

Chapter Outline

- 39.1 – Animals Use Innate and Adaptive Mechanisms to Defend Themselves against Pathogens
- 39.2 – Innate Defenses Are Nonspecific
- 39.3 – The Adaptive Immune Response Is Specific
- 39.4 – The Adaptive Humoral Immune Response Involves Specific Antibodies
- 39.5 – The Adaptive Cellular Immune Response Involves T Cells and Their Receptors

To maintain health and prevent infection, multicellular organisms can mount a coordinated defense against invasion by pathogenic organisms. Pathogenic invaders disrupt homeostasis in their hosts, sometimes even to the point of death. Animal and plant defense systems are abundantly represented in the AP Biology Curriculum Framework, so this chapter is especially relevant to exam preparation. Though this chapter is extremely detailed, memorization of these details (e.g., the structure of specific antibodies) is not expected. Rather, focus on how these ideas are united in immunology.

There are two major levels of defense: innate immunity and adaptive immunity. Diverse, nonspecific, innate defenses protect most animals against invasion. For example, salty skin with its own flora is not often a hospitable environment for additional bacterial growth. In addition, natural killer cells roam the body, attacking invaders as they are encountered and recognized chemically as foreign.

Most multicellular organisms have adaptive immune responses. A major conceptual premise is that an organism's adaptive immunity must distinguish between self and nonself so only the latter will be subject to attack. Activated by the chemical recognition of invaders, B and T lymphocytes are key players in adaptive immunity. Host cells coordinate defense by using chemical signals. Adaptive immunity expressly allows an organism to respond

quickly and emphatically to specific pathogens that had been previously encountered and defeated, a sort of chemical memory that thwarts reinfection and forms the basis of modern vaccination practices.

Chapter 39 spans **Big Idea 2**, **Big Idea 3**, and **Big Idea 4**. The specific parts of the AP Biology curriculum covering **Big Idea 2**: Biological systems utilize free energy and molecular building blocks to grow, to reproduce, and to maintain dynamic homeostasis, include:

- **2.D.3**: Biological systems are affected by disruptions to their dynamic homeostasis.
- **2.D.4**: Plants and animals have a variety of chemical defenses against infections that affect dynamic homeostasis.

The specific parts addressing **Big Idea 3**: Living systems store, retrieve, transmit, and respond to information essential to life processes, include:

- **3.D.2**: Cells communicate with each other through direct contact with other cells or from a distance via chemical signaling.

The specific parts covering **Big Idea 4**: Biological systems interact, and these systems and their interactions possess complex properties, include:

- **4.C.1**: Variation in molecular units provides cells with a wider range of functions.

Chapter Review

Concept 39.1 describes the primary differences between innate (nonspecific) and adaptive (specific) immunity. White blood cells, including phagocytes, leucocytes, and natural killer cells, are involved in both forms of immunity. Cytokines are chemical messengers that coordinate activities of immune-system components.

1. Identify and label each of the following immune mechanisms as innate (I) or adaptive (A).

- ___ Stomach acid that destroys ingested bacteria
- ___ T-cells that destroy viruses
- ___ Skin defenses that prevent viruses from entering
- ___ Defensins that destroy invaders with plasma membranes
- ___ Interferons that prevent viruses from spreading between neighboring cells
- ___ Antibodies that prevent reinfection by chicken pox

2. White blood cells can be classified as phagocytes or lymphocytes. Explain the similarities and differences between these classifications.

- a. Similarities: _____

- b. Differences: _____

Concept 39.2 focuses on the innate (nonspecific) immune system, including the skin, mucus, lysozymes, and defensins. Other innate defenses involving proteins and cellular defenses include phagocytes, natural killer cells, complement proteins, and interferons. Many of these defenses also cause inflammation with more blood flow, swelling due to increased intercellular fluids, and release of chemical signals, which can enhance protective defenses.

3. Describe how the innate immune system meets a pathogen in each of the following scenarios:

- a. A pathogen lands on your skin. _____

- b. A pathogen lands in your mouth. _____

- c. A pathogen is ingested from a drink of water. _____

4. Describe natural killer cells, and explain how they can be part of both the innate and adaptive immune systems.

5. Describe how the inflammation response aids in fighting infection.

6. Many people take antihistamines to control allergies. Explain how these drugs can reduce allergic responses.

7. Explain how interferons are involved in cell communication. Include sources and targets in your answer.

8. Synthetic cortisol-like drugs (agonists) are often injected into swollen and painful bone-joints (e.g., tennis elbow, pitcher's arm, and arthritic knees). Describe how the immune system responds to the injected agonists, and discuss how this can provide some relief to the patient.

9. Suppose that you were exposed to a newly synthesized “artificial” bacterium and all signs of the bacterium were gone from your body within 24 hours. Assume further that this bacterium is novel enough that it does not share chemical identity signals with other bacteria. Given the time frame in this scenario, decide if your immune system’s victory over this bacterium was via innate or adaptive immunity. Be sure to explain some of the ways the bacterium was defeated.

Concept 39.3 introduces the four premises for adaptive response: specificity, diversity, self-recognition, and memory. Activated T-cells destroy foreign invaders displaying specific antigens. Upon exposure, B cells synthesize specific antibodies that recognize upwards of 10 million different antigens. This diversity is created by DNA changes and mutations after B cells are formed in the bone marrow. Self-recognition is important, so your immune system’s attacking cells do not harm the self cells; the latter possess major histocompatibility complex (MHC) proteins on their surfaces as a form of chemical identification.

10. Define antigens and antibodies.

11. Explain how an individual bacterium can have several antigens.

12. Explain how a single molecule (polypeptide or polysaccharide) can include multiple antigen sites.

13. Severe combined immunodeficiency (SCID) is a genetic disease in which T and B lymphocytes are nonfunctional. Describe a transplant that might establish the production of normal lymphocytes in a patient.

14. Describe two types of disease that are of special concern in SCID.

15. After winter break at a boarding school, many students get sick with the flu or other viruses. Describe the process that often results in adults being more resistant to sickness than younger people are.

16. Explain how humoral immunity differs from cellular immunity, giving a brief example of each type.

Concept 39.4 describes that the humoral immune response depends on the production of antibodies by the B cells. Antigen-antibody reactions activate effector responses to deactivate the pathogen.

17. Though you have probably never been exposed to botulism, diphtheria, or their toxins, you are making B cells and antibodies that can recognize these antigens and help protect you from botulism. Explain how the antibodies are produced even though you've had no previous exposure.

18. Discuss how the production of millions of antibodies comes about, and describe the similarities between this process and the idea of introns and splicing.

19. Discuss how the involvement of antibodies leads to the destruction of foreign pathogens or toxins.

Concept 39.5 describes how the two types of T cells, T-helper cells and cytotoxic T cells, are the basis of cellular immunity.

20. Describe the main difference between antibodies interacting with pathogens and antibodies interacting with the major histocompatibility complex (MHC) proteins.

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Science Practices & Inquiry

In the AP Biology Curriculum Framework, there are seven **Science Practices**. In this chapter, we will focus on **Science Practice 1**: The student can use representations and models to communicate scientific phenomena and solve scientific problems. More specifically, we will focus on **Science Practice 1.1**: The student can create representations and models of natural or manmade phenomena and systems in the domain.

Question 24 asks you to create representations and models to describe immune responses (**Learning Objective 2.29**).

24. For each of the scenarios below, draw a diagram or flow chart showing how a person's immune system might react to the foreign virus.

- a. While walking down a crowded hallway, someone in front of you coughs without covering her mouth. You feel the spray of the cough on your arm, but you do not get sick.
- b. While swimming in the ocean, you swallow some seawater. Later that night you feel ill and you run a temperature. The next day you're fine.
- c. A child comes down with chicken pox, but his parents do not. Both of his parents had chicken pox as children. (Create two flow charts, one for the son and one for the parents.)