Chapter 8: An Introduction to Metabolism

Concept 8.1 An organism’s metabolism transforms matter and energy, subject to the laws of thermodynamics

1. Define metabolism.

2. There are two types of reactions in metabolic pathways: anabolic and catabolic.
   a. Which reactions release energy?
   b. Which reactions consume energy?
   c. Which reactions build up larger molecules?
   d. Which reactions break down molecules?
   e. Which reactions are considered “uphill”?
   f. What type of reaction is photosynthesis?
   g. What type of reaction is cellular respiration?
   h. Which reactions require enzymes to catalyze reactions?

3. Contrast kinetic energy with potential energy.

4. Which type of energy does water behind a dam have? A mole of glucose?

5. What is meant by a spontaneous process?

Concept 8.2 The free-energy change of a reaction tells us whether the reaction occurs spontaneously

6. What is free energy? What is its symbol?

7. For an exergonic reaction, is \( \Delta G \) negative or positive?

8. Is cellular respiration an endergonic or an exergonic reaction? What is \( \Delta G \) for this reaction?

9. Is photosynthesis endergonic or exergonic? What is the energy source that drives it?
10. To summarize, if energy is released, \( \Delta G \) must be what?

**Concept 8.3 ATP powers cellular work by coupling exergonic reactions to endergonic reactions**

11. List the three main kinds of work that a cell does. Give an example of each.
   a. 
   b. 
   c. 

12. Here is a molecule of ATP. Label it. Use an arrow to show which bond is likely to break.

   ![ATP molecule diagram]

   a. By what process will that bond break?
   b. Explain the name \( \text{ATP} \) by listing all the molecules that make it up.

13. When the terminal phosphate bond is broken, a molecule of inorganic phosphate \( P_i \) is formed, and energy is ________________.

   For this reaction: \( \text{ATP} \rightarrow \text{ADP} + P_i, \Delta G = \) ________________.

   Is this reaction endergonic or exergonic? ________________

*FYI: An essay question on the 2009 AP Biology exam asked students to identify the molecules that make up ATP. What are they again?*

14. What is energy coupling?

15. In many cellular reactions, a phosphate group is transferred from ATP to some other molecule in order to make the second molecule less stable. The second molecule is said to be
16. Look for this amazing bit of trivia on page 151 in your text: If you could not regenerate ATP by phosphorylating ADP, how much ATP would you need to consume each day?

**Concept 8.4 Enzymes speed up metabolic reactions by lowering energy barriers**

17. What is a **catalyst**?

18. What is **activation energy** ($E_A$)?

19. Label the x-axis of this graph “Progress of the Reaction” and the y-axis “Free Energy.”

![Graph of enzyme action](image)

Label $E_A$ on this sketch, both with and without an enzyme.

a. What effect does an enzyme have on $E_A$?

b. Label $\Delta G$. Is it positive or negative?

c. How is $\Delta G$ affected by the enzyme?

20. Label this figure while you define each of the following terms:

- enzyme
- substrate
- active site
- products
21. What is meant by induced fit? How is it shown in the figure in question 20?

22. Explain how protein structure is involved in enzyme specificity.

23. Enzymes use a variety of mechanisms to lower activation energy. Describe four of these mechanisms.
   a. 
   b. 
   c. 
   d. 

24. Many factors can affect the rate of enzyme action. Explain each factor listed here.
   a. initial concentration of substrate
   b. pH
   c. temperature

25. Recall that enzymes are globular proteins. Why can extremes of pH or very high temperatures affect enzyme activity?

26. Name a human enzyme that functions well in pH 2. Where is it found?

27. Distinguish between cofactors and coenzymes. Give examples of each.

28. Compare and contrast competitive inhibitors and noncompetitive inhibitors. Label each type of inhibitor in this figure.

Concept 8.5 Regulation of enzyme activity helps control metabolism

29. What is allosteric regulation?
30. How is allosteric regulation somewhat like noncompetitive inhibition? How might it be different?

31. Explain the difference between an allosteric activator and an allosteric inhibitor.

32. Although it is not an enzyme, hemoglobin shows cooperativity in binding O₂. Explain how hemoglobin works at the gills of a fish.

33. Study this figure from your book (Figure 8.21) and answer the questions that follow.

![Diagram of metabolic pathway]

a. What is the substrate molecule to initiate this metabolic pathway?

b. What is the inhibitor molecule?

c. What type of inhibitor is it?

d. When does it have the most significant regulatory effect?

e. What is this type of metabolic control called?

Test Your Understanding Answers

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

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

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