Biology 12 **Name:** _____

Cell Biology **Per:** _____ **Date:** _____

Chapter 5 – Metabolism: Energy and Enzymes

Complete using BC Biology 12, pages 154 - 175

5.1 Energy Transformations & Metabolism page 158

1. **Metabolism**: sum of all chemical reactions that occur in a cell

2. Catabolism [a] refers to the breaking down of molecules while anabolism [b] refers to the building up, or synthesis, of molecules.
3. In a chemical reaction, reactants [a] are the substances that participate in a reaction (A + B [b] in the reaction below), while the products [c] are the substances that form as the result of a reaction (C + D [d] in the reaction below).

A + B → C + D

4. **Free energy** (ΔG): amount of energy available **after** a chemical reaction has occurred
5. **Exergonic reactions**: spontaneous, release energy
   a. Examples: cellular respiration
6. **Endergonic reactions**: require an input of energy
   a. Examples: protein synthesis, muscle contraction, nerve impulse conduction

ATP: Energy for Cells

7. ATP is the common energy currency [a]. When cells require energy they "spend" ATP. The more active [b] the organism the greater [c] the demand for ATP. However, the amount on hand at any one moment is minimal [d] because ATP is constantly being generated from ADP [e] and a molecule of phosphate [f].
8. Place the appropriate letters next to each statement (use Figure 5.1 on page 158 to help)

   En = endergonic Ex = exergonic

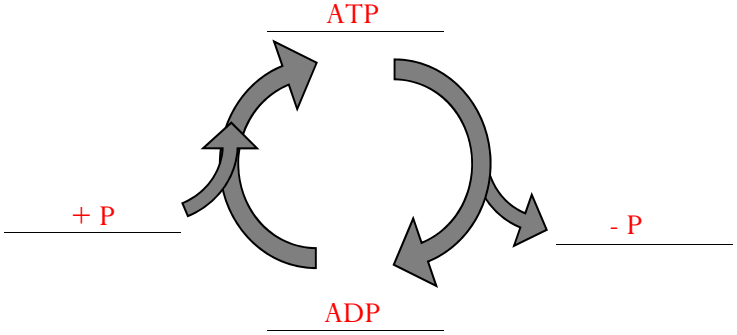
   a. Ex Energy is released as the reaction occurs.
   b. En Energy is required to make the reaction go.
   c. En Reaction used by the body for muscle contraction and nerve conduction.
   d. Ex ATP → ADP + (P).
   e. En ADP + (P) → ATP
9. Label this diagram, using these terms:

   ATP

   ADP

   -P (release of phosphate)

   +P (additional of phosphate)



10. Explain whether an anabolic reaction is more likely to be exergonic or endergonic. Endergonic, as molecule synthesis requires energy to form new bonds

5.2 Enzymes & Metabolic Pathways pages 159 - 164

11. **Metabolic pathway**: series of linked reactions, beginning with a particular reactant and terminating with an end product
12. While it is possible to write an overall [(a)] equation for a pathway as if the beginning reactant [(b)] went to the end product [(c)] in one step, actually many specific steps occur in between.
13. Consider the following diagram of a metabolic pathway:

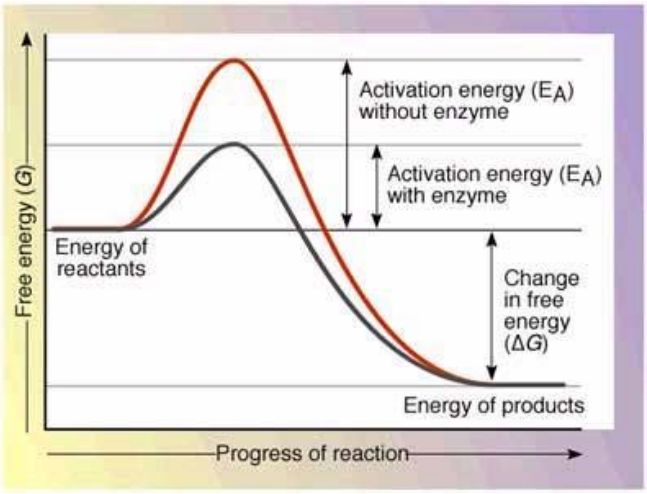
$$A \xrightarrow{E_1} B \xrightarrow{E_2} C \xrightarrow{E_3} D \xrightarrow{E_4} E \xrightarrow{E_5} F \xrightarrow{E_6} G$$

    a. A – F are reactants
    b. B – G are products
    c. E_1 – E_6 are enzymes
    d. A is a subtrate for the first enzyme and B is the product

14. **Enzyme**: a protein that increases the rate of a chemical reaction in an organism (biological catalyst)
15. **Substrate**: reactants in an enzymatic reaction (e.g. H_2O_2 is the substrate for the enzyme catalase)

Energy of Activation

16. **Energy of activation**: energy that must be added to cause molecules to react with one another
17. Enzymes lower the amount of energy required for activation [(a)] to occur. Nevertheless, the addition of the enzyme does not change the end result [(b)] of the reaction. Without the enzyme, the reaction rate will be very slow [(c)]. By lowering the energy of activation, the enzyme increases the rate [(d)] of the reaction.
18. Draw and label a diagram of the energy of activation using the following terms:
    A. energy of activation (with enzyme)
    B. energy of activation (without enzyme)
    C. energy of reactants
    D. energy of products
    E. free energy
    F. progress of the reaction

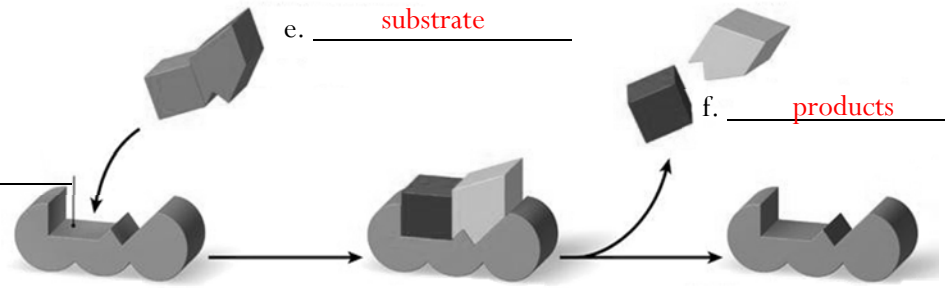


How Enzymes Function

19. Write the equation used to indicate than an enzyme forms a complex with its substrate (include all labels).

S + E → ES → E + P
substrate + enzyme → enzyme-substrate complex → enzyme + product

20. Label this diagram, using the following terms
    - active site
    - enzyme (twice)
    - enzyme-substrate complex
    - products
    - substrate



a. active site
e. substrate
f. products
b. enzyme
c. enzyme-substrate complex
d. enzyme

21. Is the reaction above a synthetic reaction or a degradative reaction? degradative
    How do you know? Substrate is broken down into smaller products

22. What is the **induced fit model** and how does it differ from the model cell biologists used previously?
    Old model was the "lock-and-key" where an enzyme was an exact fit for the substrate. Now scientists believe the enzyme modifies its shape to fir the substrate perfectly

23. If enzymes are so important for chemical reactions, then why is only a small amount of enzyme needed in a cell?
    Enzymes perform their role in a reaction, but are not used up so can work on more substrate when finished

24. Why are enzymes named after their substrate (e.g. maltase speeds breakdown of maltose)? Because they are specific to their substrate

Factors Affecting Enzymatic Speed

25. Complete each statement with the term *increases* or *decreases*.
    a. Enzyme activity increases as substrate concentration increases.
    b. Raising the temperature generally increases the rate of an enzymatic reaction.
    c. Boiling an enzyme drastically decreases the rate of the reaction.
    d. Changing the pH toward the optimum pH for an enzyme increases the rate of the reaction.
    e. Introducing a competitive inhibitor decreases the availability of an enzyme for its normal substrate.
    f. Due to feedback inhibition, the affinity of the active site for the substrate decreases

26. **Denatured**: change in enzymes shape (due to temperature or pH) that causes enzyme to stop functioning

27. Describe how the concentration of a specific product is always kept within a certain range (hint: read section on enzyme activation). Genes are turned on or off to regulate the concentration. Phosphate groups can be added on or removed to activate or inactivate.

28. Enzyme inhibition occurs when the substrate is unable to bind to the active site of an enzyme. There are two types of enzyme inhibitors *(not in your textbook, will be completed with teacher)*
    a. Non-competitive: binds to enzyme, changes its shape, making it difficult for substrate to bind (reversible, causes slow death)
        i. Examples: mercury, lead, arsenic
    b. Competitive: bind to active site (similar shape to substrate) making it impossible for substrate to bind (non-reversible, rapid death)
        i. Examples: cyanide, penicillin (bacteria)

29. Many enzymes require an inorganic [(a)] ion or an organic, but non-protein [(b)], helper to function properly. The inorganic ions are metals such as copper, iron, zinc [(c)]; these helpers are called cofactors [(d)]. The organic, non-protein molecules are called coenzymes [(e)] and vitamins [(f)] are often components of these, becoming part of the coenzyme's molecular structure.

30. A deficiency of any one of these vitamins [(a)] results in a lack of the coenzyme and therefore a lack of certain enzymatic actions [(b)]. Niacin deficiency results in a skin disease called pellagra [(c)] and a riboflavin deficiency results in cracks at corners of mouth [(d)].

5.3 Metabolic Rate & the Thyroid and Parathyroid Glands — pages 164 - 165

31. The **thyroid gland** is located in the neck and the **parathyroid glands** are embedded behind the thyroid gland.

32. Explain the difference the two hormones produced by the thyroid gland.
    a. **triiodothyronine** ($\mathbf{T_3}$) : contains 3 iodine atoms *more potent
    b. **thyroxine** ($\mathbf{T_4}$) : contains 4 iodine atoms

33. Where do we get the iodine necessary to produce these hormones? Iodized salt in our diet

34. How do the thyroid hormones increase metabolic rate? stimulate most of the cells in our body to metabolize more glucose and use more energy

35. Describe the functional relationship between **calcitonin** and **parathyroid hormone** (PTH). If calcium levels are high in blood **calcitonin** helps bones absorb. If levels are low, **PTH** causes release of calcium from bones to be reabsorbed into blood.

Chapter 5 Review Questions

pages 172 - 175

1. D
2. D
3. B
4. A
5. D
6. C
7. C
8. C
9. B
10. B
11. A
12. C
13. C
14. A
15. C
16. A
17. B
18. C
19. C
20. D
21. C
22. A
23. D
24. B
25. B
26. A
27. B
28. A
29. B
30. D

31. Don't draw a graph, just explain. If the substrate concentration is increased then there is a greater chance for enzyme – substrate interactions. This will result in an increase in the rate of the reaction until there are no more enzymes available to bind to more substrate.

32. Substrate binds with an enzyme to form the enzyme-substrate complex. With water added, the sucrose breaks down into products

33. sucrose + H_2O → glucose + fructose

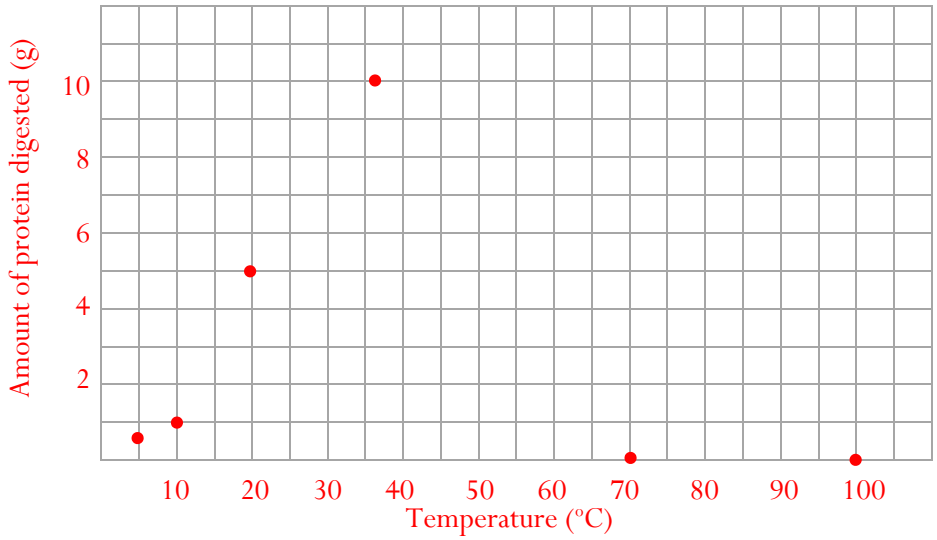
34. Increasing the temperature denatures the enzymes in the bacteria which leads to their death

35. Prolonged high temperatures will cause our own enzymes to denature, slowing down our vital reactions and leads to death

37. Think of the processes discussed in Chapter 3. Active transport (going up a concentration gradient)

38. Stomach doesn't have enzymes to break down carbohydrates but the small intestine does. Therefore the cellulose won't break down until the small intestine and will release its contents there.

39. Create a graph below. Connect the points in a smooth line.



40. 37°C
41. Denatured trypsin
42. Hydrolytic enzyme
43. Proteins
44. Peptides
45. hydrolytic
46. H_2O
47. Trypsin only work on peptides (enzyme specificity)

Mark the review questions using the answer key on pages 533 - 534