Name _____ **Period** _____

Chapter 11: Cell Communication

The special challenge in Chapter 11 is not that the material is so hard to understand but that most of the material will be completely new to you. Cell communication is normally not covered in introductory high school biology courses, yet perhaps no other section of biology has grown as much as our understanding of cell signaling in the last decade. In the AP Biology Curriculum Framework, Enduring Understanding 3.D covers cell communication in depth, with nine Learning Objectives. This heavy emphasis underscores the importance of this topic in biology. Take your time with this section, and you will be rewarded with a knowledge base that will be most helpful in this course and courses to come.

Overview: Cellular Messaging

1. What are three examples of signals that cells may receive? What is the most common type of signal?

2. How does cell signaling provide evidence to justify the claim that all life is related?

Concept 11.1 External signals are converted to responses within the cell

3. What is a *signal transduction pathway*?

4. How does yeast mating serve as an example of a signal transduction pathway?

5. What is *quorum sensing*? How is it related to *biofilms*?

6. How can chemical signals pass between animal cells? Plant cells?

7. Some chemical signals are received by specific target cells. What is required for reception by a target cell?

8. Complete the chart of local chemical signaling in cell communication in animals.

Local Signaling Types	Description	Specific Example
Paracrine signaling		
Synaptic signaling		

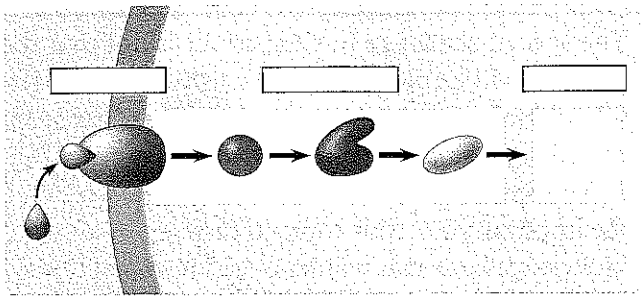
9. How does a hormone qualify as a *long-distance signaling* example?

10. A signal transduction pathway has three stages. Use Figure 11.6 in your text to label the missing parts of the following figure, and then explain each step. This is only a preview.

reception

transduction

response



Concept 11.2 Reception: A signaling molecule binds to a receptor protein, causing it to change shape

11. Explain the term *ligand.* (This term is not restricted to cell signaling. You will see it in other situations during the year.)

12. Study the GPCR shown on the top of page 215, Figure 11.8, and read the accompanying text. How does a G protein receive a signal? Why are cells able to respond to many different signals?

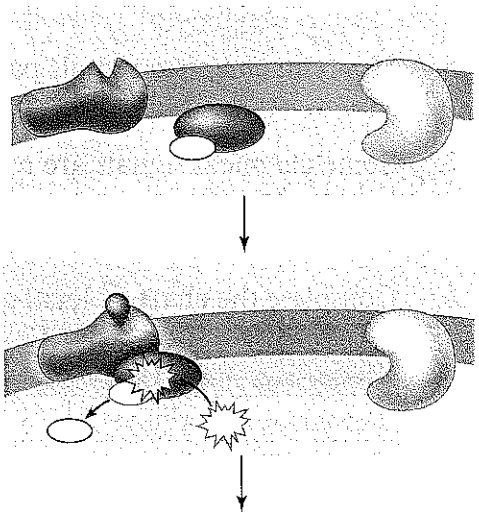
13. What processes in humans depend on GPCRs? What are examples of errors in GPCR signaling?

14. The text explains the three major types of membrane receptors in Figure 11.8. This material is of fundamental importance, so we will work through the specific figures for each type of membrane receptor. The first example is a *G protein-coupled receptor (GPCR).* In the first figure, label the components and then describe the role of the three components.

G protein-coupled receptor

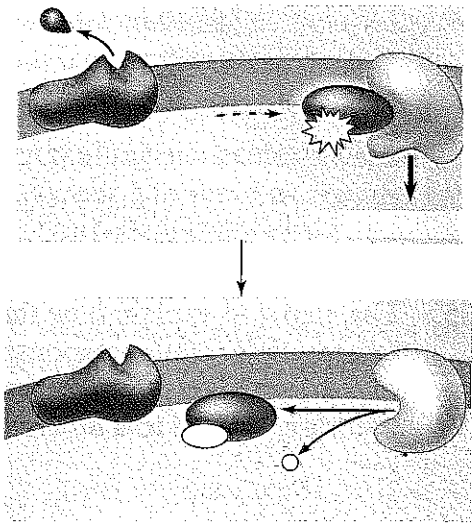
G protein

GDP



15. Label and then describe what happens in step 2.

16. Label and then describe what happens in step 3. (The yellow box at the bottom right is important!)



17. Equally important to starting a signal is stopping a signal. Step 4 stops the signal. (Failure to do so can lead to serious problems, like cancer.) Label and then describe how the signal is halted.

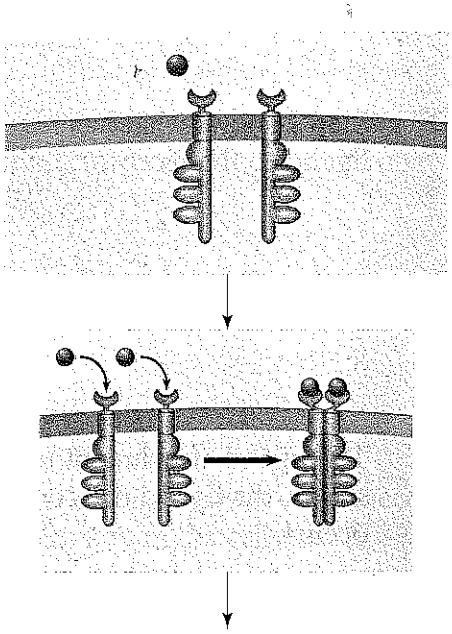
18. A G protein is also a GTPase enzyme. Why is this important?

19. The second type of receptor described is the *receptor tyrosine kinases (RTKs)*. Explain what a *kinase* enzyme does.

20. How does tyrosine kinase function in the membrane receptor?

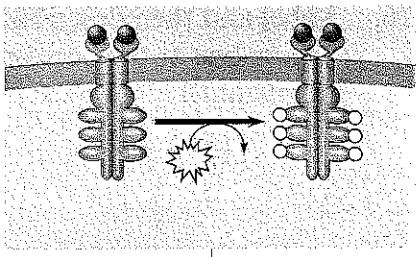
21. What is a key difference between receptor tyrosine kinases and G protein-coupled receptors?

22. Use Figure 11.8 in your text to provide all of the missing labels on the diagram below; then explain what happens in step 1.

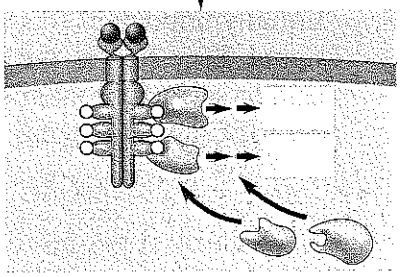


23. Label step 2 and then describe what happens to receptor tyrosine kinases when signaling molecules have attached.

24. Label and explain how the receptors are activated in step 3.



25. Use step 4 to explain how the activated receptor can stimulate multiple cellular response pathways. Each activated protein shown in this step triggers a *different* signal transduction pathway, leading to a *different* cellular response.

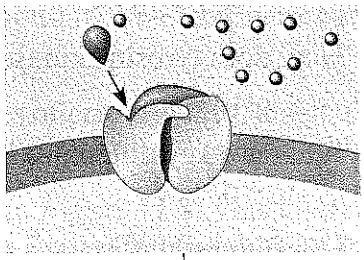


26. Look next at *ion channel receptors*. This figure shows the flow of ions into the cell. Ion channel receptors can also stop the flow of ions. These comparatively simple membrane receptors are explained in three steps. Label this diagram of the first step and then explain the role of the labeled molecules.

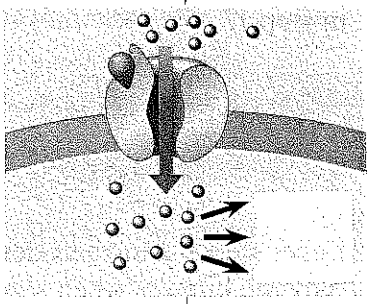
ligand

ligand-gated ion channel receptor

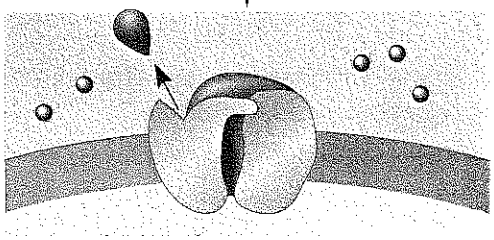
ions



27. Step 2 shows what has happened with the binding of the ligand to the receptor. Label and explain what occurs.



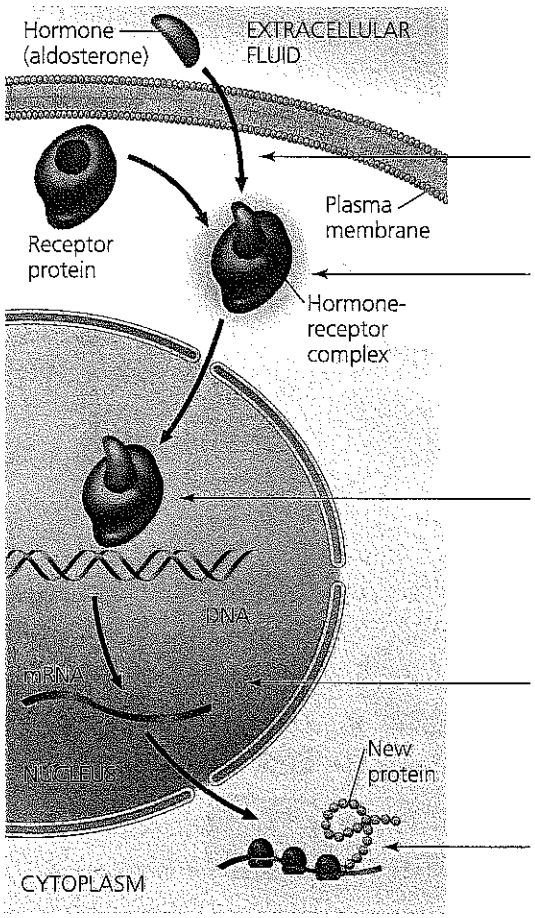
28. The ligand attachment to the receptor is brief. In step 3, the ligand dissociates. Label and explain what occurs.



29. Read the final paragraph below the Ion Channel Receptors figure carefully. In what body system are *ligand-gated ion channels* and *voltage-gated ion channels* of particular importance?

30. Where are intracellular receptors found? This means the signalling molecules must be able to pass through the plasma membrane. What types of molecules can serve as signals? Give examples.

31. The figure below shows how testosterone, a hydrophobic steroid hormone, triggers a cell-signaling pathway. It is important as an example of how intracellular receptors work. At each arrow, add an explanation of what is happening in the cell.



32. The important concept of gene regulation by activation of *transcription factors* is introduced in Figure 11.9 of your text. Explain the function of transcription factors in the cell.

Concept 11.3 Transduction: Cascades of molecular interactions relay signals from receptors to target molecules in the cell

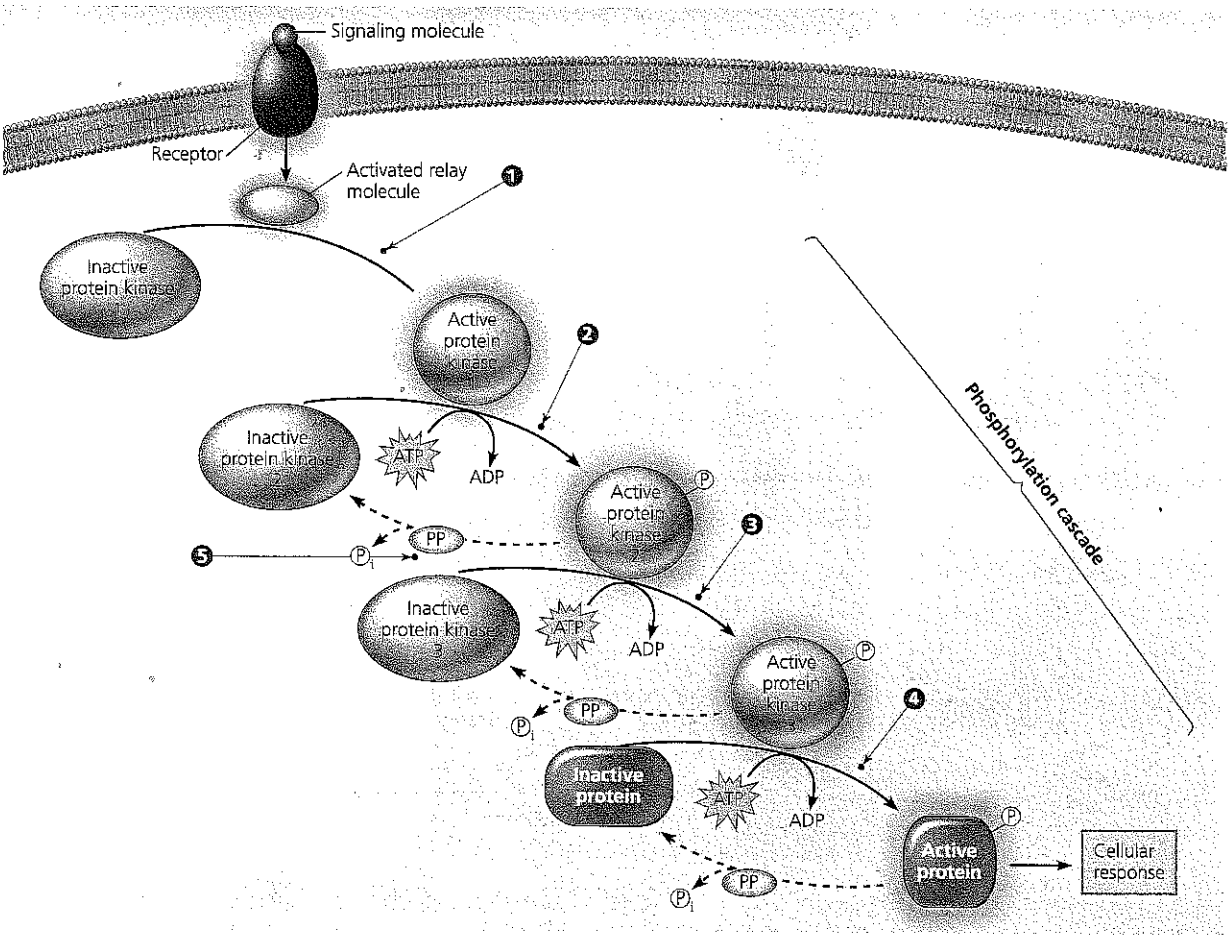
33. What are two benefits of multistep pathways like the one in Figure 11.10 in your book?

34. Explain the role in transduction of these two categories of enzymes:

protein kinases

protein phosphatases

35. Using Figure 11.10 as your guide, explain what is occurring in the cell at each arrow.



36. What is the difference between a first messenger and a second messenger?

37. Two common *second messengers* are *cyclic AMP (cAMP)* and *calcium ions* (Ca^{2+}). Explain the role of the second messenger cAMP in Figure 11.12 in the text.

38. Consider again the discussion of how epinephrine triggers the breakdown of glycogen in the liver, begun in Concept 11.1. For this pathway, what is the first messenger? What is the second messenger? Why could glycogen phosphorylase be activated only when epinephrine was added to *intact* cells?

39. What is the important relationship between the second messenger and *protein kinase A*?

40. Figure 11.12 explains how a cellular response is initiated; how might that response be inhibited?

41. Use your new knowledge of cell signaling to explain the mechanism of disease in cholera.

42. List three types of cellular responses often induced by calcium ions. Be sure to include a plant example!

43. What happens to the cytoplasmic concentration of calcium when it is used as a second messenger?

Concept 11.4 Response: Cell signaling leads to regulation of transcription or cytoplasmic activities

44. The response to a cell signal can occur either in the nucleus or in the cytoplasm. Read the text on page 223, and study Figure 11.15. What normally happens in a nuclear response?

45. Figure 11.16 shows a cytoplasmic response to a signal. How is this different from a nuclear response in terms of both the signal molecule and its effect?

46. Figure 11.16 in your text shows how a signal can be amplified in a phosphorylation cascade. A single molecule of epinephrine results in the formation of approximately how many molecules of glucose 1-phosphate?

47. How is it that some cells do not respond to specific signaling molecules, and for the cells that do respond, it is often in different ways?

48. Figure 11.17 in your text shows four different cellular results from a single signaling molecule. Briefly describe each response.

Cell A **Cell C**

Cell B **Cell D**

49. How do *scaffolding proteins* enhance a cellular response?

Concept 11.5 Apoptosis integrates multiple cell-signaling pathways

50. What specifically happens to a cell during the process of *apoptosis*?

51. Describe three examples of apoptosis, including normal as well as abnormal functions.

52. The signal for apoptosis can come from outside or inside the cell. Give one example when the signal comes from outside the cell and two examples of cellular occurrences that would prompt an apoptosis signal from inside the cell.

Test Your Understanding Answers

Now you should be ready to test your knowledge. Place your answers here:

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

7. _____