The lymphatic system, with its many lymphoid organs and vessels derived from veins of the cardiovascular system, is a rather strange system. Although both types of organs help to maintain homeostasis, these two elements of the lymphatic system have substantially different roles. The lymphatic vessels keep the cardiovascular system functional by maintaining blood volume. The lymphoid organs help defend the body from pathogens by providing operating sites for phagocytes and cells of the immune system.

The immune system, which serves as the body’s specific defense system, is a unique functional system made up of billions of individual cells, most of which are lymphocytes. The sole function of this defensive system is to protect the body against an incredible array of pathogens. In general, these “enemies” fall into three major camps: (1) microorganisms (bacteria, viruses, and fungi) that have gained entry into the body, (2) foreign tissue cells that have been transplanted (or, in the case of red blood cells, infused) into the body, and (3) the body’s own cells that have become cancerous. The result of the immune system’s activities is immunity, or specific resistance to disease.

The body is also protected by a number of nonspecific defenses provided by intact surface membranes such as skin and mucosae, and by a variety of cells and chemicals that can quickly mount an attack against foreign substances. The specific and nonspecific defenses enhance each other’s effectiveness.

Chapter 12 tests your understanding of the functional roles of the various lymphatic system elements and both the nonspecific and specific body defenses.

**THE LYMPHATIC SYSTEM**

**Lymphatic Vessels**

1. Complete the following statements by writing the missing terms in the answer blanks.

   1. Together the cardiovascular and lymphatic systems make up the circulatory system. Although the cardiovascular system has a pump (the heart) and arteries, veins, and capillaries, the lymphatic system lacks two of these structures: the _1_ and _2_. Like the _3_ of the cardiovascular system, the vessels of the lymphatic system are equipped with _4_ to prevent backflow. The lymphatic vessels act primarily to pick up leaked fluid, now called _5_, and return it to the bloodstream. About _6_ of fluid is returned every 24 hours.
2. Figure 12–1 provides an overview of the lymphatic vessels. In part A, the relationship between lymphatic vessels and the blood vessels of the cardiovascular system is depicted schematically. Part B shows the different types of lymphatic vessels in a simple way. First, color-code and color the following structures in Figure 12–1.

- Heart
- Arteries
- Veins
- Blood capillaries
- Lymphatic vessels/lymph node
- Loose connective tissue around blood and lymph capillaries

Then, identify by labeling these specific structures in part B:

- A. Lymph capillaries
- B. Lymph duct
- C. Lymphatic collecting vessels
- D. Lymph node
- E. Valves
- F. Vein

3. Circle the term that does not belong in each of the following groupings.

1. Blood capillary
   - Lymph capillary
   - Blind-ended
   - Permeable to proteins

2. Edema
   - Blockage of lymphatics
   - Elephantiasis
   - Inflammation

   Abundant supply of lymphatics

3. Skeletal muscle pump
   - Flow of lymph
   - Respiratory pump

   High-pressure gradient
   - Action of smooth muscle cells in walls of lymph vessels

4. Minivalves
   - Endothelial cell overlap
   - Impermeable
   - Lymphatic capillaries

---

**Figure 12–1**
Lymph Nodes and Other Lymphoid Organs

4. Match the terms in Column B with the appropriate descriptions in Column A. More than one choice may apply in some cases.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The largest lymphatic organ; a blood reservoir</td>
<td>A. Lymph nodes</td>
</tr>
<tr>
<td>2. Filter lymph</td>
<td>B. Peyer's patches</td>
</tr>
<tr>
<td>3. Particularly large and important during youth; produces hormones that help to program the immune system</td>
<td>C. Spleen</td>
</tr>
<tr>
<td>4. Collectively called MALT</td>
<td>D. Thymus</td>
</tr>
<tr>
<td>5. Removes aged and defective red blood cells</td>
<td>E. Tonsils</td>
</tr>
<tr>
<td>6. Prevents bacteria from breaching the intestinal wall</td>
<td></td>
</tr>
</tbody>
</table>

5. Figure 12-2 depicts several different lymphoid organs. Label all lymphoid organs indicated by a leader line and add labels as necessary to identify the sites where the axillary, cervical, and inguinal lymph nodes would be located. Color the lymphoid organs as you like, and then shade in light green the portion of the body that is drained by the right lymphatic duct.
6. Figure 12–3 is a diagram of a lymph node. First, using the terms with color-coding circles, label all structures on the diagram that have leader lines. Color those structures as well. Then, add arrows to the diagram to show the direction of lymph flow through the organ. Circle the region that would approximately correspond to the medulla of the organ. Finally, answer the questions that follow.

- Germinal centers of follicles
- Cortex (other than germinal centers)
- Medullary cords
- Capsule and trabeculae
- Hilum
- Afferent lymphatics
- Efferent lymphatics
- Sinuses (subcapsular and medullary)
Chapter 12  The Lymphatic System and Body Defenses

1. Which cell type is found in greatest abundance in the germinal centers?

2. What is the function of their daughter cells, the plasma cells?

3. What is the major cell type in cortical areas other than the germinal centers?

4. The third important cell type in lymph nodes (usually found clustered around the medullary sinuses) are the ___________________.
   These cells act as ___________________.

5. Of what importance is the fact that there are fewer efferent than afferent lymphatics associated with lymph nodes?

6. What structures ensure the one-way flow of lymph through the node?

7. The largest collections of lymph nodes are found in what three body regions?

8. What is the general function of lymph nodes?
BODY DEFENSES

Nonspecific (Innate) Body Defenses

7. The three major elements of the body's nonspecific defense system are: the
   (1) ________________________ , consisting of the skin and ________________________ ;
   defensive cells, such as (2) ________________________ and phagocytes; and a whole
deluge of (3) ________________________ .

8. Indicate the sites of activity or the secretions of the nonspecific defenses by
   writing the correct terms in the answer blanks.
   1. Lysozyme is found in the body secretions called ___________ and ___________.
   2. Fluids with an acid pH are found in the ___________ and ___________.
   3. Sebum is a product of the ___________ glands and acts at the surface
      of the ___________.
   4. Mucus is produced by mucus-secreting glands found in the respiratory and
      ___________ system mucosae.

9. Figure 12–4 diagrams the events involved in the inflammatory response.
   Assume the following events have already occurred: tissue injury and
   invasion of microbes, and release of inflammatory chemicals by mast cells.
   Each subsequent event is represented by a square with one or more arrows.
   From the list below, write the correct number in each event square in the
   figure. Then, color-code and color the structures that appear below the
   numbered list.
   1. WBCs are drawn to the injured area by the release of inflammatory chemicals.
   2. Tissue repair occurs.
   3. Local blood vessels dilate, and the capillaries become engorged with blood.
   4. Phagocytosis of microbes occurs.
   5. Fluid containing clotting proteins is lost from the bloodstream and enters
      the injured tissue area.
   6. Margination and diapedesis occur.
      ○ Monocyte          ○ Neutrophil(s)          ○ Endothelium of capillary
      ○ Epithelium         ○ Macrophage            ○ Microorganisms
      ○ Erythrocyte(s)     ○ Subcutaneous tissue   ○ Fibrous repair tissue
10. Circle the term that does not belong in each of the following groupings.

1. Redness  Pain  Swelling  Itching  Heat
2. Neutrophils  Macrophages  Phagocytes  Natural killer cells
3. Inflammatory chemicals  Histamine  Kinins  Interferon
4. Intact skin  Intact mucosae  Inflammation  First line of defense
5. Interferons  Antiviral  Antibacterial  Proteins

11. Match the terms in Column B with the descriptions of the nonspecific defenses of the body in Column A. More than one choice may apply.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Have antimicrobial activity</td>
<td>A. Acids</td>
</tr>
<tr>
<td>2. Provide mechanical barriers</td>
<td>B. Lysozyme</td>
</tr>
<tr>
<td>3. Provide chemical barriers</td>
<td>C. Mucosae</td>
</tr>
<tr>
<td>4. Entraps microorganisms entering the respiratory passages</td>
<td>D. Mucus</td>
</tr>
<tr>
<td>5. Part of the first line of defense</td>
<td>E. Protein-digesting enzymes</td>
</tr>
<tr>
<td></td>
<td>F. Sebum</td>
</tr>
<tr>
<td></td>
<td>G. Skin</td>
</tr>
</tbody>
</table>
12. Describe the protective role of cilia in the respiratory tract.  

13. Define *phagocytosis*.  

14. Check (√) all phrases that correctly describe the role of fever in body protection.  

   ___ 1. Is a normal response to pyrogens  
   ___ 2. Protects by denaturing tissue proteins  
   ___ 3. Reduces the availability of iron and zinc required for bacterial proliferation  
   ___ 4. Increases metabolic rate  

15. Match the terms in Column B with the descriptions in Column A concerning events of the inflammatory response.  

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Accounts for redness and heat in an inflamed area</td>
<td>A. Chemotaxis</td>
</tr>
<tr>
<td>2. Inflammatory chemical released by injured cells</td>
<td>B. Diapedesis</td>
</tr>
<tr>
<td>3. Promote release of white blood cells from the bone marrow</td>
<td>C. Edema</td>
</tr>
<tr>
<td>4. Cellular migration directed by a chemical gradient</td>
<td>D. Fibrin mesh</td>
</tr>
<tr>
<td>5. Results from accumulation of fluid leaked from the bloodstream</td>
<td>E. Histamine</td>
</tr>
<tr>
<td>6. Phagocytic offspring of monocytes</td>
<td>F. Increased blood flow to an area</td>
</tr>
<tr>
<td>7. Leukocytes pass through the wall of a capillary</td>
<td>G. Inflammatory chemicals (including E)</td>
</tr>
<tr>
<td>8. First phagocytes to migrate into the injured area</td>
<td>H. Macrophages</td>
</tr>
<tr>
<td>9. Walls off the area of injury</td>
<td>I. Neutrophils</td>
</tr>
</tbody>
</table>
16. Complete the following description of the activation and activity of complement by writing the missing terms in the answer blanks.

1. Complement is a system of plasma that circulate in the blood in an inactive form. Complement is when it becomes attached to the surface of foreign cells (bacteria, fungi, red blood cells). One result of this complement fixation is that appear in the membrane of the foreign cell. This allows to rush in, which causes of the foreign cell. Some of the chemicals released during complement fixation enhance phagocytosis. This is called. Others amplify the inflammatory response.

17. Describe the event that leads to the synthesis of interferon and the result of its synthesis.

18. Complete the following statements relating to antigens by writing the missing terms in the answer blanks.

1. Antigens are substances capable of mobilizing the. Of all the foreign molecules that act as complete antigens, are the most potent. Small molecules are not usually antigenic, but when they bind to self-cell surface proteins they may act as, and then the complex is recognized as foreign, or.
Cells of the Immune System: An Overview

19. Using the key choices, select the term that correctly completes each statement. Insert the appropriate term or letter in the answer blanks.

Key Choices

A. Antigen(s)  D. Cellular immunity  G. Lymph nodes
B. B cells  E. Humoral immunity  H. Macrophages
C. Blood  F. Lymph  I. T cells

1. Immunity is resistance to disease resulting from the presence of foreign substances or ___(1)___ in the body. When this resistance is provided by antibodies released to body fluids, the immunity is called ___(2)__. When living cells provide the protection, the immunity is referred to as ___(3)__. The major actors in the immune response are two lymphocyte populations, the ___(4)___ and the ___(5)__. Phagocytic cells that act as accessory cells in the immune response are the ___(6)__. Because pathogens are likely to use both ___(7)___ and ___(8)___ as a means of getting around the body, ___(9)___ and other lymphatic tissues (which house the immune cells) are in an excellent position to detect their presence.

20. A schematic of the life cycle of the lymphocytes involved in immunity is shown in Figure 12-5. First, select different colors for the areas listed below and use them to color the coding circles and the corresponding regions in the figure. If there is overlap, use stripes of a second color to indicate the second identification. Then respond to the statements following the figure, which relate to the two-phase differentiation process of B and T cells.

- Area where immature lymphocytes arise
- Area seeded by immunocompetent B and T cells
- Area where T cells become immunocompetent
- Area where the antigen challenge and clonal selection are likely to occur
- Area where B cells become immunocompetent
1. What signifies that a lymphocyte has become immunocompetent?

2. During what period of life does immunocompetence develop?

3. What determines which antigen a particular T or B cell will be able to recognize?
   A. its genes or B. "its" antigen

4. What triggers the process of clonal selection in a T or B cell?
   A. its genes or B. binding to "its" antigen

5. During development of immunocompetence, the ability to tolerate ______________ must also occur if the immune system is to function normally.
21. T cells and B cells exhibit certain similarities and differences. Check (√) the appropriate spaces in the table below to indicate the lymphocyte type that exhibits each characteristic.

<table>
<thead>
<tr>
<th><strong>Characteristic</strong></th>
<th><strong>T cell</strong></th>
<th><strong>B cell</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Originates in bone marrow from stem cells called hemocytoblasts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Progeny are plasma cells</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Progeny include regulatory, helper, and cytotoxic cells</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Progeny include memory cells</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is responsible for directly attacking foreign cells or virus-infected cells</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Produces antibodies that are released to body fluids</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bears a cell-surface receptor capable of recognizing a specific antigen</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forms clones upon stimulation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accounts for most of the lymphocytes in the circulation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

22. Circle the term that does not belong in each of the following groupings.

1. Antibodies Gamma globulin Cytokines Immunoglobulins
2. Protein Complete antigen Nucleic acid Hapten
3. Lymph nodes Liver Spleen Thymus Bone marrow

Humoral (Antibody-Mediated) Immune Response

23. The basic structure of an antibody molecule is diagrammed in Figure 12–6. Select different colors, and color in the coding circles below and the corresponding areas on the diagram.

- heavy chains
- light chains

Add labels to the diagram to correctly identify the type of bonds holding the polypeptide chains together. Also label the constant (C) and variable (V) regions of the antibody, and add "polka dots" to the variable portions. Then, answer the two questions following the figure.
1. Which portion of the antibody—V or C—is its antigen-binding site?

2. Which portion acts to determine antibody class and specific function?

24. Match the antibody classes in Column B to their descriptions in Column A. Place the correct term(s) or letter response(s) in the answer blanks.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Bound to the surface of a B cell</td>
<td>A. IgA</td>
</tr>
<tr>
<td>2. Crosses the placenta</td>
<td>B. IgD</td>
</tr>
<tr>
<td>3. The first antibody released during the primary response</td>
<td>C. IgE</td>
</tr>
<tr>
<td>4. Fixes complement (two classes)</td>
<td>D. IgG</td>
</tr>
<tr>
<td>5. Is a pentamer</td>
<td>E. IgM</td>
</tr>
<tr>
<td>6. The most abundant antibody found in blood plasma and the chief antibody released during secondary responses</td>
<td></td>
</tr>
<tr>
<td>7. Binds to the surface of mast cells and mediates an allergic response</td>
<td></td>
</tr>
<tr>
<td>8. Predominant antibody found in mucus, saliva, and tears</td>
<td></td>
</tr>
</tbody>
</table>
25. Complete the following descriptions of antibody function by writing the missing terms in the answer blanks.

1. Antibodies can inactivate antigens in various ways, depending on the nature of the __(1)__ . __(2)__ is the chief ammunition used against cellular antigens such as bacteria and mismatched red blood cells. The binding of antibodies to sites on bacterial exotoxins or viruses that can cause cell injury is called __(3)__ . The cross-linking of cellular antigens into large lattices by antibodies is called __(4)__ ; Ig __(5)__ , with its 10 antigen binding sites, is particularly efficient in this mechanism. When molecules are cross-linked into lattices by antibodies, the mechanism is more properly called __(6)__ . In virtually all these cases, the protective mechanism mounted by the antibodies serves to disarm and/or immobilize the antigens until they can be disposed of by __(7)__ .

26. Determine whether each of the following situations provides, or is an example of, active or passive immunity. If passive, write P in the blank; if active, write A in the blank.

   _____ 1. An individual receives Sabin polio vaccine
   _____ 2. Antibodies migrate through a pregnant woman's placenta into the vascular system of her fetus
   _____ 3. A student nurse receives an injection of gamma globulin (containing antibodies to the hepatitis virus) after she has been exposed to viral hepatitis
   _____ 4. "Borrowed" immunity
   _____ 5. Immunologic memory is provided
   _____ 6. An individual suffers through chickenpox

27. There are several important differences between primary and secondary immune response(s). If the following statements best describe a primary response, write P in the blank; if a secondary response, write S in the blank.

   _____ 1. The initial response to an antigen; gearing-up stage
   _____ 2. A lag period of several days occurs before antibodies specific to the antigen appear in the bloodstream
   _____ 3. Antibody levels increase rapidly and remain high for an extended period
   _____ 4. Immunologic memory is established
   _____ 5. The second, third, and subsequent responses to the same antigen
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**Cellular (Cell-Mediated) Immune Response**

28. Several populations of T cells exist. Match the terms in Column B to the descriptions in Column A. Place the correct term or letter response in the answer blanks.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Binds with and releases chemicals that activate B cells, T cells, and macrophages</td>
<td>A. Helper T cell</td>
</tr>
<tr>
<td>2. Activated by recognizing both its antigen and a self-protein presented on the surface of a macrophage</td>
<td>B. Cytotoxic T cell</td>
</tr>
<tr>
<td>3. Turns off the immune response when the &quot;enemy&quot; has been routed</td>
<td>C. Regulatory T cell</td>
</tr>
<tr>
<td>4. Directly attacks and lyses cellular pathogens</td>
<td>D. Memory T cell</td>
</tr>
<tr>
<td>5. Initiates secondary response to a recognized antigen</td>
<td></td>
</tr>
</tbody>
</table>

29. Using the key choices, select the terms that correspond to the descriptions of substances or events by inserting the appropriate term or letter in the answer blanks.

**Key Choices**

A. Anaphylactic shock  D. Complement  F. Inflammation
B. Antibodies          E. Cytokines   G. Interferon
C. Chemotaxis factors

1. A protein released by macrophages and activated T cells that helps to protect other body cells from viral multiplication
2. Any types of molecules that attract neutrophils and other protective cells into a region where an immune response is ongoing
3. Proteins released by plasma cells that mark antigens for destruction by phagocytes or complement
4. A consequence of the release of histamine and of complement activation
5. C and G are examples of this class of molecules
6. A group of plasma proteins that amplifies the immune response by causing lysis of cellular pathogens once it has been "fixed" to their surface
7. Class of chemicals released by macrophages
30. Organ transplants are often unsuccessful because self-proteins vary in different individuals. However, chances of success increase if certain important procedures are followed. The following questions refer to this important area of clinical medicine.

1. Assuming that autografts and isografts are not possible, what is the next most successful graft type and what is its source?

2. What two cell types are important in rejection phenomena?

3. Why are immunosuppressive drugs (or therapy) provided after transplant surgery, and what is the major shortcoming of this therapy?

31. Figure 12-7 is a flowchart of the immune response that tests your understanding of the interrelationships of that process. Several terms have been omitted from this schematic. First, complete the figure by inserting appropriate terms from the key choices below. (Note that oval blanks indicate that the required term identifies a cell type, and rectangular blanks represent the names of chemical molecules. Also note that solid lines represent stimulatory or enhancing effects, whereas broken lines indicate inhibition.) Then color the coding circles and the corresponding ovals, indicating the cell types identified.

**Key Choices**

**Cell types:**
- B cell
- Helper T cell
- Cytotoxic T cell
- Macrophage
- Memory B cell
- Memory T cell
- Neutrophils
- Plasma cell
- Regulatory T cell

**Molecules:**
- Antibodies
- Chemotactic factors
- Complement
- Cytokines
- Interferon
- Perforin
- Suppressor factors
Antigen invades
Engulfed by
Processes and presents antigen to
Activate
Releases
Secretes
Stimulate
Interacts with and stimulates cloning of
Clones
Some activate
Some become
Secretes
Some stimulate
Secretes
Some attract
Secretes
Directly attacks the cellular antigen causing its lysis
Enhance the inflammatory response
Inhibits
Upon later stimulation, clone to form
Inhibits
Some become
Most differentiate further to become
Some attract
Bind to antigens and (some) fix
Secretes
Some attract
Enhance the inflammatory response
Secretes
Some attract
Enhance the inflammatory response
Some attract
Secretes
Some become
Most differentiate further to become
Some attract
Bind to antigens and (some) fix
Secretes
Some attract
Enhance the inflammatory response
Some attract
Secretes
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Secretes
Some attract
Enhance the inflammatory response
Some attract
Secretes
Some become
Most differentiate further to become
Some attract
Bind to antigens and (some) fix
Secretes
Some attract
Enhance the inflammatory response

Figure 12-7
Disorders of Immunity

32. Using the key choices, identify the type of immunity disorder described. Insert the appropriate term or letter in the answer blank.

Key Choices
A. Allergy/Hypersensitivity  B. Autoimmune disease  C. Immunodeficiency

1. AIDS and SCID
2. The immune system mounts an extraordinarily vigorous response to an otherwise harmless antigen
3. A hypersensitivity reaction
4. Occurs when the production or activity of immune cells or complement is abnormal
5. The body's own immune system produces the disorder; a breakdown of self-tolerance
6. Affected individuals are unable to combat infections that would present no problem for normally healthy people
7. Multiple sclerosis and rheumatic fever
8. Hay fever and contact dermatitis
9. Typical symptoms of the acute response are tearing, a runny nose, and itching skin

DEVELOPMENTAL ASPECTS OF THE LYMPHATIC SYSTEM AND BODY DEFENSES

33. Complete the following statements concerning the development and operation of the immune system during the life span by inserting your answers in the answer blanks.

1. Lymphatic vessels that "bud" from developing ____(1)____ are visible by the fifth week of development. The first lymphoid organs to appear are the ____(2)____ and the ____(3)____. Most other lymphoid organs are poorly formed before birth; their development is believed to be controlled by the thymic hormone ____(4)____.
2. The earliest lymphocyte stem cells that can be identified appear during the first month of development in the fetal ____(5)____. Shortly thereafter, bone marrow becomes the lymphocyte origin site; but after birth, lymphocyte proliferation occurs in the ____(6)____. The development of immunocompetence has usually been accomplished by ____(7)____.
During old age, the effectiveness of the immune system (8), and elders are more at risk for (9), (10), and (11). Part of the declining defenses may reflect the fact that (12) antibodies are unable to get to the mucosal surfaces where they carry out their normal protective role.

A Visualization Exercise for the Immune System

Something quite enormous and looking much like an octopus is nearly blocking the narrow tunnel just ahead.

34. Where necessary, complete statements by inserting the missing word(s) in the answer blanks.

For this journey, you are equipped with scuba gear before you are miniaturized and injected into one of your host's lymphatic vessels. He has been suffering with a red, raw "strep throat" and has swollen cervical lymph nodes. Your assignment is to travel into a cervical lymph node and observe the activities going on there that reveal that your host's immune system is doing its best to combat the infection.

On injection, you enter the lymph with a "WHOOSH" and then bob gently in the warm yellow fluid. As you travel along, you see what seem to be thousands of spherical bacteria and a few large globular (1) molecules that, no doubt, have been picked up by the tiny lymphatic capillaries. Shortly thereafter, a large dark mass, shaped like a kidney bean, looms just ahead. This has to be a (2), you conclude, and you dig in your wet suit pocket to find the waterproof pen and recording tablet.

As you enter the gloomy mass, the lymphatic stream becomes shallow and begins to flow sluggishly. So that you can explore this little organ fully, you haul yourself to your feet and begin to wade through the slowly moving stream. On each bank you see a huge ball of cells that have large nuclei and such a scant amount of cytoplasm that you can barely make it out. You write, "Sighted the spherical germinal centers composed of (3)." As you again study one of the cell masses, you spot one cell that looks quite different and reminds you of a nest of angry hornets because it is furiously spewing out what seems to be a horde of tiny Y-shaped "bees." "Ah ha," you think, "another valuable piece of information." You record, "Spotted a (4) making and releasing (5)."
That done, you turn your attention to scanning the rest of the landscape. Suddenly you let out an involuntary yelp. Something quite enormous and looking much like an octopus is nearly blocking the narrow tunnel just ahead. Your mind whirs as it tries to figure out the nature of this cellular “beast” that appears to be guarding the channel. Then it hits you—this has to be a __6__ on the alert for foreign invaders (more properly called __7__), which it “eats” when it catches them.

The giant cell roars, “Halt, stranger, and be recognized,” and you dig frantically in your pocket for your identification pass. As you drift toward the huge cell, you hold the pass in front of you, hands trembling because you know this cell could liquefy you as quick as the blink of an eye. Again the cell bellows at you, “Is this some kind of a security check? I’m on the job, as you can see!” Frantically you shake your head “NO,” and the cell lifts one long tentacle and allows you to pass. As you squeeze by, the cell says, “Being inside, I’ve never seen my body’s outside. I must say, humans are a rather strange-looking lot!” Still shaking, you decide that you are in no mood for a chat and hurry along to put some distance between yourself and this guard cell.

Immediately ahead are what appear to be hundreds of the same type of cell sitting on every ledge and in every nook and cranny. Some are busily snagging and engulfing unfortunate strep bacteria that float too close. The slurping sound is nearly deafening. Then something grabs your attention: The surface of one of these cells is becoming dotted with some of the same donut-shaped chemicals that you see on the strep bacteria membranes; a round cell, similar, but not identical, to those you earlier saw in the germinal centers, is starting to bind to one of these “doorknobs.” You smile smugly because you know you have properly identified the octopus-like cells. You then record your observations as follows: “Cells like the giant cell just identified act as __8__. I have just observed one in this role during its interaction with a helper __9__ cell.”

You decide to linger a bit to see if the round cell becomes activated. You lean against the tunnel walls and watch quietly, but your wait is brief. Within minutes, the cell that was binding to the octopus-like cell begins to divide, and then its daughter cells divide again and again at a head-spinning pace. You write, “I have just witnessed the formation of a __10__ of like cells.” Most of the daughter cells enter the lymph stream, but a few of them settle back and seem to go into a light sleep. You decide that the “napping cells” don’t have any role to play in helping get rid of your host’s present strep infection but instead will provide for __11__ and become active at a later date.

You glance at your watch and wince as you realize that it is already 5 minutes past the time for your retrieval. You have already concluded that this is a dangerous place for those who don’t “belong” and are far from sure about how long your pass is good, so you swim hurriedly from the organ into the lymphatic stream to reach your pickup spot.
35. A young man is rushed to the emergency room after fainting. His blood pressure is alarmingly low, and his companion reports the man collapsed shortly after being stung by a wasp. What has caused his hypotension? What treatment will be given immediately?

36. Patty Hourihan is a strict environmentalist and a new mother. Although she is very much against using disposable diapers, she is frustrated by the fact that her infant breaks out in a diaper rash when she uses cloth diapers. Considering that new cloth diapers do not cause the rash, but washed ones do, what do you think the problem is?

37. James, a 36-year-old engineer, appeared at the clinic in an extremely debilitated condition. He had purple-brown lesions on his skin and a persistent cough. A physical examination revealed swollen lymph nodes. Laboratory tests revealed a low lymphocyte count. Information taken during the personal history revealed that James is homosexual. The skin lesions proved to be evidence of Kaposi's sarcoma. What is James's problem?

38. About 6 months after an automobile accident in which her neck was severely lacerated, a young woman comes to the clinic for a routine checkup. Visual examination shows a slight swelling just inferior to her larynx; her skin is dry and her face is puffy. When questioned, the woman reports that she fatigues easily, has been gaining weight, and her hair is falling out. What do you think is wrong?
39. Young Joe Chang went sledding, and the runner of a sled hit him in the left side and ruptured his spleen. Joe almost died because he did not get to the hospital fast enough. Upon arrival, a splenectomy was performed. What, would you guess, is the immediate danger of spleen rupture? Will Joe require a transplant for spleen replacement?

40. Use of birth control pills decreases the acidity of the vaginal tract. Why might this increase the incidence of vaginal infection (vaginitis)?

41. After surgery to remove lymphatic vessels associated with the removal of a melanoma, what condition can be expected relative to lymph drainage? Is this a permanent problem? Why or why not?

42. David's lymphatic stream contains a high number of plasma cells. Has the relative number of antibodies in his bloodstream increased or decreased at this time? What is the basis of your response?

43. Is the allergen in poison ivy sap a water-soluble or lipid-soluble molecule? Explain your reasoning.
THE FINALE: MULTIPLE CHOICE

44. Select the best answer or answers from the choices given.

1. Statements that apply to lymphatic capillaries include the following:
   A. The endothelial cells have continuous tight junctions.
   B. They are open ended like straws.
   C. Minivalves prevent the backflow of fluid into the interstitial spaces.
   D. The endothelial cells are anchored by filaments to the surrounding structures.

2. Chyle flows into the:
   A. lacteals
   B. intestinal lymph nodes
   C. intestinal trunk
   D. cisterna chyli

3. Which parts of the lymph node show increased activity when antibody production is high?
   A. Germinal centers
   B. Outer follicle
   C. Medullary cords
   D. Sinuses

4. The classification lymphoid tissues includes:
   A. the adenoids
   B. the spleen
   C. bone marrow
   D. the thyroid gland

5. The spleen functions to:
   A. remove aged RBCs
   B. house lymphocytes
   C. filter lymph
   D. store some blood components

6. Which characteristics are associated with the thymus?
   A. Providing immunocompetence
   B. Hormone secretion
   C. Hypertrophy in later life
   D. Cauliflower-like structural organization

7. The tonsils:
   A. have a complete epithelial capsule
   B. have crypts to trap bacteria
   C. filter lymph
   D. contain germinal centers

8. Possible APCs include:
   A. dendritic cells
   B. Langerhans' cells
   C. macrophages
   D. neutrophils

9. Effector T cells secrete:
   A. tumor necrosis factor
   B. histamine
   C. perforin
   D. interleukin 2

10. Neutrophils die in the line of duty because:
    A. they ingest infectious organisms
    B. their membranes become sticky and they are attacked by macrophages
    C. they secrete cellular toxins, which affect them in the same way they affect pathogens
    D. the buildup of tissue fluid pressure causes them to lyse
11. Macrophages:
   A. form exudate
   B. present antigens
   C. secrete interleukin 1
   D. activate helper T cells

12. Antibodies secreted in mother’s milk:
   A. are IgG antibodies
   B. are IgA antibodies
   C. provide natural active immunity
   D. provide natural passive immunity

13. Conditions for which passive artificial immunity is the treatment of choice include:
   A. measles
   B. botulism
   C. rabies
   D. venomous snakebite

14. Which of these antibody classes is usually arranged as a pentamer?
   A. IgG
   B. IgM
   C. IgA
   D. IgD

15. Which of the following antibody capabilities causes a transfusion reaction with A or B blood cell antigens?
   A. Neutralization
   B. Precipitation
   C. Complement fixation
   D. Agglutination

16. Class II MHC proteins are found on the membranes of:
   A. all body cells
   B. macrophages
   C. activated B lymphocytes
   D. some T cells

17. Which of the following terms is applicable to the use of part of the patient’s great saphenous vein in coronary bypass surgery?
   A. Isograft
   B. Xenograft
   C. Allograft
   D. Autograft