# 5 Cell Membranes and Signaling

## Chapter Outline



Living organisms, such as birds and fish, are made up of cells. These cells are collections of molecules that work together. Surrounding each cell is a plasma membrane that serves as a boundary between the cell and the environment. The cell membrane is much more than a just a boundary, because it includes proteins that regulate what goes into or out of the cell.

Intercellular communication is essential for multicellular forms of life. It provides precision in homeostasis, serves as the site of self-recognition and cell defense (immune system), and responds to changes in the environment. Proteins in membranes serve as receptors for many communication messages from other cells.

Chapter 5 emphasizes **Big Idea 3** but also includes some of **Big Idea 2** and **Big Idea 4**.

**Big Idea 2** states that the utilization of free energy and the use of molecular building blocks are characteristic of all life. Specific parts of the AP Biology curriculum that are covered in Chapter 5 include:

- **2.B.1:** Cell membranes are selectively permeable due to their structure.
- **2.B.2:** Growth and dynamic homeostasis are maintained by the constant movement of molecules across membranes.

**Big Idea 3** states that living systems store, retrieve, transmit, and respond to information essential to life processes. Chapter 5 explains cell communication, addressing:

- **3.B.2:** A variety of intercellular and intracellular signal transmissions mediate gene expression.
- **3.D.1:** Cell communication processes share common features that reflect a shared evolutionary history.
- **3.D.3:** Signal transduction pathways link signal reception with cellular response.
- **3.D.4:** Changes in signal transduction pathways can alter cellular response.

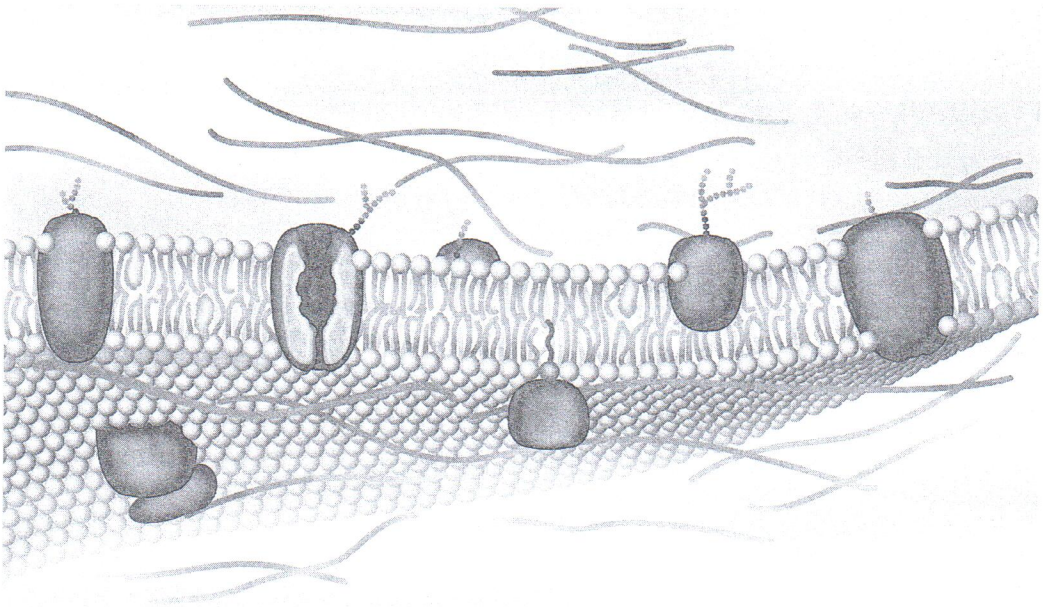
**Big Idea 4** states that biological systems interact in complex ways. Specifically Chapter 5 includes:

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

## Chapter Review

**Concept 5.1** *explains that membranes surrounding cells have a common structure through all forms of life: a phospholipid bilayer that is embedded with proteins, and carbohydrates that serve several functions. Additional characteristics of membranes include a thick, hydrophobic middle layer as well as inner and outer layers. The inner and outer layers are thin and have hydrophilic properties.*

1. On the diagram below, label the following: phospholipid, cholesterol, cytoskeleton, cell interior (cytoplasm), integral protein, peripheral protein, and carbohydrate. In the space below the figure, explain what information you would use to determine which side of the membrane faces the inside of the cell and which side faces the extracellular environment.

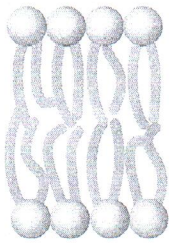


2. Descriptions of the plasma membrane often refer to a "fluid mosaic" model. Provide evidence that the membrane is "fluid," and describe the "mosaic" of this model.

3. Explain how the structure of an individual phospholipid molecule allows these molecules to form a membrane with a nonpolar/hydrophobic middle layer and polar/hydrophilic inner and outer layers.

4. Describe one physical factor and one chemical factor that influence membrane fluidity.

5. In addition to phospholipids, many other molecules have both polar and nonpolar regions. For a large protein that spans the phospholipid membrane, describe how this characteristic facilitates its correct placement in membranes. Add an amphipathic protein embedded in the membrane to the diagram at the right . Label the polar and nonpolar regions of both the membrane and the large protein.

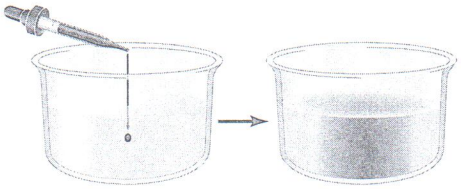


6. Explain how some organisms cope with the temperature extremes of hot summers and cold winters by altering the biochemical composition of membranes.

7. Describe the two major structural components and one function of glycoproteins.

**Concept 5.2** *explains that kinetic energy drives the movement of substances from an area of high concentration to an area of low concentration. Diffusion is the term that describes such movement across cell membranes. Not all molecules readily diffuse across membranes, because the molecular size and polarity of a molecule determine whether or not it can enter the phospholipid bilayer. Osmosis is the diffusion of water across membranes.*

8. In the example at the right, a drop of ink was placed into a bowl of gelatin. Explain how the ink diffused throughout the gel even though there were no currents to help move it around.



9. Describe two differences between passive transport and active transport.

10. Briefly explain how each of the following factors can alter the diffusion rates of solutes across membranes.

a. Size of the diffusing solute: _____

b. Temperature: _____

c. Concentration gradient: _____

11. Some topical anesthetics dissolve into the membranes of sensory neurons to reduce their activity. Describe two structural properties of an anesthesia-inducing molecule that would make it a likely candidate for this route of anesthetic effect.

_____

12. Even though water can readily move across many natural membranes, explain why it might be expected to move slowly or not at all through artificial membranes constructed without proteins.

_____

13. The three terms below are used when comparing solute concentration on either side of a cell membrane. Define each term and describe how that condition might affect a cell's shape.

a. Isotonic: _____

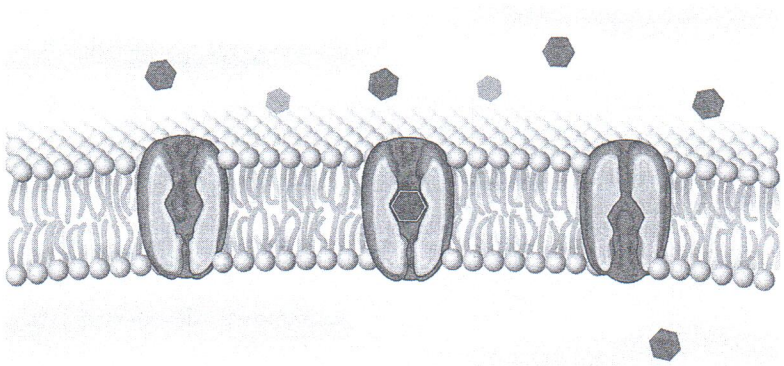
b. Hypotonic: _____

c. Hypertonic: _____

14. Facilitated diffusion refers to a special type of transport. For example, the entry of glucose into the muscles in your body is considered facilitated diffusion. Is this type of transmembrane movement an example of active transport or passive transport? Explain why.

15. After several days without watering, plants tend to wilt. When a wilted plant is watered, it will often return to its normal shape. Explain how cells and water movements are involved in the transition from wilted to not wilted.

16. Explain how the carrier protein in the diagram below is facilitating the diffusion of a molecule. Include an explanation for why the protein is needed.



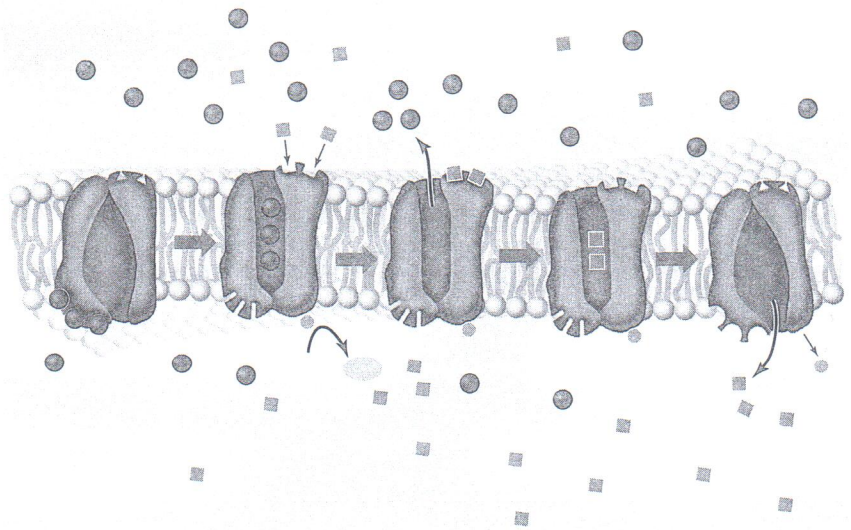
**Concept 5.3** *considers active transport and describes the movement of substances against their chemical concentration gradient, which requires energy.*

17. Describe the primary chemical process that occurs inside the cell to drive active transport.

18. Complete the table below:

| | Simple diffusion | Facilitated diffusion (channel or carrier protein) | Active transport |
|---|---|---|---|
| Cellular energy required? | | | |
| Driving force | | | |
| Membrane protein required? | | | |
| Specificity | | | |

19. The $Na^+$–$K^+$-ATPase is the most active and widespread active-transport system in the human body. Add labels and processes on the diagram below to describe how this pump functions.



**Concept 5.4** *examines how many large molecules cannot cross membranes via transporters embedded in membranes; rather, such compounds enter or leave cells via vesicles, in a process called endocytosis or exocytosis, respectively.*

20. Explain the similarities and differences between phagocytosis and pinocytosis.

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21. Describe receptor-mediated endocytosis, using details that explain whether this process meets the criteria for active transport or passive transport.

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**Concept 5.5** *explains how some hormones (e.g., insulin and many other signals from outside the cell) are received and alter the cell's activity. This process is called a signal transduction. In order to respond, the cell must have a specific receptor that is modified by the stimulus. Once a receptor in the membrane is activated by the signal, it sets off a series of biochemical changes within the cell. These pathways are sequences of events and chemical reactions that lead to a cell's response to a signal. This ability to respond to the environment is critical to the organism's or cell's ability to maintain precision in its homeostatic mechanisms.*

22. Describe the three major steps in cell signaling.

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23. Different receptor proteins for different signals are found either on the membrane of the cell or in the cytoplasm of the cell, implying that the signal must enter the cell. Give an example of each receptor type below, and discuss the properties of the ligand (signal molecule) that activates this receptor.

a. Intracellular receptor protein: _____

_____

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_____

b. Membrane-bound receptor protein: _____

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_____

_____

24. If a cell has no proteins in its membrane, will it be able to respond to any environmental stimuli? Explain your answer.

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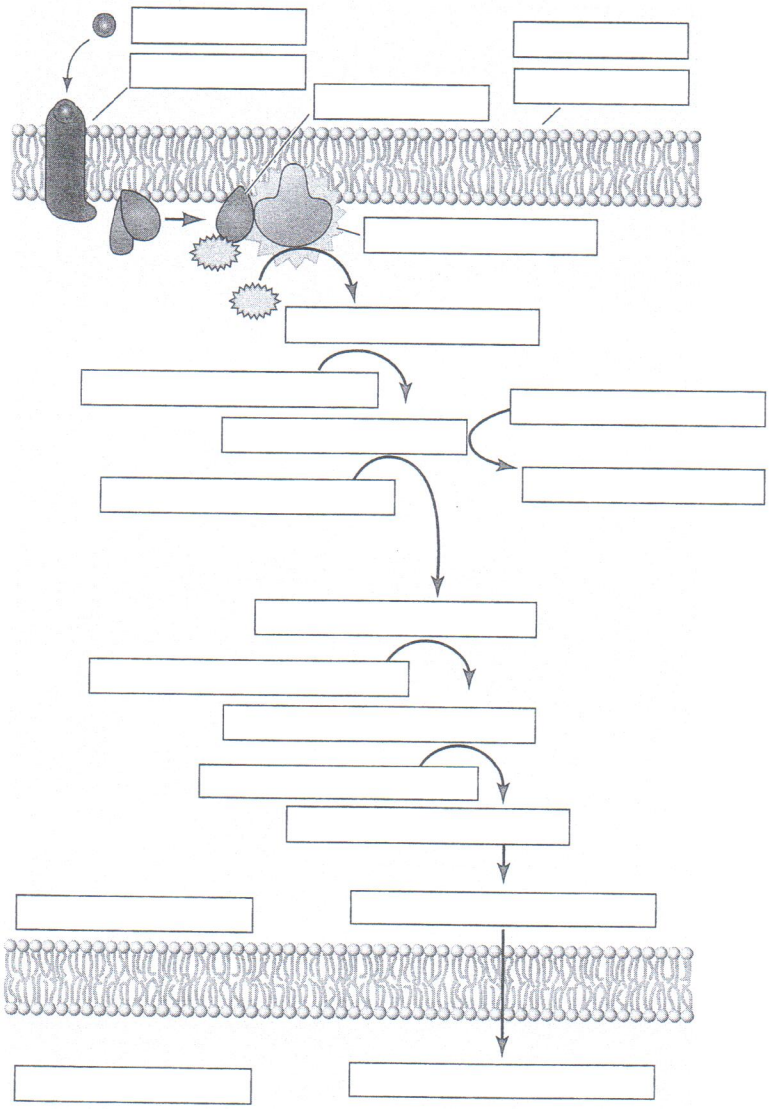
**Concept 5.6** *shows how physical or chemical signals initiate responses from cells that have a signal transduction pathway for that signal. For example, signals that modify receptor proteins in membranes rapidly initiate a series of biochemical changes within the cell. The pathways affected by these biochemical changes are typically components in a signaling cascade that amplifies and distributes responses by effector proteins in the cell.*

25. Complete the diagram below showing an example of a signal cascade.



26. Explain how the signal cascade in Question 25 achieves amplification.