chapter 8 Cellular Energy

section 3 Cellular Respiration

MAIN Idea

Living organisms obtain energy during cellular respiration.

What You'll Learn

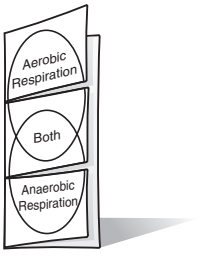
- the role of electron carriers in cellular respiration
- the difference between alcoholic fermentation and lactic-acid fermentation

Mark the Text

Identify Main Ideas
As you read, underline or highlight the main ideas in each paragraph.

FOLDABLES™

Compare Make a three-tab Venn diagram Foldable from one sheet of paper to compare and contrast aerobic and anaerobic respiration.



Before You Read

The energy your body uses comes from the Sun. On the lines below, explain how energy from the Sun is passed to you.

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Read to Learn

Overview of Cellular Respiration

Organisms get energy through cellular respiration. Electrons from carbon compounds such as glucose are collected, and the energy is used to make ATP. ATP is used by cells. The equation for respiration, shown below, is the opposite of the equation for photosynthesis.

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{energy}$$

Cellular respiration begins with glycolysis, a process in which glucose is broken down into pyruvate. Glycolysis is an **anaerobic process**, meaning it does not need oxygen. Glycolysis is followed by **aerobic processes**, which require the presence of oxygen. During **aerobic respiration**, pyruvate is broken down and ATP is made. Aerobic respiration occurs in two parts: the Krebs cycle and electron transport.

Glycolysis

During **glycolysis**, two phosphate groups are joined to glucose, using two molecules of ATP. The 6-carbon molecule is then broken down into two 3-carbon compounds. Two phosphates are added, and electrons and protons combine with two NAD^+ molecules to form two NADH molecules. The two 3-carbon molecules are changed into two molecules of pyruvate. Four molecules of ATP are made.

Krebs Cycle

Next, the pyruvate, made during glycolysis, is transported into the mitochondria. There it is converted into carbon dioxide in a series of reactions called the **Krebs cycle**.

What are the steps of the Krebs cycle?

Before the pyruvate enters the Krebs cycle, it reacts with coenzyme A (CoA) to form a 2-carbon intermediate called acetyl CoA. Carbon dioxide is released, and NAD^+ is changed to NADH. Acetyl CoA then moves to the mitochondria, where it combines with a 4-carbon molecule to form citric acid. Citric acid is then broken down, releasing two molecules of carbon dioxide and making one ATP, three NADH, and one $FADH_2$. Acetyl CoA and citric acid are made, and the cycle continues. Two pyruvate molecules are made during glycolysis, resulting in two turns of the Krebs cycle for each glucose molecule.

Reading Check

1. Identify In the Krebs cycle, what is pyruvate converted to?

Electron Transport

Electron transport, the final stage of cellular respiration, takes place in the mitochondria. The high-energy electrons and protons from NADH and $FADH_2$ are used to change ADP to ATP.

Electrons are passed along a series of proteins. Electrons and protons are released from NADH and $FADH_2$ into the mitochondria. Protons and electrons are transferred to oxygen to make water. Electron transport makes 24 ATP molecules.

Picture This

2. Identify Complete the figure by writing the location of each stage of cellular respiration.

Overview of Cellular Respiration

	Location	Main Activity	High-Energy Molecules Made per Glucose Molecule
Glycolysis		Glucose is converted to pyruvate.	2 ATP, 2 NADH
Krebs cycle		Pyruvate is converted to carbon dioxide.	2 ATP, 8 NADH, 2 $FADH_2$
Electron transport		Electrons and protons combine with oxygen to make water.	28 ATP

Do prokaryotes use cellular respiration?

Some prokaryotes also undergo aerobic respiration. Since they have no mitochondria, electron transport occurs in the cellular membrane instead. Pyruvate does not move to mitochondria, saving the prokaryotic cell two ATP. Prokaryotes make 38 molecules of ATP from one molecule of glucose.

Anaerobic Respiration

Anaerobic respiration takes place when oxygen is low. Some prokaryotes that do not need oxygen use anaerobic respiration all the time. Other cells use anaerobic respiration when oxygen levels are low.

How is ATP made during anaerobic respiration?

Anaerobic respiration, or **fermentation**, follows glycolysis when oxygen is absent. Glycolysis makes two ATP from each glucose molecule. Fermentation makes a small amount of ATP and regenerates the cell's supply of NAD^+ so glycolysis can continue. Two important types of fermentation are lactic-acid fermentation and alcohol fermentation.

Reading Check

3. Define What two processes make up anaerobic respiration?

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What are the types of fermentation?

Lactic-acid fermentation changes pyruvate into lactic acid. It takes place in skeletal muscle cells during strenuous exercise, when the body cannot supply enough oxygen. It is also used to make foods like cheese, yogurt, and sour cream.

Yeast and some bacteria undergo a type of fermentation known as alcohol fermentation. These organisms use pyruvate to make ethyl alcohol and carbon dioxide.

Photosynthesis and Cellular Respiration

Photosynthesis and cellular respiration are important ways that cells get and use energy. These processes are related in important ways. The products of photosynthesis—oxygen and glucose—are needed for cellular respiration. The products of respiration—carbon dioxide and water—are needed for photosynthesis. The figure below shows this relationship.

Picture This

4. Classify What type of organisms have cells that carry out all of the processes shown at the right?

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