In the last chapter, you explored the lymphatic system and how it provides immunity to our body. If you recall, there are two different types of immunity: innate (nonspecific) immunity and adaptive (specific) immunity.

Our innate immunity has been with us since birth and is made up of defense mechanisms which do not identify one type of threat from another. Adaptive defenses utilize multiple immune cells which target and attack specific pathogens.

One question you may be asking is...

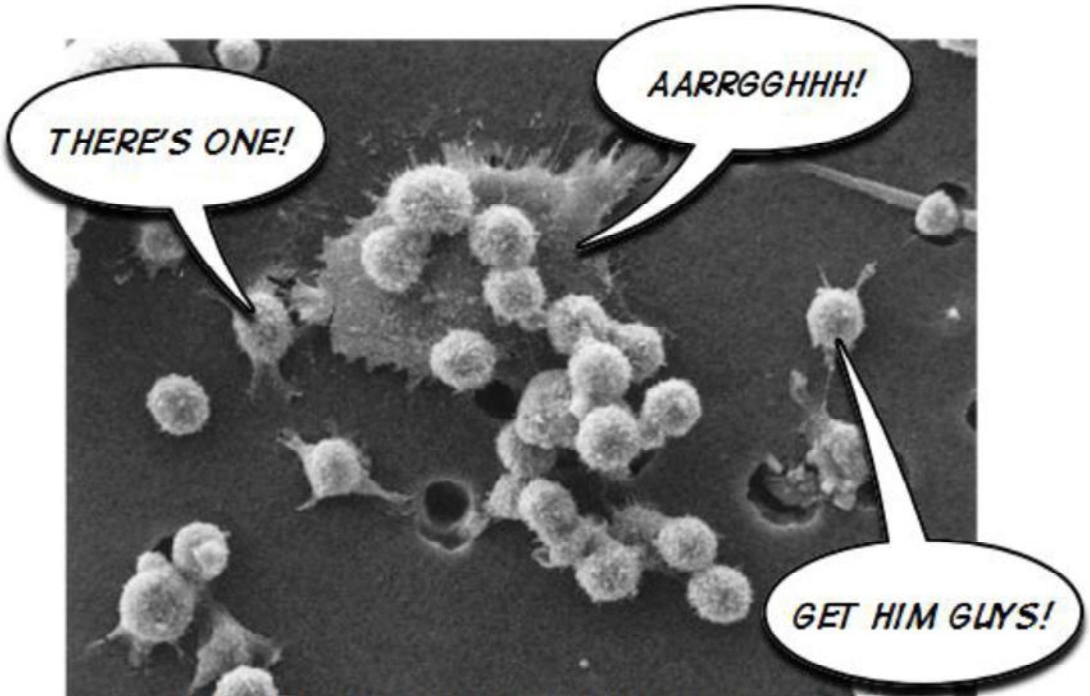
How do cells attack and destroy their targets?

This is a very good question whose answers could fill volumes of books. For the purpose of this textbook however, we will simplify this down to three of our most popular attackers: T cells, NK cells, and **macrophages**.

- NK cells utilize chemicals to break down the cell membrane of abnormal cells within the body. These cells are very good at identifying and destroying cancerous cells in many different ways!

- T cells also utilize chemical weaponry to attack cells that have been marked for death. Several different types of compounds can be secreted by "killer" T cells once they have been programmed to attack a specific target within the thymus.

- Macrophages are unique cells which work within both the innate immunity and the adaptive immunity. Their primary role is to consume pathogens or cellular fragments within the blood and lymph. You first learned about phagocytic cells back in Chapter 15 as "tiny protectors…which literally mean 'cells that eat.'"



MACROPHAGES HUNTING DOWN CANCER CELLS

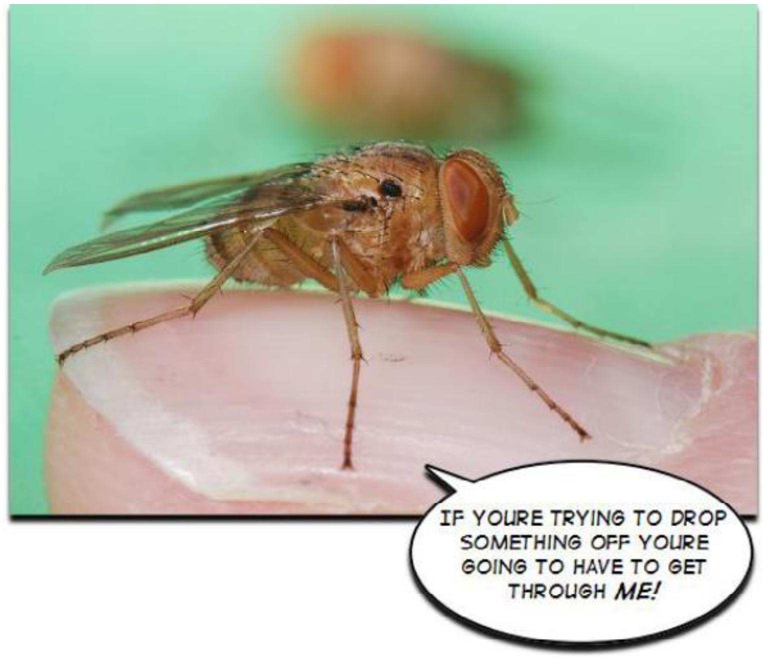
Now let's take a deeper look into our innate and adaptive immunities. Our first stop...

Innate (nonspecific) Immunity

Our innate immunity has seven different defensive tools in its arsenal:

Physical barriers
Phagocytic cells
Immunological surveillance
Interferons
Complement
Inflammation
and Fever

Physical barriers



Physical barriers such as hair and fingernails keep dangerous organisms and materials from entering the body. For example, a bacterium that lands on your finger is unlikely to enter your body as it cannot penetrate your fingernail.

Immunological surveillance

Immunological surveillance is a defense mechanism utilized in large part by the natural killer (NK) cells. NK cells recognize and destroy abnormal cells found within our bodies. The way these cells recognize abnormal cells is very similar to a process you learned back in Chapter 16 about red blood cells and the specific "locks" on their outer surface known as antigens. Abnormal cells (such as cancer cells) contain antigens on their outer surface that are detected by the "keys" of the natural killer cells. Once any of these abnormal cells have been recognized, NK cells rapidly attack and destroy its target.

Interferons

Interferons are proteins which are released by lymphocytes and cells which are infected with viruses. These proteins have two functions: 1) bind to the surface of healthy cells neighboring the infected cells and instruct them to produce their own protective proteins. These proteins are a defense mechanism to prepare the cell should the virus find a way inside its membrane; and, 2) interferons floating throughout the body tend to flag NK cells and macrophages towards the area of infection. With more defenders in the area of infection, there is a greater chance that any pathogens in the area will be identified and attacked.

Complement

Complement is a group of proteins circulating through the blood and lymph which assists or "complements" the actions of our adaptive (specific) immunity. Generally speaking, complementary proteins help to "mark" pathogens by attaching themselves to the foreign invader.

As more and more complement proteins attach themselves to a pathogen, a series of steps (which we do not have the time to discuss here) take place which can either destroy the cell membrane of the pathogen, allow it to be attacked by NK cells and macrophages more easily, or trigger the release of a chemical known as **histamines** which help to trigger inflammation and increased blood flow towards the infected area.

Inflammation

Inflammation is a topic you first learned about in Chapter 7. Inflammation involves swelling, redness, excessive warmth, and pain in the area that contains the damaged tissues. These actions produce an environment which is not favorable for bacteria and viruses to grow and reproduce thus keeping the pathogens within the area of infection from spreading further.

Fever

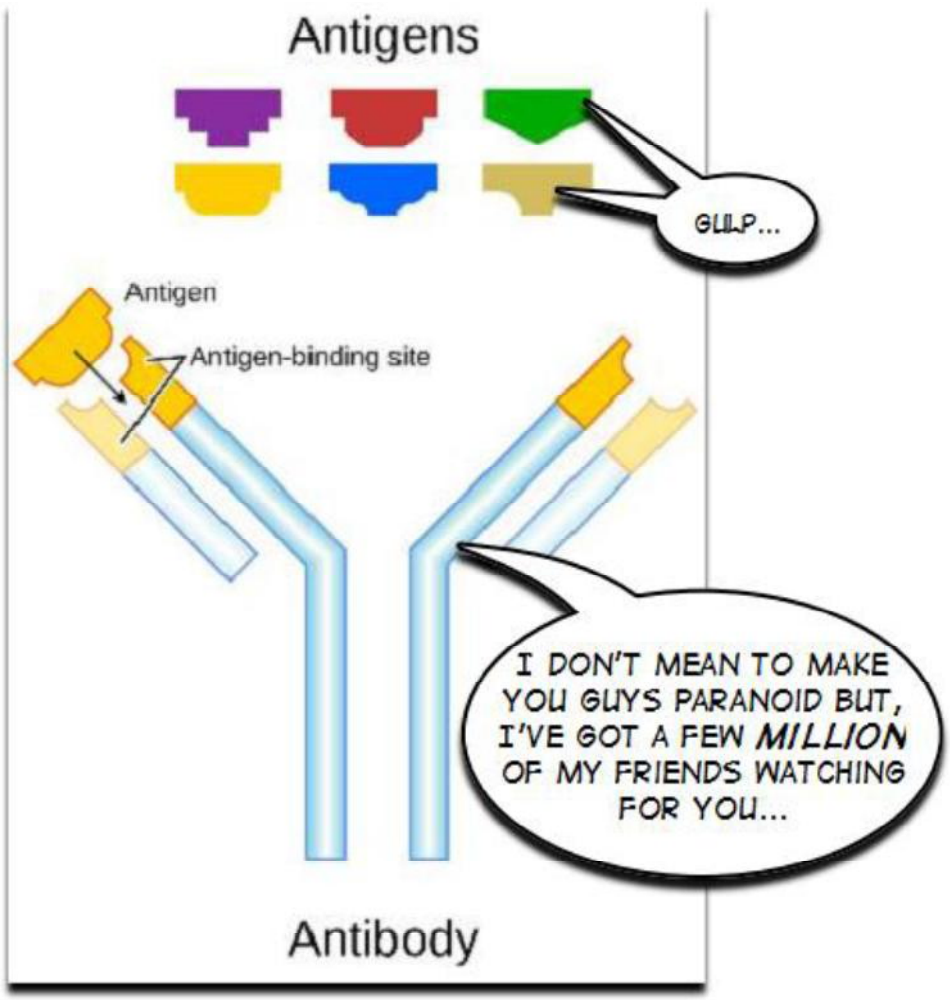
Fever is a condition in which the body temperature is increased above 37.2°C (99°F). A fever can be helpful to the immune system as the increased temperature decreases the growth of some bacteria and viruses. In addition, cellular motion and chemical reactions tend to speed up in warmer environments which, in turn, increase the speed of the immune system to repair infected areas.

Remember, all of these defenses have been present since the day you were born and act the same regardless of the type of pathogen. In this next section, we will look at another type of immune system which responds to specific threats to our health.

Adaptive (specific) Immunity

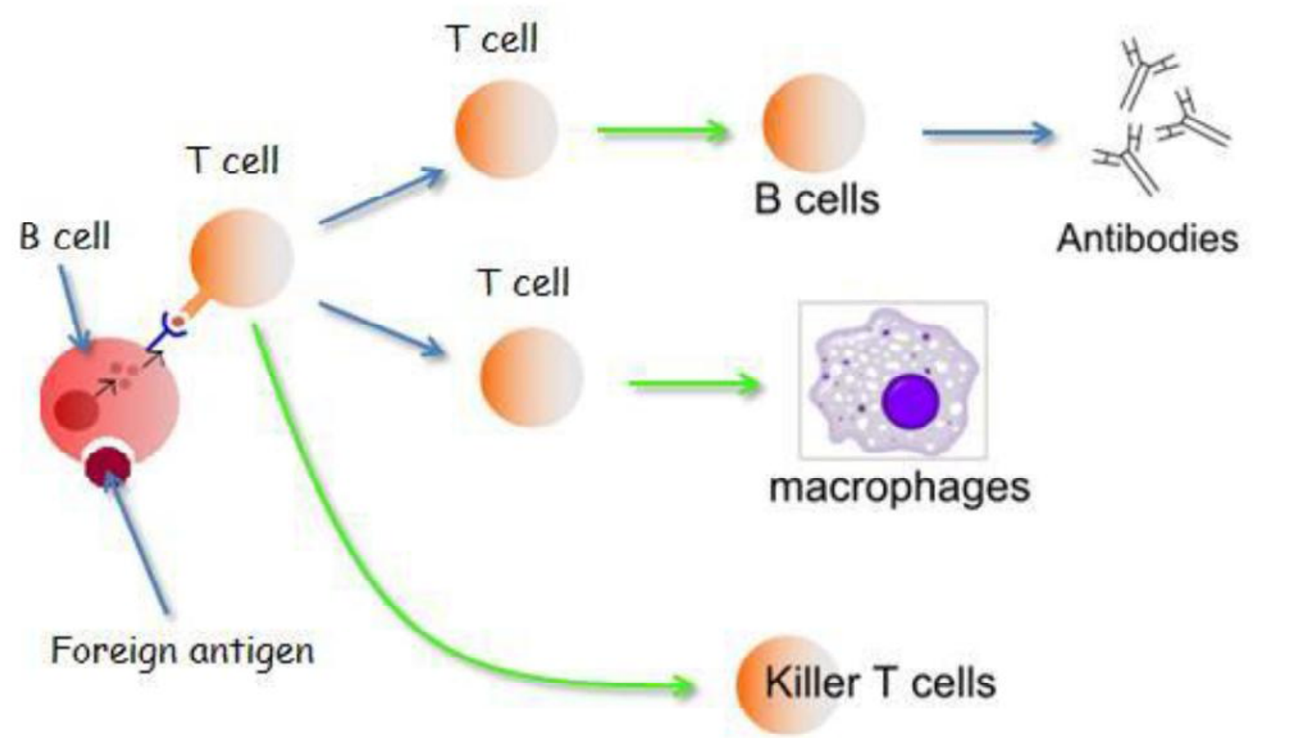
Our adaptive immunity is not present within us at the time of our birth. Instead, we acquire this type of immunity after we are exposed to particular surface antigens of pathogens or if we receive particular antibodies from another source.

Antibodies are large Y-shaped proteins produced by the B cells which can identify and attach themselves to the foreign invaders within the body. Although the general structure of antibodies is the same, a small area at their tip contains unique chemical "keys" which can only bind with specific antigens (locks) on the surface of pathogens. This allows millions of different antibodies to exist within the body, all prepared to attach themselves to unique pathogens.



Antibodies work with the complement proteins of our innate immunity to help mark specific pathogens for attack.

Once attached, the pathogen is marked for attack by various cells of the immune system. During an infection, B cells will congregate within areas such as the lymph nodules where they can concentrate their production of specific antibodies. The following image will help you understand the various roles of the B cell within our immune response:



B cells are triggered when they encounter a matching antigen. The B cell engulfs the antigen and digests it, allowing fragments of the digested material outside on its surface. These fragments are identified by a mature T cell. This activates the T cell to produce chemicals known as cytokines (simulated by the green arrows in the diagram) that further stimulate the activity of macrophages, killer T cells and B cells, the latter producing antibodies.

Our adaptive immunity can be broken down into two separate sections:

Active Immunity and Passive Immunity

Active Immunity

Our **active immunity** develops when our body produces its own antibodies in response to the presence of a foreign antigen. As you just read, the body is capable of housing millions of different antibodies, each designed to mark an individual antigen. However, this defense mechanism is only activated **after** an antigen is detected. Our active immunity can be further broken down into two subsections:

Naturally acquired active immunity

and

Artificially acquired active immunity

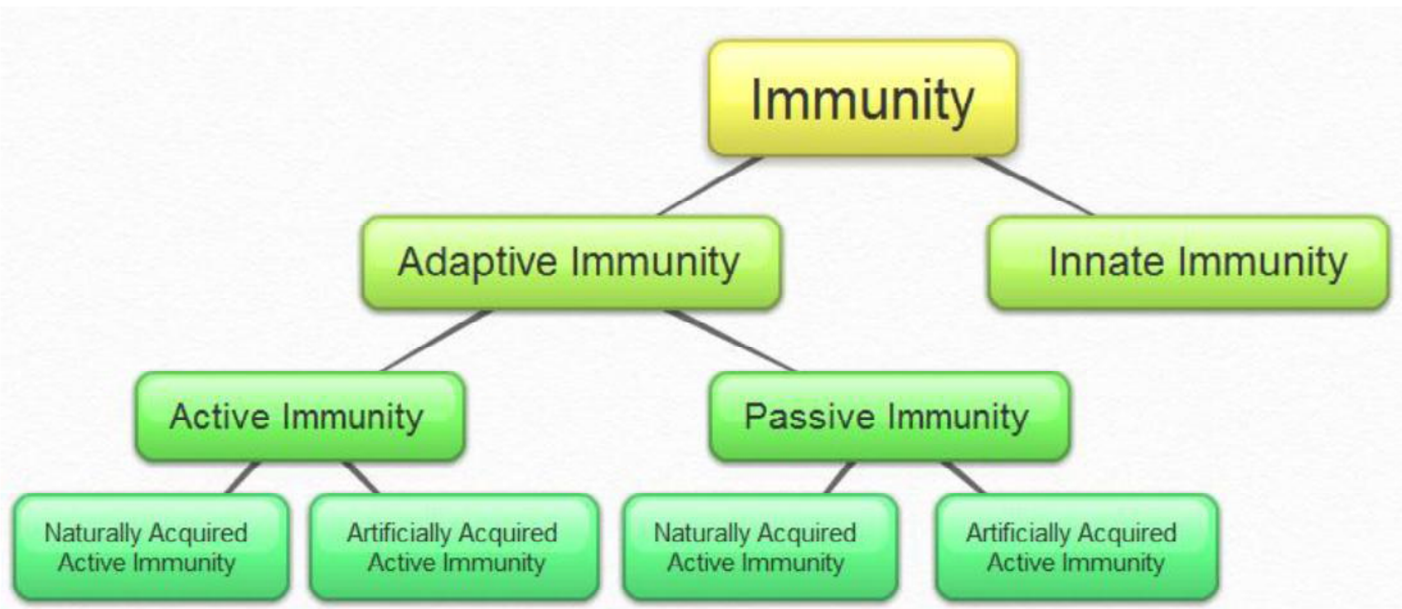
A **naturally acquired active immunity** develops from birth and continues throughout a person's lifetime. In essence, every foreign antigen triggers the development of a new antibody which can patrol the body for years.

An **artificially acquired active immunity**, much like the use of a **vaccine**, stimulates the body to produce antibodies under safe conditions. With the production and distribution of these antibodies within the body, future exposure to the same pathogen can more readily be identified and destroyed. A vaccine is a solution containing dead or inactive pathogens along with their unique antigens. The presence of these antigens within the body will trigger the production of specific antibodies; however, as these pathogens are either dead or inactive, they are unable to cause a patient to become ill.

Passive Immunity

Our **passive immunity** can be either naturally or artificially acquired as well. This type of immunity is produced by transferring antibodies from another source. For example, a **naturally acquired passive immunity** is generated within a baby as she received antibodies from her mother through breast milk. Antibodies can also be placed within our bodies, as when we receive an injection following a rabid dog bite. This injection contains the antibodies needed to attack the rabies virus and is an example of an **artificially acquired passive immunity**.

The following chart will help you separate the individual levels of our immune system:



Let's take a moment to explore what we have learned so far.

Foreign pathogens are initially repelled by the body through ***physical barriers*** *such as hair and nails. However, if these particles find their way into the body, a series of activities within our* ***innate immunity*** *work to stop them from spreading. Abnormal (cancerous) cells are also identified and destroyed by the* ***NK cells*** *of our innate immunity.*

Our adaptive immunity works to identify pathogens by reading the unique antigens their surfaces. This is accomplished through the work of the B cell lymphocyte. B cells engulf and display fragments of antigens on their surface which are read by the T cells. Once attached, T cells release cytokines which stimulate activity of killer T cells, macrophages, or additional B cells which can generate large numbers of antibodies into the blood. These antibodies will continue to fasten themselves to the surface antigens of the pathogen throughout the body. These antibodies act as "flags" for attack by other cells such as macrophages or "killer" T cells which have been programmed to identify these individualized antibodies during their maturation process within the thymus.

Since your immune system must be prepared to identify any antigen at any time, multiple copies **(clones)** of lymphocytes are produced when they come into contact with a specific antigen. Each of these clones is able to identify the same type of antigen. This is very important as it takes a massive amount of lymphocytes to overcome the rapid growth and spread of many pathogens. Two different types of clones are produced after connecting with a surface antigen. One type actively works to destroy the invading pathogen; the other becomes an army of **memory cells**.

These types of cells remain inactive and flow throughout the body. Once these memory cells encounter the same antigens in future infections, they may be quickly activated to generate a faster immune response than compared to the first infection. At any given time, the human body contains an army of memory T and B cells flowing through its blood and lymph in addition to a wealth of antibodies pre-programmed to mark future pathogens for attack as well. This explains how unlikely it is to contract the same disease (such as chicken pox or measles) twice in your life.

The molecular actions of our adaptive immunity are remarkable! Researchers are discovering new activities of our immune system every day. You will not be disappointed by spending a little time studying the innovative details of our amazing immune system beyond this textbook.

In the next chapter, we will be exploring some of the common problems that occur within the fluids, transport systems, and immune responses of our body.

Anatomy & Physiology - Connections

How the following body systems affect the immune system		How the immune system affects the following body systems	
Integumentary	Skin provides protective barrier against incoming pathogens	Secretes antibodies into tissues of integumentary system	**Integumentary**
Skeletal	Hematopoiesis creates white blood cells within red bone marrow	Helps to repair damaged bone tissues	**Skeletal**
Muscular	Contractions of skeletal muscles push lymph through lymphatic vessels	Helps to repair damaged muscle tissues	**Muscular**
Nervous	Production of antigens trigger active immunity	Production of hormones which induce the hypothalmus to secrete several hormones as well	**Nervous**
Endocrine	Production of several hormones which reduce inflammation, produce/mature lymphocytes, etc.	Production of T cells by thymus; secretion of various hormones assist cells throughout body	**Endocrine**
Cardiovascular	Distributes lymphocytes, antibodies, and proteins needed for blood clots	Defends organs against infection; lymphatic vessels return fluids back into the blood	**Cardiovascular**

Match the following vocabulary terms with their correct definition:

active immunity	inflammation
artificially acquired active immunity	interferons
artificially acquired passive immunity	macrophage
clones	memory cells
complement	naturally acquired active immunity
fever	naturally acquired passive immunity
histamines	passive immunity
immunological surveillance	physical barriers
	vaccine

1) ____________ a condition in which the body temperature is increased above 37.2°C (99°F)

2) ____________ a group of proteins which help to "mark" pathogens by attaching themselves to the foreign invader

3) ____________ a solution of dead or inactive pathogens containing their unique antigens; common source for a person's artificially acquired active immunity

4) ____________ a type of immunity which is produced by transferring antibodies from another source

5) ____________ a type of white blood cell which sweeps through the blood and consumes pathogens and cellular fragments

6) ____________ any one of the many identical copies of specific lymphocytes

7) ____________ chemical which helps to trigger inflammation and increases blood flow towards the infected area

8)	____________	clones which remain inactive and flow throughout the body after an infection; can be quickly activated to generate a faster immune response during future infections
9)	____________	defense mechanism utilized by the natural killer (NK) cells to identify surface antigens on foreign cells before destroying the invader
10)	____________	initial barrier of the body's innate immunity; external structures such as hair and fingernails keep dangerous organisms and materials from entering the body
11)	____________	proteins released by lymphocytes and/or cells which are infected with viruses; tags the infected cells for attack by the immune system or instructs healthy cells to prepare for the impending spread of infection
12)	____________	symptoms such as swelling, redness, excessive warmth, and pain in an area that contains damaged tissues
13)	____________	type of active immunity which develops from birth and continues throughout a person's lifetime
14)	____________	type of active immunity which stimulates the body to produce antibodies under safe conditions
15)	____________	type of immunity which develops after the body produces its own antibodies in response to the presence of a foreign antigen
16)	____________	type of passive immunity in which antibodies are transferred into another individual through artificial means (i.e. as through a tetanus or rabies shot)
17)	____________	type of passive immunity in which antibodies are transferred into another individual without any artificial means (i.e. via breast milk)

Choose the correct answer from the following questions:

1) **Tissues invaded by viruses may secrete proteins called __________ to protect nearby cells from becoming infected.**
   A) histamine
   B) memory cells
   C) complement
   D) interferon

2) **What specific type of acquired immunity do vaccines provide:**
   A) naturally acquired artificial immunity
   B) naturally acquired passive immunity
   C) artificially acquired passive immunity
   D) artificially acquired active immunity
   E) naturally acquired active immunity

3) **Which one of the following is NOT one of the four most common indicators of the inflammation:**
   A) redness
   B) heat
   C) swelling
   D) pain
   E) fever

4) **The body's first line of defense against the invasion of pathogens is:**
   A) phagocytes
   B) skin
   C) natural killer cells
   D) fever
   E) inflammation

5) **True or false:** Natural killers are unique phagocytic defense cells that can kill cancer cells well before the immune system is activated.

6) **True or false:** Artificially acquired passive immunity is administered to a person when one receives "anti-venom" after being bit by a poisonous snake.

Application Question:

You learned in Chapter 11 that the cornea and lens of the eye both refract (bend) light as it enters the eye. What you may not have known is that both of these structures are completely lacking in capillaries. How do you believe this fact is related to the high success of transplants of corneas from donors?

Chapter 21

Fluid Transportation: What can go wrong?