

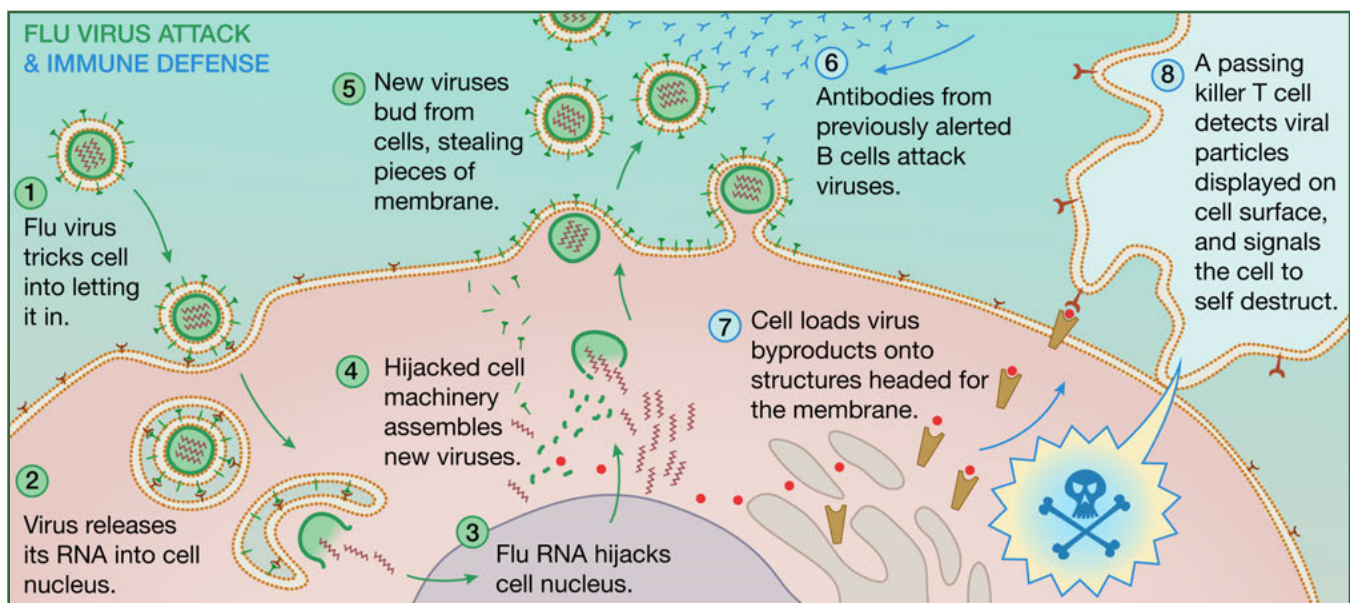
Teacher Tune-up

Quick Content Refresher for Busy Professionals

How are cell involved in disease?

The job of the immune system is to protect the body from infectious diseases, and also from cancer. **Infectious diseases** are diseases that spread from host to host. They are caused by **pathogens** (disease-causing viruses, bacteria, fungi, and parasites) that infect people. Bacteria, fungi, and parasites are all cellular organisms.

Viruses are not cellular; they are just little bits of DNA or RNA wrapped in protein, and are not generally considered to be alive. Viruses and some bacteria get right inside the cells of their hosts. Because viruses are not alive and don't have any way of reproducing themselves by themselves, they hijack host cells, turning them into virus factories. (This process is a little like loading unwanted computer code into a computer and making the computer send copies of that code to other computers, which is why that kind of code is referred to as a computer virus; the code in that analogy is like a virus, with the computer acting as a host cell.)



Some diseases are not caused by germs and are not infectious, like diabetes, heart diseases, stroke, osteoporosis, etc. **Cancer** is also different from germ-caused illnesses. Cancer happens when the body's own cellular DNA becomes damaged in such a way that cells start reproducing in an unhealthy, uncontrolled manner. Cancer cells keep dividing and spreading, crowding out healthy body cells and consuming too many resources. A multicellular organism depends on cooperation and coordination between all of its member cells. In a sense, cancer cells have forgotten how to cooperate; they have become home-grown parasites, selfish and greedy, reproducing wildly and grabbing up space and resources to the point where they can damage or even kill the multicellular organism.

How do your cells help you fight disease?

The cells of the body's immune system have three important jobs in fighting infectious disease and cancer. They must *recognize*, *remove*, and *remember* threats to the body.

Recognize

The immune system must distinguish between self and non-self. And even though there are hundreds of kinds of cells in the human body (skin cells, muscle cells, epithelial cells, red and white blood cells, neurons, etc.), the immune system needs to be able to recognize that they are all in some important way the same: they are self. Recognition is basically done with various kinds of chemoreception, equivalent to our senses of taste and smell. Molecules that tip off the immune system to intruders are called, collectively, **antigen** (because they cause the immune system to **generate antibody**, as we shall see). White blood cells are constantly checking everything they come in contact with for antigen. This way, they can identify foreign cells like bacteria that need to be removed. The cells of the immune system can also identify cancer cells as “non-self,” so they can try to prevent the runaway growth of mutated cells.

Remove

The immune system has a variety of ways of fighting germs (and cancer cells). Some white blood cells (called phagocytes, “cell eaters”) basically eat germs. The most abundant of these are neutrophils. After engulfing germs, certain phagocytes like macrophages and dendritic cells break them into tiny pieces and become “antigen-presenting” cells, showing antigen to other white blood cells in order to teach them what to hunt for.

“Teaching” is a huge simplification—the process involves finding the needle-in-a-haystack special immune cells (known as B and T lymphocytes) that are already specifically adapted to attack that antigen. The antigen-presenting cells activate the appropriate lymphocytes, which clone themselves into an army of B and T cells. This process is called “clonal selection”: in effect, the germ itself selects the appropriate army of defending cells.

When a B cell is activated (by an antigen-presenting cell and also a confirming signal from a T cell that is specific for the same antigen), the B cell divides into two cell lines: memory cells and plasma cells. The plasma cells produce a flood of **antibody** molecules that match the antigen like a lock and key. Antibodies help fight germs in more than one way. They mark the germs so that they become easier targets for other white cells to identify and attack. Antibodies can also interfere directly with the efficient functioning of germs.

There are other white cells, like natural killer (NK) cells and killer T cells, that destroy infected human cells in order to interrupt germ reproduction.

Remember

What about that second line of daughter cells from the activated B lymphocyte, the memory cells? Well, it takes a while for the immune system to figure out how to fight and remove new germs. While the immune system is getting together the right tools to fight an infection, the germs are multiplying and spreading and becoming a bigger and bigger problem. However, if the immune system can remember the germs it has fought in the past, it can respond more quickly when they show up again. So part of the job of the immune system is to keep a record of past infections and have tools ready to fight those old enemies.

This is where the memory B cells come in. Unlike their sister plasma cells, memory B cells don't pump out antibody; instead, they remain as sentinels for future infections by the same germ. When they encounter the same germ in a subsequent infection, the memory cells can quickly clone themselves into a new army of antibody-producing plasma cells.

The ability of the immune system to recognize germs regardless of whether it has encountered them before is called **innate immunity** (innate refers to something that is present from the beginning and doesn't have to be

learned). The ability of the immune system to remember previously encountered germs and hit them extra hard and fast if they show up again is called **adaptive immunity** (because the immune system adapts—it learns and it makes special preparations to fight germs that it remembers).

How does vaccination work?

Normally, of course, this selection of the appropriate B cell happens in response to an active infection. For dangerous pathogens, that can sometimes be too late. But by giving the immune system a taste of antigen ahead of time, using dead or weakened germs (or even just pieces of germs), a **vaccine** can stimulate disease-specific B cells to spring into action. A bit of injected antigen will cause its matching B cell to start dividing. Some of the daughter cells will become plasma cells, producing lots of antibody, which isn't really needed right now. The payoff comes from the B cell's other daughter cells: the memory cells. These memory cells now stand guard for the long term, ready to turn into plasma cells and roll out an overwhelming batch of antibody on short notice if it's ever really needed.

What about humoral immunity?

This entire discussion has focused on cellular immunity—they way a team of cells works together to fight disease. But in addition to antibody produced by B cell lymphocytes, there are other large molecules that float around outside of cells and help fight germs. This aspect of the immune system is called **humoral immunity**.

An important part of humoral immunity is the **complement** system, so called because it complements the work of phagocytes and antibody. Complement is produced in the liver and is abundant in blood and tissues all around the body. It's made up of about twenty proteins that attack pathogens in several ways. Complement proteins can attach to pathogenic cell surfaces and self-assemble to pores that let the contents of those cells gush out. Complement can also attract white blood cells to infection sites, opsonize germs (i.e. tag them for attack by cell-eaters like macrophages), and make the surface of slimy bacteria easier for macrophages to grab.