

## Programmed Instruction: Biotherapy

### The Immune System and Cancer

Jeanette G. Tomaszewski, R.N., M.S.N., O.C.N.; Leslie DeLaPena, R.N., M.S., O.C.N.; Susan B. Gantz, R.N., B.S.N., M.S.; D. Laurie Beranto, R.N., M.N., C.E.T.N.; Myra Woolery-Antill, R.N., M.N., C.P.O.N.; Kathleen DiLorenzo, R.N., B.S.N., O.C.N.; Jean Molenda, R.N., B.S.N.; and Shannon Folts, R.N., B.S.N.

This is the first in a series of five self-learning modules that will review biotherapy. The focus of this module is to introduce the immune system and its relationship to cancer. This first module will provide the foundation for understanding why biotherapy is used as a treatment for cancer.

#### OBJECTIVES

After completion of this self-learning module, the nurse will be able to do the following:

- Identify the functions of the immune system.
- Identify the components of a competent immune system.
- Describe the immune system's major responses to nonself and mutated self cells.
- Discuss the relationship between the immune system and cancer.

This self-learning module has three components:

- a pretest
- content, with question and answer section
- a posttest

Jeanette G. Tomaszewski is a Clinical Nurse, National Institutes of Health, Clinical Center, Cancer/Human Genome Nursing Service, Bethesda, Maryland.

Leslie DeLaPena is a Clinical Nurse Educator, National Institutes of Health, Clinical Center, Cancer/Human Genome Nursing Service, Bethesda, Maryland.

Susan Gantz is a Clinical Nurse, National Institutes of Health, Clinical Center, Cancer/Human Genome Nursing Service, Bethesda, Maryland.

D. Laurie Bernato is a Clinical Nurse Specialist, National Institutes of Health, Clinical Center, Cancer/Human Genome Nursing Service, Bethesda, Maryland.

#### INSTRUCTIONS

Instructions are as follows:

- Complete the pretest.
- Read each content section and answer the questions below each section.
- Complete the posttest after completion of the self-learning module.

This module will take approximately 60 minutes to complete, but the module can be completed at one's own pace. The answers to the pretest and content questions are located at the end of each section.

This module meets the requirement of the Board of Nursing, State of Florida, for Continuing Education Nursing Contact Hours Recognition as approved by the University of Florida College of Nursing Continuing Education Studies (Provider Number 27U0290). Instructions for submission for C.N.E. credit can be found on page 331.

Myra Woolery-Antill is a Clinical Nurse Specialist, National Institutes of Health, Clinical Center, Cancer/Human Genome Nursing Service, Bethesda, Maryland.

Kathleen DiLorenzo is a Clinical Nurse, National Institutes of Health, Clinical Center, Cancer/Human Genome Nursing Service, Bethesda, Maryland.

Jean Molenda is a Clinical Nurse, National Institutes of Health, Clinical Center, Cancer/Human Genome Nursing Service, Bethesda, Maryland.

Shannon Folts is a Clinical Nurse, National Institutes of Health, Clinical Center, Cancer/Human Genome Nursing Service, Bethesda, Maryland.

**PRETEST**

Please answer true or false to the following questions.

1. The immune system is composed of cells, tissues, organs, and hormone-like proteins.  
True      False
2. The immune system consists of a number of interrelated cellular pathways.  
True      False
3. The major mechanisms of cellular toxicity are the inflammatory, cell-mediated, and humoral immune responses.  
True      False
4. Currently, all newly discovered cytokines are named interleukin followed by a number.  
True      False
5. The cell responsible for presenting an antigen to the T and B cells is also called a lymphocyte.  
True      False
6. Antibodies are part of the cell-mediated immune response.  
True      False
7. B cells can exhibit memory.  
True      False
8. One of the mechanisms by which cancer cells may escape the immune system is through defective antigen processing.  
True      False
9. Cancer cells do not have antigen.  
True      False
10. Biotherapy uses the immune system to treat cancer.  
True      False

1. True
2. True
3. True
4. True
5. False

6. False
7. True
8. True
9. False
10. True

## INTRODUCTION

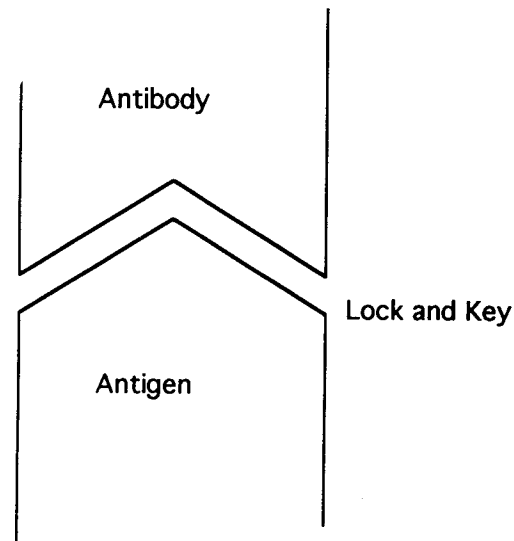
Researchers have long believed that there is a relationship between the immune system and the development of cancer. Information discovered in the last two decades indicates that proper immune functioning plays an important role in cancer prevention and that stimulation of some immune responses can be considered a cancer-treatment modality. Therefore, it is important for the oncology nurse to have basic knowledge of the immune system to understand how it influences cancer development and cancer treatment.

## DEFINITION OF THE IMMUNE SYSTEM

The human immune system is a complex, highly specialized, interactive system. Major functions of the immune system are to:

- Defend the body from organisms and cells capable of causing harm,
- Maintain homeostasis by detecting and eliminating damaged cells, worn-out cells, and debris, and
- Act as a surveillance system that detects and removes nonself and mutated cells.

The immune system is able to accomplish these functions because of its unique properties (see Glossary): surveillance, recognition of self versus nonself, "lock and key" binding (Fig. 1), removal of cells from the body, memory, and feedback. The immune system is composed of organs such as the thymus, spleen, and tonsils; tissues such as the bone marrow and lymph nodes; and cells such as lymphocytes and macrophages. In addition, some immune system cells secrete hormone-like proteins, cytokines, that modulate the immune response.



**FIG. 1.** Antigen–Antibody lock-and-key mechanism of binding.

1. What are the three functions of the immune system?

1. \_\_\_\_\_  
 2. \_\_\_\_\_  
 3. \_\_\_\_\_

2. What are the unique properties of the immune system that enable it to accomplish its functions?

1. \_\_\_\_\_  
 2. \_\_\_\_\_  
 3. \_\_\_\_\_  
 4. \_\_\_\_\_  
 5. \_\_\_\_\_  
 6. \_\_\_\_\_

1. defend the body; maintain homeostasis, and act as a surveillance system
2. surveillance, recognition of self versus nonself, "lock and key" binding, removal of cells from the body, memory, feedback.

## OVERVIEW OF ORGANS AND TISSUES

The immune system is present at birth but is immature. The organs responsible for the development of the components of the immune system are:

- the primary lymphoid organ, the thymus, a small gland behind the sternum.
- the primary lymphoid tissue, the bone marrow, which produces cells.

The secondary lymphoid organ and tissues include the spleen, lymph nodes, and tonsils, through which cells circulate or are stored. In children, the thymus and tonsils are the main centers of immune cells. As children's long bones develop, the role of the bone marrow increases, and the role of the thymus and tonsils decreases.

3. What are the primary organ and tissue of the immune system?

1. \_\_\_\_\_
2. \_\_\_\_\_

## INTRODUCTION TO CELLS

A multitude of immune system cells evolve from a single stem cell. This pluripotent stem cell is the most primitive and important blood-forming cell (Fig. 2). It is found primarily in the bone marrow and differentiates into either myeloid stem cells or lymphoid stem cells.

A special feature of all immune cells is their ability to recognize "self" and "nonself." This action is made possible because all nucleated body cells have proteins on their surface membranes that are unique to the person, called human leukocyte antigens (HLAs) or tissue type, which serve as a marker or cellular blueprint for that person. The immune system cells move throughout the body and, using these markers, can recognize self (normal, healthy body cells) that should remain in the body versus nonself that should be removed or destroyed. Nonself cells are foreign cells such as bacteria, viruses, protozoa, helminths, pollens, molds, and so on, which can invade the body, as well as cells from animals and other people. Body cells that are no longer completely healthy also are considered nonself. Such nonself cells include cancer cells and those cells infected by a virus or other type of intracellular parasite.

4. The pluripotent stem cell differentiates into what two cell lines?

1. \_\_\_\_\_
2. \_\_\_\_\_

3. primary organ and tissue: thymus and bone marrow

4. Myeloid and lymphoid cells

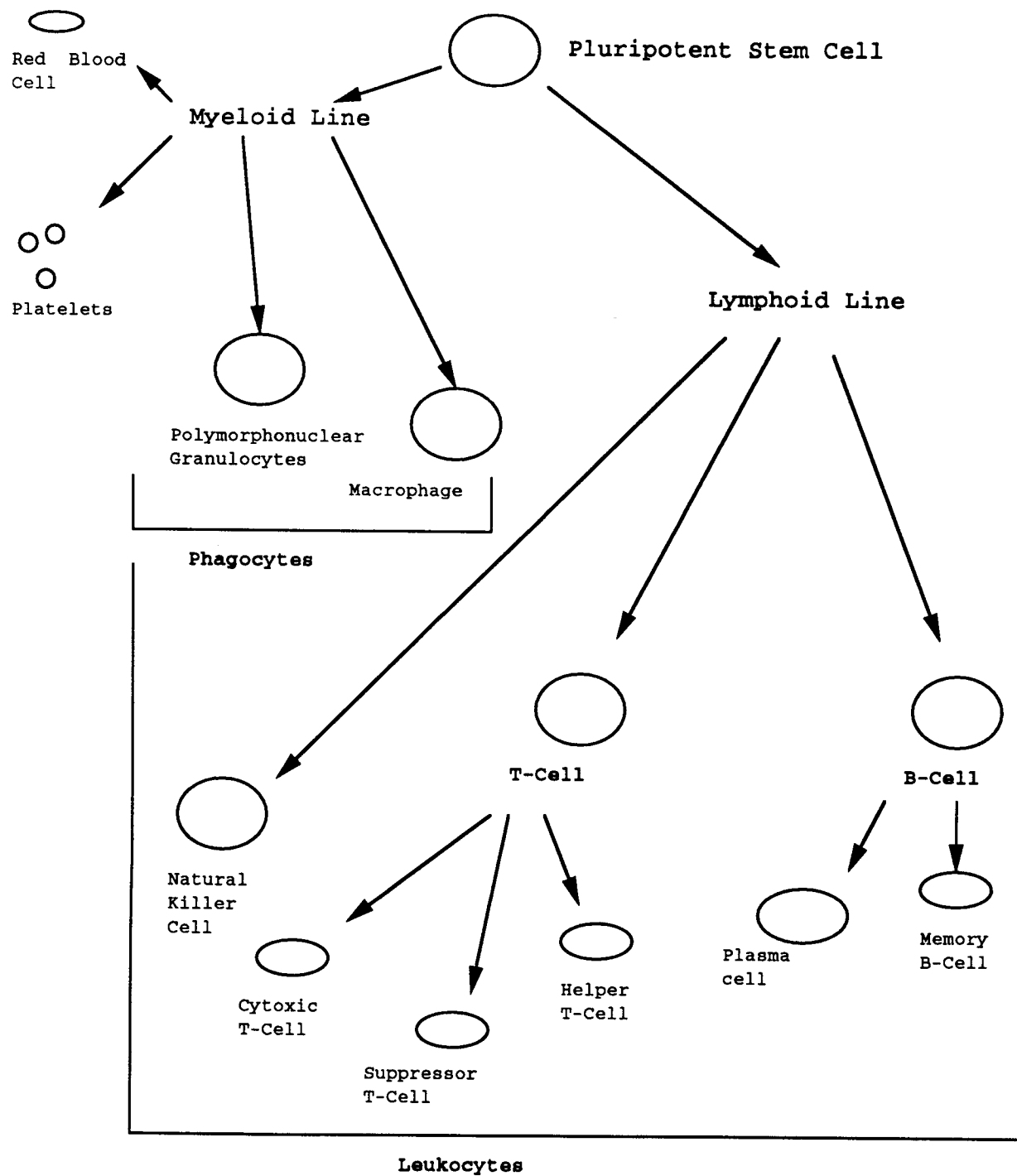


FIG. 2. Differentiation of immune cells from a pluripotent stem cell.

### MYELOID CELL LINE

Myeloid stem cells mature into red blood cells, platelets, macrophages, and polymorphonuclear granulocytes such as neutrophils, eosinophils, and basophils. The cells of the myeloid line involved in immunity and inflammation are the polymorphonuclear granulocytes and the macrophages. Granulocytes are involved in tissue injury and the removal of nonself cells. Granulocytes remove nonself cells through phagocytosis, which occurs when nonself cells are engulfed, or swallowed, and enzymatically digested.

Macrophages are referred to as scavengers, removing worn-out cells, nonself cells, and cellular debris. Monocytes mature in the bone marrow, where some are stored until needed. Others are found throughout the body in tissues where they mature and become macrophages and are named based on their location. For example:

- Monocytes when circulating in the blood system,
- Macrophages when located in the tissues,
- Kupffer's cells when in the liver,
- Alveolar macrophages when in the lungs,
- Histiocytes/Langerhans when in the skin and subcutaneous tissues, and
- Antigen-processing cells, also known as antigen-presenting cells (APCs), when their function is to process and present antigens to B and T cells.

Macrophage functions include:

- Recognition and cell lysis, which occurs when secreting enzymes and antimicrobial agents lyse the targeted non-self cell wall.
- Phagocytosis.
- Antigen presentation, which occurs when nonself particles are processed and presented to helper T cells.

5. What are three functions of the macrophage?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_

### LYMPHOID CELL LINE

Lymphoid stem cells develop into:

- T lymphocytes, also known as T cells, which mature in the thymus. Examples include cytotoxic T cells (T4, T8), helper T cells (T4, CD4, TH), and suppressor T cells (TS, T8, CD8).
- B lymphocytes, also known as B cells, which mature in bone marrow and fetal liver.
- Natural killer cells, also known as NK cells (T16, CD16), which mature in the bone marrow.

T cells function by:

- Secreting substances called cytokines, which serve as chemical messengers.
- Directly attacking targeted nonself cells.
- Initiating cell propagation, maturation, and activation of other immune cells, such as B cells.

The B cells function by:

- Recognizing and removing specific antigen targets.
- Producing substances called antibodies, also known as immunoglobulins, which recognize specific nonself cells.

Natural killer cells function by killing targeted cells on cell-to-cell contact and are especially effective at killing cancer cells.

6. What are the three lymphoid cells of the immune system?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_

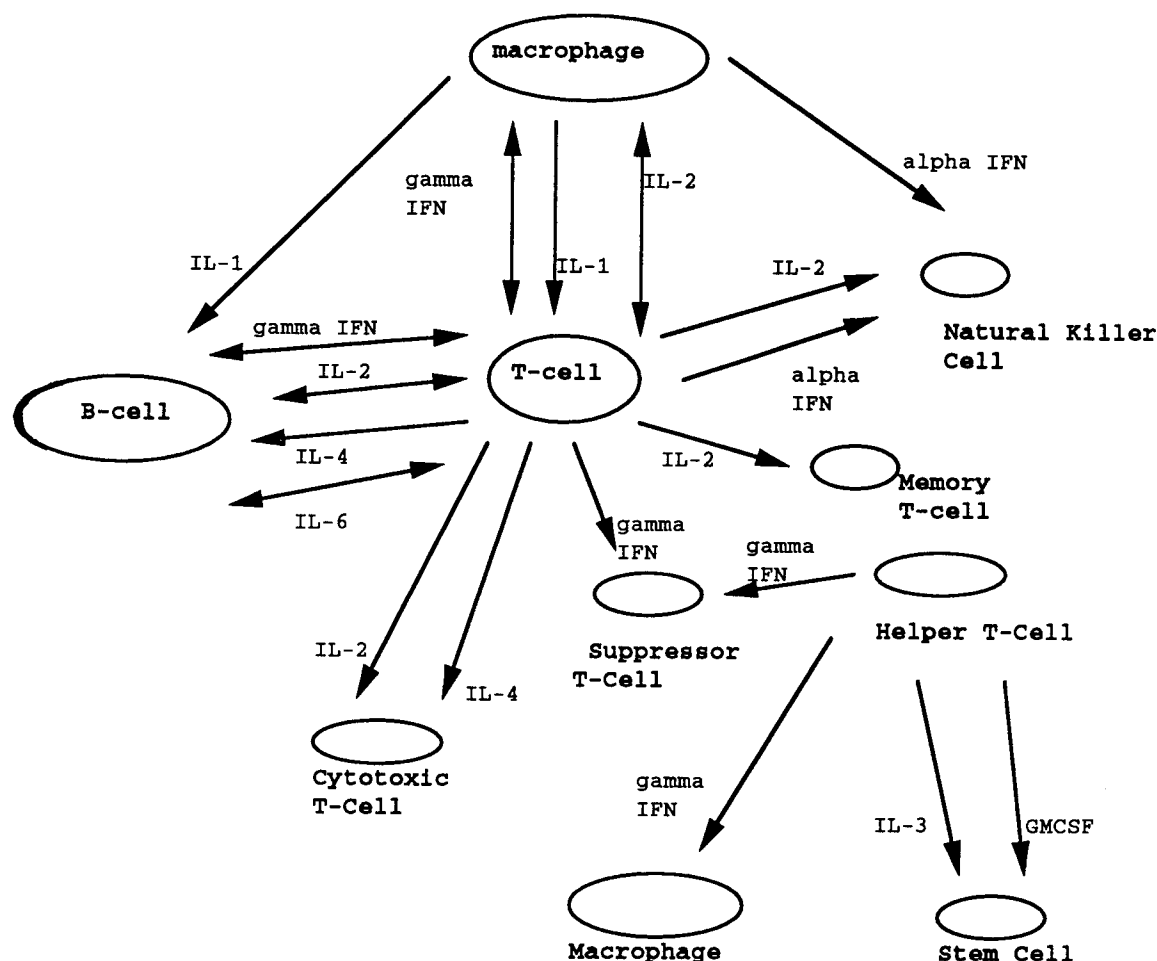
5. cell lysis, phagocytosis, and antigen presentation

6. T cells, B cells, and natural killer cells

## CYTOKINES

The immune system incorporates a number of interrelated cellular pathways (Fig. 3). The cells of the immune system function interdependently through communication and stimulation by direct cellular contact or by chemical messengers such as cytokines. The cytokines, secreted individually or in combination, stimulate the cell division and maturation of immune cells and aid in the production of cytokines.

Frequently more than one term exists to describe these cytokines. Prior to 1986, investigators named their discoveries based on the function of the cytokine. Consequently, the same cytokine, depending on discoverer and function, may have different names. In 1986, at the 6th International Congress of Immunology, a committee was designated to standardize the naming process. Currently, all cytokines are named *interleukin* followed by a number (i.e., interleukin-2). Some cytokines discovered before 1986 have main-



**FIG. 3.** Interrelatedness of immune cells and cytokines. IL, interleukin; IFN, interferon; GMCSF, granulocyte macrophage colony-stimulating factor.

tained their names, [i.e., tumor necrosis factor (TNF), interferon (IFN), granulocyte colony-stimulating factor (GCSF), and granulocyte-macrophage colony-stimulating factor (GMCSF)].

7. How do immune cells function interdependently?
- 
- 

8. Since 1986, how are all cytokines named?
- 

### MAJOR RESPONSES OF THE IMMUNE SYSTEM

Immune cells remove nonself cells, mutated cells, and antigens. Cellular toxicity is accomplished in three ways:

- Inflammatory response.
- Cell-mediated response.
- Antibody-mediated (humoral) response.

If any one of these immune responses is impaired, the entire immune system is compromised.

One of the immune cells common to all three responses is the macrophage. In the inflammatory response, the macrophage removes nonself cells through phagocytosis. Macrophages or antigen-processing cells (APCs) also initiate both cellular and antibody-mediated responses to both T cells and B cells. For the most part, only T cells need antigen to be processed and presented. Some B cells are able to recognize antigen structures.

9. What are the three major responses of the immune system?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_

7. through communication and stimulation, which occurs by direct cellular contact or by chemical messengers such as cytokines  
8. interleukin, followed by a number

9. inflammatory, cell-mediated, and antibody-mediated responses



**INFLAMMATORY RESPONSE**

Inflammation occurs in response to tissue injury as well as to the presence of nonself cells. The cellular components involved in response to the presence of nonself cells are the phagocytes: granulocytes (primarily the neutrophil) and the macrophage. These cells remove nonself cells through phagocytosis. The major steps involved in phagocytosis are recognition, engulfment, and destruction of nonself cells. Recognition of nonself cells occurs through:

- opsonization, the coating of nonself cells, promoting phagocyte adherence and effector cell (T cell) function.
- complement activation, a cascade of enzymatic reactions resulting in the fixation of complement proteins to the nonself cell wall, thereby promoting cell lysis.

After the cell is engulfed or swallowed, destruction of nonself cells may occur by enzymatic digestion.

10. During the immune response, granulocytes and macrophages remove nonself cells by what method?

---

**CELL-MEDIATED RESPONSE**

Cell-mediated immunity (CMI) recognizes nonself cells or mutated cells or both and responds by:

- Directing activities of immune cells and cytokines.
- Initiating activities of humoral or antibody-mediated immunity.

The cellular components involved in CMI include:

- APCs or macrophages.
- T cells.
- Natural killer cells.

CMI occurs through two major mechanisms of action:

- Recognition and killing of nonself or mutated self cells or both by T cells and natural killer cells.
- Regulation of immune responses.

11. What are the three cellular components involved in cell-mediated immunity?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_

12. What are the two mechanisms of action in cell-mediated immunity?

1. \_\_\_\_\_
2. \_\_\_\_\_

10. by phagocytosis

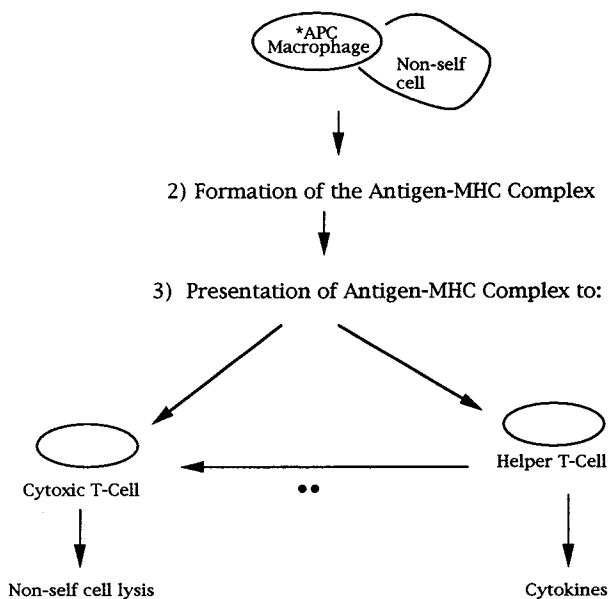
11. antigen-processing cells (APCs) or macrophages, T cells, and natural killer cells
12. recognition and killing of nonself or mutated cells or both by T cells and natural killer cells; and regulation of immune responses

### REMOVAL OF CELLS BY T CELLS

Removal of cells by T cells occurs either directly by the cytotoxic T cells or indirectly by the helper T cells. First, recognition of nonself cells occurs through three sequential steps, which results in the formation and presentation of an antigen–major histocompatibility complex (MHC) to the T cells (Fig. 4):

1. Antigen processing, in which APCs or macrophages recognize a nonself cell through its surface antigen.
2. Association of the MHC with nonself cells' antigens or part of an antigen forming an antigen–MHC complex.
3. Presentation of the antigen–MHC complex by the APCs to either a helper or cytotoxic T cell.

#### 1) Antigen Recognition and Processing



**FIG. 4.** Nonself cell recognition by the APC and presentation to the T cells. \* Antigen-processing/presenting cell; \*\* Helper T cells assist in maturation of cytotoxic T cell for effective killing of target cell.

Helper T cells secrete cytokines, such as the interleukins and interferons, which stimulate or regulate a variety of immune cells. For example, helper T cells stimulate maturation of cytotoxic T cells. Concurrently, the cytotoxic T cells kill nonself cells by direct enzymatic activity.

13. What are the first three steps in removing nonself cells by cell-mediated immunity?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_

14. After the antigen–MHC complex is presented to the T cell, what are the two concurrent steps in cell-mediated immunity?

1. \_\_\_\_\_
2. \_\_\_\_\_

13. antigen recognition and processing, formation of the antigen–MHC complex, and presentation of the antigen–MHC complex to either the helper or suppressor T cell  
 14. secretion of cytokines by the helper T cells and killing of nonself cells by cytotoxic T cells

### RECOGNITION AND REMOVAL OF NONSELF CELLS BY NATURAL KILLER CELLS

Natural killer cells are also responsible for killing mutated self and nonself cells by recognizing and binding to targeted cells. Target cell killing then occurs by one of two mechanisms of action:

- Direct lysosomal enzymatic activity or
- Secretion of natural killer cytotoxic factors, which lyse cell walls.

15. By what two mechanisms do natural killer cells kill nonself and mutated cells?

1. \_\_\_\_\_
2. \_\_\_\_\_

### REGULATION OF CMI

Cell-mediated immunity is regulated by both helper and suppressor T cells that turn the immune response on and off. Helper T cells initiate the activation and maintenance of the immune response. Suppressor T cells turn the immune response off through feedback, inhibiting the secretion and function of cytokines. Because of the opposing activities of the helper T cells and suppressor T cells, a balance must occur between these two types of T cells for optimal functioning of CMI.

16. By what mechanism do the helper T cells regulate the immune response?

\_\_\_\_\_

17. By what mechanism do suppressor T cells regulate the immune responses?

\_\_\_\_\_

15. direct lysosomal enzymatic activity; secretion of natural killer cytotoxic factors

16. by initiating the activation and maintenance of the immune response  
17. through feedback inhibiting cytokine secretion and function

### ANTIBODY-MEDIATED (HUMORAL) RESPONSE

Antibody-mediated immunity (AMI) is the part of the immune system that involves specific responses involving antibodies and complement. Its cellular components include:

- Antigen-processing cells.
- B cells.

AMI is activated, in part, by the presence of antibodies, leading to the formation of an immune complex. The removal of nonself cells with antigen occurs through two major mechanisms (Fig. 5): direct immune complex reactions, and complement activation.

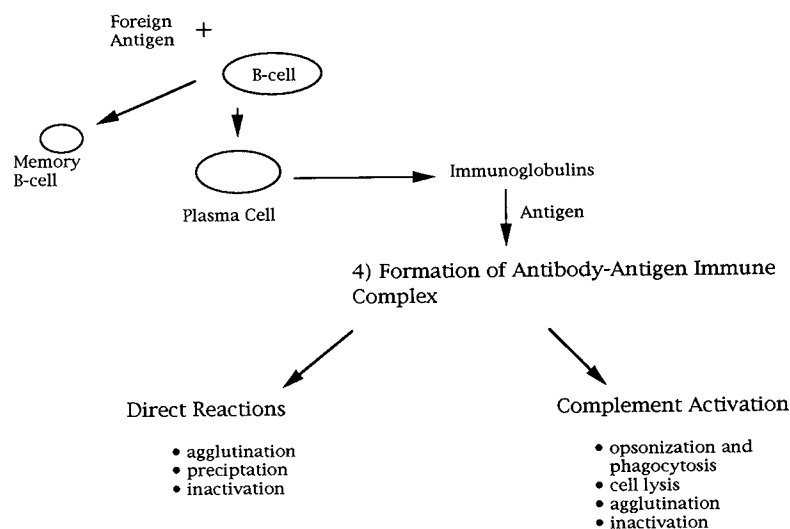


FIG. 5. Antibody-mediated immunity.

18. What activates antibody-mediated immunity to remove nonself cells?

\_\_\_\_\_

19. What are the two mechanisms by which nonself cells are removed in antibody-mediated immunity?

1. \_\_\_\_\_

2. \_\_\_\_\_

18. the presence of antibodies, leading to the formation of an immune complex.
19. direct immune complex reactions and complement activation

**ACTIVATION OF AMI**

After B cells encounter antigen, they evolve into memory cells and plasma cells. Memory cells maintain sustained immunity by becoming sensitized to the antigen at the initial encounter and responding quickly to subsequent exposures to the same antigen. Plasma cells secrete antibodies that bind through the "lock and key" mechanism to a specific antigen. In other words, each antibody (key) is specific for only one lock (antigen). Binding of the antibody to antigen results in the formation of an immune complex.

20. After B cells encounter antigen, what two types of cells do they evolve into?
1. \_\_\_\_\_
  2. \_\_\_\_\_
21. An antigen-antibody immune complex formed by what mechanism of binding?
- \_\_\_\_\_

**DIRECT IMMUNE COMPLEX REACTIONS**

The immune complex causes antigen elimination by stimulating a series of simultaneous reactions:

- Agglutination, which occurs when the antibody is stabilized to the antigen so that the antigen is neutralized, allowing other leukocytes the opportunity to recognize and kill the nonself cells.
- Precipitation, which occurs when the antibody binds to the antigen, resulting in a large insoluble complex that is unable to remain suspended in the blood, allowing nonself cell recognition and killing by leukocytes.
- Inactivation, which occurs when antibody binding interferes with antigen function, thus neutralizing it so that the nonself cell can be recognized and killed.

22. What three reactions are directly stimulated by the immune complex?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_

20. memory cells that maintain sustained immunity and plasma cells that secrete antibodies  
21. by binding through a lock-and-key mechanism

22. agglutination, precipitation, and inactivation

**COMPLEMENT ACTIVATION**

The immune complex also stimulates the removal of nonself cells by activating complement. This cascade of enzymatic reactions results in:

- opsonization, leading to phagocytosis of nonself cells,
- nonself cell lysis,
- agglutination of the antigen, and
- inactivation of the antigen.

23. Activating complement in AMI results in what four reactions?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_

**THE IMMUNE SYSTEM AND  
CANCER DEVELOPMENT**

Research is currently exploring the immune system's role in the development of cancer and its treatment. For example, cancer cells may not be recognized by the immune system as nonself; therefore, they are not removed. Some theories regarding the development and proliferation of cancer cells are:

- The immune system is dysfunctional, overwhelmed, immature, or a combination of these.
- Cancer cells may escape the immune system by getting started in immunoprivileged sites, such as the central nervous system.
- Cancer may result from exposure to chemical or physical carcinogens.
- Cancer may result from exposure to a virus.

24. What are four theories for the cause of cancer?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_

23. opsonization leading to phagocytosis of nonself cells, nonself cell lysis; agglutination of antigen; and inactivation of antigen

24. dysfunctional immune system; cancer may elude the immune system; chemical or physical carcinogens; viral exposure

### CANCER'S ESCAPE FROM THE IMMUNE SYSTEM

The immune system has been associated with the development of cancer. Like the cells of the immune system, cancer cells have surface antigens or surface markers. The presence of these markers has been used by researchers to identify prognostic status for a variety of cancers. It has been proposed that cancer cells may escape surveillance because of:

- Differences among cancer cells, resulting in a reduction or absence of expressed tumor antigen.
- Defective antigen processing, which renders CMI impotent.
- Cancer cells that secrete substances that directly suppress immunologic reactivity.

25. What are three means by which cancer may escape surveillance?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_

### CONCLUSION

Knowledge of the immune system allows the nurse to understand cancer and its treatment. For example, biotherapy is currently being used to:

- Restore, augment, or modulate the host's immunity, and
- Directly affect tumors.

Subsequent modules will introduce this new therapy. The next self-learning module will introduce an overview of biotherapy. The three sequential modules will focus on cytokines: interferons, interleukins, and colony-stimulating factors. These modules will provide the nurse with information to understand the therapy and provide nursing care.

26. In what two ways is biotherapy being used as a treatment for cancer?

1. \_\_\_\_\_
2. \_\_\_\_\_

25. reduction or absence of expressed tumor antigen; defective antigen processing; secretion of substances by tumor cells that suppress immunologic activities

26. to restore, augment, or modulate the host's immunity and directly affect tumors

## APPENDIX

**Glossary of Terms**

**Surveillance:** Immune cells must be able to recognize self versus nonself cells, unhealthy or defective cells, and worn-out cells:

**Recognition:** Immune cells differentiate self versus nonself cells. Surface antigens, also known as surface markers, are responsible for this recognition. The surface antigen is capable of inducing an immune response when it does not match the specific antigen receptors on T and B cells. The major histocompatibility complex is an example of recognition.

**Lock-and-key binding:** Antibodies attach to antigens and fit like a lock and key.

**Memory:** The immune system has the ability to respond quicker to subsequent exposures of foreign antigen.

**Removal of cells from the body:** Occurs by (a) elimination through phagocytosis (b) destruction through cell lysis, or

(c) neutralization, in which the function of the targeted nonself cells is interrupted.

**Feedback:** Allows the immune system to turn itself on and off.

## REFERENCES

- Guyton AC. *Textbook of medical physiology*. Philadelphia: W.B. Saunders, 1991.
- Roitt I, Brostoff J, Male D. *Immunology*. St. Louis, MO: Mosby, 1993.
- Stites DP, Terr AI, Parslow TG. *Basic and clinical immunology*. Norwalk, CT: Appleton & Lange, 1994.
- U.S. Department of Health and Human Services. *The immune system—how it works*. Bethesda, MD: NIH Publication No. 92-3229, 1992.
- Workman ML, Ellershorst-Ryan J, Hargrave-Koertge V. *Nursing of the immunocompromised patient*. Philadelphia: W.B. Saunders, 1993.



*Directions:* Transfer your answers to the Answer Key on Continuing Education (p. 331), complete the form, and mail to address indicated to receive CNE credit.

### POSTTEST

Please answer true or false to the following questions:

1. The immune system's only function is to defend the body from harm.
2. The myeloid cell line and the lymphoid cell line evolve from the same primitive cell, a pluripotent stem cell.
3. The cell common to all three immune responses is the macrophage.
4. Cytokines act as chemical messengers.
5. T cells function by producing antibodies.
6. TNF, interleukin, and interferon are examples of cytokines.
7. The humoral-mediated immune response uses direct immune complex reactions and complement activation to remove nonself cells.
8. The immune cells use surface antigens to differentiate self versus nonself cells.
9. Cancer will never develop if the immune system is competent.
10. Biotherapy is a treatment using the immune system to fight cancer.

Please pick the best response to the following questions:

11. All of the following are functions of the immune system except
  - A. Defending the body from organisms and cells capable of causing harm.
  - B. Maintaining homeostasis by detecting and removing damaged cells, worn-out cells, and debris.
  - C. Acting as a surveillance system that detects and removes nonself cells and defective cells.
  - D. Evolving T cells and B cells from a pluripotent stem cell.
12. The mechanism that describes antigen-antibody binding is
  - A. memory
  - B. feedback
  - C. surveillance
  - D. lock and key

13. The primary organ(s) and tissue(s) of the immune system are
  - A. spleen and lymph nodes
  - B. bone marrow
  - C. thymus and bone marrow
  - D. tonsils
14. All of the following cells are involved in immunity except
  - A. T cell
  - B. B cell
  - C. macrophage
  - D. red blood cell
15. The immune system normally removes all of the following types of cells except
  - A. mutated cells
  - B. nonself cells
  - C. normal cells
  - D. worn-out cells
16. In cell-mediated immunity, antigen processing and presentation is accomplished by the following cell:
  - A. helper T cell
  - B. macrophage
  - C. plasma cell
  - D. neutrophil
17. In cell-mediated immunity, the antigen-MHC is presented to all of the following cells except the
  - A. helper T cell
  - B. cytotoxic T cell
  - C. natural killer cell
  - D. suppressor T cell
18. In antibody-mediated immunity, the formation of an immune complex results in the removal of nonself cells by activation of a cascade named
  - A. agglutination
  - B. complement
  - C. precipitation
  - D. neutralization
19. Immunoglobulins bind with antigen to form
  - A. antigen-major histocompatibility complex
  - B. antibody-antigen immune complex
  - C. plasma cell-antigen complex
  - D. none of the above

20. The reaction in which the antibody is stabilized to the antigen, resulting in neutralization, is referred to as
  - A. agglutination
  - B. precipitation
  - C. inactivation
  - D. complement fixation
21. Cancer may develop as a result of
  - A. a dysfunctional immune system
  - B. tumor cells' ability to escape the immune system
  - C. viral exposure
  - D. carcinogen exposure
  - E. all of the above
22. Cancer cells may escape the immune system by all of the following mechanisms except
  - A. Cancer cells may have a reduction or absence of antigens
  - B. Defective antigen processing may render CMI impotent
  - C. Cancer cells may secrete substances that directly suppress immune reactivity
  - D. Cancer cells are never recognized by the immune system