The New England BEACON

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THE IMMUNE SYSTEM

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When your body is invaded by a virus, like the flu, or by bacteria such as on a thorn that pricks your skin, your immune system works to protect you. It tries to identify, kill, and eliminate these foreign invaders that might hurt you. What is the immune system made of? It is a network of cells and tissues throughout the body that work together to fight foreign organisms and substances (called **antigens**) that enter the body.

White blood cells are the army of the human immune system. Although they make up only about 1 percent of blood, they are the primary mechanism for defending the body against invading bacteria, viruses, fungi, and parasites. Because blood circulates through our entire body, white cells are present everywhere. However, there are places where white blood cells are particularly concentrated – the lymph nodes and the spleen – which are the sites where the immune system launches its attack against an infection. Immune cells also concentrate in parts of the body that come in contact with the outside world through food or air, such as the mouth, nose, lungs and the gut. Many white blood cells are also found in the skin, where they can destroy any germs right where they enter the body.

The Cells of the Immune System

All immune cells are made in the bones. Bones are very hard, but they have a spongy core called the bone marrow. Blood cells are made from special cells in the bone marrow called hematopoietic cells. Newly made immune cells stream out from the bone marrow into the body via blood vessels. These are the cells that make up the immune system *(Figure 1).*

Neutrophil

In the event of injury or infection, the immune system reacts with a response known as inflammation. During inflammation, neutrophils, a group of white blood cells that are always present in the blood, become activated, pass through the walls of the blood vessels, and migrate to the site to destroy the germs.

Macrophage

Another type of white blood cell is the macrophage, which destroys bacteria directly by "eating" them. You will find macrophages in the lungs, liver, skin and gut.

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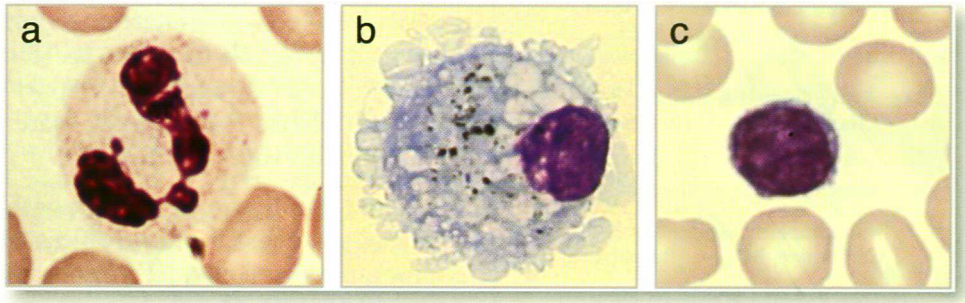

Figure 1: a. Neutrophils, b. Macrophage, c. Lymphocytes as seen by light microscopy

MARIE COYLE RECEIVES MYRA KRAFT MVP AWARD FOR VOLUNTEERISM

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Lymphocytes

Lymphocytes are another type of white blood cell, and they are the smallest members of the family. They can measure less than a 100th of a millimeter, or 10 microns. There are several different types of lymphocytes, each with its own specialized function. B and T lymphocytes are the most abundant. In response to antigenic stimuli, such as a bacterium, virus, parasite or transplanted organs, B lymphocytes produce antibodies, which are proteins that neutralize the antigens by binding specifically to them. After being generated in the bone marrow, T lymphocytes complete maturation in the thymus gland, and orchestrate the immune system's response to infected or malignant cells, either by secretion of regulatory proteins called cytokines, which moderate further immune response, or by direct killing.

Distinguishing Among Antigens

The cells of the immune system can tell the difference between mumps virus and measles virus, for example, because they recognize them as two entirely different things. The job of distinguishing among different antigens belongs to the lymphocytes. Both T cells and B cells have special tools on their surfaces that tell antigens apart. These tools are called **antigen receptors**, but their shapes and functions are a little different between B cells and T cells *(Figure 2)*. B cell antigen receptors look like the letter "Y" and have a hole at the end of each arm. T cell antigen receptors look like rods and have just one hole at the end. Each of these holes on antigen receptors is shaped to fit only with a specific antigen. This characteristic is called **antigen specificity** and works like a key in a keyhole. Each lymphocyte has only one type of antigen receptor. The mumps virus will be detected only by lymphocytes

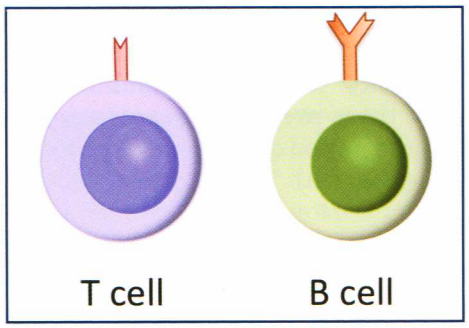

Figure 2: Antigen receptors on the cell surface of B and T lymphocytes.

with antigen receptors that "recognize" it, while cells that detect other antigens such as the measles virus will ignore it. However, all around us are millions of different germs, so the body needs to have an enormous number of different lymphocytes to protect it. Several studies have shown that there are over 10 billion different kinds of these lymphocytes, and with so many different receptors the immune system can protect the body from a huge variety of antigens.

Immunological Memory

Lymphocytes can remember pathogens that they have met before so that if a person was to catch one of these pathogens a second time, they will not fall ill. This is called **immunological memory**. The first time a B cell meets an antigen, it takes over a week for the cell to produce antibodies against it. During this time the B cell changes itself into a cell that produces antibody. Some B cells – called memory cells – have the job of remembering the new antigen. When a memory B cell meets the same antigen again, it produces an enormous amount of antibodies in just a few days. T cells also make memory cells. T cells normally travel around the body patrolling it. When they come across an antigen, the T cells with matching antigen receptors began to divide rapidly and attack it. This response also takes about one week to build up. During this time some T cells change into memory T cells so that if they meet the same antigen again they are primed to eliminate it immediately. In this way people who have recovered from the mumps, for example, have a large number of memory B and T cells that can recognize just that virus and will protect them from getting sick with it again.

Regulation of the Immune Response and Autoimmunity

The immune system provides the body with an extremely reliable defense system. However, it has to be restrained from reacting to every thing that it comes across, like food or pollen, or from over-reacting and causing more damage than good. The immune system can not only halt a response already underway, it can also prevent an unnecessary one from launching, including an attack against the body itself. The ability to accept the body's own cells is called **self tolerance**. Newly-made lymphocytes are tested to see if their antigen receptors match the body's own cells before they are released into the blood. For B cells this test takes place in the bone marrow, while for T cells it occurs in the thymus. Cells that have dangerous antigen receptors are destroyed on the spot. But sometimes, these dangerous cells manage to survive and reach the blood stream, where other regulatory mechanisms can destroy them. However, if this ability to tolerate itself breaks down, the body ends up under attack as the immune system mistakes the body's cells for invaders *(Figure 3)*. This condition is called **autoimmune disease.**

The National Institutes of Health (NIH) estimates that as many as 23.5 million Americans suffer from autoimmune disease and that the prevalence is rising. Researchers have identified more than 100 different autoimmune diseases. These diseases are chronic and can be life-threatening. In an autoimmune reaction, antibodies or immune cells attack the body's own healthy tissues.

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BOSTON PATRIOTS MYRA KRAFT MVP AWARD HONORS MARIE COYLE FOR VOLUNTEERISM

Marie Coyle poses with Patriots owner Robert Kraft, quarterback Tom Brady, linebacker Jerod Mayo, alumni Joe Andruzzi, and 25 other Myra Kraft MVP Award winners.

On June 9, Marie Coyle was recognized at a luncheon and award ceremony at Gillette Stadium. Each Community MVP awardee received grants for their respective nonprofit organizations. Marie was one of fifteen $5,000 winners honored for their volunteer work.

Because of a misdiagnosis at age 12 informing her she probably only had five more years to live, Marie not only beat the odds but has dedicated herself to educating the public about scleroderma. She founded the Scleroderma Foundation in 1973 and has worked as a full-time unpaid volunteer for the past 41 years. She continues to work tirelessly to raise research dollars to help find both a cause and cure for scleroderma and the Myra Kraft Award will be included in that effort.

Asked how she felt about winning the award, Marie answered, "Winning the award was absolutely wonderful, but getting to meet Tom Brady was an added bonus!"

GO PATRIOTS!

Regulation of the Immune Response and Autoimmunity *(continued from page 4)*

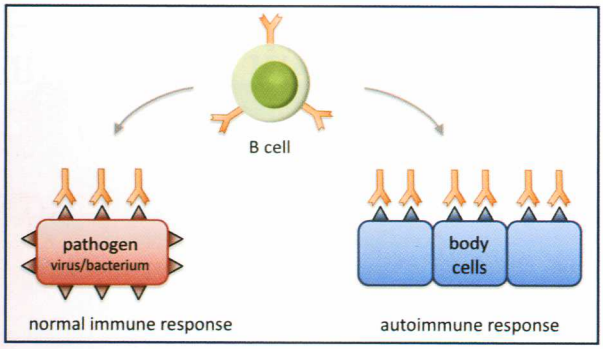

Figure 3: Normal immune response to pathogens and autoimmune response to the body cells by B lymphocytes.

Autoimmune diseases can affect almost any part of the body, including the heart, brain, nerves, muscles, skin, eyes, joints, lungs, kidneys, gland, the digestive tract, and blood vessels. **Scleroderma** is an autoimmune disease characterized by excessive production of collagen in the skin and blood vessels. In more severe forms, collagen can build up in the kidneys, lungs, heart, and gastrointestinal tract, leading in some cases to organ failure. The immune system in patients with scleroderma loses its control. Antibodies specific to the nucleus, a structure present in every cell of the body, are found in the blood of these patients and immune cells produce cytokines and other substances that cause inflammation all over their body as well as stimulate collagen production, resulting in excessive fibrosis. It is not yet understood why the body begins to attack itself. In most cases, a combination of factors is probably at work. For example, a person might have a genetic tendency to develop the disease. A virus infection or the exposure to chemical substances can also be risk factors that provide the initial tissue injury which activates the immune system.

Most autoimmune diseases, including scleroderma, are treated with drugs that suppress the body's immune system while trying to help the function of joints and organs that have been weakened by the attack. However, there are people for whom this treatment does not work or for whom the side effects, such as the weakened immune system, increase the risk of infection. Clearly developing new treatment strategies is important.

(Reprinted with permission from the University of Pittsburgh Scleroderma Center's Collagen Connection, Summer 2014 issue)

"There is no education like adversity."
~ Benjamin Disraeli