Chapter 36: Resource Acquisition and Transport in Vascular Plants

36.1 Give examples of plant adaptations for acquiring resources.
36.2 Distinguish between short- and long-distance transport mechanisms in a plant.
36.3 Relate transpiration to the transport of water and minerals in a plant.
36.4 Explain the role of stomata in regulating transpiration.
36.5 Trace the path of sugar in a plant from source to sink.
36.6 Describe the structure and function of the symplast.

As you work through this chapter, continue your efforts to see how natural selection shapes adaptations to fit a new environment—in this case, movement of plants onto land. Concentrate your study on water potential and how it affects the movement of water through plants and plant cells. The process of transpiration ties your study back to Chapter 3, Water and Life, as well as connecting to plant anatomy and photosynthesis.

Study Tip: Figure 36.1 summarizes the transport section of the chapter. Plants transport water and minerals in one system while transporting sugars and other organic compounds like hormones in another system. Complete the missing information on the figure below to get an overview of the two transport systems.

Concept 36.1 Adaptations for acquiring resources were key steps in the evolution of vascular plants

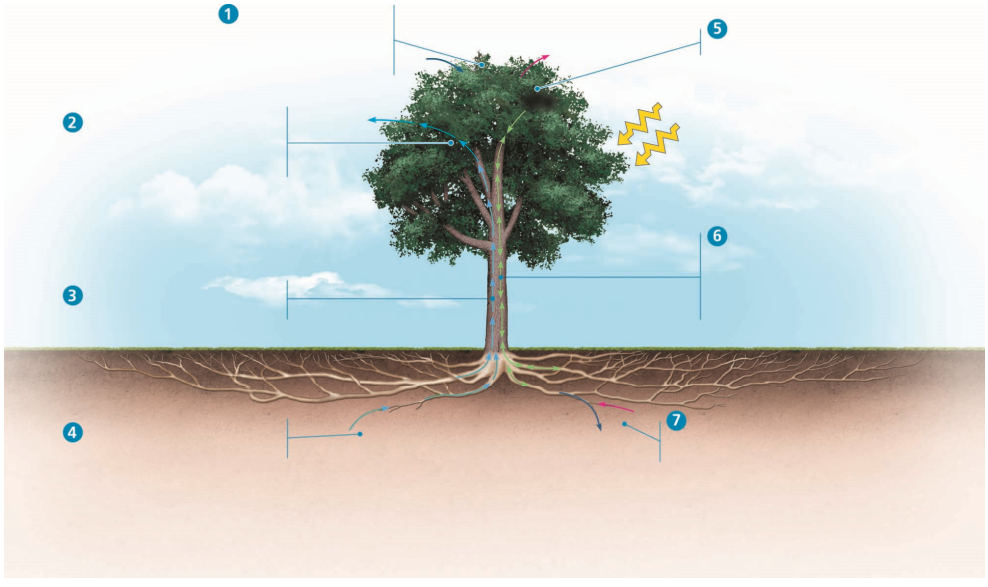
LO 36.1: Give examples of plant adaptations for acquiring resources.

1. Transport in plants occurs in either xylem or phloem. Define these two terms.

   xylem

   phloem

2. Competition for light, water, and nutrients is intense among the land plants. Plant success is generally related to photosynthesis, so evolution has resulted in many structural adaptations for efficiently acquiring light from the sun, CO_2 from the air, and water and minerals from the soil. The following figure gives an overview of resource acquisition and transport. Describe each point of resource acquisition at the seven points of emphasis on the figure.



3. There are many adaptations to increase light capture. What are two ways plants reduce *self-shading*?

4. What triggers *self-pruning*?

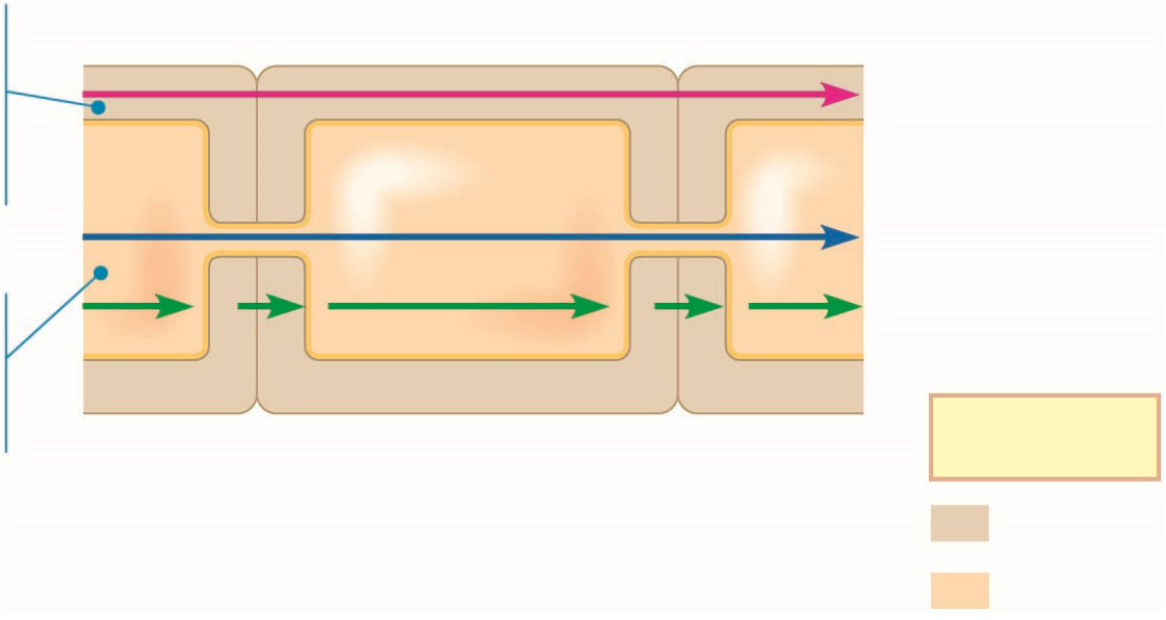
5. The evolution of *mycorrhizae* was a critical step in the successful colonization of land by plants. What are they, and what is their role in resource acquisition?

Concept 36.2 Different mechanisms transport substances over short or long distances

LO 36.2: Distinguish between short- and long-distance transport mechanisms in a plant.

This section gives you a good review of the transport mechanisms you studied in Chapter 7. The information in the next group of questions should be familiar. Now is also a good time to review water potential.

6. Water and solutes move through plant tissues in several ways, including between and around cell walls, and from cell to cell. Communication between plant cells is accomplished because the cytosol of adjacent cells is continuous, connected by *plasmodesmata*. Use the figure below to explain how the two main compartments in plant tissues, the *apoplast* and *symplas*t, differ in transport routes.



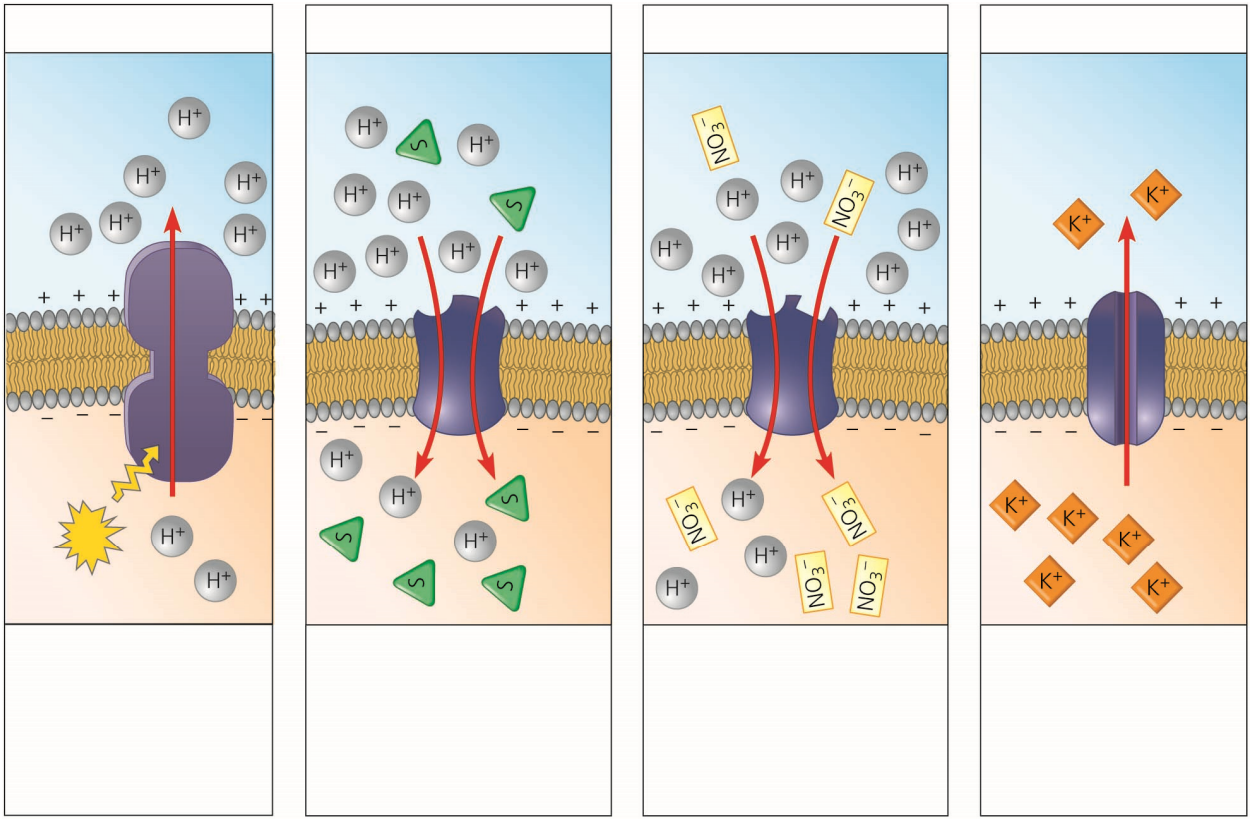
7. To be sure you are solid about the general principles of transport, answer the following questions. Reference Chapter 7 if you are unsure about any of the questions.

   a. What is *passive transport*?

   b. What is *active transport*?

   c. What are *transport proteins*?

8. Transport in plants involves many of the same mechanisms seen in other groups. For now, focus on areas where plants differ from animals in solute transport. Study and complete Figure 36.6 to highlight processes of solute transport across plant cell membranes. Label each mechanism type in the top box and the key ions or molecules involved. Describe each process in the bottom box.



9. What is *osmosis*?

Study Tip

In order to fully understand transport in plants, you need understand the concept of water potential. Because this is a new concept to most students, we are going to break it down into many parts. When you are done, you should be comfortable explaining water potential as well as using it to predict water movement in plants.

10. Because plant cells have a rigid cell wall, pressure can develop within a cell and affect the movement of water into and out of a cell. Define *water potential.*

11. The equation for water potential is

$$\Psi = \Psi_s + \Psi_p,$$

where Ψ is *water potential*, Ψ_s is the *solute potential*, and Ψ_p is the *pressure potential*. What is *solute potential*?

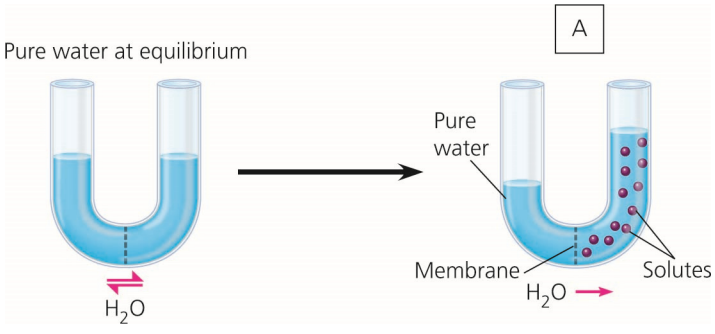
12. How does adding solutes to pure water affect water potential?

13. The *solute potential* of a solution is therefore always _____. (negative or positive)

14. By definition, what is the Ψ_s of pure water?

15. What is *pressure potential*? Under what conditions will it decrease?

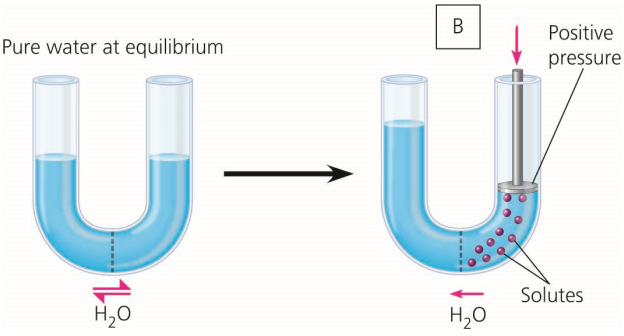
16. The two figures that follow show U-tubes, in which water or a solution (indicated by red dots) is placed, with the two arms of the tube separated by a selectively permeable membrane (indicated by the black dotted line). The membrane will freely allow the passage of water. In these figures, the red arrow(s) show the net movement of water molecules. What is the water potential on the left side of tube A? Why?



17. Is the water potential on the right side of tube A positive or negative? Use the equation for water potential to explain your response.

18. Explain, in terms of water potential, why the level of the liquid is higher on the right side of tube A.

19. In the U-tubes shown below, pressure is being applied on the right side in tube B. This is much like the pressure exerted by the cell wall when a plant cell takes up water. Explain, in terms of water potential, why the level of the liquid is higher on the left side.

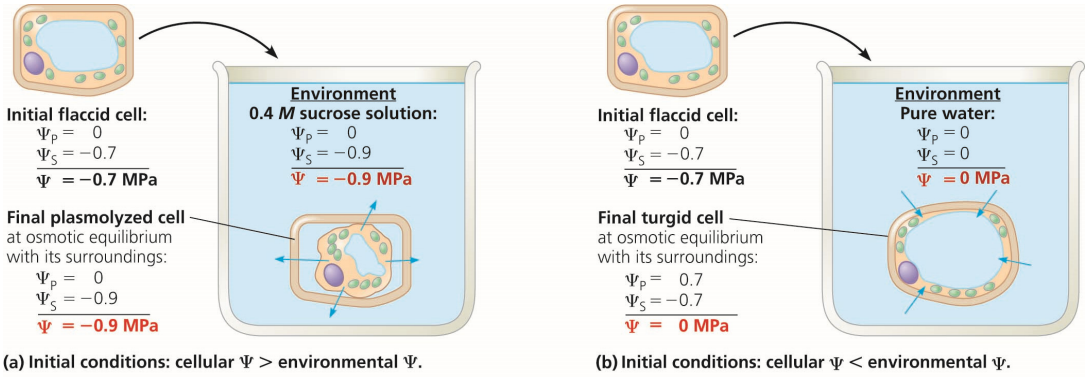


20. To summarize, *water moves from regions of* _____ *water potential to regions of* _____ *water potential.*

21. Use the concept of water potential to describe what occurs in *plasmolysis.*

22. If a *flaccid* plant cell is bathed in pure water, describe how it will change. Use the terminology of water potential to frame your answer.

23. In the following figure, a plant cell that has an initial water potential of –0.7 MPa is placed into two different conditions. Explain, in terms of water potential, what happens in each case.



a.

b.

24. What are *aquaporins*?

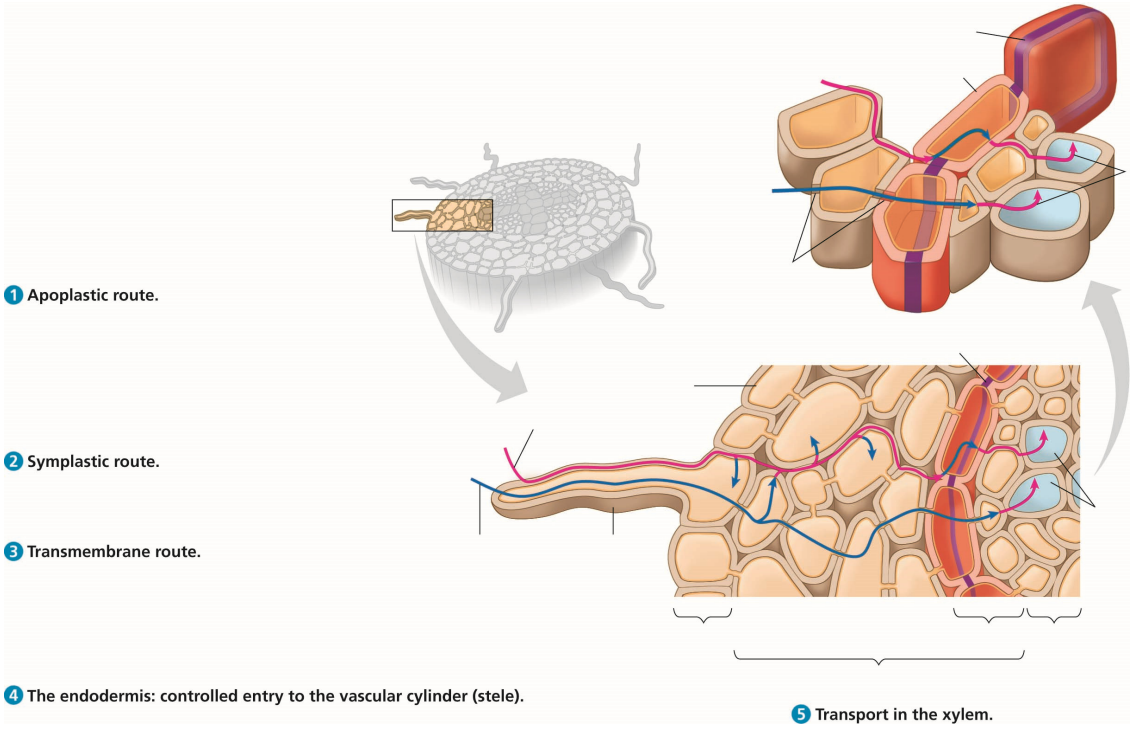
25. What is *bulk flow*? Does it depend on solute concentration?

26. Summarize the three processes that act together to transport resources through the whole plant.

Concept 36.3 Transpiration drives the transport of water and minerals from roots to shoots via the xylem

LO 36.3: Relate transpiration to the transport of water and minerals in a plant.

27. On the following sketch, use colored pencils to trace the uptake of water and minerals from root hairs to the xylem and phloem within the root, following a symplastic route and an apoplastic route. Completely label the figures then explain what is occurring at each labeled number.



28. Test your understanding by answering the following questions.

    a. Which structure controls the movement of water and minerals into the xylem? How are its cells modified to achieve this function?

b. How is the surface area for absorption greatly increased?

c. How is it possible for water to pass from one root cell to another?

29. Define the following:

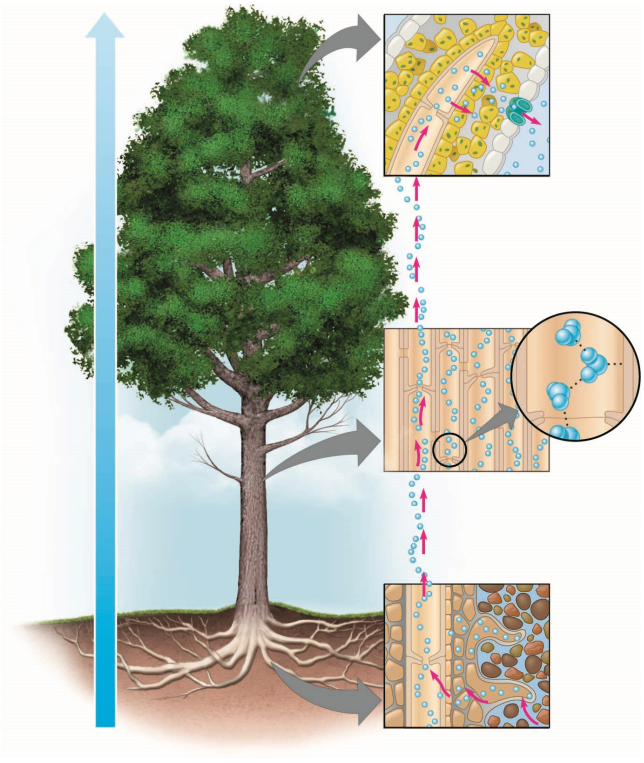
xylem sap

transpiration

30. What is the *cohesion-tension hypothesis*?

31. Explain *transpirational pull*.

32. The primary mechanism that pulls water up through the plant involves transpiration, adhesion, and cohesion. Refer to Figure 36.12 in your text. Note that water moves from a region of high water potential to a region of lower water potential. The arrow on the left side of the figure shows this gradient. Write an essay to explain the movement of water from the roots to the leaves. Include each of these terms in your essay, and label them on the figure: *root hairs*, *lower water potential*, *higher water potential*, *hydrogen bonding*, *adhesion*, *cohesion*, *xylem tubes*, and *stoma*. **Spend time with this figure and its explanation. It is an essential concept!**



Concept 36.4 The rate of transpiration is regulated by stomata

LO 36.4: Explain the role of stomata in regulating transpiration.

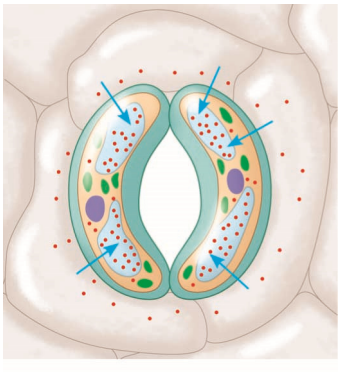
33. Leaves generally have large surface areas and high surface-to-volume ratios. Give an advantage and disadvantage of these traits.

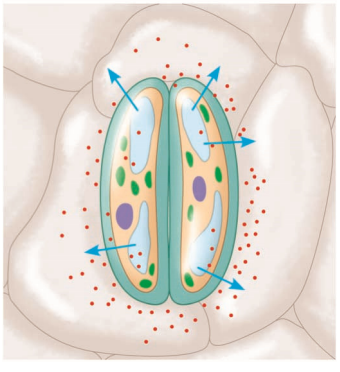
advantage

disadvantage

34. Plants lose 95% of their water through stomata! What controls the amount of water loss?

35. On the following sketches, label the *guard cell, stomata,* K^+, and H_2O. Explain why the stoma opens when K^+ accumulates in the guard cells and closes when the guard cells lose K^+.





36. Three types of environmental stimuli can cause guard cells to open and close stomata. Name and explain how each one works.

Stimulus for Stomatal Opening and Closing	Explanation

37. What plant hormone is produced in response to water deficiency?

38. Reducing water loss is important for terrestrial plants and drives many evolutionary adaptations. List four different physiological or morphological adaptations of *xerophytes* and explain how each of them reduces water loss.

Adaptation	Explanation for Reduction of Water Loss

Concept 36.5 Sugars are transported from sources to sinks via the phloem

LO 36.5: Trace the path of sugar in a plant from source to sink.

39. Define the following:

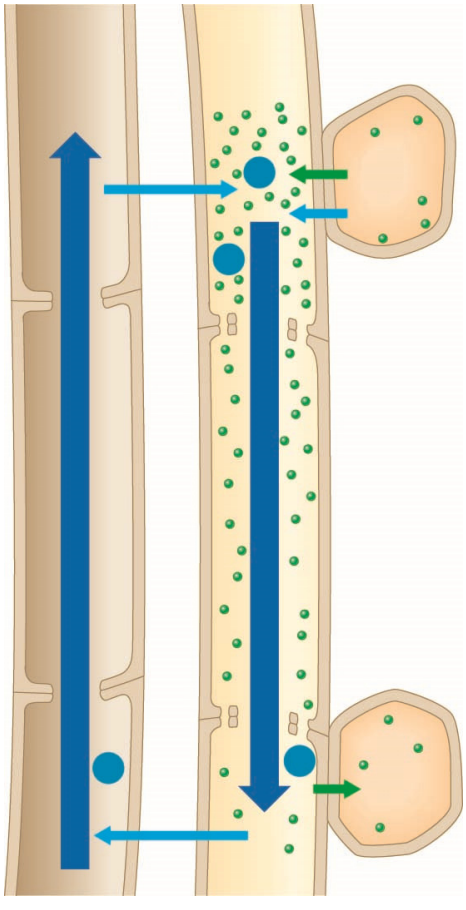
translocation

phloem sap

40. What is a *sugar source*, and what is a *sugar sink*? Give an example of each.

41. Sucrose must be loaded against its concentration gradient into sieve tube cells before being exported to sugar sinks. Draw and label the chemiosmotic process that uses cotransport to load sieve tube cells.

42. Explain the process of *pressure flow* by annotating the figure below. Refer to your text and divide this process into four steps.



43. Study Inquire Figure 36.18 in your text. How do aphids feed? When houseplants are infested with aphids, why is there a sticky mess on the floor around them?

Concept 36.6 The symplast is highly dynamic

LO 36.6: Describe the structure and function of the symplast.

44. An important concept is how cells communicate with other cells in an organism. Read how phloem serves as an information superhighway. Give three specific signals that move through the symplast and describe the function of each signal.

Symplast Signals	Function

Test Your Understanding, p. 804

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

7. _____ 8. _____