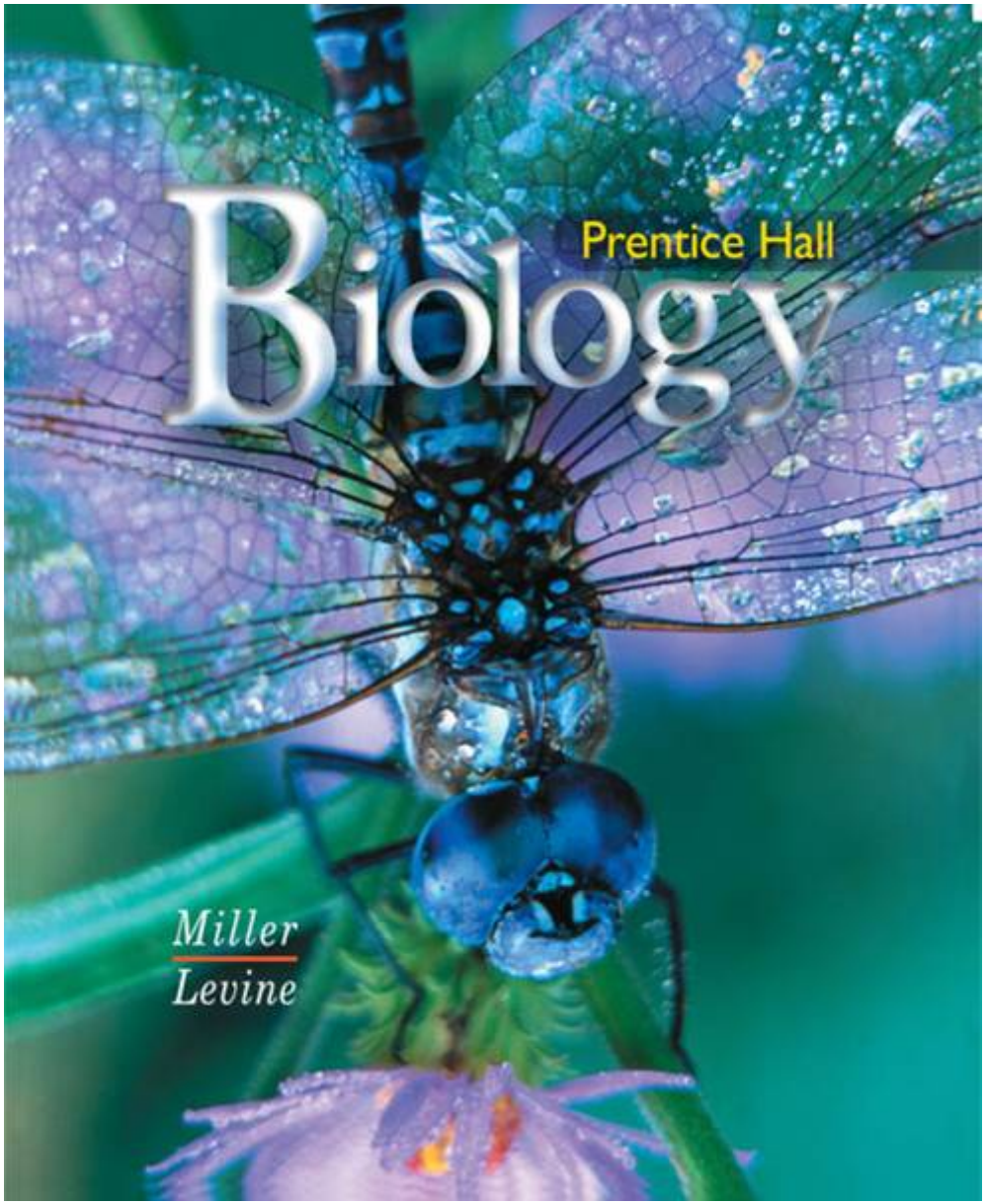

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9-1 Chemical Pathways

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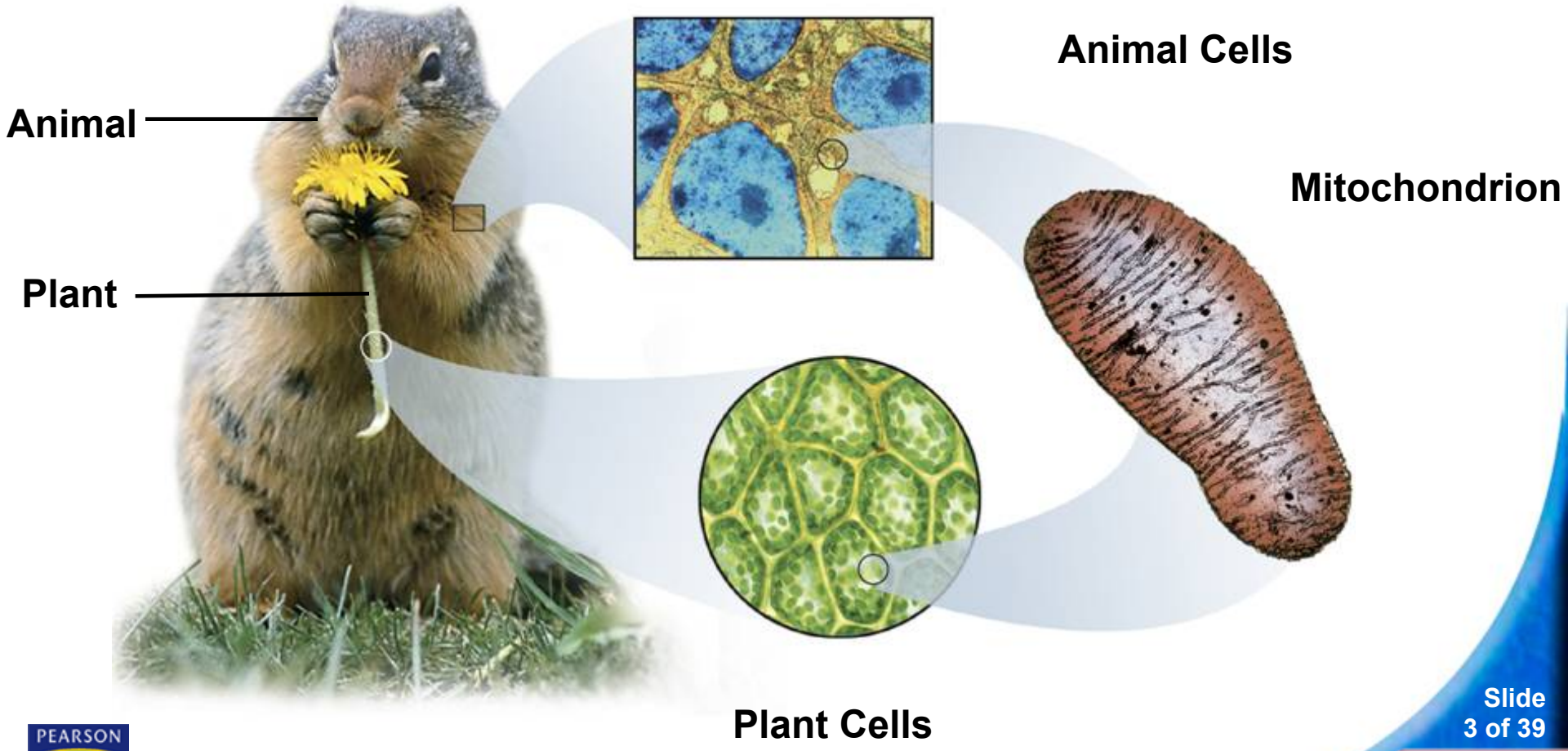
Food serves as a source of raw materials for the cells in the body and as a source of energy.



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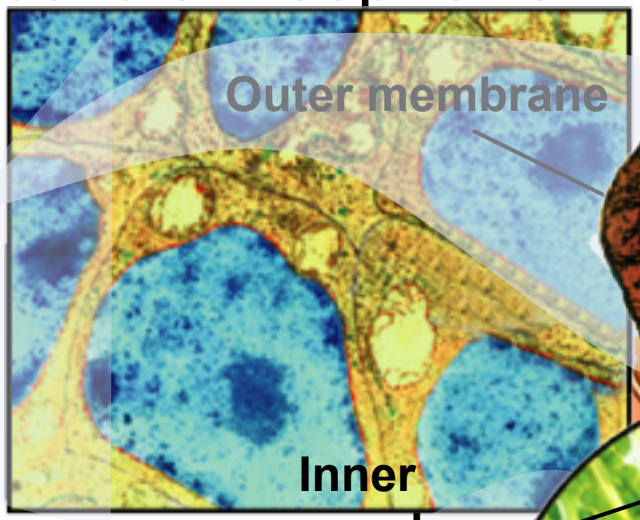
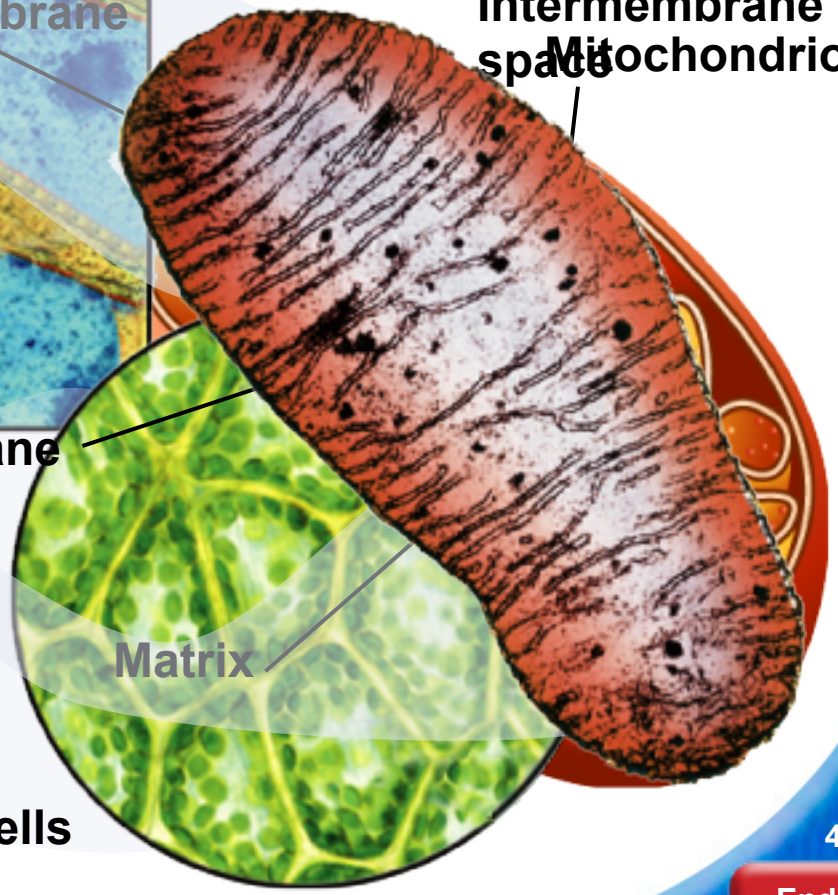
Both plant and animal cells carry out the final stages of cellular respiration in the mitochondria.

Animal Cells





Plant Cells

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Chemical Energy and Food

One gram of the sugar glucose ($C_6H_{12}O_6$), when burned in the presence of oxygen, releases 3811 calories of heat energy.

A **calorie** is the amount of energy needed to raise the temperature of 1 gram of water 1 degree Celsius.

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What is cellular respiration?

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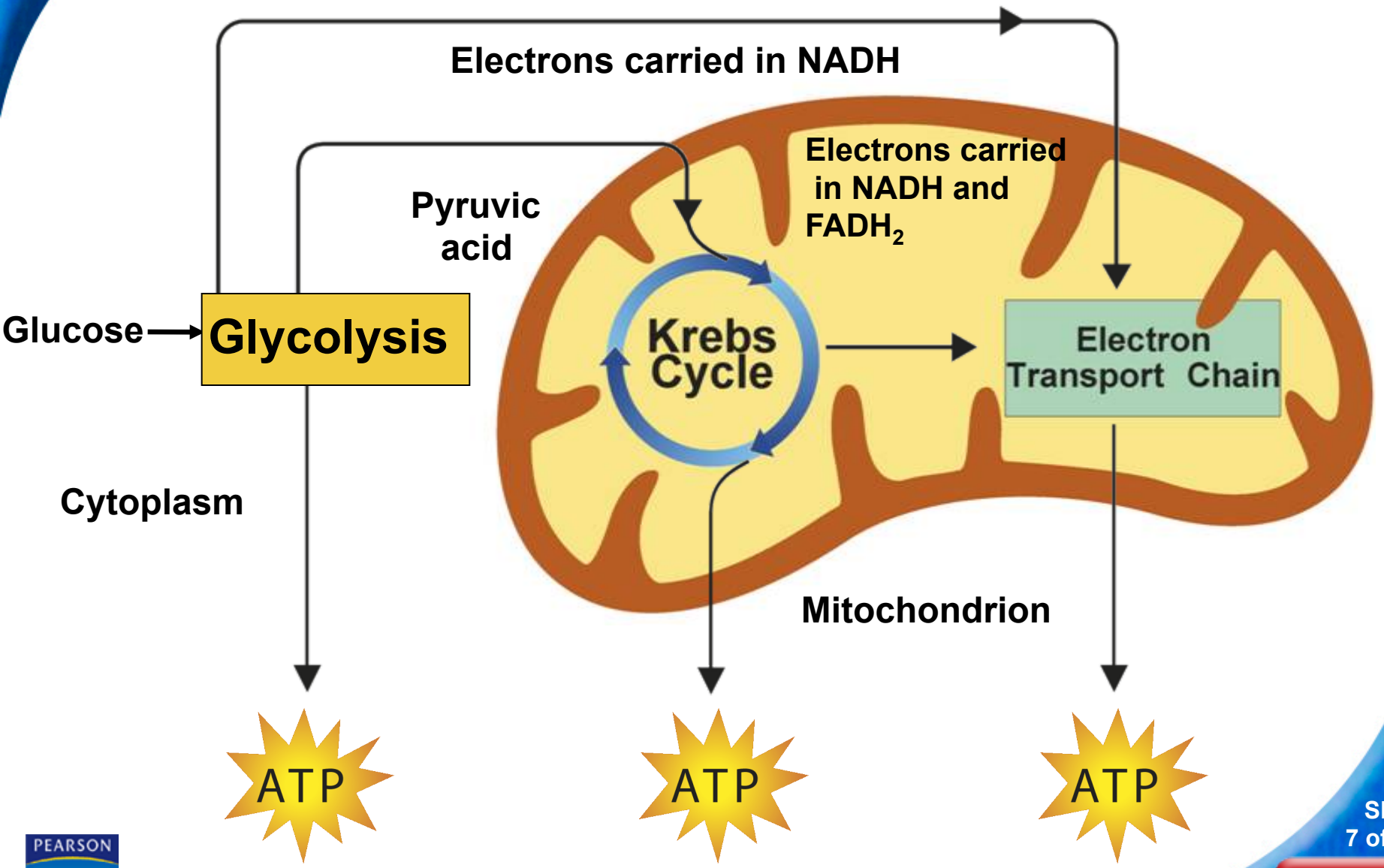

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Cellular respiration is the process that releases energy by breaking down glucose and other food molecules in the presence of oxygen.

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The equation for cellular respiration is:

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

oxygen + glucose → carbon dioxide + water + Energy

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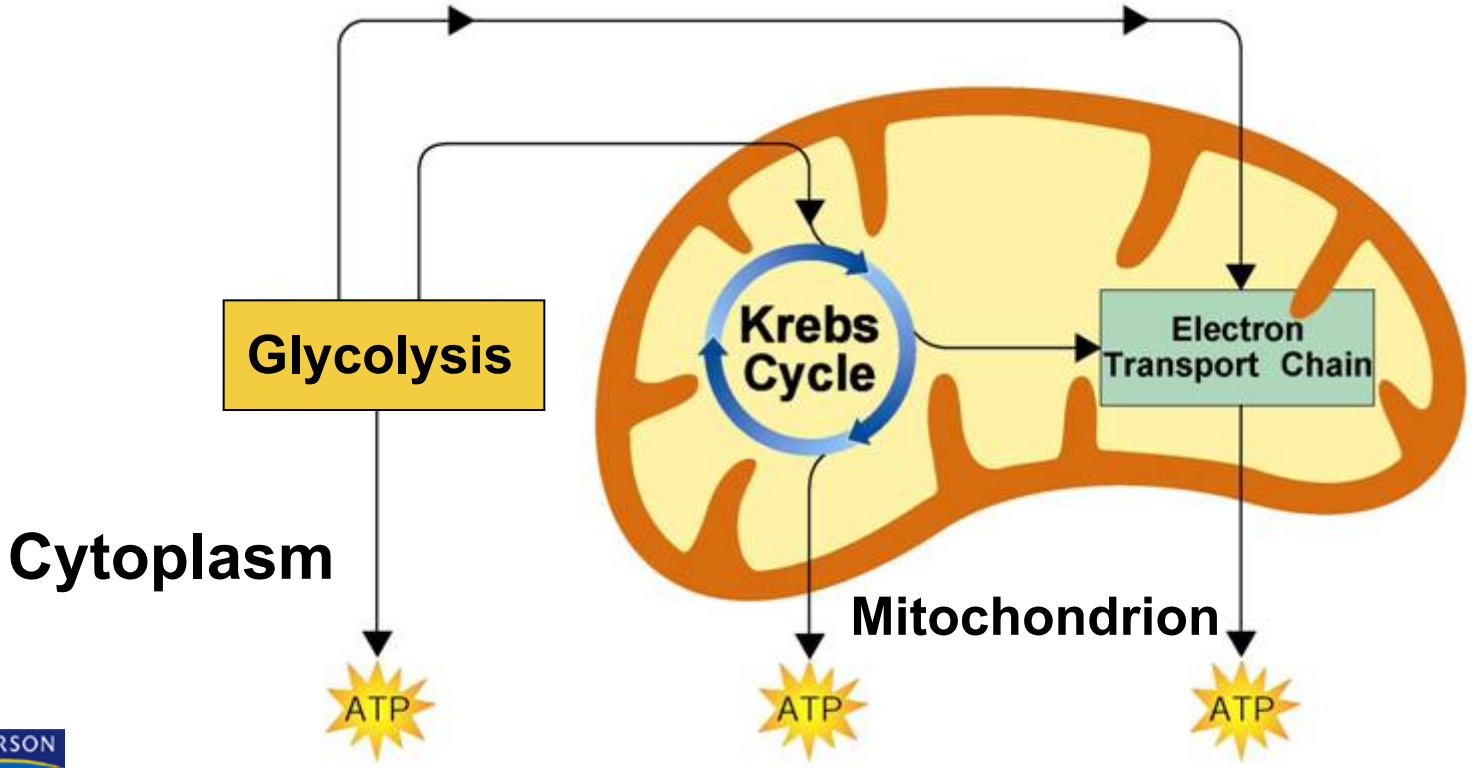
Glycolysis takes place in the cytoplasm. The Krebs cycle and electron transport take place in the mitochondria.



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What happens during the process of glycolysis?

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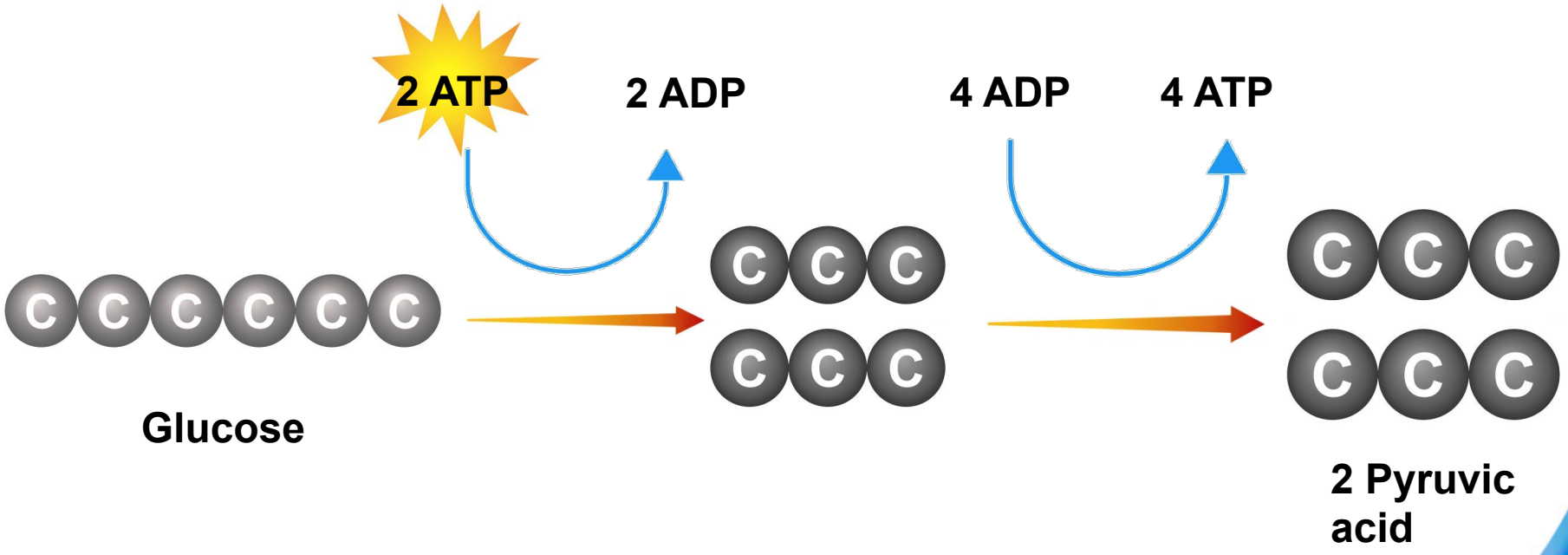
ATP Production

At the beginning of glycolysis, the cell uses up 2 molecules of ATP to start the reaction.



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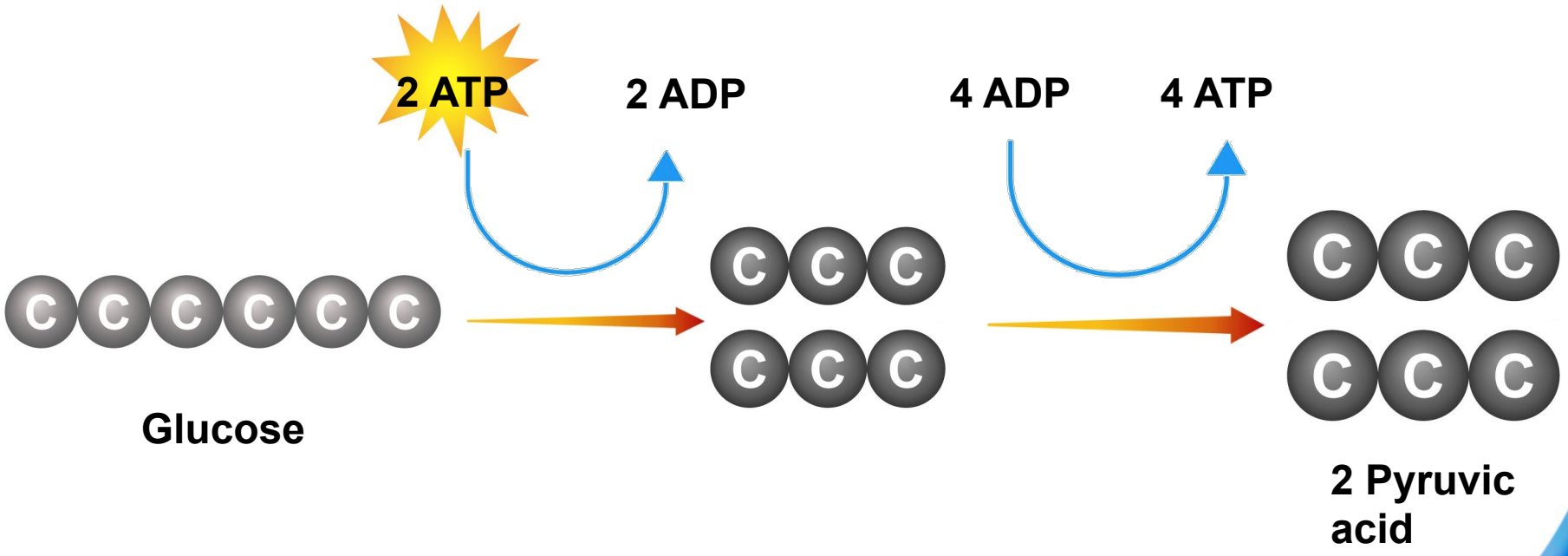
When glycolysis is complete, 4 ATP molecules have been produced.



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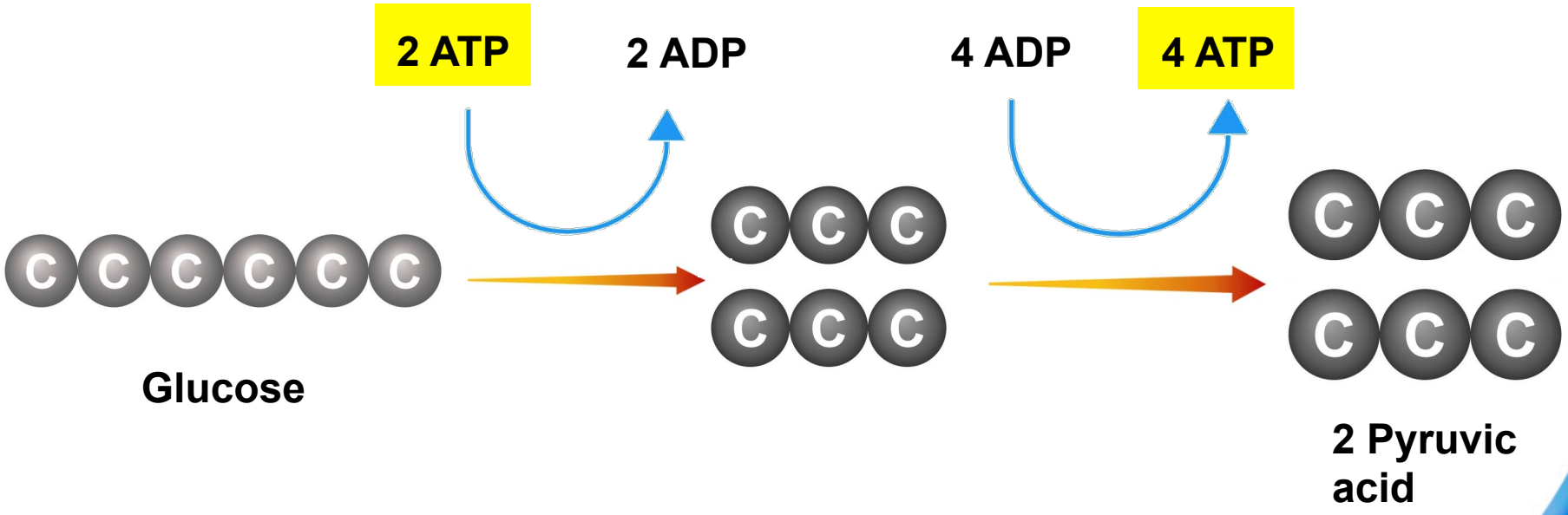
This gives the cell a net gain of 2 ATP molecules.



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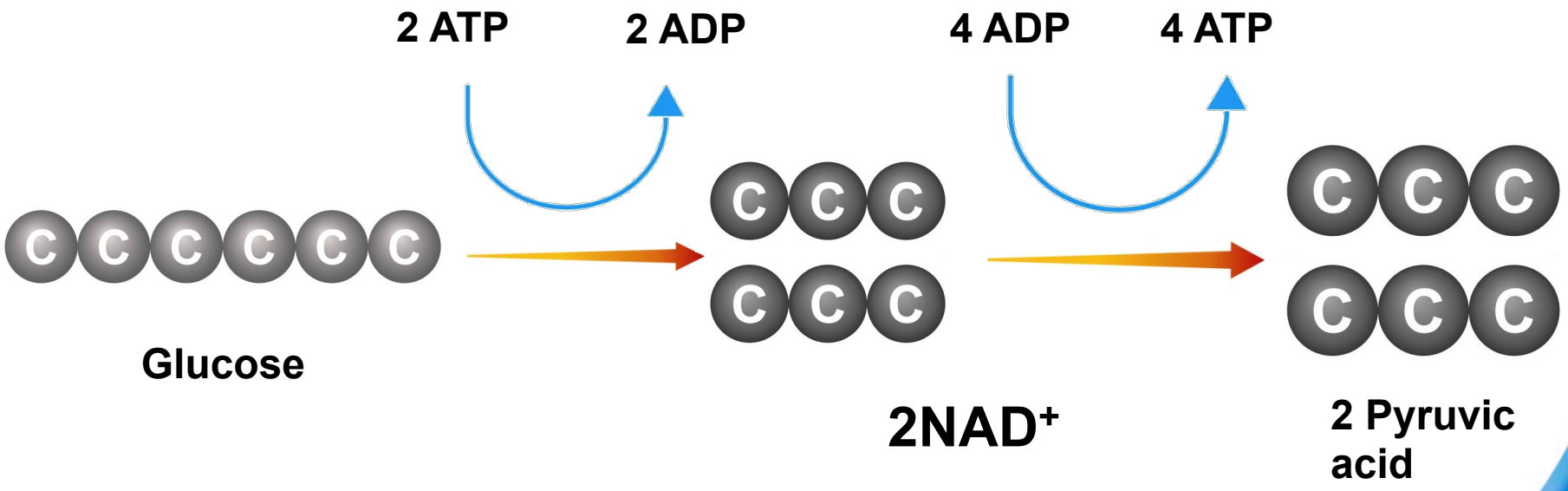
NADH Production

One reaction of glycolysis removes 4 high-energy electrons, passing them to an electron carrier called **NAD^+**.



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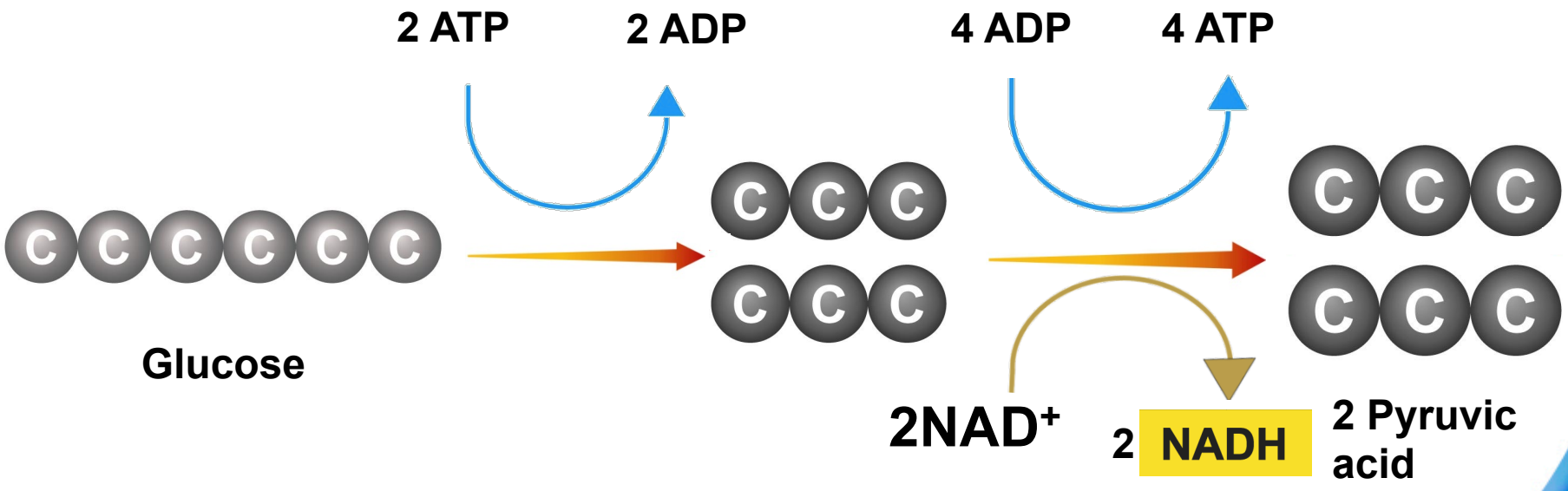
Each NAD^+ accepts a pair of high-energy electrons and becomes an NADH molecule.



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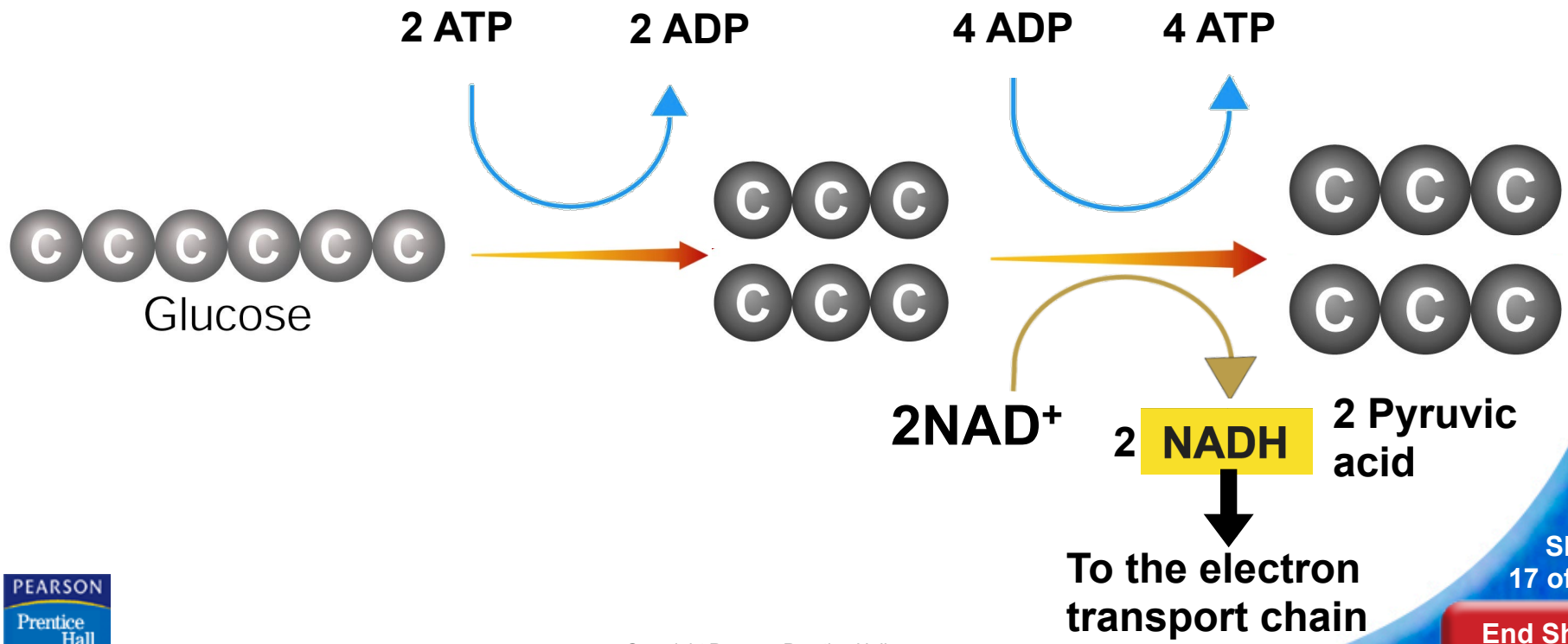
The NADH molecule holds the electrons until they can be transferred to other molecules.



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The Advantages of Glycolysis

The process of glycolysis is so fast that cells can produce thousands of ATP molecules in a few milliseconds.

Glycolysis does not require oxygen.

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Fermentation

When oxygen is not present, glycolysis is followed by a different pathway. The combined process of this pathway and glycolysis is called fermentation.

Fermentation releases energy from food molecules by producing ATP in the absence of oxygen.

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During fermentation, cells convert NADH to NAD^+ by passing high-energy electrons back to pyruvic acid.

This action converts NADH back into NAD^+, and allows glycolysis to continue producing a steady supply of ATP.

Fermentation does not require oxygen—it is an **anaerobic** process.

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What are the two main types of fermentation?

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Alcoholic Fermentation

Yeasts and a few other microorganisms use alcoholic fermentation, forming ethyl alcohol and carbon dioxide as wastes.

The equation for alcoholic fermentation after glycolysis is:

pyruvic acid + NADH $\rightarrow$ alcohol + CO_2 + NAD^+

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Lactic Acid Fermentation

In many cells, pyruvic acid that accumulates as a result of glycolysis can be converted to lactic acid.

This type of fermentation is called **lactic acid fermentation**. It regenerates NAD^+ so that glycolysis can continue.

The equation for lactic acid fermentation after glycolysis is:

$$\text{pyruvic acid} + NADH \rightarrow \text{lactic acid} + NAD^+$$

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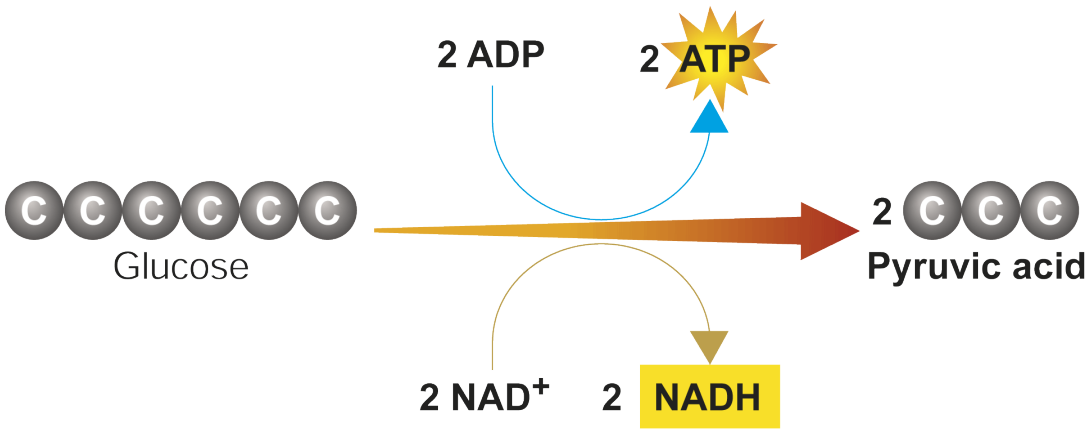
The first part of the equation is glycolysis.



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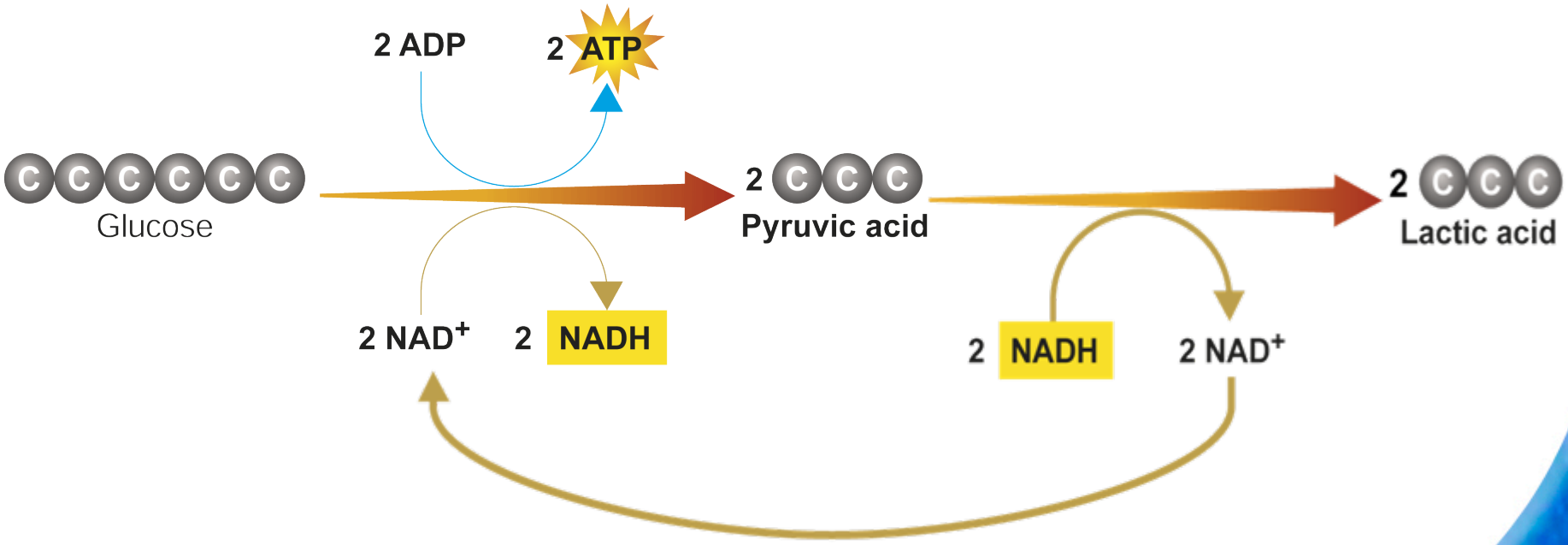
The second part shows the conversion of pyruvic acid to lactic acid.



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9-1 Section QUIZ

1 The raw materials required for cellular respiration are

a. carbon dioxide and oxygen.

b. glucose and water.

c. glucose and oxygen.

d. carbon dioxide and water.

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2 Glycolysis occurs in the

a. mitochondria.

b. cytoplasm.

c. nucleus.

d. chloroplasts.

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3 The net gain of ATP molecules after glycolysis is

a. 3 ATP molecules.

b. 2 ATP molecules.

c. 3 pyruvic acid molecules.

d. 4 pyruvic acid molecules

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4 Fermentation releases energy from food molecules in the absence of

a. oxygen.

b. glucose.

c. NADH.

d. alcohol.

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5 The first step in fermentation is always

a. lactic acid production.

b. the Krebs cycle.

c. glycolysis.

d. alcohol production.

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END OF SECTION