

The Immune System and Disease

Chapter 40: Biology II

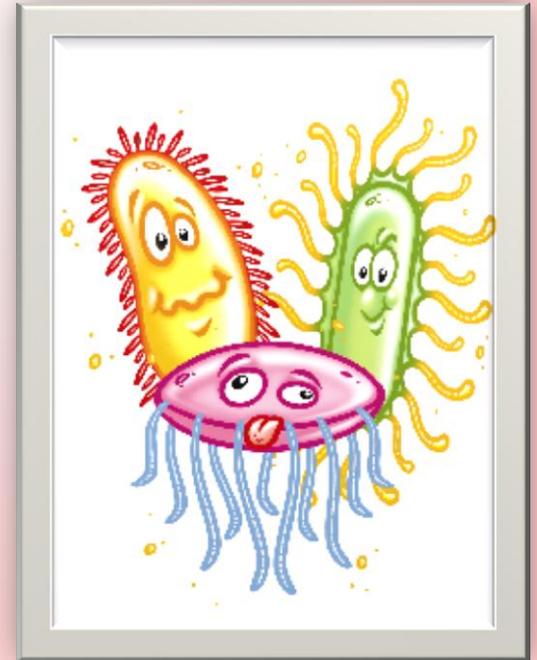
Disease

- Any change, other than an injury, that disrupts the normal functions of the body
 - Inherited
 - Hemophilia
 - Environmental
 - Cigarette smoke
 - Infectious
 - Bacteria
 - Viruses
 - Fungi
 - Protozoa
 - Parasites



Infectious Disease

- Pathogens: disease-causing agents
- “sickness-makers”
- Enter, or infect, the body of the person who gets sick



The Germ Theory of Disease

- Idea that infectious diseases are caused by microorganisms, or germs
- People use to think that diseases were caused by curses, evil spirits, or night vapors

The Germ Theory of Disease

- Louis Pasteur
 - French scientist in the 1850s
 - Proposed that specific microorganisms caused diseases
- Joseph Lister
 - British surgeon 1860s
 - Patients survived operations more often when operating tools were cleaned (Listerine was named after him!!!)
- Robert Koch
 - German scientist
 - Found he could make a healthy animal sick by injecting it with pathogens from a sick animal

History of Medicine

FIGURE 31.1 History of Medicine

Most modern understanding about diseases occurred after Pasteur's **germ theory**.

B.C. 7000

Spirits Ancient societies drill holes in people's heads to release the evil spirits believed to cause disease.



A.D. 1330–1352

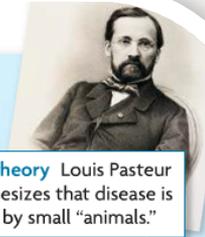
Herbal treatments People use incense in an attempt to cure those with the Black Death, caused by bacteria transmitted by rats' fleas.



(LM; magnification 15x)

1857

Germ theory Louis Pasteur hypothesizes that disease is caused by small "animals."



B.C. A.D.

B.C. 460–B.C. 377

Humors Greek physician Hippocrates hypothesizes that fluids, called humors, cause disease.



1400–1600

Anatomy People begin to study anatomy. This drawing was made in the Middle East in 1555.

1865

Antiseptic technique Joseph Lister finds that cleaning his surgical tools reduces patients' infections.



1883

Koch's postulates Robert Koch finds four conditions that prove a pathogen causes a disease.

1928

Antibiotics Sir Alexander Fleming discovers penicillin.



1900

1900s

Applying antiseptic technique Cities around the world start treating drinking water with chlorine, reducing the cases of cholera.



1955

Polio vaccine Jonas Salk's vaccine against polio becomes available. The disease is eliminated in the U.S. in 1994.



2002

New diseases First cases of SARS, a disease that affects the respiratory system, spring up in China.

2000

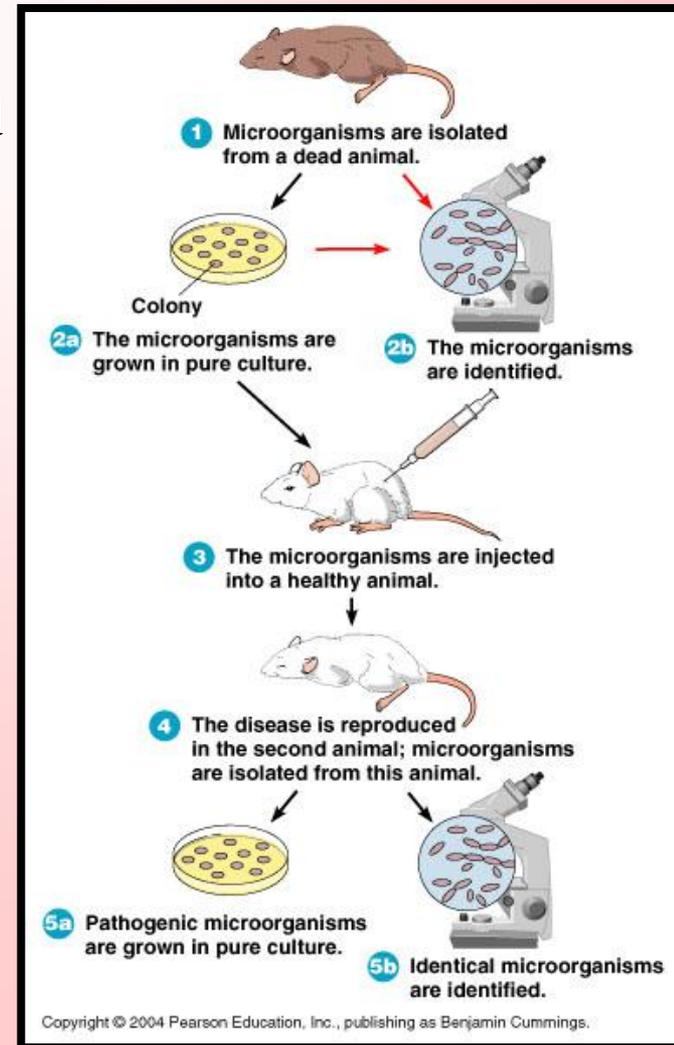
2005

Polio comeback Worldwide efforts increase to vaccinate people against polio, and the polio virus reemerges in fewer than ten people in the U.S.



Koch's Postulates

- 1. The pathogen should always be found in the body of a sick organism and should not be found in a healthy one
- 2. The pathogen must be isolated and grown in the laboratory in pure culture
- 3. When the purified pathogens are placed in a new host, they should cause the same disease that infected the original host
- 4. The injected pathogen should be re-isolated from the second host. It should be identical to the original pathogen

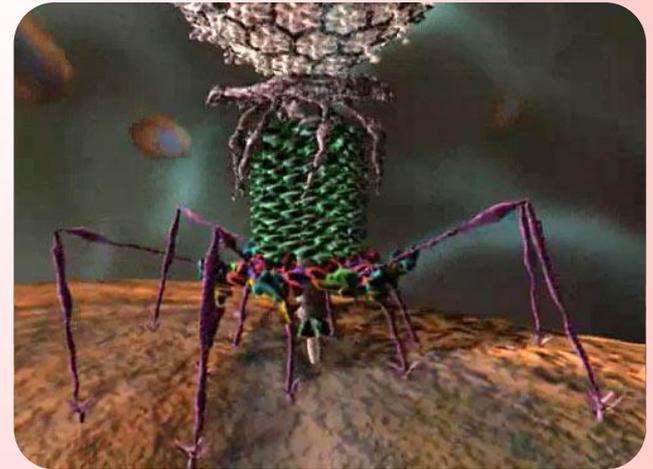


Agents of Disease

- Bacteria: either break down the tissues in an infected organism or release toxins into the body
- Toxins: poisons that produce illness by disrupting bodily functions

Agents of Disease

- Protists: can act as parasites
- Fungi: can act as parasites
- Worms: can act as parasites
- Viruses: nonliving pathogen; uses the materials of a host cell to make copies of the virus until the cell bursts

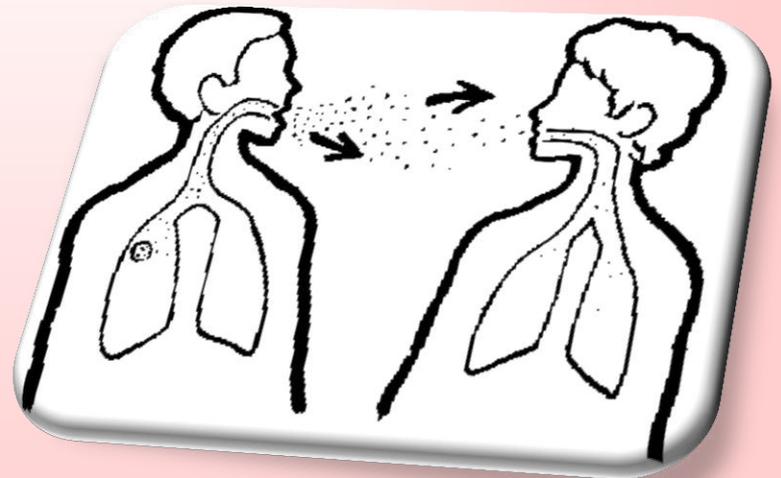


Common Infectious Diseases

DISEASE	PATHOGEN TYPE	HOW IT SPREADS	AFFECTED BODY SYSTEMS	DEATHS ANNUALLY
HIV	virus	body fluids	immune	3,100,000
Pneumonia	virus, bacteria	airborne	respiratory	2,000,000
Tuberculosis	bacteria	airborne	respiratory, digestive	1,800,000
Malaria	protozoa	mosquito bite	digestive, circulatory, muscular	1,000,000
Hepatitis B	virus	contaminated food/water	digestive, immune	1,000,000
Measles	virus	airborne	respiratory, nervous	500,000
Influenza	virus	airborne, direct contact	respiratory	400,000

How Diseases Are Spread

- One person to another
 - Coughing
 - Sneezing
 - Physical contact
- Contaminated food or water
- Infected animals

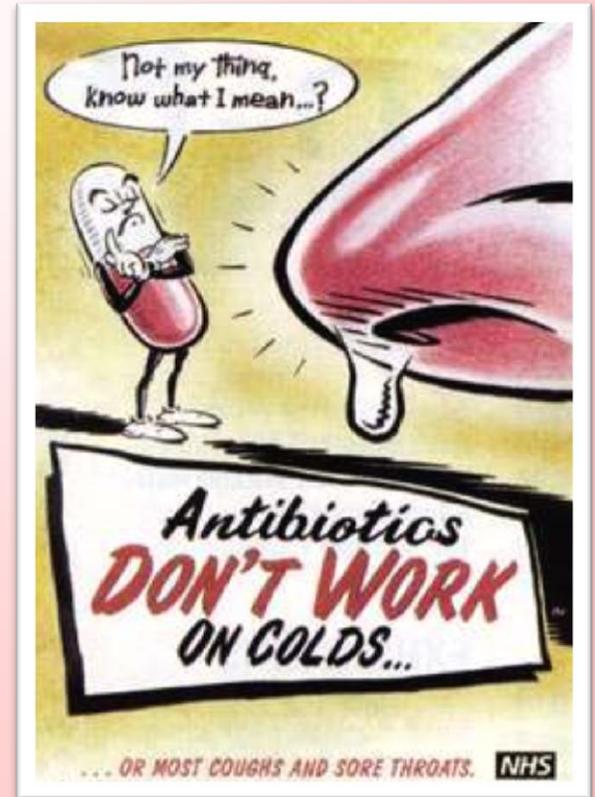


How Diseases Are Spread

- Vector: animal that carries disease-causing organisms from person to person
 - Ticks
 - Mosquitoes
- Sexually Transmitted Diseases (STDs): spread from person to person by sexual contact
 - Hepatitis B, hepatitis C, genital herpes, AIDS

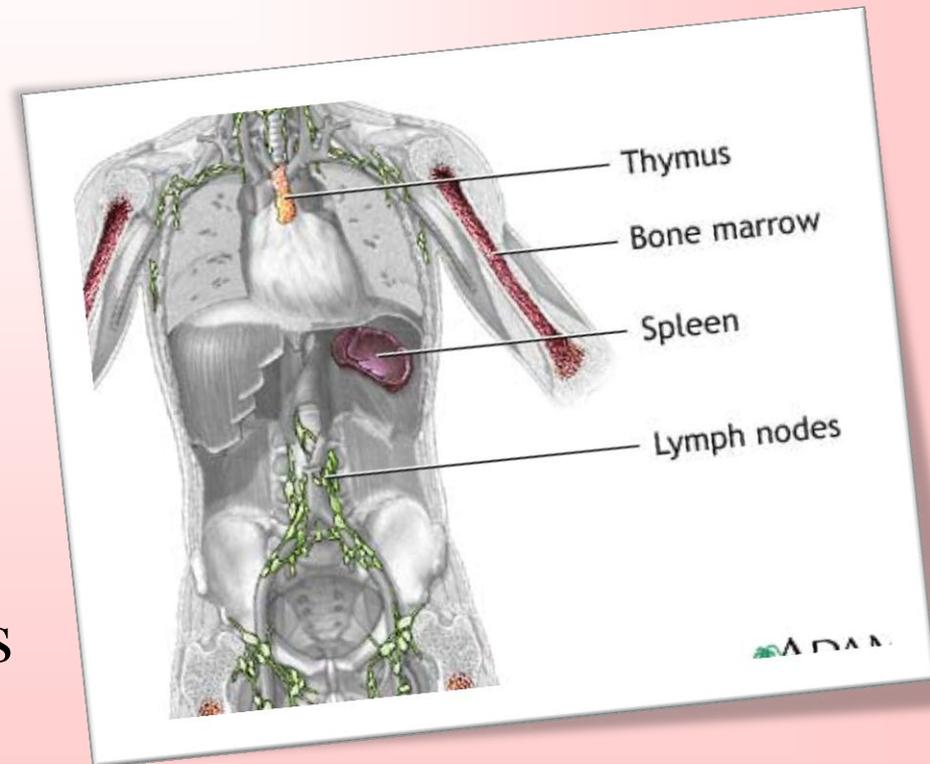
Fighting Infectious Diseases

- Antibiotic: compound that blocks the growth and reproduction of bacteria
- Do not harm the cells of humans or animals
- Penicillin: first antibiotic



The Immune System

- Body's primary defense against pathogens
- Nonspecific defenses: keep everything out
- Specific defenses: track down harmful pathogens that have managed to break through the body's nonspecific defenses

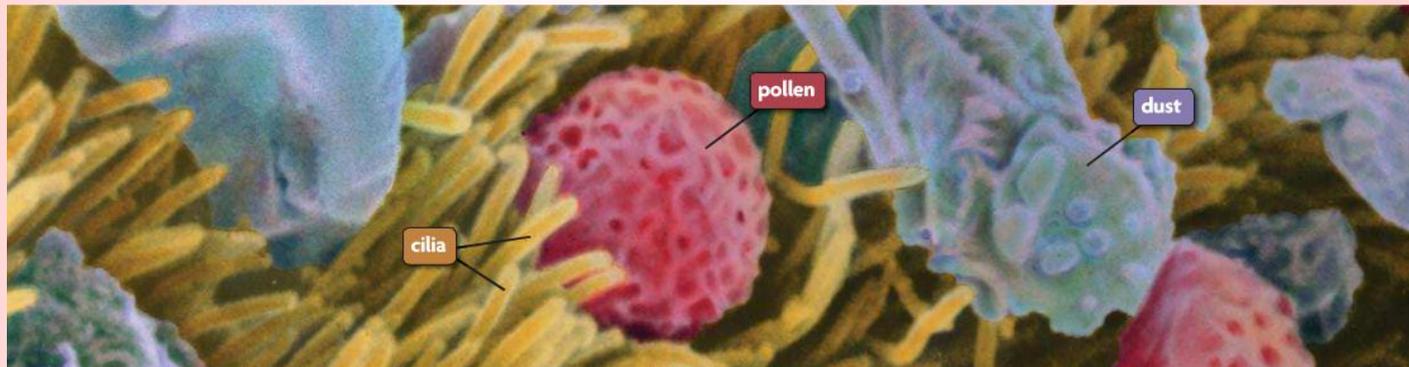


First Line of Defense

- KEEP PATHOGENS OUT!
- Skin, mucus, sweat, and tears protect you
- Skin: most important nonspecific defense
 - Oils and sweat glands make an acidic environment that kills bacteria
- SKIN IS BROKEN, OH NO!!
 - Pathogens can enter your body and multiply
 - Cause symptoms such as swelling, redness, and pain
 - Can enter through your mouth and nose

First Line of Defense

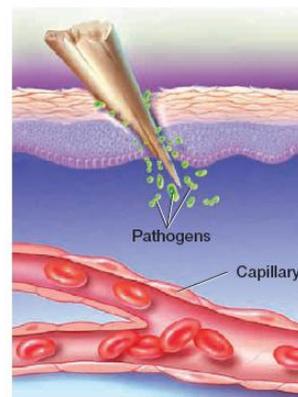
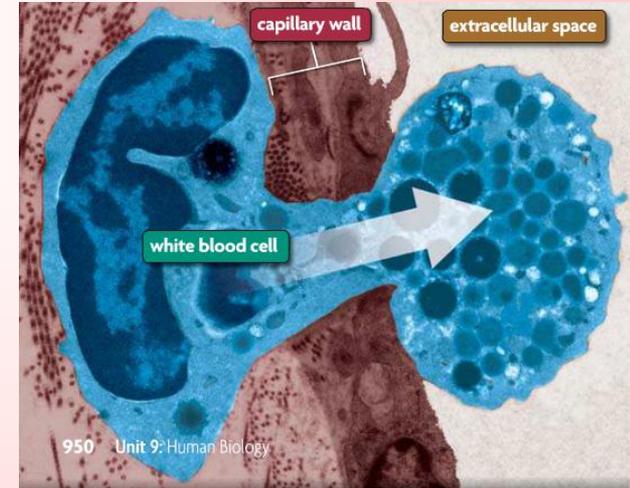
- Mucus in nose and throat traps viruses and bacteria and cilia push them away from your lungs



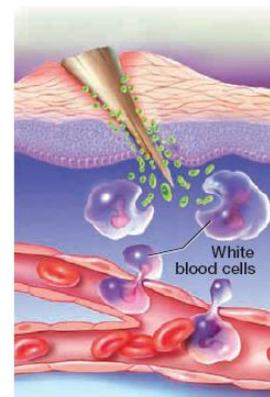
- Stomach acid and digestive enzymes destroy many pathogens that make their way into your stomach
- Lysozyme: an enzyme that breaks down the cell walls of many bacteria found in body secretions (mucus, saliva, sweat & tears)

Second Line of Defense

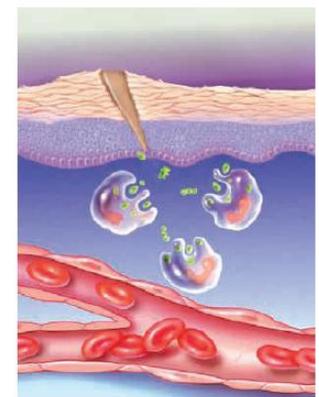
- INFLAMMATORY RESPONSE: if pathogens enter the body
- Nonspecific defense reaction to tissue damage caused by injury or infection
- Blood vessels near the wound expand, and WBCs leak from the vessels to enter infected tissues



1. When the skin is punctured, pathogens enter the body.



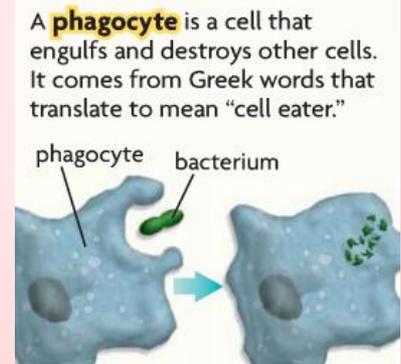
2. Blood flow to the area increases, causing swelling and redness.



3. White blood cells attack and destroy the pathogens.

Second Line of Defense

- Phagocytes: WBCs that engulf and destroy bacteria
- Infected tissue may become swollen and painful
- Immune system produces millions of WBCs, which fight the infection
- Fever: elevated body temperature that occurs in response to infection



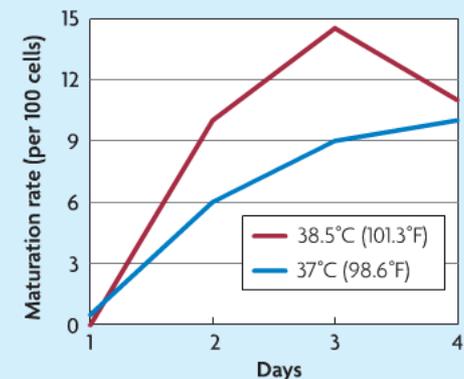
Second Line of Defense

- Elevated temperature slows or stops the growth of such pathogens
- Increases heart rate so that WBCs get to the infection sites faster

FIGURE 31.6 White Blood Cells

NAME	FUNCTION
Basophil	makes chemicals that cause inflammation in the bloodstream
Mast cell	makes chemicals that cause inflammation in other body tissues
Neutrophil	engulfs pathogens and foreign invaders; phagocyte
Macrophage	engulfs dead or damaged body cells and some bacteria; phagocyte
Lymphocyte	destroys infected body cells or produces proteins that inactivate pathogens
Eosinophil	injects poisonous packets into parasites, such as protozoa

FIGURE 31.9 WHITE BLOOD CELL MATURATION



Scientists put immature white blood cells in a nutrient solution and found that they matured faster when the cells were heated as in a low fever (red line).

Interferon

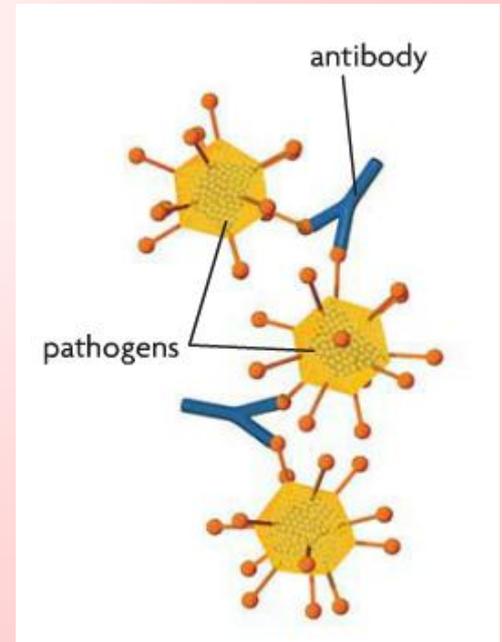
- One of a group of proteins that helps cells resist viral infection
- They “interfere” with the virus
- Inhibit the synthesis of viral proteins in infected cells and help block viral replication

Specific Defenses

- If a pathogen gets past the nonspecific defenses, the immune system reacts with a series of specific defenses that attack the disease-causing agent
- Immune response: the body's specific defenses that attack a disease-causing agent
- Antigen: protein markers on the surfaces of cells and viruses that help the immune system identify a foreign cell or virus
- Antibody: specialized protein that helps destroy disease-causing organisms

Specific Defenses

- Humoral Immunity: immunity against pathogens in the body fluids that relies on antibodies
 - Causes pathogens to burst, become inactive, or clump
- Cell-Mediated Immunity: an immune response in which killer T cells attack antigen-bearing cells directly
 - cause pathogens to burst



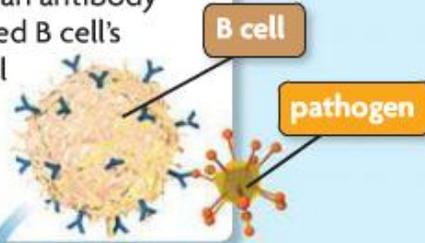
Specific Defenses

- Memory Cell: specialized white blood cell that contributes to acquired immunity by acting quickly to a foreign substance that infected the body previously
 - T Cell: WBC that matures in the thymus and destroys infected body cells by causing them to burst; also called T-lymphocyte
 - B Cell: WBC that matures in the bone marrow and produces antibodies that fight off infection; also called B-lymphocyte

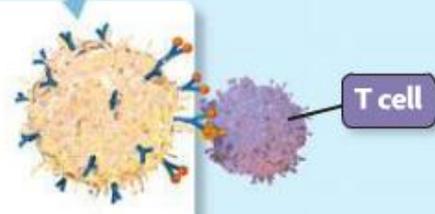
FIGURE 31.11 Humoral Immunity

In **humoral immunity**, B cells produce antibodies that help destroy pathogens.

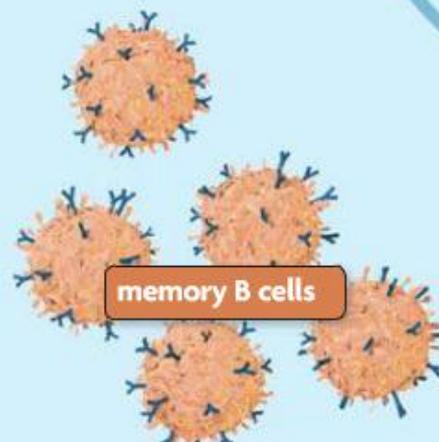
- 1** A pathogen binds to an antibody that is in an inactivated B cell's membrane. The B cell keeps a part of the antigen attached to its antibody.



- 2** A T cell binds to the trapped antigen fragment and stimulates the B cell.



- 3** The B cell divides and differentiates into memory B cells and activated B cells.



- 5** Phagocytes eat the pathogen clumps.



- 4** The activated B cells produce antibodies that cause the pathogens to clump.

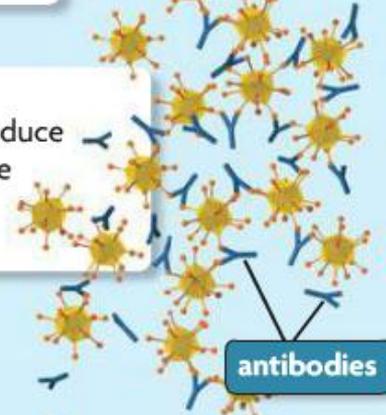
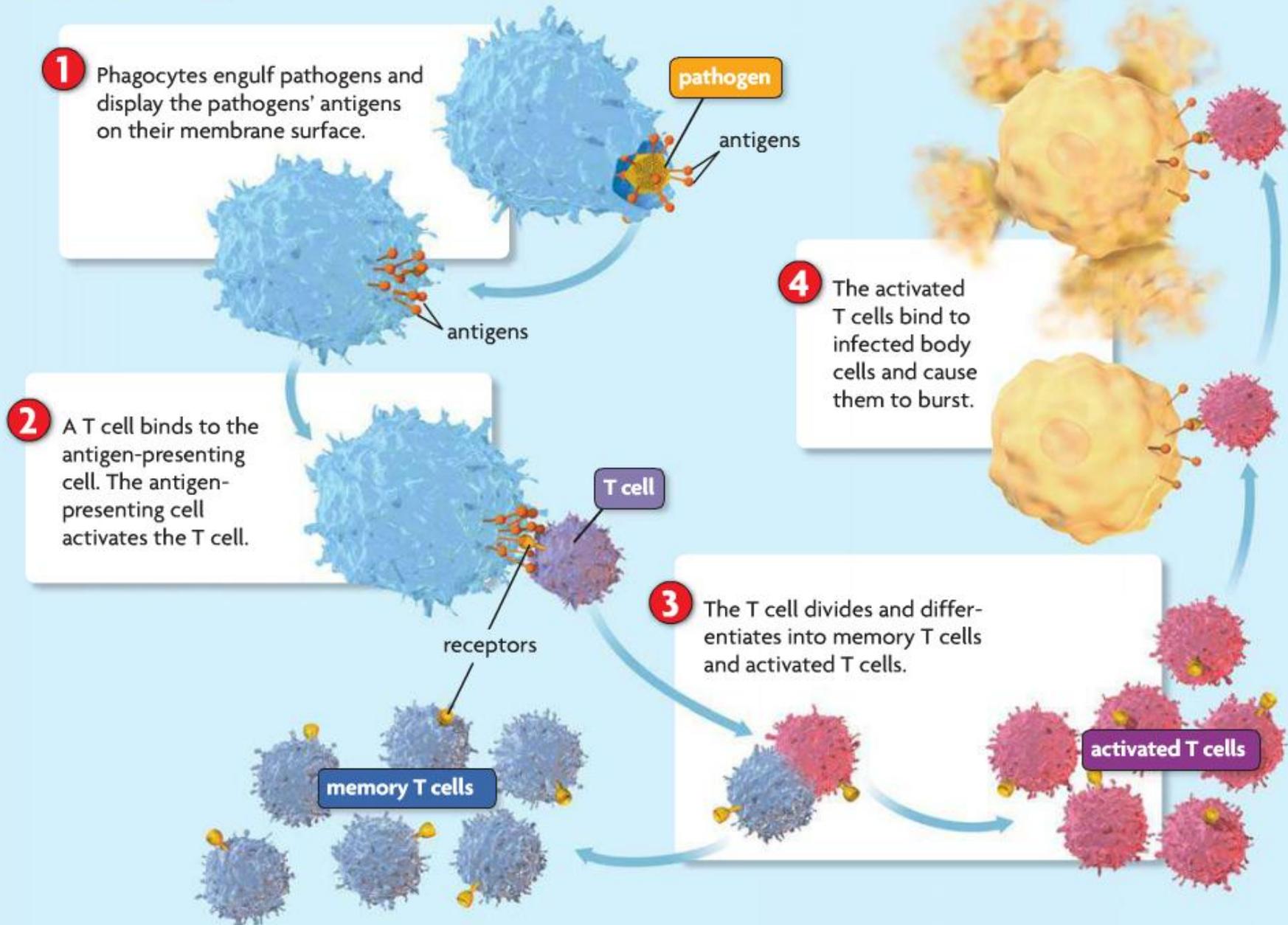


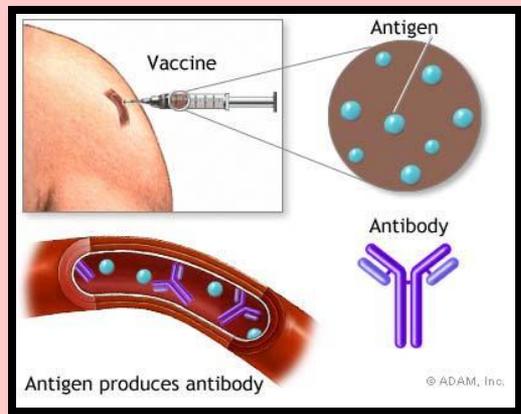
FIGURE 31.10 Cellular Immunity

In **cellular immunity**, T cells destroy infected body cells.



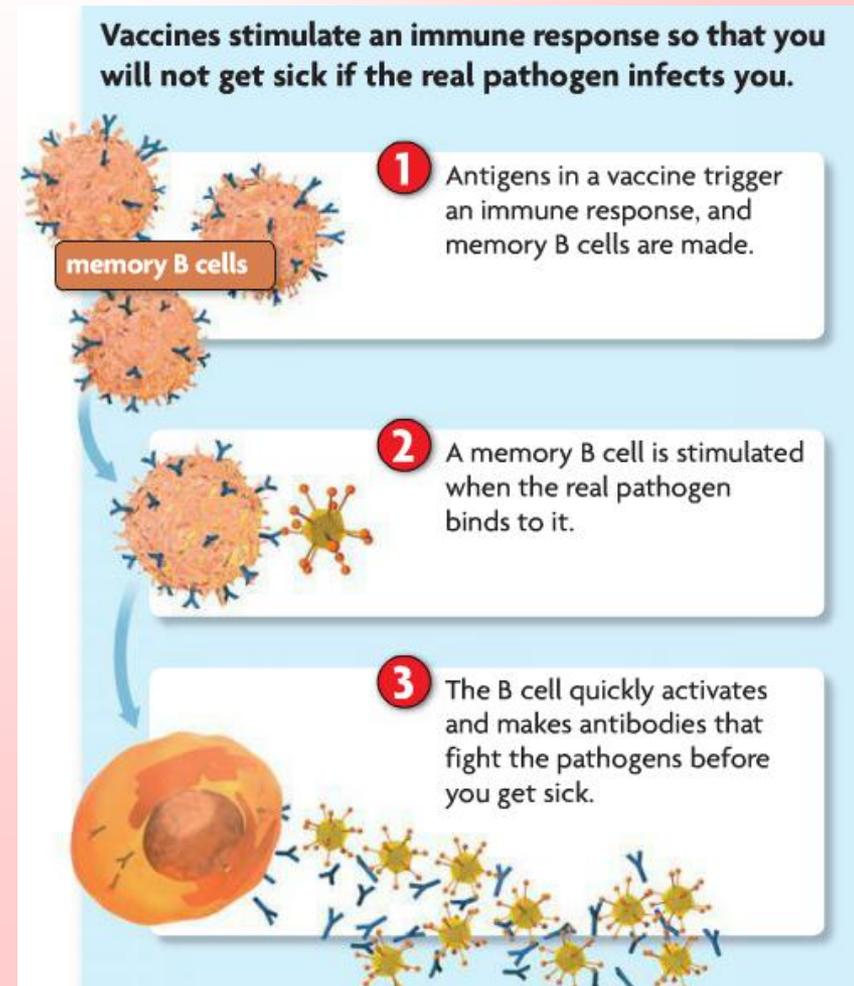
Specific Defenses

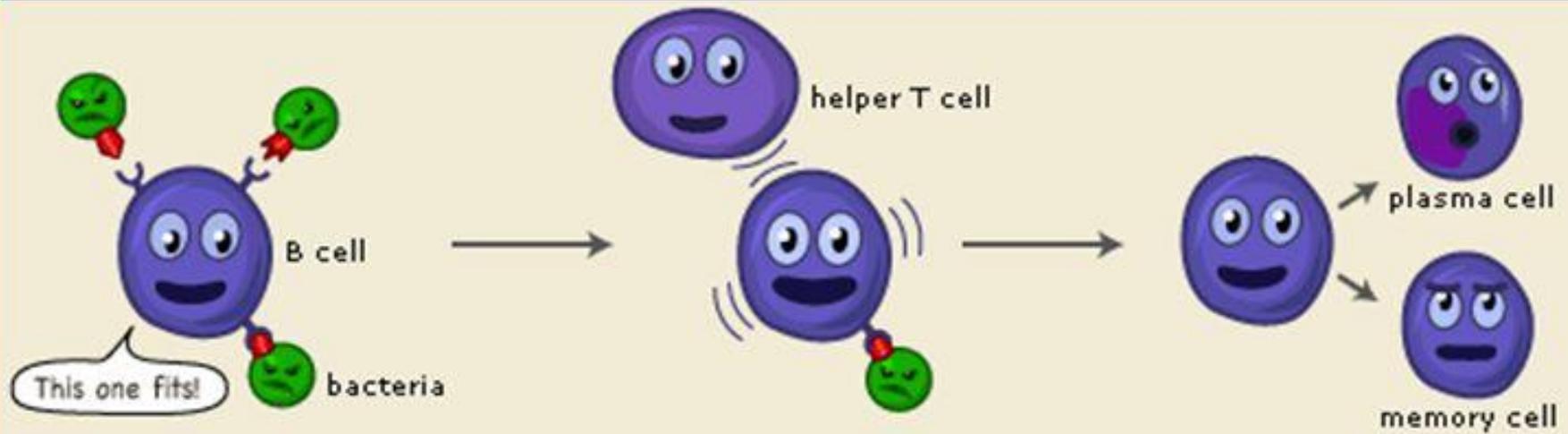
- Permanent immunity: condition in which people who have survived exposure to a disease never develop it again
- Examples: measles, smallpox



Active Immunity

- Immunity produced by a vaccine
- The body has the ability to mount an active immune response against the pathogen
- Vaccination: injection of a weakened or mild form of a pathogen to produce immunity

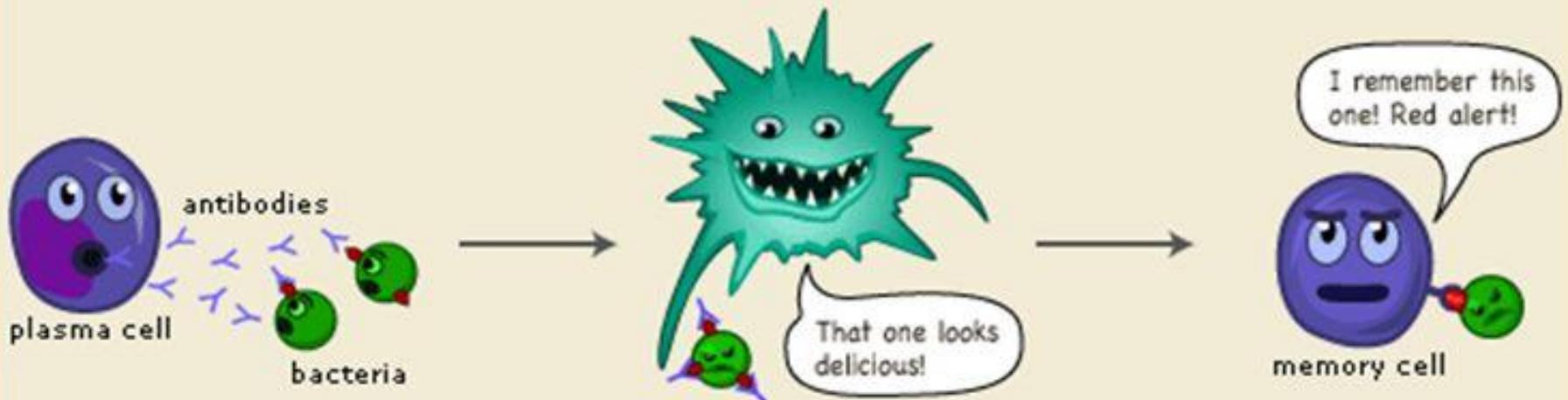




1. The B cell finds an antigen which matches its receptors.

2. It waits until it is activated by a helper T cell.

3. Then the B cell divides to produce plasma and memory cells.



4. Plasma cells produce antibodies that attach to the current type of invader.

5. "Eater cells," prefer intruders marked with antibodies, and "eat" loads of them.

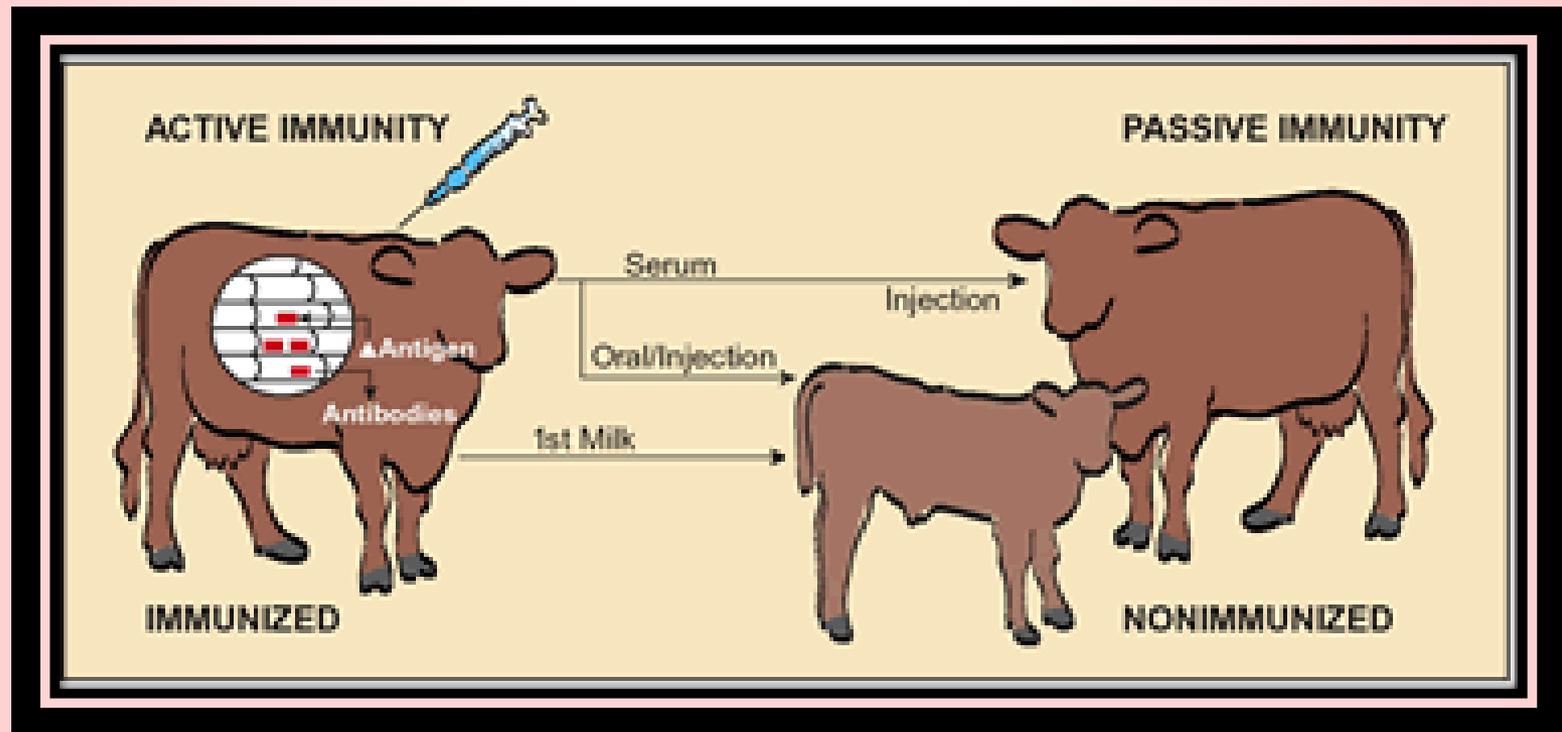
6. If the same intruder invades again, memory cells help the immune system to activate much faster.

Passive Immunity

- Antibodies produced by other animals for a pathogen are injected into the bloodstream
- Lasts only a short time because the body destroys the borrowed antibodies
- Example: maternal immunity



Active and Passive Immunity



Immune System Disorders

- The immune system may overreact to an antigen, producing discomfort or even disease
- The cellular nature of the immune response is a potential weak point
- What would happen if a disease attacked the lymphocytes, which are the heart of the immune system?

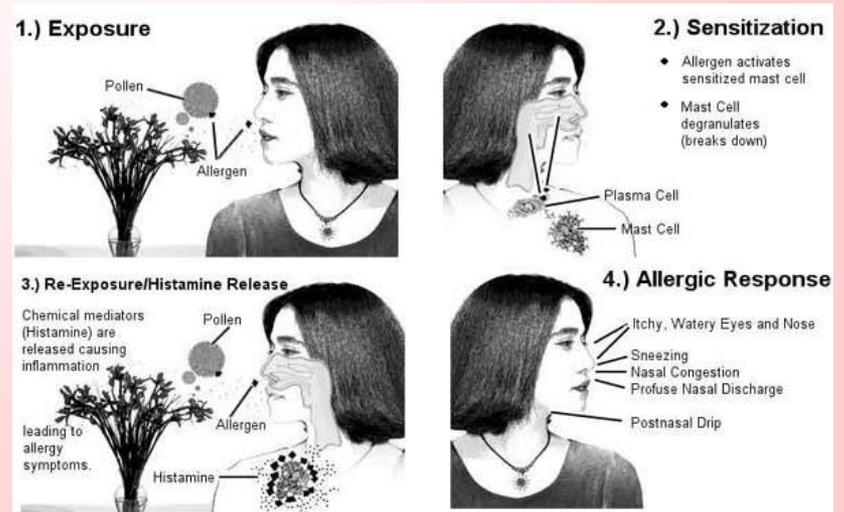
Allergy

- Overreaction of the immune system that results when antigens bind to mast cells
- Mast cells: type of immune cell; common in the linings of the nasal passages
- Histamine: chemical released by activated mast cells that increase the flow of blood and fluids to the surrounding area
- Produce the sneezing, runny eyes and nose



Allergy

- Antihistamines: drugs that are used to counteract the effects of histamines
- Asthma: allergic reaction in which smooth muscle contractions reduce the size of air passageways in the lungs and make breathing very difficult



Autoimmune Disease

- When the immune system makes a mistake and attacks the body's own cells
- Normally the immune system can distinguish between “self” and “nonself”
- Juvenile-onset diabetes, myasthenia gravis, multiple sclerosis, AIDS

Autoimmune Diseases

AUTOIMMUNE DISEASES	BODY SYSTEMS AFFECTED	THE IMMUNE SYSTEM . . .	HOW MANY AFFECTED
Rheumatoid arthritis	integumentary	breaks down tissues that line joints, making movement difficult	70 in 10,000
Type 1 diabetes mellitus	endocrine, digestive	attacks the pancreas, stopping the digestion of sugars	60 in 10,000
Hashimoto's thyroiditis	endocrine	attacks the thyroid gland, causing it to make fewer hormones	15 in 10,000
Multiple sclerosis (MS)	nervous	breaks down myelin sheaths, disrupting nerve communication	10 in 10,000
Graves' disease	endocrine	stimulates the thyroid gland, causing it to make more hormones	5 in 10,000

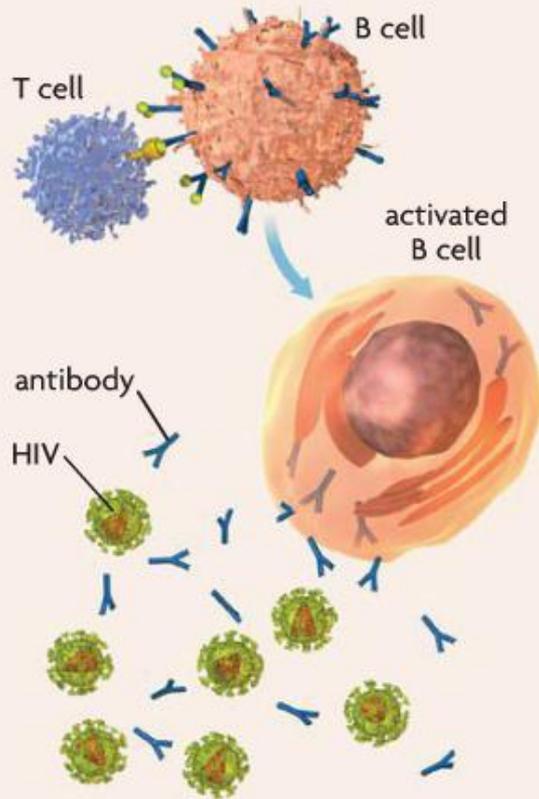
AIDS

- Acquired Immune Deficiency Syndrome
- Protozoa in the lungs, fungal infections in the mouth and throat, and a rare form of skin cancer
- Caused by HIV: human immunodeficiency virus

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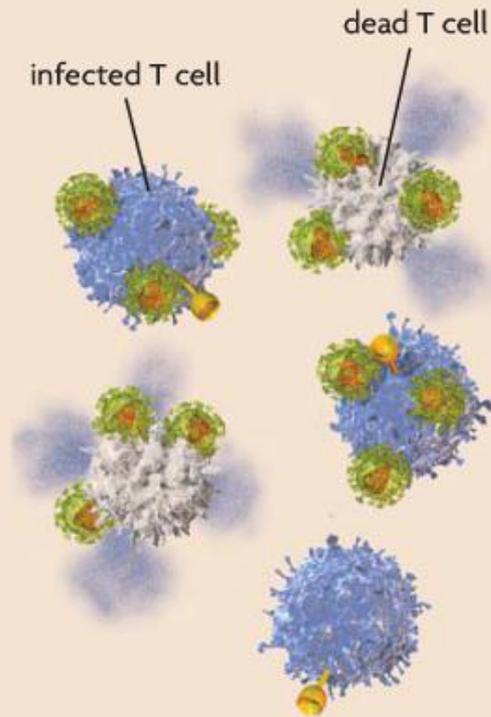
HIV ENTERS THE BODY

When HIV first enters the body, T cells activate B cells, and the activated B cells make antibodies against HIV.

**2**

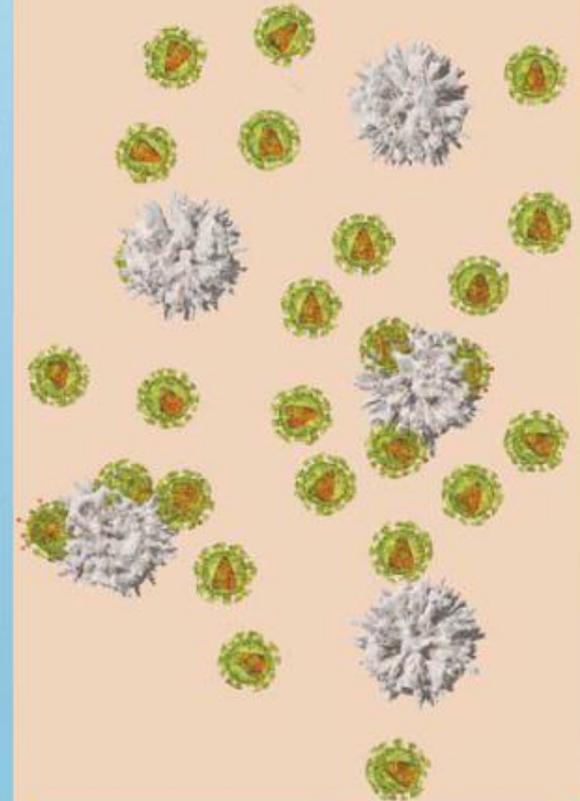
HIV DESTROYS T CELLS

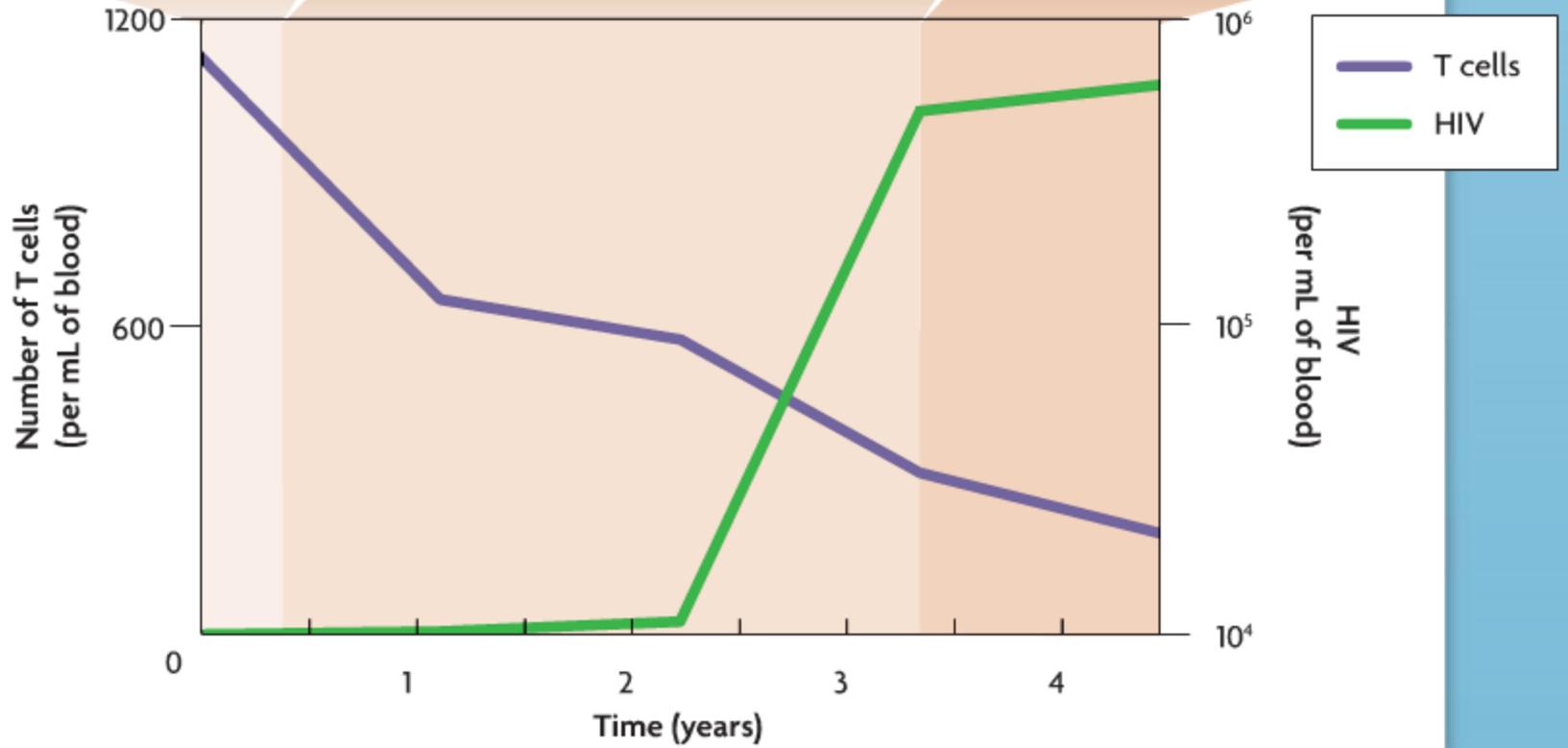
Because HIV kills T cells and reproduces more quickly than T cells, as HIV continues to reproduce, fewer and fewer T cells remain in the body.

**3**

HIV OVERPOWERS THE IMMUNE SYSTEM

With fewer T cells, B cells cannot be activated to make antibodies. HIV and pathogens that cause opportunistic diseases take over the body.





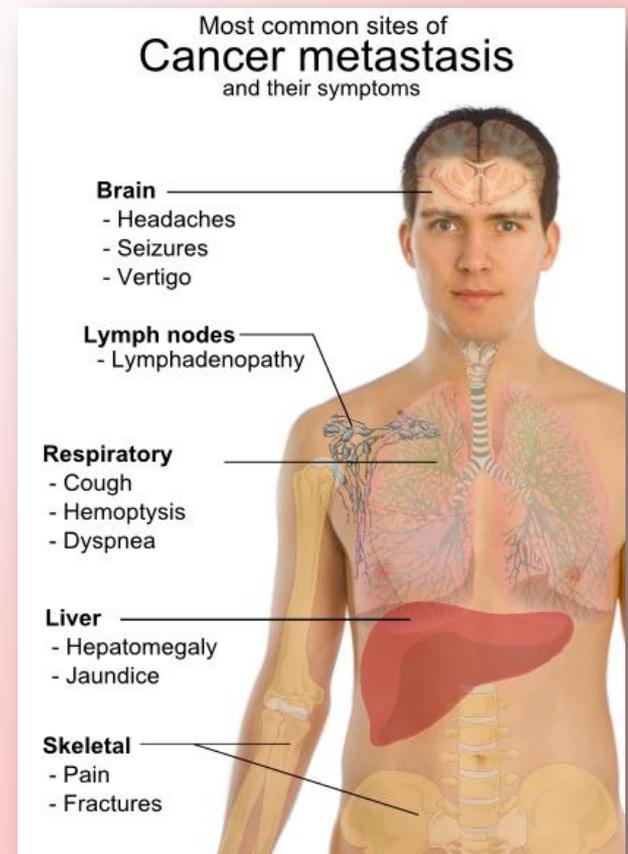
Source: Mellors, J.W. et al.
Annals of Internal Medicine.

A Cellular Disease

- Cancers begin when something goes wrong with the controls that normally regulate cell growth and division
- Tumor: mass of growing tissue that may form when a cell or group of cells begins to grow and divide uncontrollably

A Cellular Disease

- Malignant: term used to describe cancerous tumors, which can invade and destroy surrounding healthy tissue
- Metastasis: spread of cancerous tumor beyond its original site



Causes of Cancer

- Caused by defects in the genes that regulate cell growth and division
- Viral cancers
- Radiation
- Chemicals

Fighting Cancer

- Protect your DNA from agents that cause cancer
- Don't smoke! Exercise regularly! Eat a balanced diet!
- Surgery
- Radiation Therapy
- Drug Therapy/Chemotherapy

Teachable Moment...Current Meningitis Outbreak

What is Meningitis?

- Inflammation of the coverings of the brain and spinal cord
- Viral: fairly common. It usually does not cause serious illness. In severe cases, it can cause prolonged fever and seizures.
- Bacterial: not as common but is very serious. It needs to be treated right away to prevent brain damage and death.
- BOTH ARE CONTAGIOUS.

Fungal Meningitis

- Rare and usually the result of spread of a fungus through blood to the spinal cord.
- NOT CONTAGIOUS.
- Can be caught after taking medications that weaken your immune system.
 - steroids (such as prednisone)
 - medications given after organ transplantation
 - Anti-TNF medications

OUTBREAK!

- Tainted steroids
- New England Compounding Center, Framingham, MA
- Has killed 32 people and sickened 438 others in 19 states, according to the Centers for Disease Control and Prevention*

- *as of 11/15/12

OUTBREAK!

- Early symptoms
 - headache, fever, dizziness, nausea, sensitivity to light, stiff neck, weakness or numbness, slurred speech and pain, and redness or swelling at the injection site -- can take more than a month to appear.
- The longest duration from the time of injection to the onset of symptoms in the current outbreak is 42 days, according to the CDC.
- Diagnosed through a spinal tap, which draws cerebrospinal fluid from the spine that can be inspected for signs of the disease.
- Once detected, it can be treated with high doses of intravenous antifungal medications.