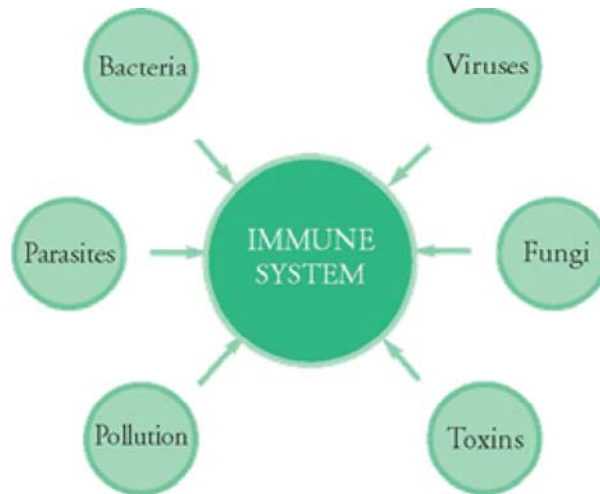


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IMMUNE SYSTEM



Unit Overview

This unit is all about your immune system, its parts, and how it works. You will learn how the immune system is vital to your existence and how it is working constantly to keep you healthy.

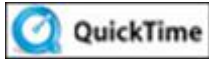


How Your Immune System Works

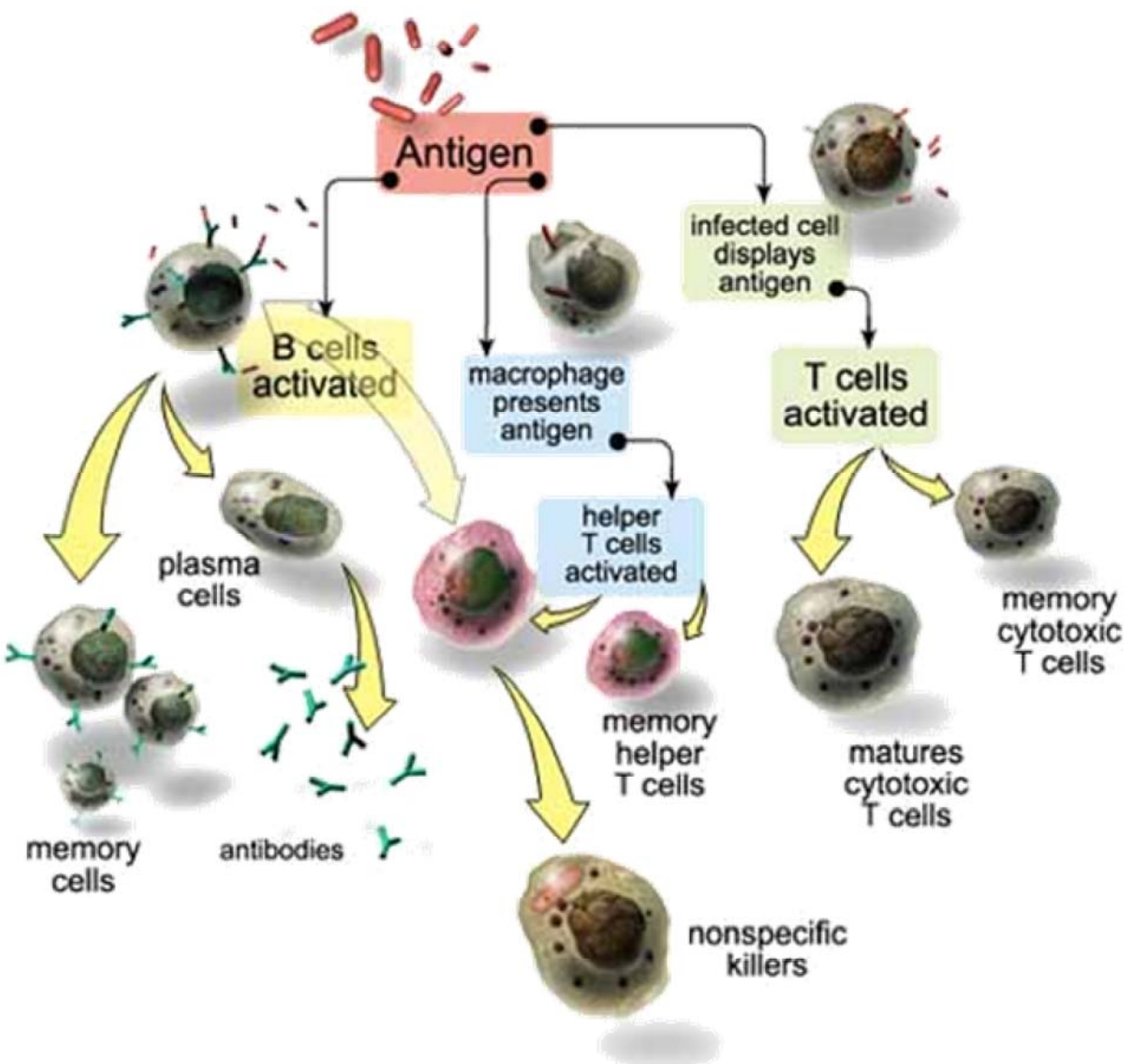
Inside your body there is an amazing protection mechanism called the immune system. It is designed to defend you against millions of bacteria, microbes, viruses, toxins and parasites that would love to invade your body. To understand the power of the immune system, all that you have to do is look at what happens to anything once it dies. That sounds gross, but it does show you something very important about your immune system.

When something dies, its immune system (along with everything else) shuts down. In a matter of hours, the body is invaded by all sorts of bacteria, microbes, parasites... None of these things are able to get in when your immune system is working, but the moment your immune system stops the door is wide open. Once you die it only takes a few weeks for these organisms to completely dismantle your body and carry it away, until all that's left is a skeleton. Obviously your immune system is doing something amazing to keep all of that dismantling from happening when you are alive.

The immune system is complex, intricate and interesting. And there are at least two good reasons for you to know more about it. First, it is just plain fascinating to understand where things like fevers, hives, inflammation, etc., come from when they happen inside your own body. You also hear a lot about the immune system in the news as new parts of it are understood and new drugs come on the market -- knowing about the immune system makes these news stories understandable. In this unit, we will take a look at how your immune system works so that you can understand what it is doing for you each day, as well as what it is not.



The Immune System (03:57)



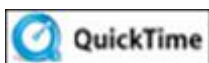
Seeing Your Immune System

Your immune system works around the clock in thousands of different ways, but it does its work largely unnoticed. One thing that causes us to really notice our immune system is when it fails for some reason. We also notice it when it does something that has a side effect we can see or feel. Here are several examples:

- When you get a cut, all sorts of bacteria and viruses enter your body through the break in the skin. When you get a splinter you also have the splinter of wood as a foreign object inside your body. Your immune system responds and eliminates the invaders while the skin heals itself and seals the puncture. In rare cases the immune system misses something and the cut gets infected. It gets inflamed and will often fill with pus. Inflammation and pus are both side-effects of the immune system doing its job.
- When a mosquito bites you, you get a red, itchy bump. That too is a visible sign of your immune system at work.
- Each day you inhale thousands of germs (bacteria and viruses) that are floating in the air. Your immune system deals with all of them without a problem. Occasionally a germ gets past the immune system and you catch a cold, get the flu or worse. A cold or flu is a visible sign that your immune system failed to stop the germ. The fact that you get over the cold or flu is a visible sign that your immune system was able to eliminate the invader after learning about it. If your immune system did nothing, you would never get over a cold or anything else.
- Each day you also eat hundreds of germs, and again most of these die in the saliva or the acid of the stomach. Occasionally, however, one gets through and causes food poisoning. There is normally a very visible effect of this breach of the immune system: vomiting and diarrhea are two of the most common symptoms.
- There are also all kinds of human ailments that are caused by the immune system working in unexpected or incorrect ways that cause problems. For example, some people have allergies. Allergies are really just the immune system overreacting to certain stimuli that other people don't react to at all. Some people have diabetes, which is caused by the immune system inappropriately attacking cells in the pancreas and destroying them. Some people have rheumatoid arthritis, which is caused by the immune system acting inappropriately in the joints. In many different diseases, the cause is actually an immune system error.
- Finally, we sometimes see the immune system because it prevents us from doing things that would be otherwise beneficial. For example, organ transplants are much harder than they should be because the immune system often rejects the transplanted organ.



Now answer questions 1-5.



The Enemy Within: Bacteria (03:09)

Basics of the Immune System

Let's start at the beginning. What does it mean when someone says "I feel sick today?" What is a disease? By understanding the different kinds of diseases it is possible to see what types of disease the immune system helps you handle. When you "get sick", your body is not able to work properly or at its full potential. There are many different ways for you to get sick -- here are some of them:

- Mechanical damage - If you break a bone or tear a ligament you will be "sick" (your body will not be able to perform at its full potential). The cause of the problem is something that is easy to understand and visible.
- Vitamin or mineral deficiency - If you do not get enough vitamin D your body is not able to metabolize calcium properly and you get a disease known as rickets. People with rickets have weak bones (they break easily) and deformities because the bones do not grow properly. If you do not get enough vitamin C you get scurvy, which causes swollen and bleeding gums, swollen joints and bruising. If you do not get enough iron you get anemia, and so on.
- Organ degradation - In some cases an organ is damaged or weakened. For example, one form of "heart disease" is caused by obstructions in the blood vessels leading to the heart muscle, so that the heart does not get enough blood. One form of "liver disease", known as Cirrhosis, is caused by damage to liver cells (drinking too much alcohol is one cause).
- Genetic disease - A genetic disease is caused by a coding error in the DNA. The coding error causes too much or too little of certain proteins to be made, and that causes problems at the cellular level. For example, albinism is caused by a lack of an enzyme called tyrosinase. That missing enzyme means that the body cannot manufacture melanin, the natural pigment that causes hair color, eye color and tanning. Because of the lack of melanin, people with this genetic problem are extremely sensitive to the UV rays in sunlight.
- Cancer - Occasionally a cell will change in a way that causes it to reproduce uncontrollably. For example, when cells in the skin called melanocytes are damaged by ultraviolet radiation in sunlight they change in a characteristic way into a cancerous form of cell. The visible cancer that appears as a tumor on the skin is called melanoma. (See How Sun Tans and Sunburns Work for more information.)



Now answer questions 6-10.

Viral or Bacterial Infection

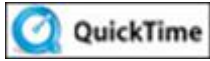
When a virus or bacteria (also known generically as a germ) invades your body and reproduces, it normally causes problems. Generally the germ's presence produces some side effect that makes you sick. For example, the strep throat bacteria (*Streptococcus*) releases a toxin that causes inflammation in your throat. The polio virus releases toxins that destroy nerve cells (often leading to paralysis). Some bacteria are benign or beneficial (for example, we all have millions of bacteria in our intestines and they help digest food), but many are harmful once they get into the body or the bloodstream. Viral and bacterial infections are by far the most common causes of illness for most people. They cause things like colds, influenza, measles, mumps, malaria, AIDS and so on. The job of your immune system is to protect your body from these infections.

The immune system protects you in three different ways:

1. It creates a barrier that prevents bacteria and viruses from entering your body.

2. If a bacteria or virus does get into the body, the immune system tries to detect and eliminate it before it can make itself at home and reproduce.
3. If the virus or bacteria is able to reproduce and start causing problems, your immune system is in charge of eliminating it.

The immune system also has several other important jobs. For example, your immune system can detect cancer in early stages and eliminate it in many cases.



Infectious Diseases (02:04)

Bacteria and Viruses

Your body is a multi-cellular organism made up of perhaps 100 trillion cells. The cells in your body are fairly complicated machines. Each one has a nucleus, energy production equipment, etc. Bacteria are single-celled organisms that are much simpler. For example, they have no nucleus. They are perhaps 1/100th the size of a human cell and might measure 1 micrometer long. Bacteria are completely independent organisms able to eat and reproduce - they are sort of like fish swimming in the ocean of your body. Under the right conditions bacteria reproduce very quickly: One bacteria divides into two separate bacteria perhaps once every 20 or 30 minutes. At that rate, one bacteria can become millions in just a few hours.

A virus is a different breed altogether. A virus is not really alive. A virus particle is nothing but a fragment of DNA in a protective coat. The virus comes in contact with a cell, attaches itself to the cell wall and injects its DNA (and perhaps a few enzymes) into the cell. The DNA uses the machinery inside the living cell to reproduce new virus particles. Eventually the hijacked cell dies and bursts, freeing the new virus particles; or the viral particles may bud off of the cell so it remains alive. In either case, the cell is a factory for the virus.

Understanding Microbes

For additional information on Bacteria and Viruses, click on the following link: [Understanding Microbes in Sickness and in Health PDF File](#)



Now answer questions 11-12.

Components of the Immune System

One of the funny things about the immune system is that it has been working inside your body your entire life but you probably know almost nothing about it. For example, you are probably aware that inside your chest you have an organ called a "heart". Who doesn't know that they have a heart? You have probably also heard about the fact that you have lungs and a liver and kidneys. But have you even heard about your thymus? There's a good chance you don't even know that you have a thymus, yet it's there in your chest right next to your heart. There are many other parts of the immune system that are just as obscure, so let's start by learning about all of the parts.

The most obvious part of the immune system is what you can see. For example, skin is an important part of the immune system. It acts as a primary boundary between germs and your body. Part of your skin's job is to act as a barrier in much the same way we use plastic wrap to protect food. Skin is tough and generally impermeable to bacteria and viruses. The epidermis contains special cells called Langerhans cells (mixed in with the melanocytes in the basal layer) that are an important early-warning component in the immune system. The skin also secretes antibacterial substances. These substances explain why you don't wake up in the morning with a layer of mold growing on your skin -- most bacteria and spores that land on the skin die quickly.

Your nose, mouth and eyes are also obvious entry points for germs. Tears and mucus contain an enzyme (lysozyme) that breaks down the cell wall of many bacteria. Saliva is also anti-bacterial. Since the nasal passage and lungs are coated in mucus, many germs not killed immediately are trapped in the mucus and soon swallowed. Mast cells also line the nasal passages, throat, lungs and skin. Any bacteria or virus that wants to gain entry to your body must first make it past these defenses. Once inside the body, a germ deals with the immune system at a different level. The major components of the immune system are:

- Thymus
- Spleen
- Lymph system
- Bone marrow
- White blood cells
- Antibodies
- Complement system
- Hormones

Let's look at each of these components in detail.



Now answer questions 13-14.

Lymph System

The lymph system is most familiar to people because doctors and mothers often check for "swollen lymph nodes" in the neck. It turns out that the lymph nodes are just one part of a system that extends throughout your body in much the same way your blood vessels do. The main difference between the blood flowing in the circulatory system and the lymph flowing in the lymph system is that blood is pressurized by the heart, while the lymph system is passive. There is no "lymph pump" like there is a "blood pump" (the heart). Instead, fluids ooze into the lymph system and get pushed by normal body and muscle motion to the lymph nodes. This is very much like the water and sewer systems in a community. Water is actively pressurized, while sewage is passive and flows by gravity.

Lymph is a clearish liquid that bathes the cells with water and nutrients. Lymph is blood plasma -- the liquid that makes up blood minus the red and white cells. Think about it -- each cell does not have its own private blood vessel feeding it, yet it has to get food, water, and oxygen to survive. Blood transfers these materials to the lymph through the capillary walls, and lymph carries it to the cells.

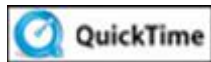
The cells also produce proteins and waste products and the lymph absorbs these products and carries them away. Any random bacteria that enter the body also find their way into this inter-cell fluid. One job of the lymph system is to drain and filter these fluids to detect and remove the bacteria. Small lymph vessels collect the liquid and move it toward larger vessels so that the fluid finally arrives at the lymph nodes for processing.

Lymph nodes contain filtering tissue and a large number of lymph cells. When fighting certain bacterial infections, the lymph nodes swell with bacteria and the cells fighting the bacteria, to the point where you can actually feel them. Swollen lymph nodes are therefore a good indication that you have an infection of some sort.

Once lymph has been filtered through the lymph nodes it re-enters the bloodstream.



Now answer questions 15-17.



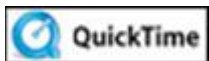
Lymphatic System: Lymph Nodes

Thymus

The thymus lives in your chest, between your breast bone and your heart. It is responsible for producing T-cells (see the next section), and is especially important in newborn babies - without a thymus a baby's immune system collapses and the baby will die. The thymus seems to be much less important in adults - for example, you can remove it and an adult will live because other parts of the immune system can handle the load. However, the thymus is important, especially to T cell maturation (as we will see in the section on white blood cells below).

Spleen

The spleen filters the blood looking for foreign cells (the spleen is also looking for old red blood cells in need of replacement). A person missing their spleen gets sick much more often than someone with a spleen.



The Spleen: Where Red Blood Cells Retire

Bone marrow

Bone marrow produces new blood cells, both red and white. In the case of red blood cells the cells are fully formed in the marrow and then enter the bloodstream. In the case of some white blood cells, the cells mature elsewhere. The marrow produces all blood cells from stem cells. They are called "stem cells" because they can branch off and become many different types of cells - they are precursors to different cell types. Stem cells change into actual, specific types of white blood cells.

White blood cells

White blood cells are described in detail in the next section.



Now answer questions 18-20.

Antibodies

Antibodies (also referred to as immunoglobulins and gammaglobulins) are produced by white blood cells. They are Y-shaped proteins that each respond to a specific antigen (bacteria, virus or toxin). Each antibody has a special section (at the tips of the two branches of the Y) that is sensitive to a specific antigen and binds to it in some way. (if the toxin comes from some form of venom, it is called an antivenin). The binding generally disables the chemical action of the toxin. When an antibody binds to the outer coat of a virus particle or the cell wall of a bacterium it can stop their movement through cell walls. Or a large number of antibodies can bind to an invader and signal to the complement system that the invader needs to be removed.

Antibodies come in five classes:

1. Immunoglobulin A (IgA)
2. Immunoglobulin D (IgD)
3. Immunoglobulin E (IgE)
4. Immunoglobulin G (IgG)
5. Immunoglobulin M (IgM)

Whenever you see an abbreviation like IgE in a medical document, you now know that what they are talking about is an antibody.



Now answer question 21.

White Blood Cells

You are probably aware of the fact that you have "red blood cells" and "white blood cells" in your blood. The white blood cells are probably the most important part of your immune system. And it turns out that "white blood cells" are actually a whole collection of different cells that work together to destroy bacteria and viruses. Here are all of the different types, names and classifications of white blood cells working inside your body right now:

- Leukocytes
- Lymphocyte

- Monocytes
- Granulocytes
- B-cells
- Plasma cells
- T-cells
- Helper T-cells
- Killer T-cells
- Suppressor T-cells
- Natural killer cells
- Neutrophils
- Eosinophils
- Basophils
- Phagocytes

Leukocytes

Learning all of these different names and the function of each cell type takes a bit of effort, but you can understand scientific articles a lot better once you get it all figured out! Here's a quick summary to help you get all of the different cell types organized in your brain.

All white blood cells are known officially as leukocytes. White blood cells are not like normal cells in the body -- they actually act like independent, living single-cell organisms able to move and capture things on their own. White blood cells behave very much like amoeba in their movements and are able to engulf other cells and bacteria. Many white blood cells cannot divide and reproduce on their own, but instead have a factory somewhere in the body that produces them. That factory is the bone marrow. Leukocytes are divided into three classes:

- Granulocytes - Granulocytes make up 50% to 60% of all leukocytes. Granulocytes are themselves divided into three classes: neutrophils, eosinophils and basophils. Granulocytes get their name because they contain granules, and these granules contain different chemicals depending on the type of cell.
- Lymphocyte - Lymphocytes make up 30% to 40% of all leukocytes. Lymphocytes come in two classes: B cells (those that mature in bone marrow) and T cells (those that mature in the thymus).
- Monocyte - Monocytes make up 7% or so of all leukocytes. Monocytes evolve into macrophages.

All white blood cells start in bone marrow as stem cells. Stem cells are generic cells that can form into the many different types of leukocytes as they mature. For example, you can take a mouse, irradiate it to kill off its bone marrow's ability to produce new blood cells, and then inject stem cells into the mouse's blood stream. The stem cells will divide and differentiate into all different types of white blood cells. A "bone marrow transplant" is accomplished simply by injecting stem cells from a donor into the blood stream. The stem cells find their way, almost magically, into the marrow and make their home there. (See the [Blood& Marrow Transplantation FAQ](#) to learn more about marrow transplants.)

Different Roles

Each of the different types of white blood cells have a special role in the immune system, and many are able to transform themselves in different ways. The following descriptions help to understand the roles of the different cells.

- Neutrophils are by far the most common form of white blood cells that you have in your body. Your bone marrow produces trillions of them every day and releases them into the bloodstream, but their life span is short -- generally less than a day. Once in the bloodstream neutrophils can move through capillary walls into tissue. Neutrophils are attracted to foreign material, inflammation and bacteria. If you get a splinter or a cut, neutrophils will be attracted by a process called chemotaxis. Many single-celled organisms use this same process -- chemotaxis lets motile cells move toward higher concentrations of a chemical. Once a neutrophil finds a foreign particle or a bacteria it will engulf it, releasing enzymes, hydrogen peroxide and other chemicals from its granules to kill the bacteria. In a site of serious infection (where lots of bacteria have reproduced in the area), pus will form. Pus is simply dead neutrophils and other cellular debris.
- Eosinophils and basophils are far less common than neutrophils. Eosinophils seem focused on parasites in the skin and the lungs, while Basophils carry histamine and therefore important (along with mast cells) to causing inflammation. From the immune system's standpoint inflammation is a good thing. It brings in more blood and it dilates capillary walls so that more immune system cells can get to the site of infection.
- Of all blood cells, macrophages are the biggest (hence the name "macro"). Monocytes are released by the bone marrow, float in the bloodstream, enter tissue and turn into macrophages. Most boundary tissue has its own devoted macrophages. For example, alveolar macrophages live in the lungs and keep the lungs clean (by ingesting foreign particles like smoke and dust) and disease free (by ingesting bacteria and microbes). Macrophages are called langerhans cells when they live in the skin. Macrophages also swim freely. One of their jobs is to clean up dead neutrophils -- macrophages clean up pus, for example, as part of the healing process.
- The lymphocytes handle most of the bacterial and viral infections that we get. Lymphocytes start in the bone marrow. Those destined to become B cells develop in the marrow before entering the bloodstream. T cells start in the marrow but migrate through the bloodstream to the thymus and mature there. T cells and B cells are often found in the bloodstream but tend to concentrate in lymph tissue such as the lymph nodes, the thymus and the spleen. There is also quite a bit of lymph tissue in the digestive system. B cells and T cells have different functions.
- B cells, when stimulated, mature into plasma cells -- these are the cells that produce antibodies. A specific B cell is tuned to a specific germ, and when the germ is present in the body the B cell clones itself and produces millions of antibodies designed to eliminate the germ.
- T cells, on the other hand, actually bump up against cells and kill them. T cells known as Killer T cells can detect cells in your body that are harboring viruses, and when it detects such a cell it kills it. Two other types of T cells, known as Helper and Suppressor T cells, help sensitize killer T cells and control the immune response.





Now answer questions 22-25.



Below are additional educational resources and activities for this unit.

[Unit 5 Immune System Terms](#)

[Unit 5 Immune System Matching](#)

[Unit 5 Immune System Matching Key](#)