# Chapter 43: The Immune System

***43.1 Outline how innate immunity blocks pathogen entry and triggers rapid responses upon recognition of pathogens.***

***43.2 Describe the origin, structure, and function of adaptive immune receptors.***

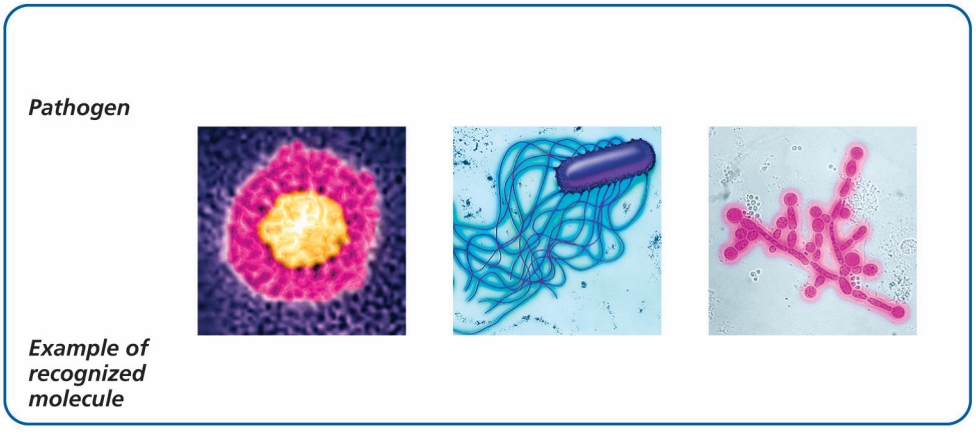
***43.3 Compare and contrast adaptive immune responses against pathogens in body fluids and in body cells.***

***43.4 Use examples to illustrate how interference with immune system function can contribute to diseases.***

Our students consider this chapter to be a particularly challenging and important one. Expect to work your way slowly through the first three concepts. Take particular care with Concepts 43.2 and 43.3. It is rewarding, however, in Concept 43.4 to put your new knowledge to work and truly understand the devastation caused by the destruction of helper T cells by HIV. In addition, the topic of cell communication underlies all the signals and responses described in this system. All in all, this chapter is core to your study of biology this year.

**Study Tip:** The broadest division of the immune system is innate immunity and adaptive immunity. Figure 43.1 in your text briefly examines each.

a. Use the figure on *innate recognition* to define the term and then explain why the examples would elicit an innate recognition response.




b. Next, define *adaptive recognition*, noting how it can attack specific pathogens rather than broad types of pathogens as the innate system does.

c. Recognition by either type of immunity triggers a _____ that can _____ or _____the pathogen.

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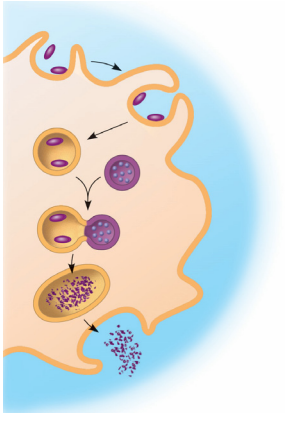
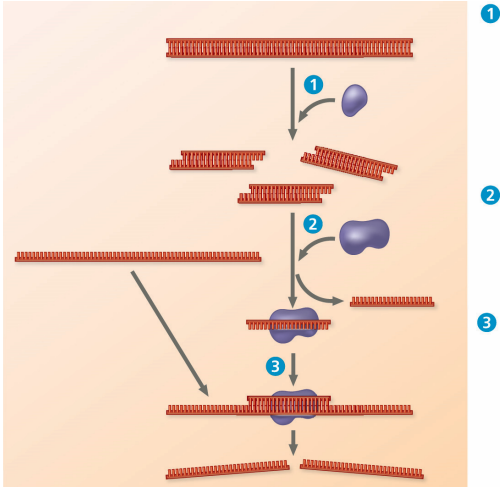
## *Concept 43.1 In innate immunity, recognition and response rely on traits common to groups of pathogens*

***LO 43.1: Outline how innate immunity blocks pathogen entry and triggers rapid responses upon recognition of pathogens.***

1. We first encountered *phagocytosis* in Chapter 6. It plays an important role in the immune systems of both invertebrates and vertebrates. Review the process in the figure by briefly explaining the six steps to ingestion and destruction of a microbe by a phagocytic cell.



2. Another example of innate immunity is the recognition of a molecule that does not normally form in animals, double-stranded RNA. Use the figure below to explain in three steps how this recognition results in stopping a viral infection.




3. Give three examples of *barrier defenses* that show their broad and varied means of repelling pathogens.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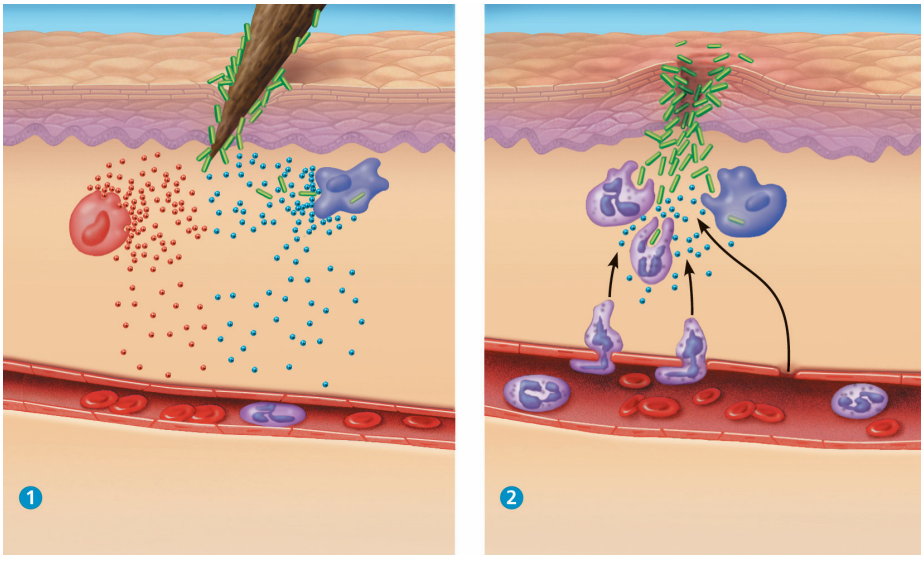
4. How are *toll-like receptors* used in cellular innate defenses? Use TLR3 and TLR4 as examples to explain the essential feature of how these receptors work.

5. In the following chart, explain the roles of the following four types of cells.

| Cell Type | Role in Defense |
|---|---|
| Neutrophils | |
| Macrophages | |
| Dendritic cells | |
| Eosinophils | |

6. *Natural killer cells* are not phagocytic. How do they assist in innate defenses, and what types of cells do they detect?

7. Use the following figure to explain the major events in a local *inflammatory response*.

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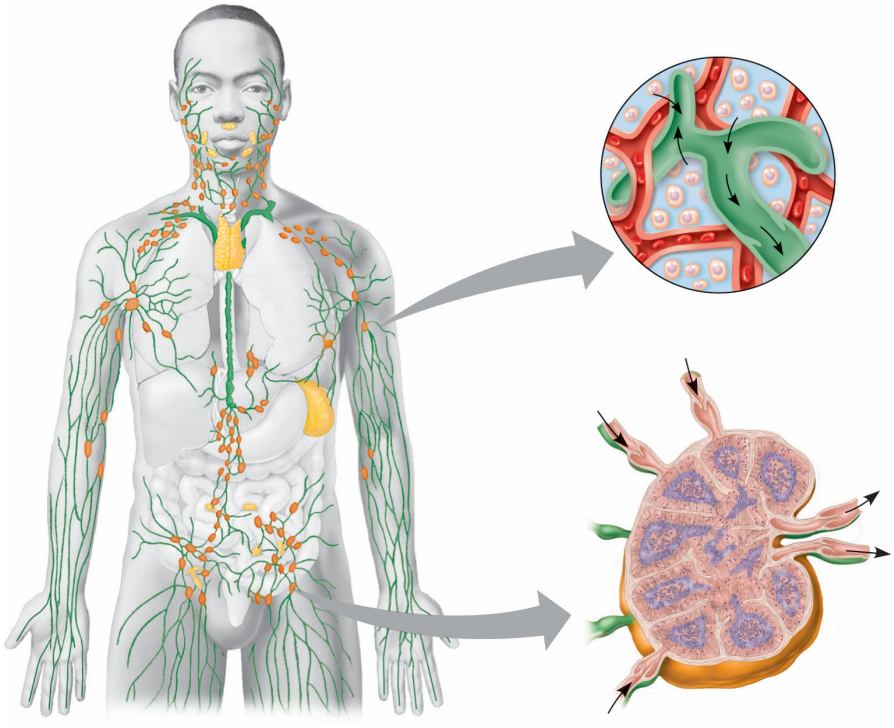
8. What two signaling molecules are used in a local inflammatory response?

9. In the following figure, trace the flow of lymph in four stages. Explain the lymphatic system's role in innate defense, paying particular attention to Step 3. (Be sure you understand the relationship between the lymphatic and circulatory system as described in Concept 42.3, Fluid Return by the Lymphatic System, p. 933.)



10. Describe what additional immune responses can occur in a systemic inflammatory response, including what occurs in *septic shock*.

11. Explain the role of the following two antimicrobial compounds.

**interferon**

**complement**

12. It might seem like pathogens have little hope of mounting an infection, but do not forget that pathogens are constantly evolving ways to circumvent our immune system. As examples, how do the pathogens that cause pneumonia and tuberculosis avoid our immune responses?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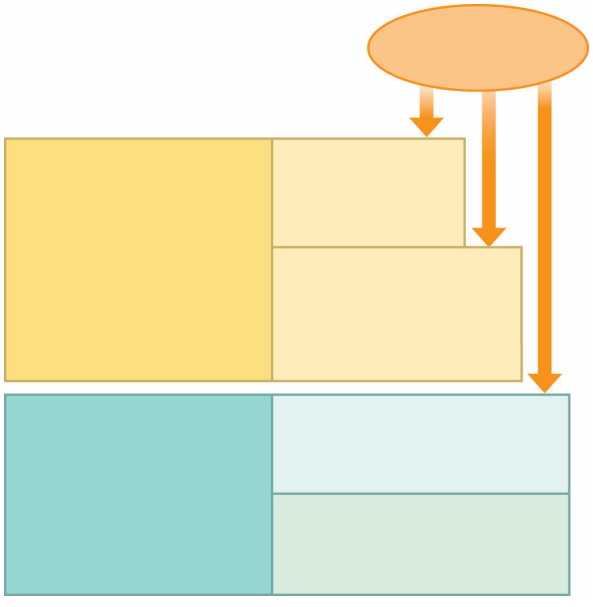
## *Concept 43.2 In adaptive immunity, receptors provide pathogen-specific recognition*

***LO 43.2: Describe the origin, structure, and function of adaptive immune receptors.***

13. Vertebrates are unique in having both innate and adaptive immunity. Complete Figure 43.7 below. The top section reviews the features of *innate immunity* which you have just learned, while the lower section will serve as an outline for *adaptive immunity*.



14. Summarize where *T cells* and *B cells* undergo development and give an overview of their functions. (Note that they are both a type of white blood cell known as a *lymphocyte*.)

15. The following brief questions will serve as a primer for immune system recognition.

    a. What is an *antigen*?

    b. What is the relationship between an *antigen receptor*, an *antibody*, and an *immunoglobin*?

    c. How is an *epitope* related to an antigen? (Look at Figure 43.10 in your text.)

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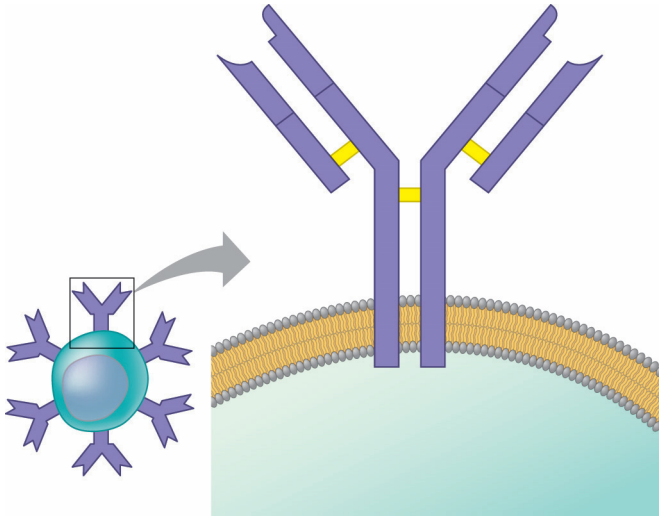
16. In the following figure of a B cell, label the *B cell antigen receptor*, *antigen-binding sites*, *light and heavy chains*, *variable and constant regions*, *transmembrane region*, and *disulfide bridges*.



17. What forms the specific *antigen-binding site*? (Be sure to recognize that each B cell produces only one type of antigen receptor. For any one cell, all antigen receptors or antibodies produced are identical.)

18. Explain the relationship between a B cell antigen receptor and an antibody. (Also see Figure 43.10 in your text.)

19. Using Figure 43.11 in your text as a guide, sketch and label the structure of a T cell antigen receptor.

20. T cells also display only one type of receptor on the cell's surface. Compare how a T cell functions in the immune response with how a B cell functions.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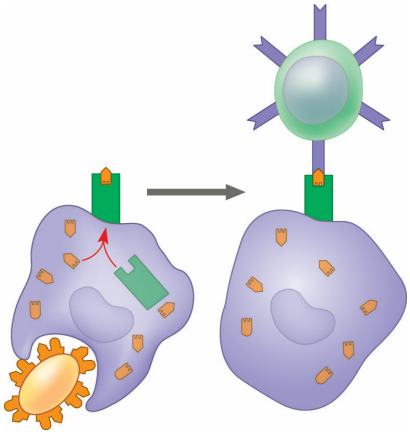
21. *B cell receptors* recognize and bind to antigens whether they are free antigens (like a secreted toxin) or on the surface of a pathogen. Explain the role of the *major histocompatibility complex* (*MHC*) to *T cell receptor* binding.

22. Using Figure 43.12 in your text, completely label the following figure and describe how a T cell recognizes an antigen by the process of *antigen presentation*.



23. Refer to the section on B cell and T cell Development on page 960 in your text. List four major characteristics of the *adaptive immune system*. This will give an important overview of adaptive immunity and will guide you through the details to follow.

    a.

    b.

    c.

    d.

24. One of the early problems in immunology was trying to understand how an organism with a limited number of genes (for humans, about 20,000) could produce a million different B cell protein receptors and 10 million different T cell protein receptors! The answer resulted in a Nobel Prize and a startling exception to the notion that all cells have exactly the same DNA. Using Figure 43.14 in your text, explain the four steps in producing genetically unique B cell receptors.

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25. Explain how the body develops *self-tolerance* in the immune system.

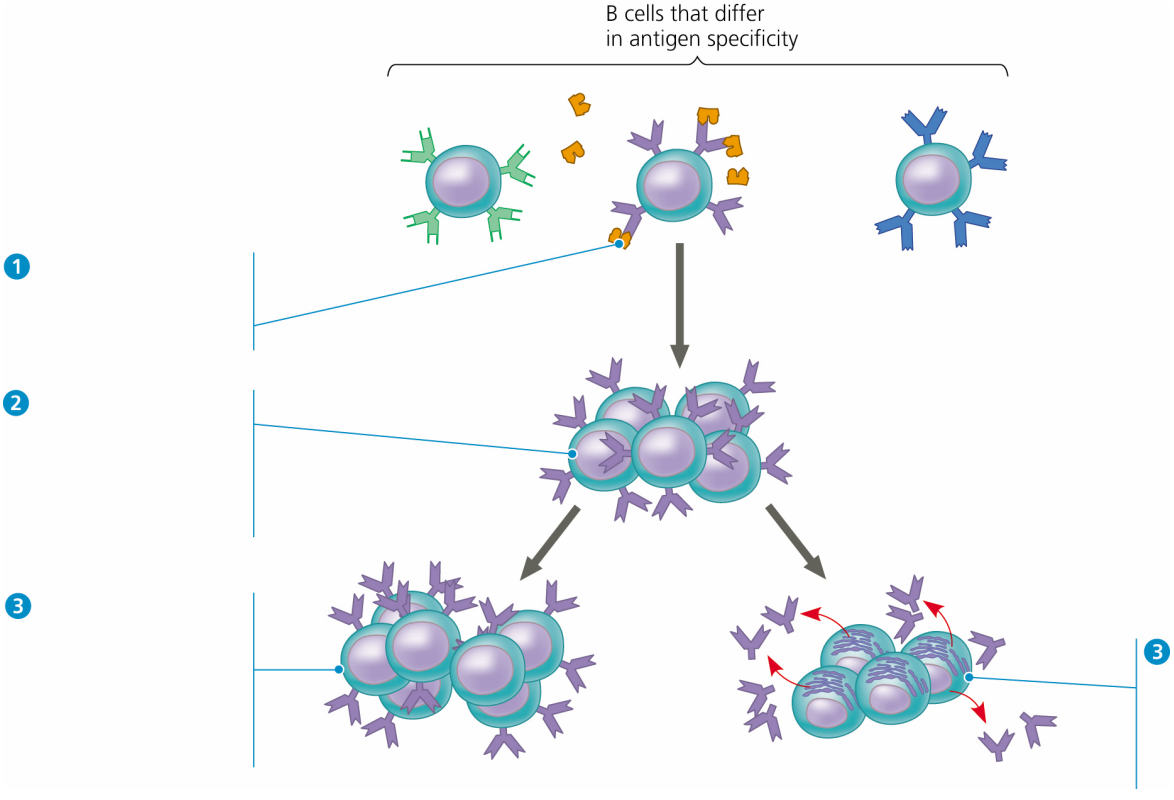
26. Define the following terms.

**effector cells**

**memory cells**

**clonal selection**

27. Using the blue text in the margin of Figure 43.16, label and explain the three key events in clonal selection.





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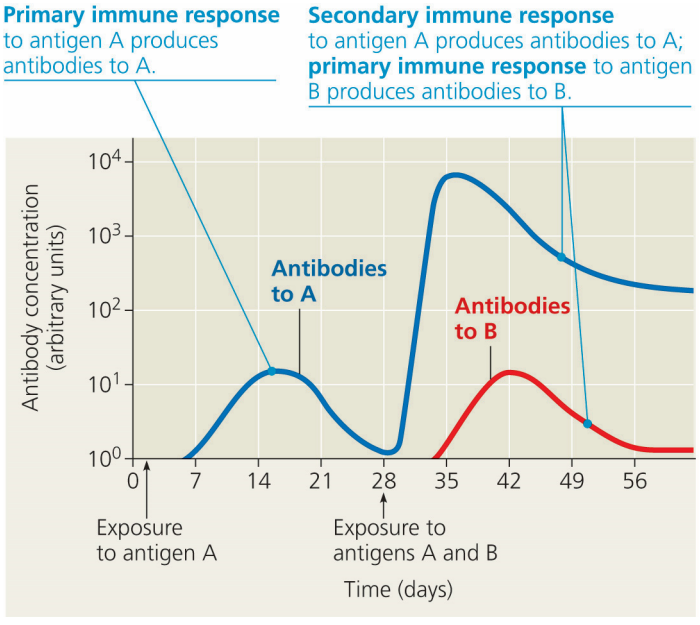
28. The graph below depicts the primary and secondary immune response. The first arrow shows exposure to antigen A. The second arrow shows exposure to antigen A again, and antigen B. Use the graph to explain the difference between a *primary* and *secondary immune response*.




29. Explain the significance of the response time difference between primary and secondary immune responses.

## *Concept 43.3 Adaptive immunity defends against infection of body fluids and body cells*

***LO 43.3: Compare and contrast adaptive immune responses against pathogens in body fluids and in body cells.***

30. Explain the function of the two divisions of acquired immunity.

**humoral immune response**

**cell-mediated immune response**

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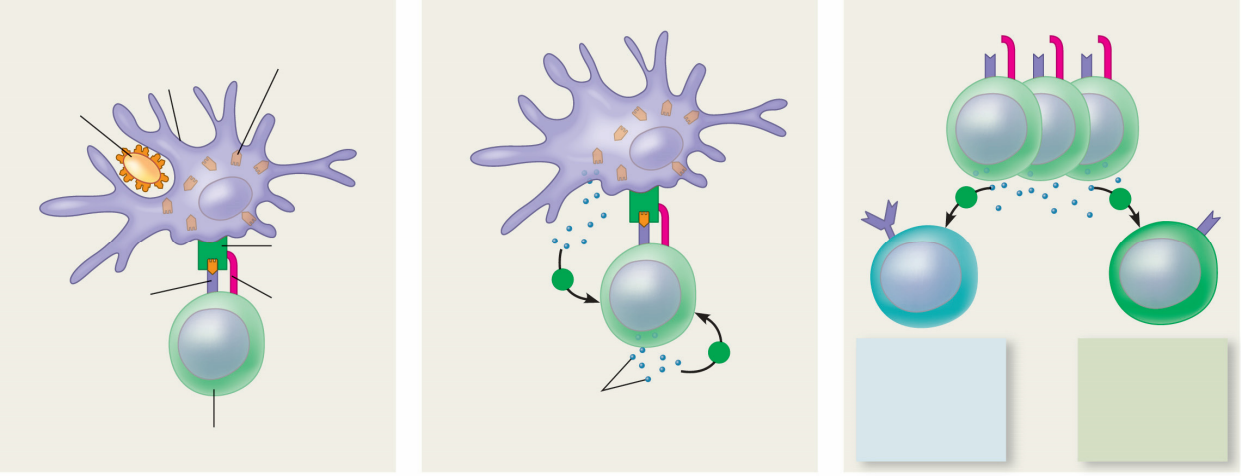
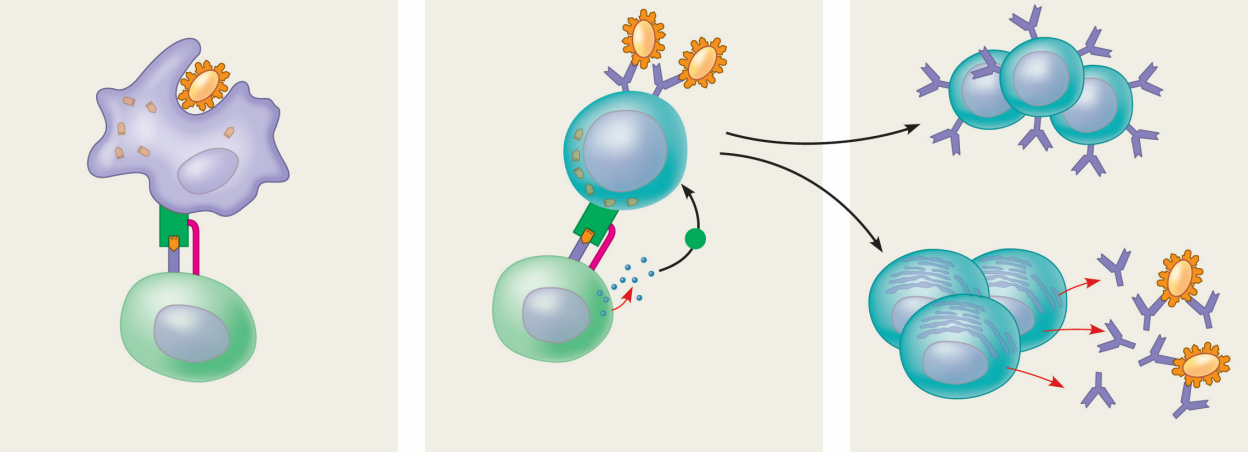
31. *Helper T cells* play a critical role in activation of both T cells and B cells. In full detail, label and explain the three steps involved using Figure 43.18.



32. Figure 43.19 is a continuation of Figure 43.18 where the helper T cell has activated a specific B cell. Continuing to Figure 43.19, completely label the diagram then carefully explain the three primary steps that occur in *B cell activation*.



33. What is the difference between *plasma cells* and *memory cells* produced from the activation of B cells?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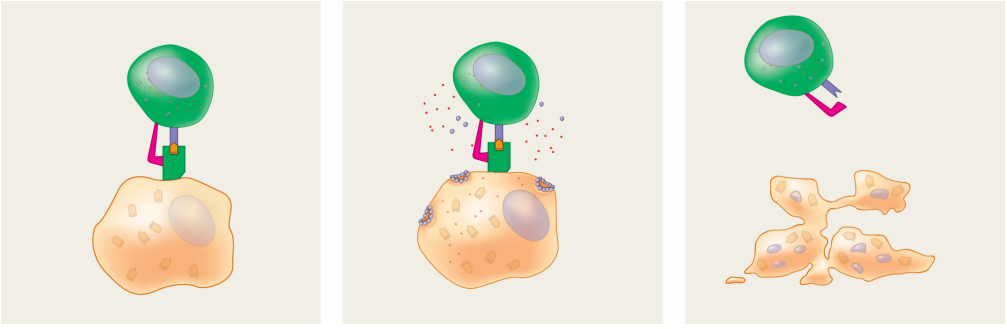
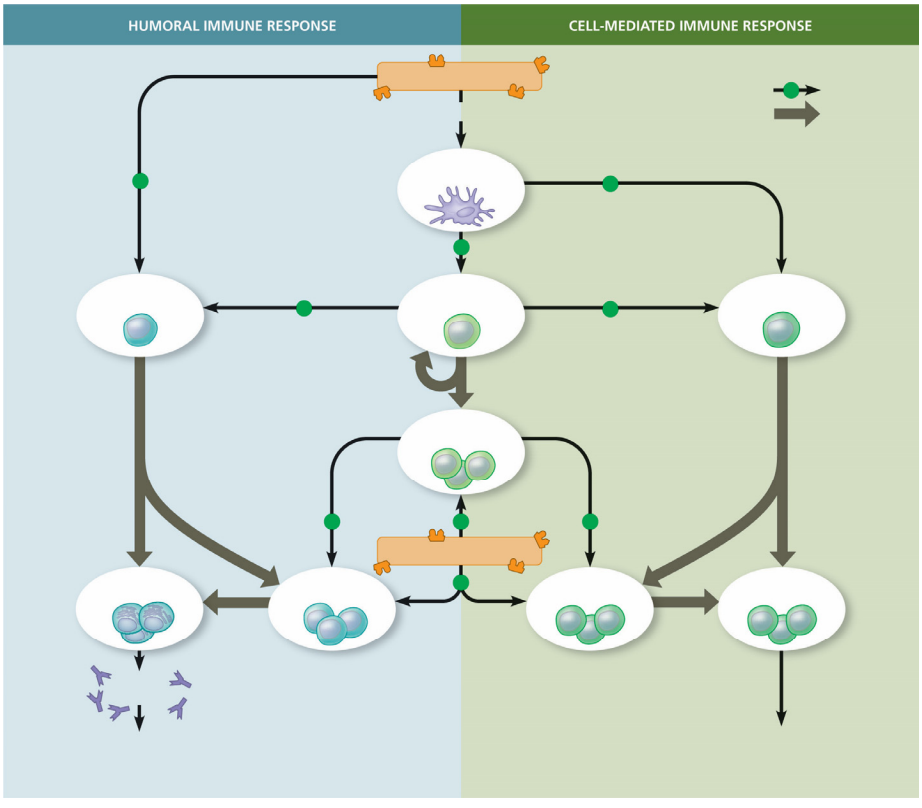
34. How do antibodies and natural killer cells work together to fight viral infections while the virus is inside the body cell?

35. Use Figure 43.22 in your text as a guide to give an overview of the three steps in the killing action of a cytotoxic T cell.



36. To put the complexities of the immune response in perspective, complete this very important summary chart while mentally tracking both arms of the adaptive immune response.

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37. Describe how *immunizations* develop active immunity.

38. How has misinformation about vaccine safety led to a public health problem with measles?

39. Using examples, explain the difference between *active* and *passive immunity*.

40. Explain how *monoclonal antibodies* are used in home pregnancy kits.

41. Why is the antibody response to a microbial infection *polyclonal*?

42. Why is immune rejection an example of a healthy immune system, but the rejection may result in a medical problem for the patient?

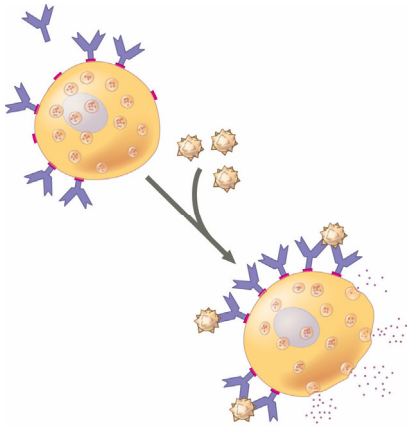
43. Briefly describe why blood types must be matched in a transfusion and how antibodies against blood types are present in the blood prior to exposure.

## *Concept 43.4 Disruptions in immune system function can elicit or exacerbate disease*

***LO 43.4: Use examples to illustrate how interference with immune system function can contribute to diseases.***

44. What are allergies?

45. Label Figure 43.26 and then use it to explain a typical allergic response.

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46. Explain what happens if a person experiences *anaphylactic shock*. Do you know anyone who carries an EpiPen loaded with epinephrine to protect against anaphylactic shock?

47. *Autoimmune diseases* occur when the immune system turns against particular molecules of the body. For reasons not completely understood females are more likely to have autoimmune diseases than males. Describe the cause and symptoms of the following autoimmune diseases.

**lupus**

**rheumatoid arthritis**

**type 1 diabetes**

**multiple sclerosis**

48. Explain how *inborn immunodeficiency* is different from *acquired immunodeficiency.*

49. Just as our immune system has evolved to thwart pathogens, pathogens have evolved to thwart our immune system. Describe the following pathogen strategies.

**antigenic variation**

**latency**

**attack on the immune system: HIV**

50. Explain how the high mutation rate in surface antigen genes in HIV has hampered development of a vaccine for AIDS. (You might take note that HIV—human immunodeficiency virus—is the virus that causes the disease AIDS—acquired immunodeficiency syndrome. These acronyms are often used incorrectly.)

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*Test Your Understanding*, p. 975.

1. _____ 2. _____ 3. _____ 4. _____ 5. _____ 6. _____

7. _____


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