The Immune System

Disease is any condition that prevents an organism from maintaining homeostasis. In humans, diseases may result from foreign invader organisms called **PATHOGENS** or from **abnormal cells that may lead to cancer.** Human diseases can also result from **toxic substances, poor nutrition, organ malfunction, inherited disorders, or risky personal behaviors.**

Causes of Disease:

- ✓ ***Inherited disorders:*** Down Syndrome, Cystic Fibrosis, Sickle Cell Anemia
- ✓ ***Exposure to Toxins***: Lead Poisoning, Radiation Poisoning
- ✓ ***Poor Nutrition:*** Goiter (iodine deficiency), Anemia (possible iron deficiency), Scurvy (Vitamin C deficiency)
- ✓ ***Organ Malfunction:*** Heart Attack, Diabetes
- ✓ ***High Risk Behaviors:*** Lung Cancer (smoking), Drug Addiction (illegal and prescription drugs), Skin Cancer (tanning – ultraviolet rays)

MCROBES are microscopic organisms such as bacteria or viruses. Many microbes are helpful to your body such as the bacteria that live in your intestines. However, microbes are often pathogens that can cause diseases.

Types of Pathogens that can Cause Diseases

- ✓ ***VIRUSES::*** nonliving, composed of proteins and nucleic acid, **ONLY REPRODUCE INSIDE LIVING HOSTS,** capable of multiplying and spreading quickly
  --examples include the common cold, influenza (flu), AIDS, and chicken pox
- ✓ ***BACTERIA***: one celled organisms, prokaryotic,, rapidly reproduce,
  --some diseases can be caused by poisoning from the release of toxins produced by certain bacteria such as food poisoning.
  --ex of bacteria that cause illnesses include strep throat, staph infection, syphilis,
  -- bacterial infections can be treated with **ANTIBIOTICS** such as penicillin,
- ✓ ***FUNGI;*** made up of one cell (yeast) or many cells (mold)
  -- can cause ringworm, athlete's foot
  -- are generally treated with fungicides and antibiotics (to prevent secondary bacterial infections).
- ✓ ***PARASITES:*** generally one celled organisms that survive by feeding off living hosts
  --ex include leeches, tapeworm, tics (Lyme disease is transmitted by a deer tick), heartworm in dogs and cats (transmitted by a worm

From the point of view of these potential pathogens, a human is a bit like a fortress. The **skin** is thick and very hard to penetrate. In addition, the skin also produces a variety of substances that are harmful to invaders. Openings such as the **eyes, nose, and mouth are protected by fluids or sticky mucus** that capture harmful attackers. The respiratory tract also has mechanical defenses in the form of ***cilia,*** tiny hairs that remove particles. Intruders that get as far as the stomach are up against a sea of **stomach acid** that kills most of them.

First Line of Defense:

- ✓ Skin acts as a protective covering, keeping most pathogens from invading the body
- ✓ Sweat, tears, and mucus, carry many dangerous microbes away from the body,
- ✓ Oil and sweat glands produce an acidic environment that kills many bacteria
- ✓ Some secretions have antimicrobial enzymes that prevent bacteria from entering the body.
- ✓ Cilia of the respiratory system sweep out mucus that can contain trapped microbes
- ✓ Stomach acid kills pathogens that enter through the nose and mouth
- ✓ Many secretions of the body, such as mucus, saliva, sweat, and tears contain the enzyme lysozyme, which catalyzes the reactions to break down the cell walls of many bacteria

But in spite of our fantastic defenses, hostile invaders still manage to get through. Some enter along with our food, while others may sneak in via the nose. And, as we all know, many things can break through our

skin. In everyday life we often receive cuts or scrapes, and every time this happens we face the risk of a full-scale invasion from bacteria or viruses. What is the magic, then, that keeps us healthy most of the time?

Second Line of Defense: When pathogens enter the body, cells are destroyed. The dying cells trigger an automatic response called ***inflammation,*** which includes dilated blood vessels and increased blood flow. An inflammation is the body's equivalent to a burglar alarm. Once it goes off, it draws defensive cells to the damaged area in great numbers. Increased blood flow helps defensive cells reach the place where they're needed. It also accounts for the redness and swelling that occur.

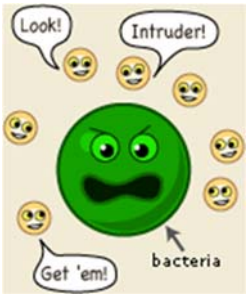
- **Inflammatory response:**
  - ✓ characterized by swelling, redness, soreness and increased temperature to the infected area.
  - ✓ This process is meant to increase the blood supply to the area, increasing oxygen and white blood cells (WBCs) to fight the disease.
  - ✓ **Histamines** (proteins that are responsible for the symptoms of the common cold –sneezing, coughing, red and itching eyes, and a runny nose) are released which cause **vasodilatation** (enlargement of blood vessels) which increase the blood supply and bring more phagocytes to gobble up the pathogens
  - ✓ Increased body temperature occurs in an effort to kill or destroy invading pathogens, many of which can only survive in a narrow range of temperatures.

The cells of the immune system work together with different proteins to seek out and destroy anything foreign or dangerous that enters our body. It takes some time for the immune cells to be activated - but once they're operating at full strength, there are very few hostile organisms that stand a chance.

Immune cells are white blood cells produced in huge quantities in the bone marrow. There are a wide variety of immune cells, each with its own strengths and weaknesses. Some seek out and devour invading organisms, while others destroy infected or mutated body cells. Yet another type has the ability to release special proteins called ***antibodies*** that mark intruders for destruction by other cells.

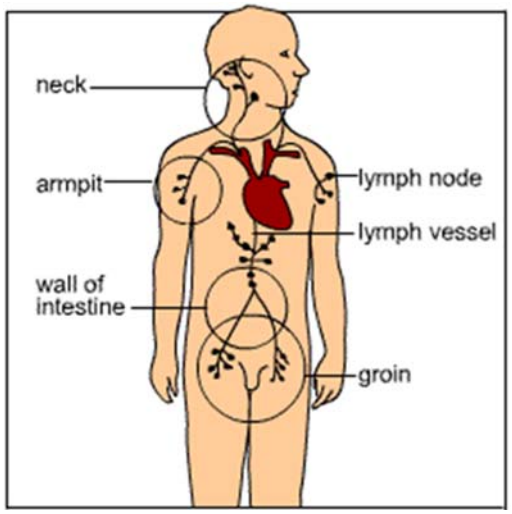
The immune system also has the ability to "remember" pathogens it fought in the past. If the immune system detects a "registered" invader, it will strike much more quickly and more fiercely against it. As a result, an invader that tries to attack the body a second time will most likely be wiped out before there are any symptoms of disease. When this happens, we say that the body has become immune.

ANTIGEN : protein on the surface of an foreign substance that triggers a response from the immune system. Often found on the surface of pathogens. Once identified, these foreign **ANTIGENS** will stimulate the body to produce the **IMMUNE RESPONSE. (antigen-antibody response)**



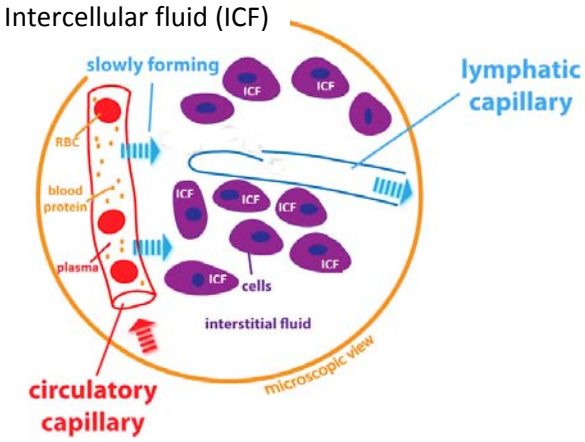
The Complement System: The first part of the immune system that meets invaders such as bacteria is a group of proteins called the ***complement system.*** These proteins flow freely in the blood and can quickly reach the site of an invasion where they can react directly with *antigens to recognize those proteins that are* molecules that the body recognizes as foreign substances. When activated, the complement proteins can **trigger inflammation, attract phagocytic WBCs to the infected area where these cells will "eat the invader by phagocytosis.**

Phagocytes: WBCs specialized in finding and "eating" bacteria, viruses, and dead or injured body cells. There are three main types of phagocytes but the one you should know is the **macrophage** ("big "eaters"). Macrophages play a key part in alerting the rest of the immune system of invaders. Macrophages start out as white blood cells called **monocytes**. *Monocytes that leave the blood stream turn into macrophages*



Lymph System

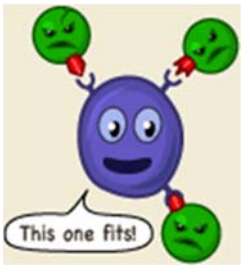
There is a second circulatory system in your body called the **lymph system,** which joins with the circulatory system near the heart. The lymph system is the **body's drainage system**. It is composed of a network of vessels and small structures called **lymph nodes.** The lymph vessels convey excess fluid collected from all over the body back into the blood circulation and also **plays a major role in the body's immune system.** Capillaries flow past cells but do not actually connect to them. What happens is that the clear, watery **blood plasma** -- containing the oxygen, proteins, glucose and white blood cells -- "leaks" out through the capillary walls and flows around all the cells. The pores in the capillaries are too small to let red blood cells through, however -- that is why lymph is clear rather than red. All of the cells in your body are therefore bathed in lymph, and they receive their nutrients and oxygen from the lymph. When the blood plasma leaves the capillaries it is called **intercellular fluid.** When it collects in the lymph ducts and enters the lymph system is it called **lymph. When it returns to the blood, it then becomes plasma again.**



Lymph Nodes: are soft, small, round or bean-shaped structures found in clusters throughout the lymph system such as in the neck, armpits, groin and inside the chest and abdomen. Lymph nodes filter the lymph fluid, removing bacteria, cancer cells, and any other foreign material.

Lymphocytes: WBCs that originate in the bone marrow but then migrate to the lymph system to the lymph nodes, spleen, tonsils, and adenoids. There are two types of lymphocytes:

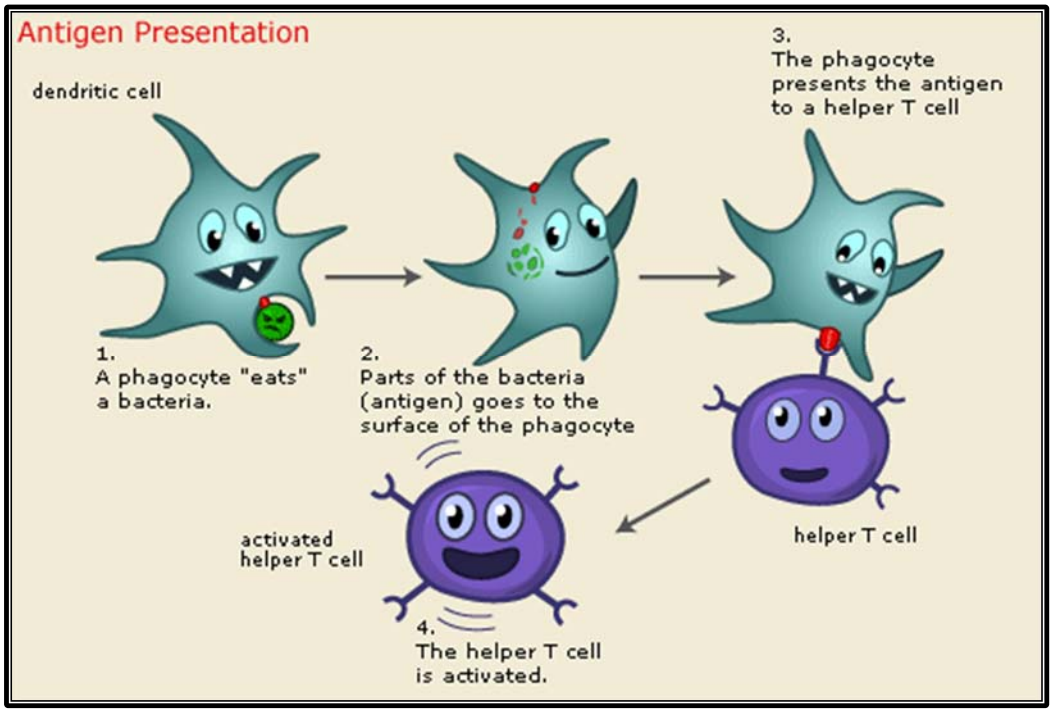
- ✓ **T lymphocytes**: fight pathogens in "front line combat"
- ✓ **B Lymphocytes** produce **antibodies** against a specific antigen

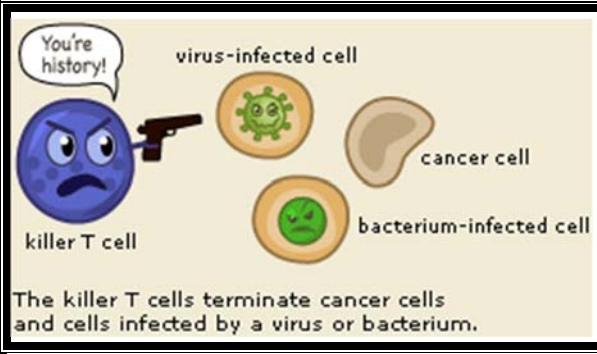


On the surface of each lymphatic cell are receptors that enable them to recognize foreign substances. **These receptors are very specialized - each can match only one specific antigen.** The lymphocyte cells travel through your body until they find an antigen of the right size and shape to match their specific receptors. It might seem limiting that the receptors of each lymphocyte cell can only match one specific type of antigen, but the body makes up for this by producing so many different lymphocyte cells that the immune system can recognize nearly all invaders.

T cells: two types – ***HELPER and KILLER T cells***

Helper T cells are the major driving force of immune defense. **Their primary task is to activate B cells and killer T cells.** However, the helper T cells themselves must be activated. This happens when a macrophage which has eaten an invader, travels to the nearest lymph node to present information about the captured pathogen(called antigen presentation) **The phagocyte displays an antigen fragment (protein) from the invader on its own surface. When the receptor of a helper T cell recognizes the antigen, the T cell is activated. Once activated, helper T cells start to divide and to produce proteins that activate B and T cells as well as other immune cells.**





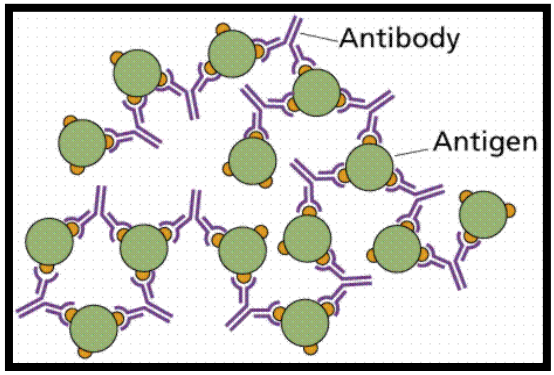
The killer T cell is specialized in attacking cells of the body infected by viruses and sometimes also by bacteria. It can also attack cancer cells. The killer T cell has receptors that are used to search each cell that it meets. If a cell is infected, it is swiftly killed. Infected cells are recognized because tiny traces of the intruder, antigen, can be found on their surface.

B Cells

The B lymphocyte cell searches for antigen matching its receptors. If it finds such antigen it connects to it, and inside the B cell a triggering signal is set off. The B cell now needs proteins produced by helper T cells to become fully activated. When this happens, the B cell starts to divide to produce clones of itself. **During this process, two new cell types are created, plasma cells and B memory cells.**

- ✓ ***The plasma cell*** is specialized in producing a specific protein called an ***antibody,*** that will respond to the same antigen that matched the B cell receptor. **Antibodies are released from the plasma cell so that they can seek out intruders and help destroy them.** Plasma cells produce antibodies at an amazing rate and can release tens of thousands of antibodies per second.

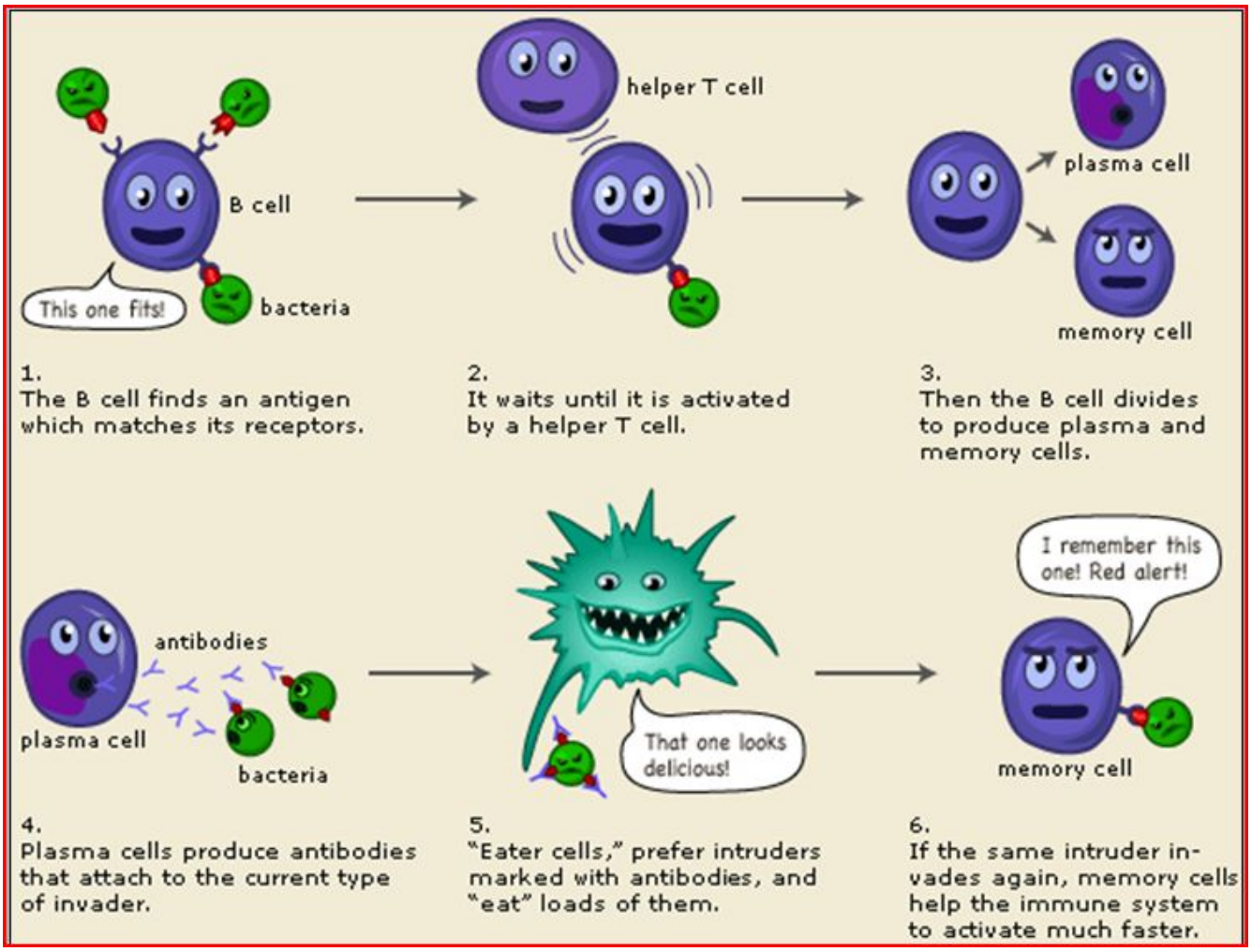
- ✓ **Antibodies** are Y shaped proteins that are specifically structured to bind to the antigen on the surface of the invading bacteria or virus. **Each antibody has the ability to bind to only one specific antigen.** The antibodies prevent the pathogen from continuing to harm the organism and mark them for destruction by phagocytic WBCs .



Each branch of the Y-shaped antibody can bind to a different antigen, so while one branch binds to an antigen on one cell, the other branch could bind to another cell - in this way pathogens are gathered into larger groups that are easier for phagocyte cells to devour. Bacteria and other pathogens covered with antibodies are also more likely to be attacked by the proteins from the complement system.

Memory Cells are the second cell type produced by the division of B cells. **These cells have a prolonged life span and can thereby "remember" specific intruders.**

- ✓ ***T cells can also produce memory cells with an even longer life span than B memory cells.*** The second time an intruder tries to invade the body, B and T memory cells help the immune system to activate much faster. The invaders are wiped out before the infected human feels any symptoms. The body has achieved immunity against the invader.



TYPES of IMMUNITY

- ✓ ***INBORN IMMUNITY :*** immunity to certain disease are present at birth
- ✓ ***ACQUIRED IMMUNITY:*** immunity that is acquired during one's lifetime. There are two types of acquired immunity:
  - -- **ACTIVE IMMUNITY:**
    - May result from ***HAVING THE DISEASE*** (having chicken pox once, you generally do not get it again because memory cells produce antibodies to fight a second infection)
    - ***VACCINATION*** (see explanation below)
  - --**PASSIVE IMMUNITY** (temporary immunity – because antibodies are BORROWED only last for a month or so)
    - ***MATERNAL IMMUNITY:*** antibodies from mother enter baby before birth and provide temporary immunity for the newborn. The newborn also receives antibodies from the mother's milk
    - Receiving an ***INJECTION OF ANTIBODIES,*** For example, if a person is bitten by a snake, you are given antibodies against the venom of the snake – these antibodies were cultured from a snake.

VACCINES (form of active immunity)

- ✓ Made of weakened, dead parts of pathogens that are combined with other materials and injected into an organism in order to stimulate the immune system to react to the pathogen with a specific immune response.

HOW A VACCINE WORKS:

1. obtain a pathogen and kill or weaken it
2. formulate a vaccine that will enable the pathogen to be infected into the organism
3. the body responds to antigens present on the pathogen by making antibodies and WBCs that attack the invader
4. B memory cells specific for the pathogen remain in the body for a long time to continue the protection from future attacks by the pathogen

AIDS **(ACQUIRED IMMUNE DEFICIENCY SYNDROME**

- ✓ Caused by ***HIV*** **(human Immunodeficiency virus)** which is a retrovirus that contains RNA as its genetic material
- ✓ HIV spreads by direct contact with infected blood or other body fluids
- ✓ HIV is also spread by sharing needles and sexual contact
- ✓ When HIV invades an organism, it attaches to T cells and replicates within these cells
- ✓ Gradually, HIV kills off most of the helper T cells, severely impairing the body's immune system. The individual is now considered to have AIDS. Without a working immune system, the infected person can become deathly ill from even the mildest of infections.

TRANSPLANTS

- ✓ An individual's body cells have protein markers on the surface of their cells that allow the immune system to recognize cells as "self"
- ✓ Organ transplant has marker proteins that are recognized as "nonself"
- ✓ Killer T cells will destroy organ transplants causing rejection
- ✓ To avoid rejection, transplant patients take medication to suppress the immune system, usually for the rest of their lives.

AUTOIMMUNE DISEASES

- ✓ An autoimmune disease develops when the immune system makes a mistake and attacks the body's own cells.
- ✓ Examples of autoimmune diseases are:
  - --***Juvenile Onset Diabetes***: the immune system attacks the insulin producing cells of the pancreas (islets of Langerhans)

--***Multiple Scleroses (MS):*** autoimmune disease of the nervous system resulting from the destruction of the myelin sheath that surrounds nerve fibers

ALLERGIES

- ✓ **A rapid immune response to environmental substances that is normally harmless.**
- ✓ Examples of some allergens include certain foods like peanuts, pollen, animals, and chemicals from insect bites.
- ✓ The immune system reacts by releasing **HISTAMINES** which leads to allergy symptoms including sneezing, runny nose, hives, asthma, and rashes
- ✓ Sometimes allergies cause swelling that can be very dangerous, particularly if the throat swells and closes, interfering with the person's ability to breathe.
- ✓ **ANTIHISTAMINES** reduce the effects of histamines and the symptoms they cause.

Information and diagrams for these notes were compiled using the Official Site of the Nobel Prize (n0belprize.org)on the human immune system which can be found at the following sites:

http://www.nobelprize.org/educational/medicine/immunity/immune-overview.html

http://www.nobelprize.org/educational/medicine/immunity/immune-detail.html

Practice: Answer on separate paper please!

1. A malfunction of the lymph nodes would most likely interfere with the
   (1) release of carbon dioxide into the lymph
   (2) filtering of glucose from the lymph
   (3) release of oxygen into the lymph
   (4) filtering of bacteria from the lymph

2. Many bacteria that enter the circulatory system are engulfed and destroyed by
   (1) phagocytic white blood cell
   (2) pinocytic red blood cells
   (3) plasma
   (4) platelets

3. Many people become infected with the chicken pox virus during childhood. After recovering from chicken pox, these people are usually immune to the disease for the rest of their lives. However, they may still be infected by viruses that cause other diseases, such as measles.
   Discuss the immune response to the chicken pox virus. In your answer, be sure to include:
   • the role of antigens in the immune response
   • the role of white blood cells in the body's response to the virus
   • an explanation of why recovery from an infection with the chicken pox virus will not protect a person from getting a different disease, such as measles
   • an explanation of why a chicken pox vaccination usually does not cause a person to become ill with chicken pox

4. Which activity is not a function of white blood cells in response to an invasion of the body by bacteria?
   (1) engulfing these bacteria
   (2) producing antibodies to act against this type of bacteria
   (3) preparing for future invasions of this type of bacteria
   (4) speeding transmissions of nerve impulses to detect these bacteria

5. State one specific way white blood cells help to protect the human body from pathogens

6. The purpose of introducing weakened microbes into the body of an organism is to stimulate the

7. (1) production of living microbes that will protect the organism from future attacks
(2) production of antigens that will prevent infections from occurring
(3) immune system to react and prepare the organism to fight future invasions by these microbes
(4) replication of genes that direct the synthesis of hormones that regulate the number of microbes

8. Which transplant method would prevent the rejection of tissue after an organ transplant?
(1) using organs cloned from the cells of the patient
(2) using organs produced by genetic engineering to get rid of all proteins in the donated organs
(3) using organs only from pigs or monkeys
(4) using an organ donated by a close relative because the proteins will always be identical to those of the recipient

9. Allergic reactions usually occur when the immune system produces (1) antibiotics against usually harmless antigens (2) antigens against usually harmless antibodies (3) antibodies against usually harmless antigens (4) enzymes against usually harmless antibodies

Base your answers to questions 10 and 11 on the information below and on your knowledge of biology.

Where is the Beef?

Out Being Irradiated E. coli bacteria in food cause an estimated 73,000 cases of infection leading to some deaths in the United States each year. Until recently, the only way to guarantee meat free of E. coli was to heat it to 160˚F, which kills E. coli. The rare hamburgers preferred by many people are not heated to this temperature, and just a few E. coli may cause severe illness.

Recently, ground beef has been decontaminated by irradiation using electron beam technology. The packaged ground beef is scanned by an electron beam that disrupts the genetic structure of the pathogens. This kills them or leaves them unable to reproduce.

This process is considered safe and has been endorsed by various governmental groups in this country as well as the World Health Organization. Irradiation is effective in preserving only certain foods, such as herbs, wheat flour, fresh fruits, vegetables, and some meats. Although some methods of irradiation can change the taste of some foods, this is not an effect of electron beam technology on ground beef.

Opponents of irradiating food are concerned that the process may result in the formation of chemicals that may be harmful or result in a loss of vitamins. Supporters claim that irradiation is safe and should be considered as just another technique for preservation of food.

10. Identify one specific pathogen found in ground beef.

11. . Identify the specific group of molecules in bacteria whose function would be interfered with by heating them to 160˚F.

12. Scientists have genetically altered a common virus so that it can destroy the most lethal type of brain tumor without harming the healthy tissue nearby. This technology is used for all of the following except
(1) treating the disease
(2) curing the disease
(3) controlling the disease
(4) diagnosing the disease

13. Cells of the immune system and the endocrine system of the human body contribute to the maintenance of homeostasis. The methods and materials these two systems use as they carry out this critical function are different. **State two ways cells of the immune system fight disease.**

14. The immune system of humans may respond to chemicals on the surface of an invading organism by
(1) releasing hormones that break down these chemicals
(2) synthesizing antibodies that mark these organisms to be destroyed
(3) secreting antibiotics that attach to these organisms
(4) altering a DNA sequence in these organisms

Base your answer to question 15 on the information below and on your knowledge of biology.

Until the middle of the 20th century, transplanting complex organs, such as kidneys, was rarely successful. The first transplant recipients did not survive. It was not until 1954 that the first successful kidney transplant was performed. Success with transplants increased as research scientists developed techniques such as tissue typing and the use of immunosuppressant drugs. These are drugs that suppress the immune system to prevent the rejection of a transplanted organ. In 2002, there were nearly 15,000 kidney transplants performed in the United States with a greater than 95% success rate.

15. Describe the relationship of the immune system to organ transplants and the use of immunosuppressant drugs to prevent the rejection of a transplanted organ. In your answer be sure to:
    - state one way the immune system is involved in the rejection of transplanted organs
    - explain why the best source for a donated kidney would be the identical twin of the recipient
    - explain why immunosuppressant drugs might be needed to prevent rejection of a kidney received from a donor other than an identical twin
    - state one reason a person may get sick more easily when taking an immunosuppressant drug