Chapter 9: Cellular Respiration and Fermentation

Cellular Basis of Life

Q: How do organisms obtain energy?

9.1 Cellular Respiration: An Overview

Chemical Energy and Food

For Questions 1–4, complete each statement by writing the correct word or words.

1. A calorie is a unit of **ENERGY**.
2. The Calorie used on food labels is equal to **1000** calories.
3. A Calorie is also referred to as a **KILOCALORIE**.
4. Cells use the energy stored in chemical bonds of foods to produce compounds that directly power the cell’s activities, such as **ATP**.

**Overview of Cellular Respiration**

*For Questions 5-10, complete each statement by writing the correct word or words.*

5. The equation that summarizes cellular respiration, using chemical formulas, is

\[ 6O_2 + C_6H_{12}O_6 \rightarrow 6CO_2 + 6 H_2O + Energy \]

6. If cellular respiration took place in just one step, most of the **ENERGY** would be lost in the form of light and **HEAT**.

7. Cellular respiration begins with a pathway called **Glycolysis**, which takes place in the **Thylakoid** of the cell.

8. At the end of glycolysis, about **90%** percent of the chemical energy is locked in the bonds of the **Pyruvic Acid** molecule.

9. Cellular respiration continues in the **Mitochondria** of the cell with the **Krebs** and electron transport chain.

10. The pathways of cellular respiration that require oxygen are said to be **Aerobic**. Pathways that do not require oxygen are said to be **Anaerobic**.

11. Complete the illustration by adding labels for the three main stages of cellular respiration.

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**Comparing Photosynthesis and Cellular Respiration**

*For Questions 12-15, write True if the statement is true. If the statement is false, change the underlined word or words to make the statement true.*

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12. The energy flow in photosynthesis and cellular respiration occurs in the **same** direction.

13. Photosynthesis **deposits** energy in Earth’s “savings account” for living organisms.

14. Cellular respiration removes **carbon dioxide** from the air.

15. Photosynthesis takes place in nearly all life.

16. Complete the table comparing photosynthesis and cellular respiration.

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Photosynthesis</th>
<th>Cellular Respiration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>energy capture</td>
<td>ENERGY RELEASE</td>
</tr>
<tr>
<td>Location of reactions</td>
<td>chloroplasts</td>
<td>CYTOPLASM AND MITOCHONDRIA</td>
</tr>
<tr>
<td>Reactants</td>
<td>CARBON DIOXIDE, WATER, LIGHT</td>
<td>GLUCOSE, WATER</td>
</tr>
<tr>
<td>Products</td>
<td>OXYGEN, GLUCOSE</td>
<td>CARBON DIOXIDE, WATER, ENERGY</td>
</tr>
</tbody>
</table>

17. How does an understanding of the process of cellular respiration support the theory that the cell is the basic functional unit of life?

   **CELL RESP IS THE PROCESS BY WHICH ENERGY FOR LIFE PROCESSES IS OBTAINED FROM FOOD MOLECULES; IT OCCURS IN THE SAME WAY IN ALMOST ALL CELLS**

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9.2 The Process of Cellular Respiration

**Glycolysis**

1. Complete the diagram by writing on the lines provided the names and numbers of molecules used and produced during glycolysis.
2. Why is it an investment for the cell to use two ATP at the beginning of glycolysis?  

**END RESULT IS 4 ATP; USING 2 AT THE FRONT GIVES A NET GAIN OF 2 AT THE END**

3. What are two advantages of glycolysis?  

**OCCURS QUICKLY; CAN SUPPLY OXYGEN QUICKLY WHEN OXYGEN IS NOT AVAILABLE**

### The Krebs Cycle

For Questions 4-7, write True if the statement is true. If the statement is false, change the underlined word or words to make the statement true.

**MITOCHONDRIA**  

4. The pyruvic acid produced in glycolysis enters the **chloroplasts** if oxygen is present in a cell.

**ACETIC**  

5. In the matrix, pyruvic acid is converted to **lactic** acid before the Krebs cycle begins.

**T**  

6. The compound that joins with a 4-carbon molecule in the Krebs cycle is called **acetyl-CoA**.

**T**  

7. Carbon dioxide is the only product of the Krebs cycle that is not re-used or used in other stages of cellular respiration.
8. Complete the flowchart to show which of the Krebs cycle’s many products go on to the third stage of cellular respiration.

[Diagram of Krebs Cycle leading to NADH and FADH2, which then lead to Electron Transport Chain]

Electron Transport and ATP Synthesis

For Questions 9-14, complete each statement by writing the correct word or words.

9. In eukaryotes, the electron transport chain is composed of a series of electron carriers located in the \textbf{INNER MEMBRANE} of the mitochondrion.

10. In prokaryotes, the electron transport chain is in the \textbf{CELL MEMBRANE}.

11. \textbf{OXYGEN} serves as the final electron acceptor of the electron transport chain.

12. \textbf{NADH} and \textbf{FADH}_2 pass high-energy electrons to the electron transport chain.

13. The transfer of high-energy electrons down the electron transport chain causes \textbf{HYDROGEN IONS} to be transported across the mitochondrial membrane.

14. ATP synthases produce the force needed to add one \textbf{PHOSPHATE GROUP} to each ADP molecule by spinning when hydrogen ions flow through them.

The Totals

15. How many ATP molecules per glucose molecule does a cell gain from each of the three stages of cellular respiration?

\textbf{GLYCOLYSIS} – 2; \textbf{KREBS} – 2; \textbf{ETC} – 32

16. Besides glucose, what other kinds of molecules can be used to produce ATP in cellular respiration?

\textbf{LIPIDS, PROTEINS, COMPLEX CARBS}

17. Why is cellular respiration considered an efficient process?

\textbf{THE 36 ATP MOLECULES GENERATED REPRESENT ABOUT 36\% OF THE TOTAL ENERGY AVAILABLE; THE CELL IS MORE EFFICIENT AT USING FOOD THAN A TYPICAL CAR ENGINE IS AT BURING GASOLINE}

18. Where does the heat that warms your body come from? Explain your answer.

\textbf{CELLS IN YOUR BODY THAT CONTAIN MITOCHONDRIA; THEY ARE BREAKING DOWN SUGARS (AND OTHER MACROMOLECULES) AND RELEASING ENERGY; ONLY ABOUT 36\% OF THE CHEMICAL ENERGY IS RECOVERED, THE REST IS LOST AS HEAT}
9.3 Fermentation

Fermentation

For Questions 1-6, write True if the statement is true. If the statement is false, change the underlined word or words to make the statement true.

T 1. Glycolysis provides the pyruvic acid molecules used in fermentation.
NAD+ 2. Fermentation allows glycolysis to continue by providing the NADPH needed to accept high-energy electrons.
ANAEROBIC 3. Fermentation is an aerobic process.
CYTOPLASM 4. Fermentation occurs in the mitochondria of cells.
T 5. Alcoholic fermentation gives off carbon dioxide and is used in making bread.
T 6. Most organisms perform fermentation using a chemical reaction that converts pyruvic acid to lactic acid.

7. Compare and contrast fermentation and cellular respiration by completing the compare/contrast table. Write your answers in the empty table cells.

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Fermentation</th>
<th>Cellular Respiration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>PRODUCES ATP WITHOUT ENERGY</td>
<td>LARGE PRODUCTION OF ATP</td>
</tr>
<tr>
<td>Reactants</td>
<td>GLUCOSE, ATP, PYRUVIC ACID, NADH</td>
<td>GLUCOSE, ATP, PYRUVIC ACID, NADH, FADH2, OXYGEN</td>
</tr>
<tr>
<td>Products</td>
<td>NAD+, ETHYL ALCOHOL AND CO2 IN ALCOHOLIC FERMENTATION; LACTIC ACID IN LACTIC ACID FERMENTATION</td>
<td>CO2, H2O, ATP</td>
</tr>
</tbody>
</table>

8. Compare and contrast alcoholic fermentation and lactic acid fermentation by completing the compare/contrast table. Write your answers in the empty table cells.

<table>
<thead>
<tr>
<th>Type of Fermentation</th>
<th>Summary Equation</th>
<th>Use in Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcoholic</td>
<td>PYRUVIC ACID + NADH → ALCOHOL _ CO2 + NAD+</td>
<td>ALCOHOLIC BEVERAGES, CAUSES BREAD DOUGH TO RISE</td>
</tr>
<tr>
<td>Lactic acid</td>
<td>PYRUVIC ACID + NADH → LACTIC ACID + NAD+</td>
<td>CHEESE, YOGURT, SOUR CREAM, PICKLES, ETC.</td>
</tr>
</tbody>
</table>

9. What causes humans to become lactic acid fermenters?

BRIEF PERIODS WITHOUT OXYGEN
10. What are three main sources of ATP available for human muscle cells?
   ATP ALREADY IN MUSCLES, ATP MADE BY LACTIC ACID FERMENTATION, ATP PRODUCED BY CELLULAR RESPIRATION

11. During a race, how do your muscle cells produce ATP after the store of ATP in muscles is used?
   LACTIC ACID FERMENTATION

12. Why does a sprinter have an oxygen debt to repay after the race is over?
   THE ONLY WAY TO GET RID OF LACTIC ACID IS THROUGH A CHEMICAL PATHWAY THAT REQUIRES OXYGEN

13. A runner needs more energy for a longer race. How does the body generate the necessary ATP?
   CELLULAR RESPIRATION

14. Why are aerobic forms of exercise so beneficial for weight control?
   GLYCOGEN RESERVES ARE ONLY GOOD FOR ABOUT 20 MINS OF PHYSICAL ACTIVITY; AFTER THAT, THE BODY BURNS OTHER RESERVES, LIKE FATS

15. Compare and contrast the role of fermentation and cellular respiration in the actual production of ATP. In your response, consider which process produces ATP and which process contributes to its production.
   FOR EVERY MOLECULE OF GLUCOSE, CELLULAR RESPIRATION PRODUCES 36 MOLECULES OF ATP, WHEREAS FERMENTATION PRODUCES ONLY 2 (DURING GLYCOLYSIS)