leave the blood and travel to the site of infection; and
5. Phagocytes then kill the pathogen.

"Not only are phagocytes important for killing pathogens, but they also process the pathogens into antigenic pieces and put the pieces on their cell surface receptors, which allows these cells to show the antigen to the adaptive immune system for activation," said Adams.



Courtesy Dr. Amanda Adams

The Adaptive Immune Response
Unlike the innate response, the adaptive immune response is specific to a particular pathogen. As mentioned, the link between innate and adaptive immunity are the more specialized phagocytes: the dendritic cells and macrophages.

"Once dendritic cells have engulfed the pathogen at the site of infection, they leave the tissue and enter the lymphatic system to travel to the lymph nodes to present the pathogen as an antigen to the lymphocytes (white blood cells of T-cells and B-cells)," for recognition, Adams explained. The lymphatic system essentially serves as a highway for immune cells to travel around the body, she added.

Adaptive immunity is learned, is pathogen-specific, is enhanced by second exposure, and has memory. It relies on the innate immune system to communicate information about pathogens in the body, particularly whether a bacteria or virus has invaded.

Two of the adaptive immune system's key components are the cell-mediated immune (CMI) responses and humoral immune responses. The CMI responses involve T-cells that can kill infected cells in the body (called cytotoxic T-cells) or that can help activate other cells (called T-helper cells). The humoral immune response activates B-cells to become plasma cells that produce antibodies.

To recap:

1. The professional phagocytes (macrophage and dendritic cells) process the antigen and leave the site of infection via the lymphatic system;
2. Dendritic cells travel to the lymph nodes or other secondary lymphatic tissue sites where they activate the adaptive immune system (T-cells and B-cells);
3. T cells travel back to the infection and kill the pathogen, while B cells produce antibodies that bind to the pathogen;
4. Infection is eliminated; and

Memory T and B cells wait in the lymph nodes for the next infection.

Take-Home Message
The immune system has to keep up with constantly changing microbes. "This is why the innate response is critical as an immediate defense mechanism," Adams said. "Once the innate immune system becomes activated, it sends the correct signals to the adaptive immune system for activation and to let the system know what kind of pathogen the body has been invaded by. Once this system is turned on, the infection can be eliminated if there are sufficient levels of activation. More importantly, activation of the adaptive immune response allows for generation of immunological memory to allow for a quicker immune response upon second exposure to that pathogen."

The equine immune system is far more complex than the brief description provided here, and a number of factors (e.g., nutrition, age, stress, vaccination history, etc.) can impact how well it functions. "Thus, optimal care of the immune system is critical for a properly functioning immune response that allows for sufficient biological defenses to ward off infection and protect the body to sustain life," Adams concluded.