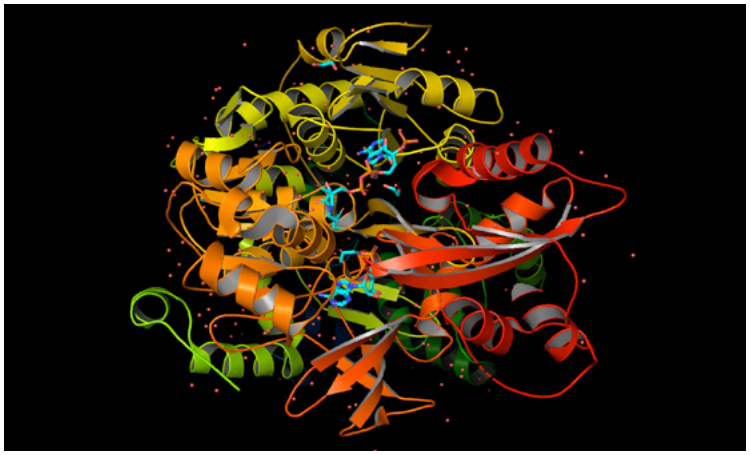
Chapter 4

How Cells Work



End of Chapter Questions

Simple Review Questions

4.1 How Things Get Into and Out of Cells

1. What is diffusion?

2. What is the difference between simple diffusion and facilitated diffusion?

3. What distinguishes passive transport from active transport?

4. How do endocytosis and exocytosis move materials into and out of cells?

4.2 Cell Communication

5. What are gap junctions? What function do they serve?

6. Describe what happens when a message molecule binds to a receptor on the cell membrane.

7. Why do only certain cells receive and respond to a specific message molecule?

4.3 ATP and Chemical Reactions in Cells

8. How does ATP provide energy for cells?

9. Describe how the sodium-potassium pump works. Which step in the active transport of sodium and potassium ions requires ATP?

4.4 Enzymes and Chemical Reactions

10. Why do cells need catalysts? What are the catalysts in cells called?

11. Describe two ways that cells can regulate enzymes.

12. How does penicillin kill bacteria?

4.5 Photosynthesis

13. Why is almost all life on Earth dependent either directly or indirectly on photosynthesis?

14. What happens during the light-dependent reactions of photosynthesis? What happens during the light-independent reactions?

15. In the chemical reaction for photosynthesis, what are the reactants and what are the products?

4.6 Cellular Respiration

16. Describe the process of glycolysis. How much ATP is produced during glycolysis?

17. About how many ATP molecules does a cell obtain from one molecule of glucose through cellular respiration? What other products result from cellular respiration?

18. What are the products of alcoholic fermentation?

19. Give two examples of cells in the human body that use lactic acid fermentation. Why does each of these cells use lactic acid fermentation?

(CLICK TO CHECK YOUR ANSWERS)

Challenging Review Questions

4.1 How Things Get Into and Out of Cells

20. Transport proteins and the molecules they transport are described as fitting together like a lock and key. Why is it important that they have such a specific fit?

21. Glucose moves into many cells through facilitated diffusion. This works because there is usually a higher concentration of glucose molecules outside the cell than inside the cell. Why is this the case? (Hint: Do cells use up the glucose inside them?)

22. Why does oxygen diffuse into cells rather than out of them? Why does carbon dioxide diffuse out of cells rather than into them?

23. What is the difference between endocytosis and using a transport protein to cross the cell membrane?

4.2 Cell Communication

24. How are gap junctions and plasmodesmata similar? How do they differ?

25. Message molecules and their receptors are described as fitting together like a lock and key. Why is it important that they have such a specific fit?

26. If growth hormone is found in the bloodstream and travels all over the body, why do only certain parts of the body respond and grow?

4.3 ATP and Chemical Reactions in Cells

27. If ATP is like a rechargeable battery, how is its energy used up, and how is it recharged?

4.4 Enzymes and Chemical Reactions

28. Enzymes and their substrates are described as having a lock-and-key fit. Why is it important that they have such a specific fit?

29. The deadly nerve gas sarin binds to an enzyme called acetylcholinesterase, which breaks down acetylcholine in the body. If acetylcholine is not broken down, muscles are unable to relax after contracting. Without prompt treatment, respiratory collapse and death follow. Sarin works by binding to acetylcholinesterase at the site where acetylcholine normally binds. What form of enzyme regulation does this represent?

30. Describe at least two different ways cells can regulate the function of enzymes.

4.5 Photosynthesis

31. What happens to a plant that is kept in the dark?

32. You collect some pondweed from a local pond to keep in your aquarium. One day, you notice that bubbles are coming out of your plant, as in the photo here. Why is the pondweed releasing bubbles? What kind of gas is in the bubbles?

33. Global warming has resulted from the large amounts of carbon dioxide released when fossil fuels such as oil and coal are burned for energy. Carbon dioxide traps heat. Why might the loss of forests also contribute to global warming?

4.6 Cellular Respiration and Fermentation

34. Why can't you live without oxygen?

35. What are some differences between fermentation and cellular respiration? Which process produces more ATP? Why do some cells in the human body use fermentation?

36. You visit a friend who is a winemaker. Some of his wine is fermenting in a vat. When you take a look, you notice that the wine is covered with a layer of bubbles. Why are there bubbles? What kind of gas is inside the bubbles?

37. Why is champagne bubbly and wine is not? (Hint: In nonbubbly wines, fermentation happens with the grape juice exposed to air. In champagne, there is an extra round of fermentation during which the bottles are capped tight.)

38. Some animals that live in desert environments, such as this kangaroo rat, never drink water. Kangaroo rats live entirely on the starches and lipids in the dry seeds they eat. Yet we know that all living organisms need water, and, in fact, the bodies of kangaroo rats have about the same water content as those of other animals. How do kangaroo rats get their water?

(CLICK TO CHECK YOUR ANSWERS)

Apply & Discuss Questions

39. You and a friend are eating lunch in the cafeteria. Suddenly, you both smell very strong perfume. "Wow," your friend says, "I wish they would turn the fan off. It's blowing that perfume right at us." You say, "Even if they turn the fan off, there would still be diffusion. You would still smell the perfume." Which of you is correct?

40. You and a friend go to a garden shop to buy fertilizer for your new plants. Your friend says, "Didn't we just learn that plants make their own organic molecules through photosynthesis? Plants shouldn't need fertilizer." Another customer overhears your discussion and looks at the bag of fertilizer you are holding. "Well," she says, "it looks like the main ingredients in fertilizer are nitrogen and phosphorus. I don't know if plants really need that stuff or not." What do you say? Do you buy the fertilizer?

41. You are talking with a winemaker about yeast. "I know that yeast can survive under both aerobic and anaerobic conditions," he says, "but what I don't understand is why they seem to need so much more sugar under anaerobic conditions. I think they gobble a hundred times as much sugar." Can you explain to him why yeast might need more sugar under anaerobic conditions than under aerobic conditions? Is his estimation of a hundred times as much sugar reasonable?

(CLICK TO CHECK YOUR ANSWERS)

End of Chapter Solutions

Simple Review Solutions

1. Diffusion is the tendency for molecules to move from an area of high concentration to an area of low concentration—that is, down a concentration gradient.

3. Passive transport requires no energy from the cell. In active transport, a transport protein moves molecules *against* a concentration gradient. In this case, energy from the cell is required.

5. Gap junctions are tiny channels that connect adjacent animal cells. These allow very local messages to pass directly from one cell to an adjacent cell.

7. Cells receive and respond to a specific message molecule only if they have the receptor for that molecule. Receptors are extremely specific about the message molecules they bind to. This is because a message molecule and its receptor fit together like a key in a lock—only the right combination will work.

9. The sodium–potassium pump is a transport protein in the cell membrane. It behaves like a swinging door, shuffling ions in and out of the cell. In its default state, the protein is open to the inside of the cell. There, it binds three sodium ions. An ATP reaction, in which a molecule of ATP transfers a phosphate group to the protein, causes the protein to shift and open to the outside of the cell. (This is the step where ATP is required.) The sodium ions are released, and two potassium ions are bound, causing the phosphate group to be released from the transport protein. The loss of the phosphate group causes the protein to shift back to its original position and to release the potassium ions inside the cell.

11. Cells regulate enzymes carefully in order to control chemical reactions. Regulation takes place in a number of different ways. First, cells control the synthesis and degradation of enzymes. (Enzymes are not used up when they catalyze a reaction, so they must be actively degraded when they are no longer needed.) Second, how well an enzyme works depends on the chemical features of its environment – the temperature, pH, and other factors. For example, if the temperature is too high or too low, an enzyme's shape may change, and the reactants may not fit. Finally, enzymes can be blocked by inhibitors.

13. Almost all life on Earth depends ultimately on photosynthesis for organic molecules and energy. This is because plants and other photosynthesizers (such as algae and certain bacteria) are food for herbivores, and herbivores are food for carnivores. So photosynthesizers are the ultimate source of all food.

15. Carbon dioxide, water, and sunlight go in (these are the reactants); glucose and oxygen come out (these are the products).

17. Cells obtain about 38 molecules of ATP from one molecule of glucose during cellular respiration. The other products of cellular respiration are water and carbon dioxide.

19. In animal muscle cells, lactic acid fermentation occurs during strenuous exercise, when the oxygen supply—despite hard breathing—can't quite meet the demand. By regenerating the molecules required for glycolysis, lactic acid fermentation allows muscle cells to continue to make ATP without oxygen. Red blood cells, which lack mitochondria, also rely on lactic acid fermentation to obtain ATP.

Challenging Review Solutions

21. There is more glucose outside cells than inside cells because glucose molecules inside cells are quickly broken down to make ATP (through cellular respiration).

23. In endocytosis, a portion of the cell membrane folds inward and pinches off, enclosing the transported material within a vesicle inside the cell. With a transport protein, the molecule entering the cell binds to the transport protein and is released inside the cell.

25. The specific fit between a message molecule and its receptor allows for messages to be targeted to specific cells—only cells with the appropriate receptors respond to the message molecule.

27. The energy stored in ATP is "used" when one of its phosphate groups is removed, leaving adenosine diphosphate, or ADP. "Recharging" happens when a phosphate group is added to ADP to build ATP.

29. This is competitive inhibition, since it binds at the enzyme's active site, where the substrate normally binds.

31. A plant that is kept in the dark will not have access to the sunlight energy it needs to perform photosynthesis. Eventually, the plant will die from its inability to make organic molecules.

33. When forests are destroyed, there are fewer trees to perform photosynthesis. Since carbon dioxide is removed from the atmosphere and converted to organic material during photosynthesis, the loss of forests contributes to increased carbon dioxide levels in Earth's atmosphere, which in turn worsens global warming.

35. Cellular respiration uses oxygen, whereas fermentation does not. Cellular respiration takes place in the cytoplasm (the first step—glycolysis) and mitochondria (the second and third steps—Krebs cycle and electron transport), whereas fermentation occurs entirely within the cytoplasm. Cellular respiration makes a lot more ATP then fermentation—38 ATP versus 2 ATP. However, muscle cells use fermentation when oxygen is unavailable to them, and blood cells use fermentation because they do not have mitochondria.

37. The bubbles come from carbon dioxide released during alcoholic fermentation.

Apply & Discuss Solutions

39. By stirring the air, the fan brings the smell of perfume to you more quickly. However, even without the fan, the perfume would diffuse all around the room eventually.

41. Yeast obtain a lot more ATP from glucose when they are in aerobic conditions and use cellular respiration—about 38 ATP per glucose molecule. When they are kept in anaerobic conditions and obtain ATP through fermentation, each molecule of glucose yields only 2 ATP (during glycolysis). This is why yeast need more sugar under anaerobic conditions—though only about 19 times as much.