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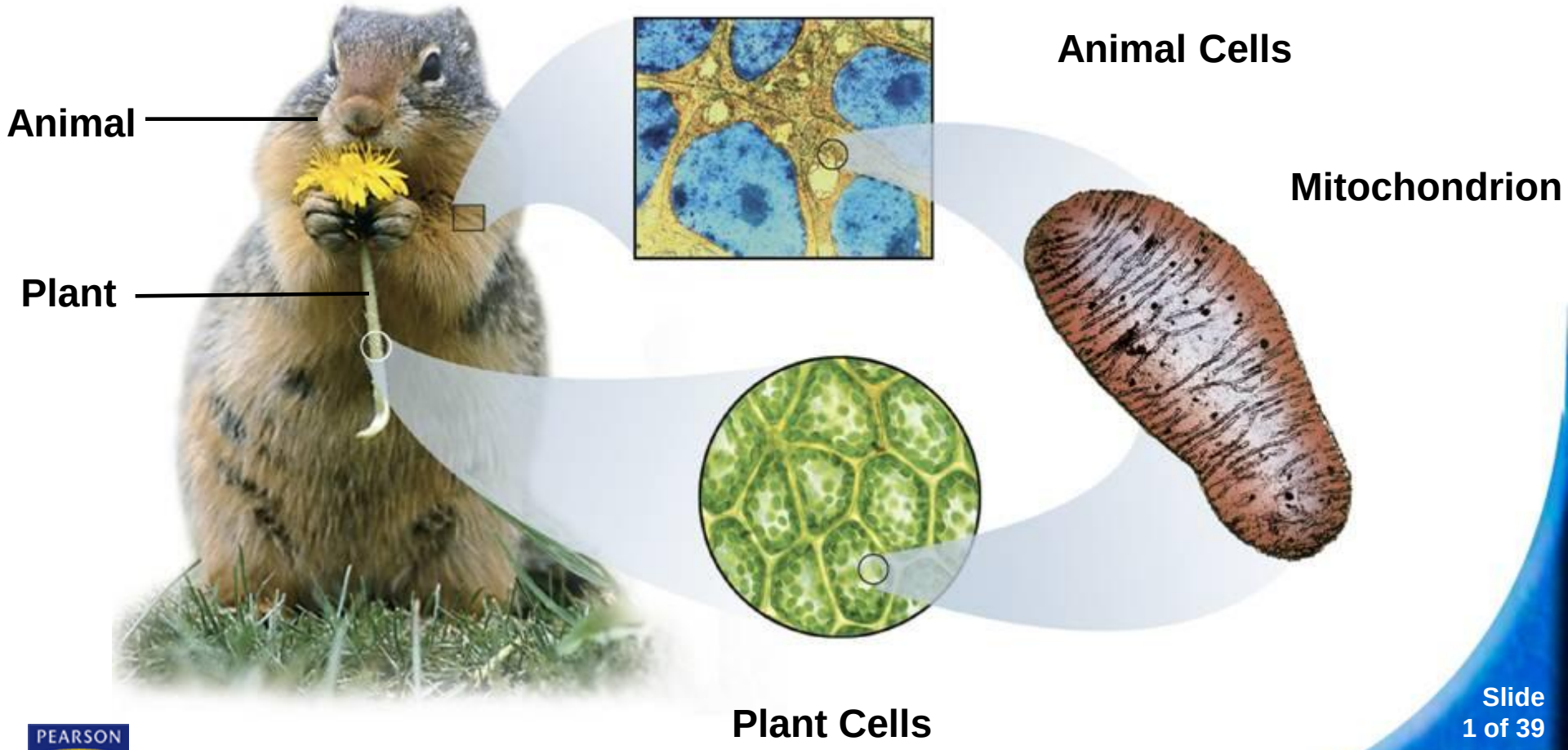
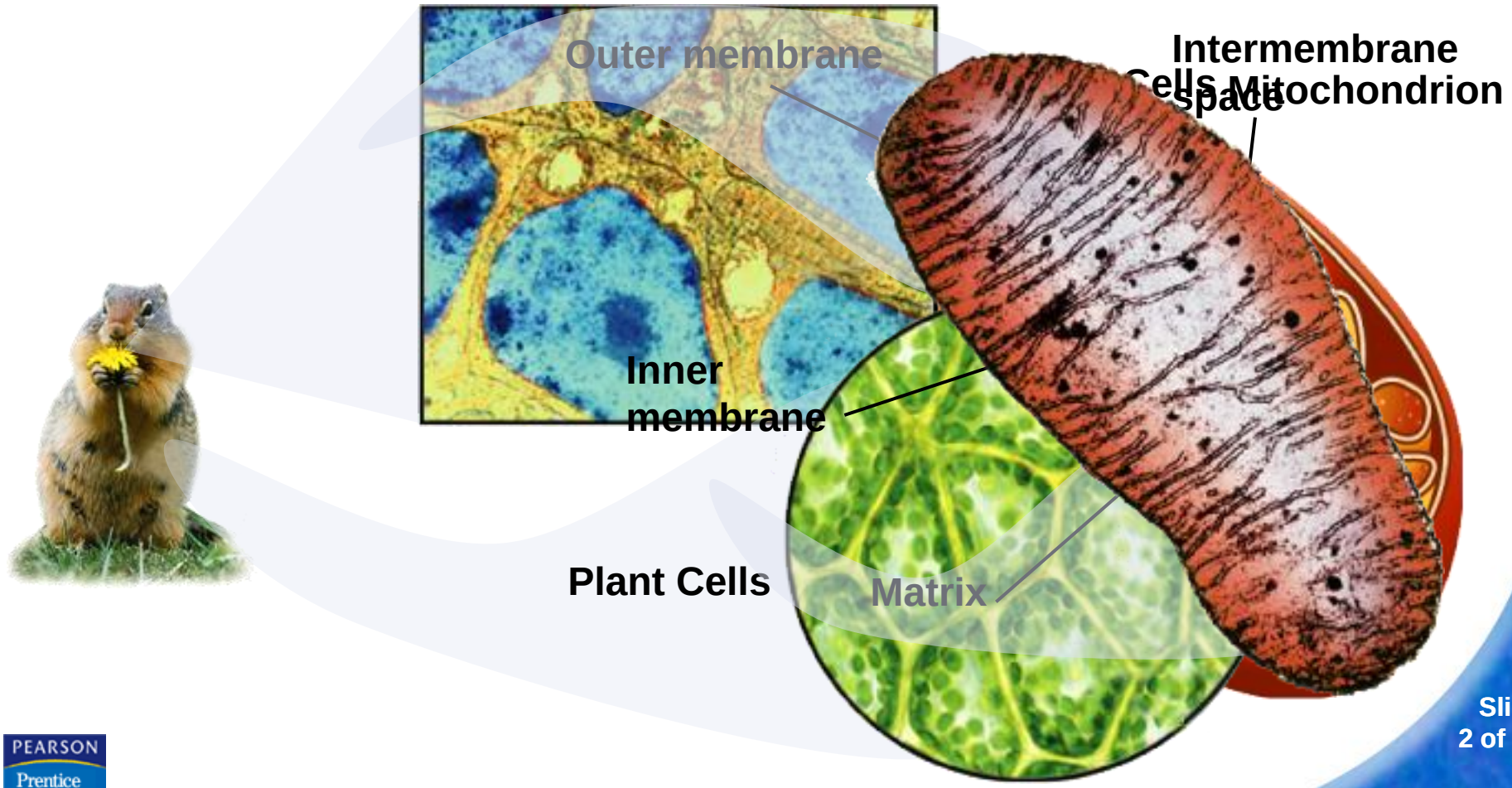
Food serves as a source of raw materials for the cells in the body and as a source of energy.



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



Chemical Energy and Food

One gram of the sugar glucose ($C_6H_{12}O_6$), when burned in the presence of oxygen, releases 3,811 calories of heat energy.

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

When talking about food, 1 calorie is really 1 Kcal, which means 8 oz pop really has 210,000 calories!

Fat: 1 gram = 9 calories
Protein: 1 gram = 4 calories
Carbohydrates: 1 gram = 4 calories

Calorie Content of Macromolecules

Fat: 1 gram = 9 Calories (9,000 calories)
Protein: 1 gram = 4 Calories (4,000 calories)
Carbohydrates: 1 gram = 4 Calories (4,000 calories)

Cells don't “burn” glucose. Instead, they gradually release the energy from glucose and other food compounds.

This process begins with a pathway called **glycolysis**.

Glycolysis releases a small amount of energy.

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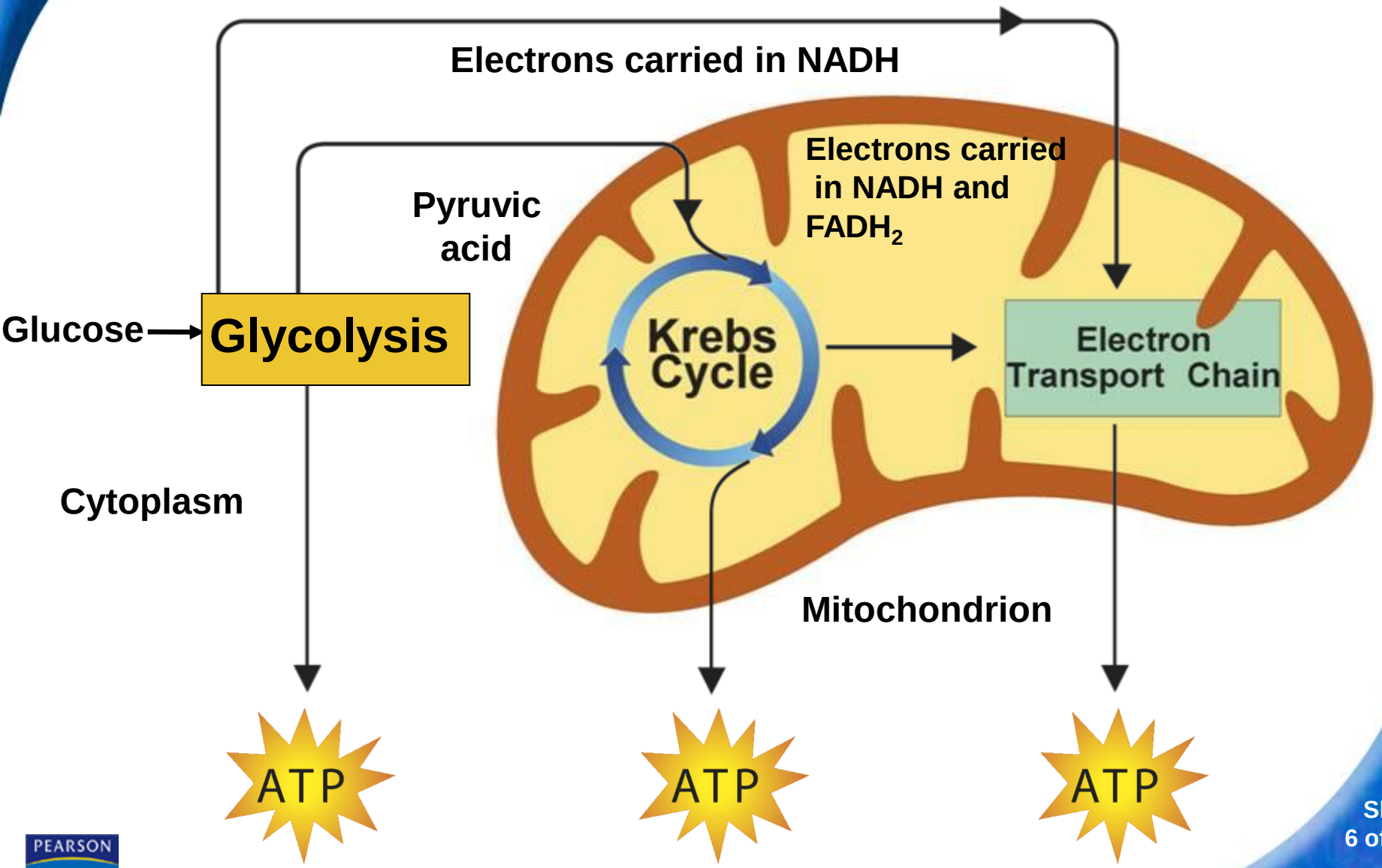
Overview of Cellular Respiration

If oxygen is present, glycolysis is followed by the Krebs cycle and the electron transport chain.

Glycolysis, the Krebs cycle, and the electron transport chain make up a process called **cellular respiration**.

What is cellular respiration?

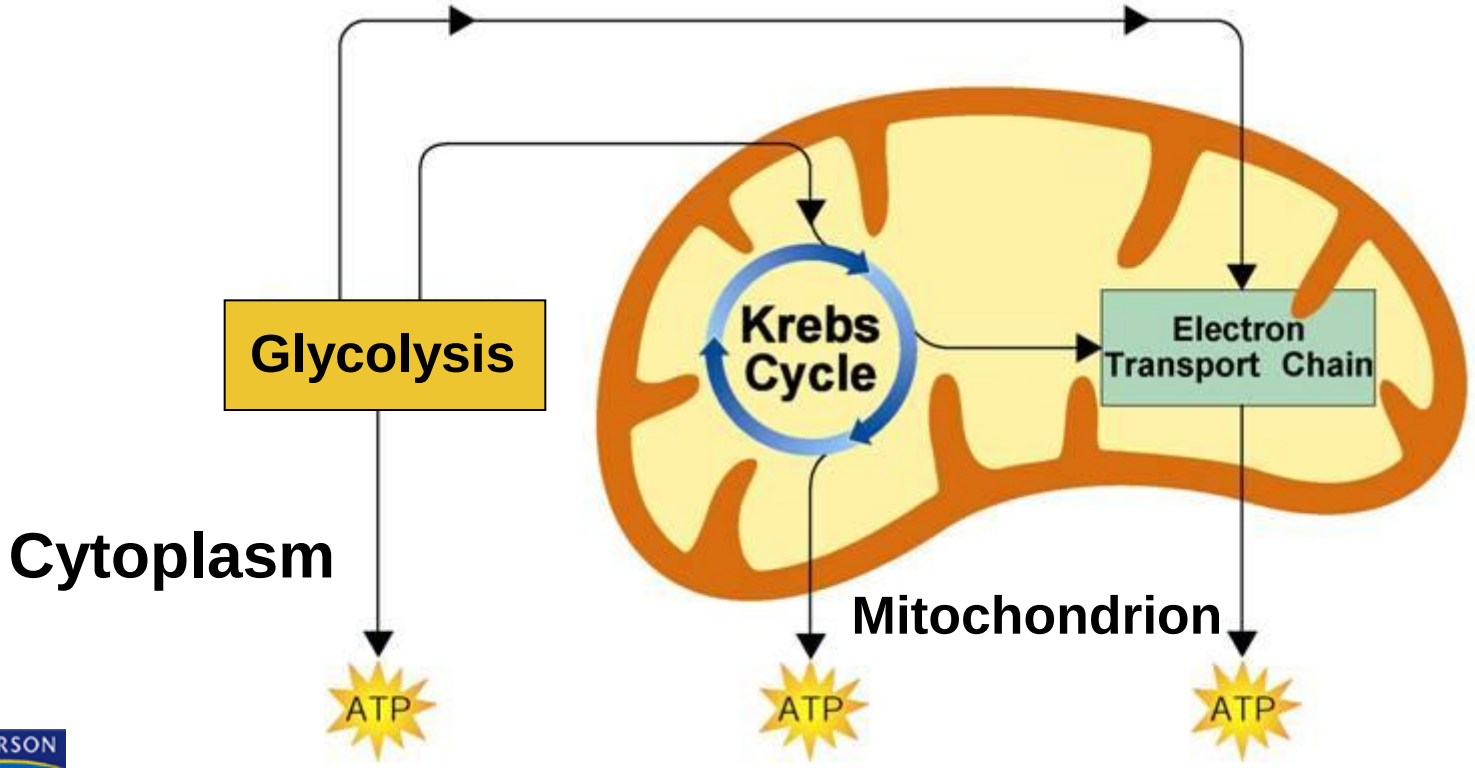


Cellular respiration is the process that releases energy by breaking down glucose and other food molecules in the presence of oxygen.

- 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

- Each of the three stages of cellular respiration captures some of the chemical energy available in food molecules and uses it to produce ATP.

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



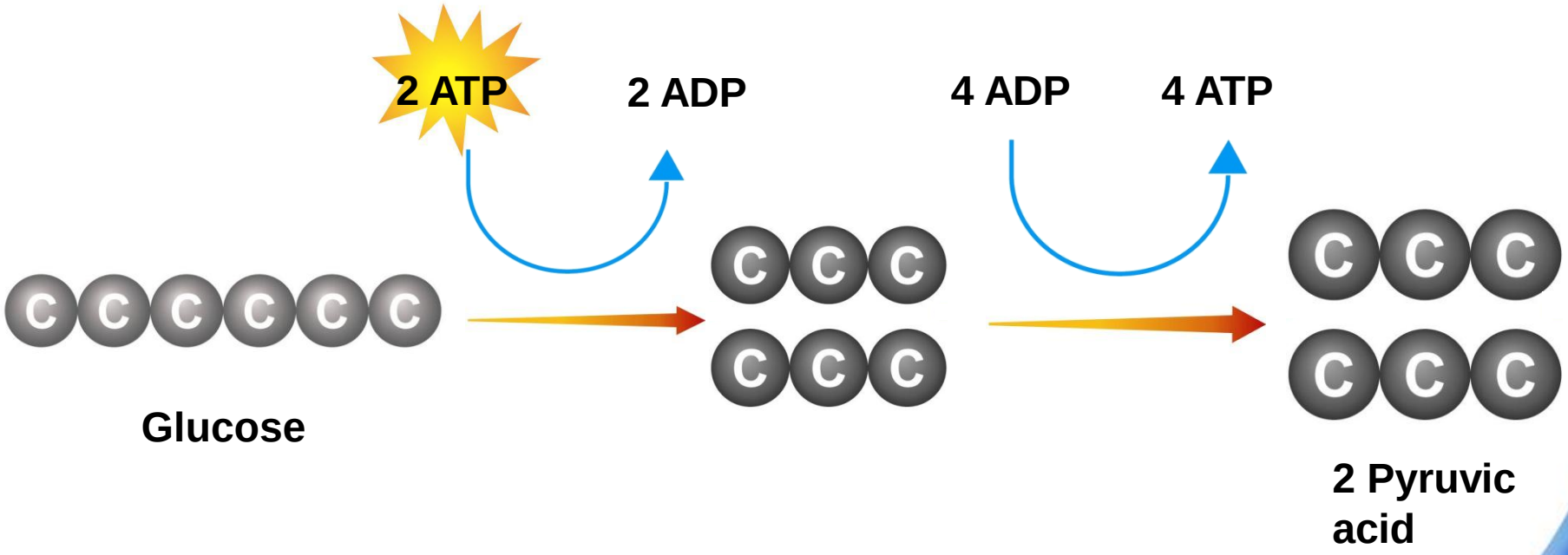
What happens during the process of glycolysis?

Glycolysis

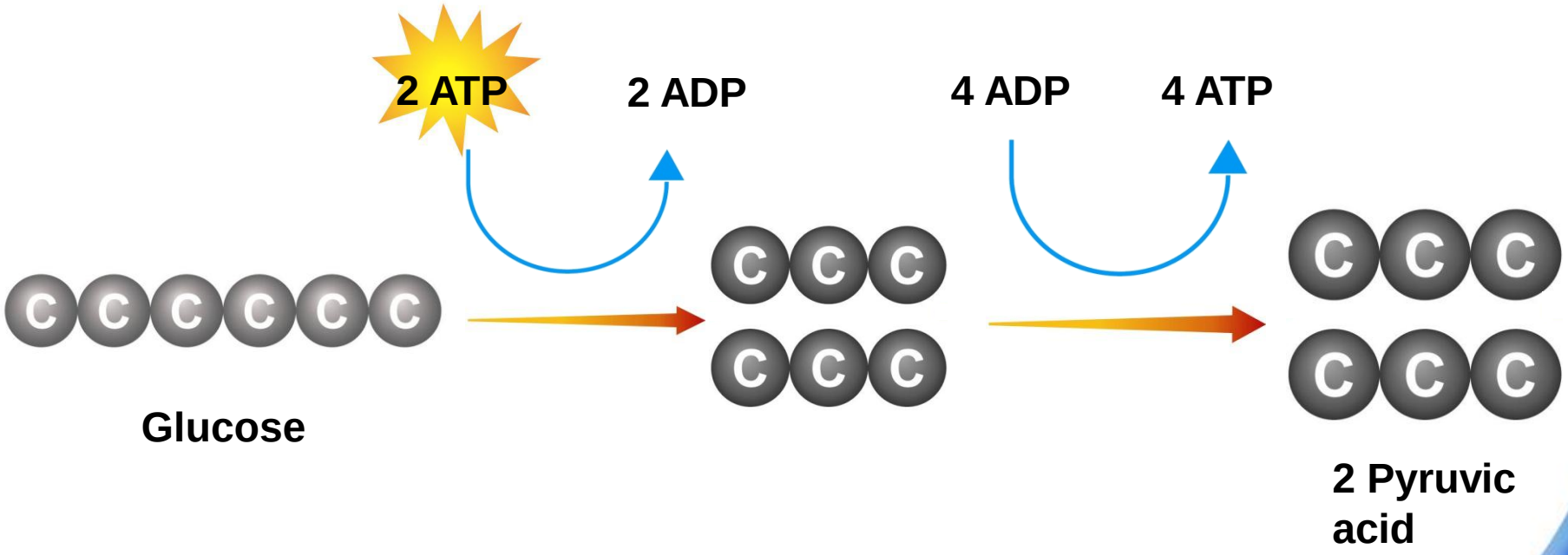
Glycolysis is the process in which one molecule of glucose is broken in half, producing two molecules of pyruvic acid, a 3-carbon compound.

ATP Production

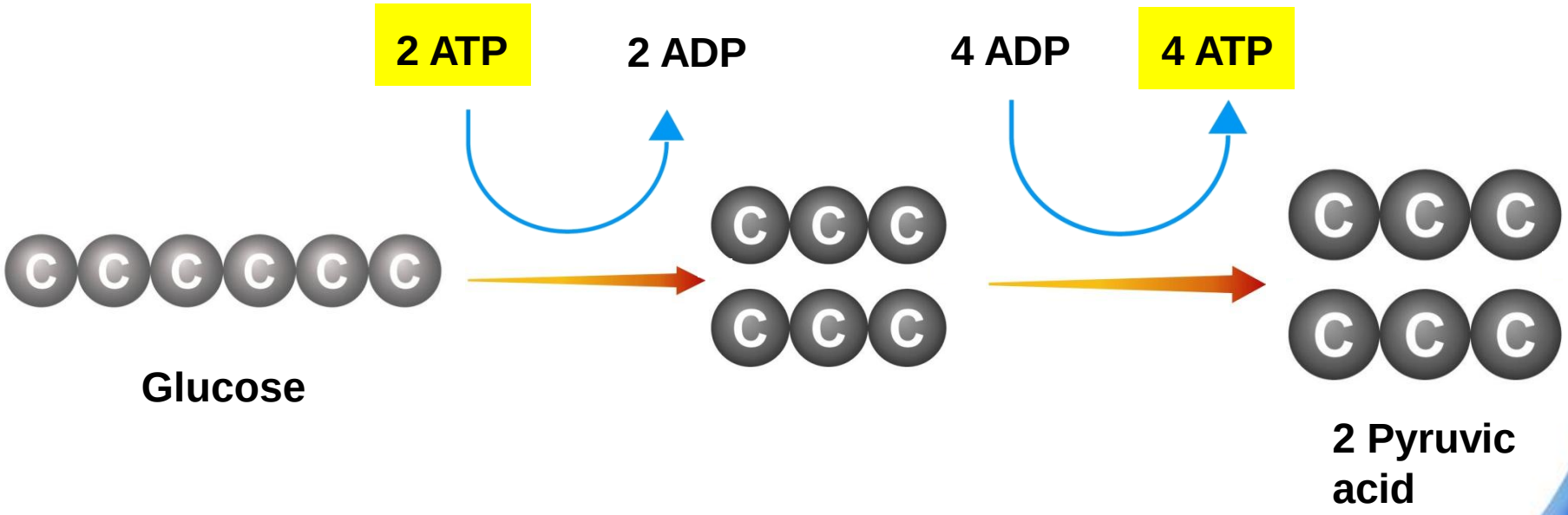
At the beginning of glycolysis, the cell uses up 2 molecules of ATP to start the reaction.



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

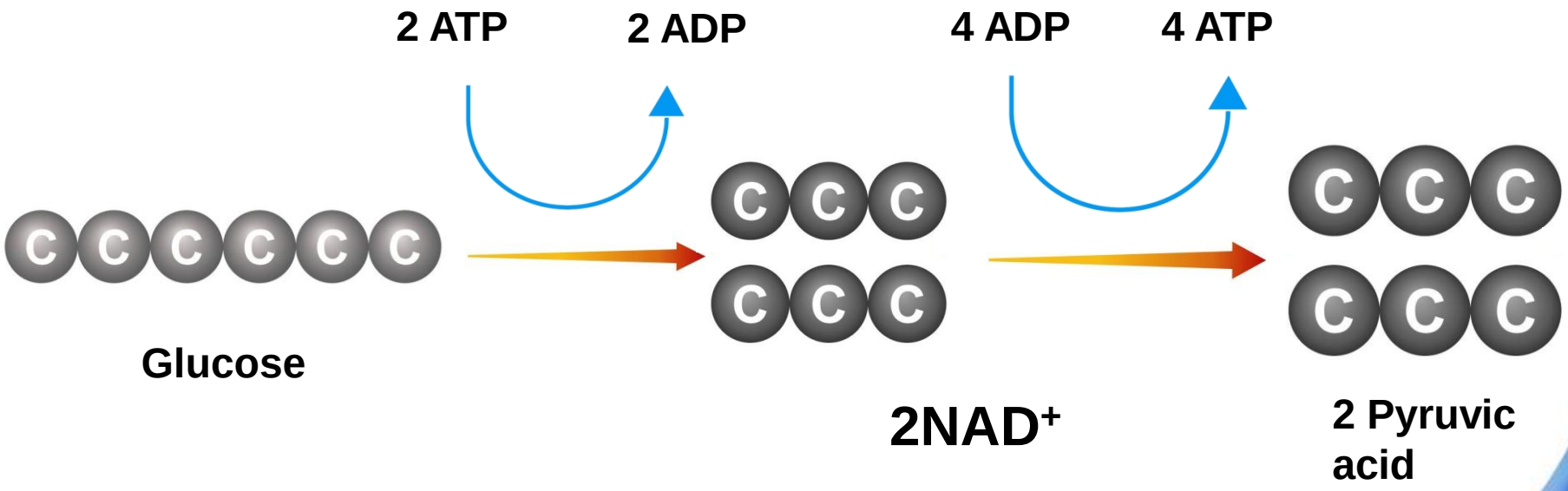


This gives the cell a net gain of 2 ATP molecules.

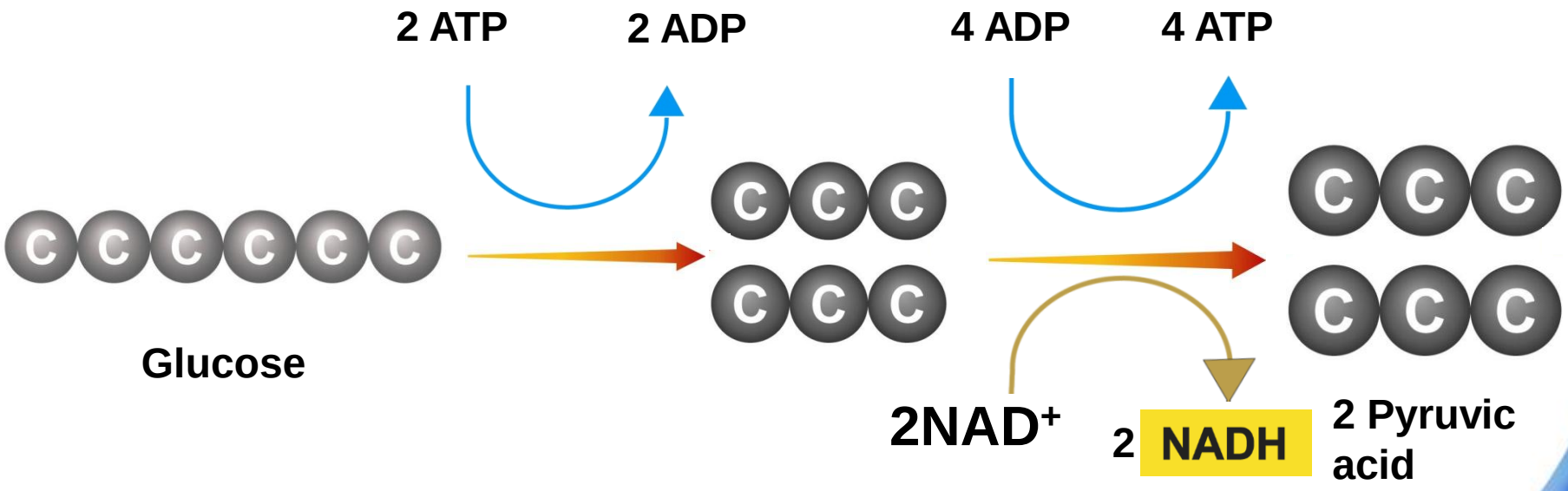


NADH Production

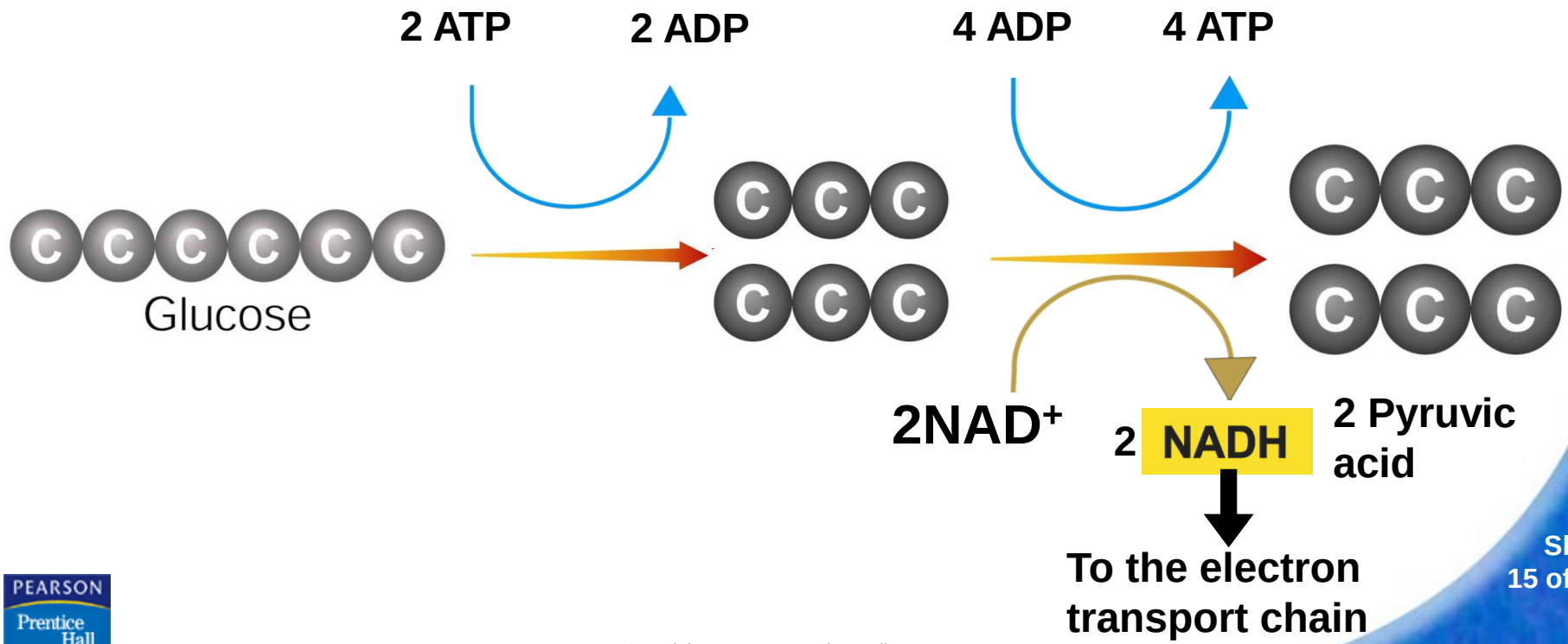
One reaction of glycolysis removes 4 high-energy electrons, passing them to an electron carrier called **NAD^+**.



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



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



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.

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.

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.

What are the two main types of fermentation?

The two main types of fermentation are lactic acid fermentation and alcoholic fermentation.

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:

$$\text{pyruvic acid} + NADH \rightarrow \text{alcohol} + CO_2 + NAD^+$$

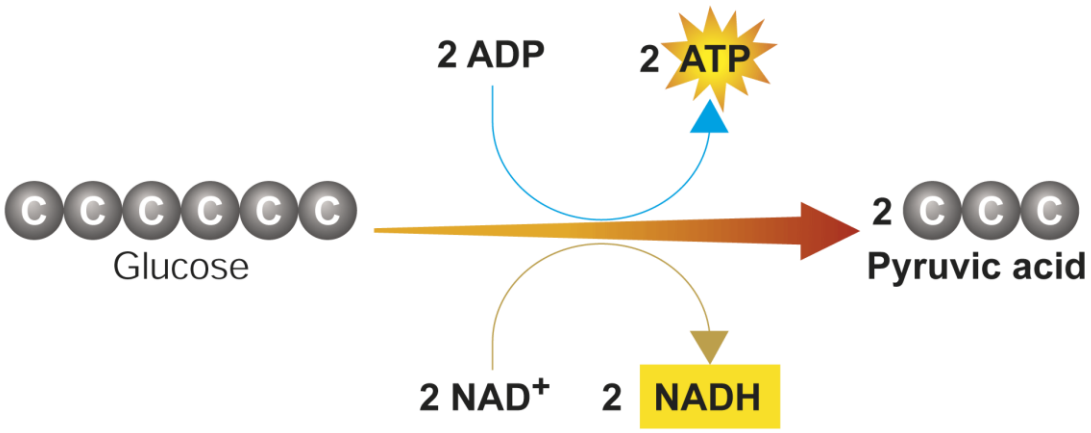
Lactic Acid Fermentation

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

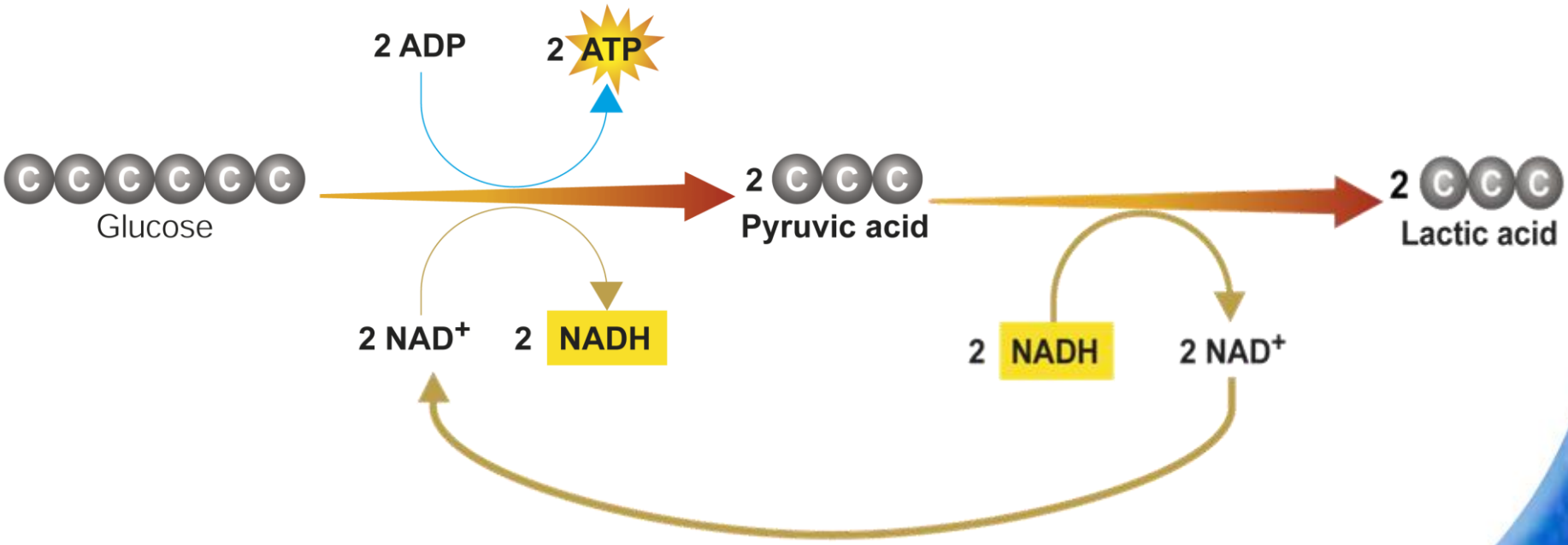
This type of fermentation is called lactic acid fermentation. It regenerates NAD^+ so that glycolysis can continue.

Lactic acid fermentation converts glucose into lactic acid.

The first part of the equation is glycolysis.



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

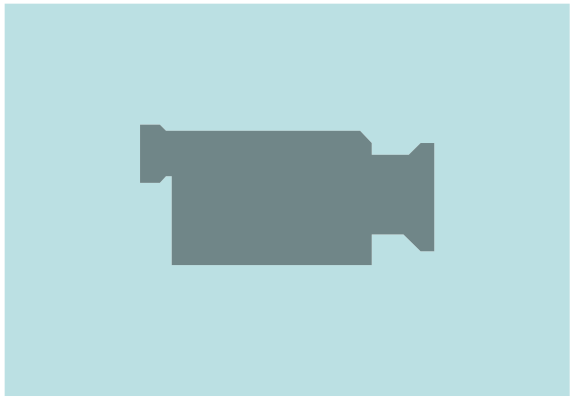


The NADH molecule holds the electrons until they can be transferred to other molecules.

By doing this, NAD^+ helps to pass energy from glucose to other pathways in the cell.

The equation for lactic acid fermentation after glycolysis is:

pyruvic acid + NADH → lactic acid + NAD^+



9-1 Section QUIZ

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Section QUIZ

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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.

2 Glycolysis occurs in the

a. mitochondria.

b. cytoplasm.

c. nucleus.

d. chloroplasts.

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.

4 Fermentation releases energy from food molecules in the absence of

a. oxygen.

b. glucose.

c. NADH.

d. alcohol.

5 The first step in fermentation is always

a. lactic acid production.

b. the Krebs cycle.

c. glycolysis.

d. alcohol production.