# How Do Biological Organisms Use Energy?

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## The Importance of ATP

All organisms use a two-step process to provide the energy needed for most of their biological activities:

- First, chemical energy from organic molecules like glucose is used to make ATP. This process is called cellular respiration.
- Then, ATP provides the energy for most biological processes.

These two steps are illustrated in the figures. First, energy from cellular respiration is used to make ATP (adenosine triphosphate, with 3 phosphates) from ADP (adenosine diphosphate, with 2 phosphates) plus a phosphate.

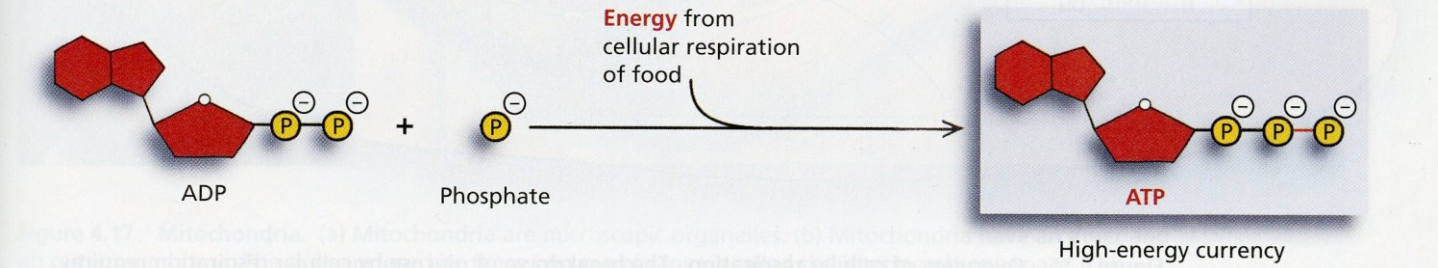


**Figure 4.13 Regenerating ATP.** ATP is regenerated from ADP and phosphate during the process of cellular respiration.

(Figures from Belk and Borden, Biology: Science for Life, 2007)

The reverse reaction (breakdown of ATP to ADP and a phosphate) releases energy which is used for many different cellular processes.

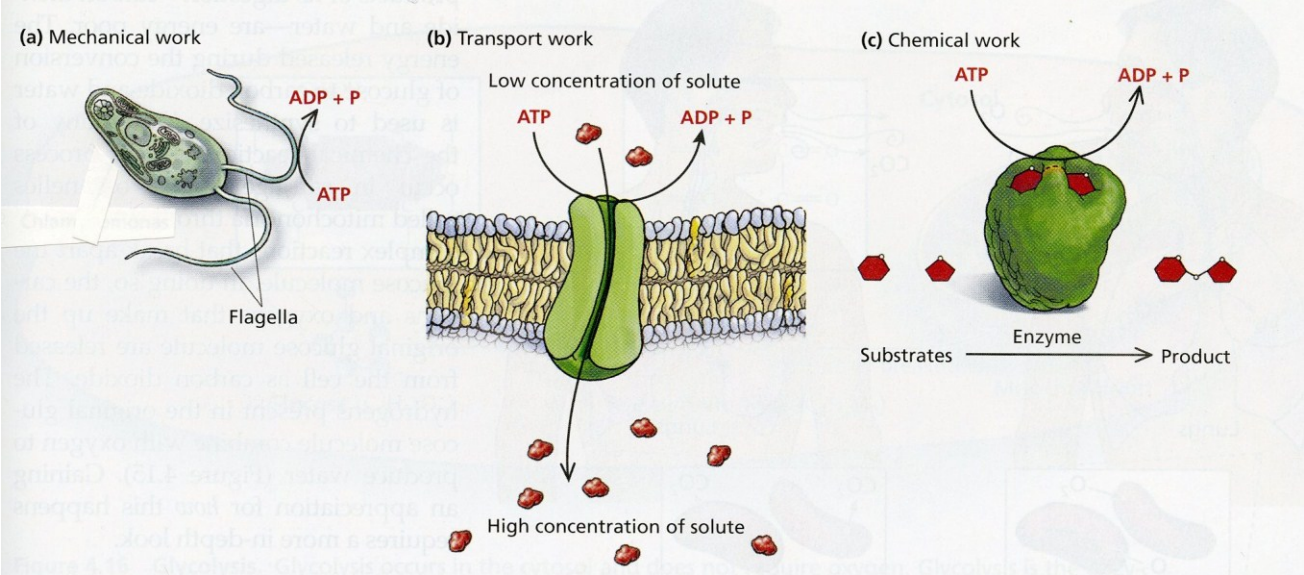


**Figure 4.12 ATP and cellular work.** ATP powers (a) mechanical work, such as the moving of the flagella of this single-celled green algae, Chlamydomonas; (b) transport work, such as the active transport of a substance across a membrane from its own low to high concentration; and (c) chemical work, such as the enzymatic conversion of substrates to a product.

[1] Teachers are encouraged to copy this student handout for classroom use. A Word file (which can be used to prepare a modified version if desired), teacher notes, comments, and links to additional activities are available at http://serendip.brynmawr.edu/exchange/bioactivities.

Questions

**1**. Explain why the reaction, ADP + phosphate -- > ATP, requires energy input. (Hint: Review the top figure on the previous page and remember that like charges repel each other.)

**2**. Explain why all biological organisms need to carry out the reaction, ATP -- > ADP + phosphate. How is this reaction useful?

## Using Energy from Organic Molecules to Make ATP -- Cellular Respiration

Cellular respiration is the process that transfers some of the chemical energy in glucose or another organic molecule to chemical energy in ATP molecules. Cellular respiration is a complex process with many steps. The following two chemical equations give a simplified overview of the cellular respiration of glucose to produce ATP.

$$C_6H_{12}O_6 + 6\ O_2 \text{ --------> } 6\ CO_2 + 6\ H_2O$$

$$\text{\textbackslash/}$$

$$\textit{energy}$$

$$\text{\textbackslash/}$$

$$\text{ADP + phosphate ---------> ATP}$$

Cellular respiration of one molecule of glucose provides enough energy to make up to 29 molecules of ATP.

Questions

**3**. Write in the names of each of the molecules in the first equation shown above.

**4**. If you search for "cellular respiration equation" on the web, some of the most popular sites give the following equation for cellular respiration of glucose.

$$C_6H_{12}O_6 + 6\ O_2 \text{ ----> } 6\ CO_2 + 6\ H_2O + ATP$$

What is wrong with this equation? (Hint: Think about where an ATP molecule comes from.)

**5**. Is the following sentence accurate?

Cellular respiration produces the energy needed for biological processes.

If the sentence is not accurate, change the wording to make it more accurate.

**6**. Why do we need to breathe all day and all night?

## Using ATP to Carry out Biological Processes

The energy released by the breakdown of ATP is used for many biological processes (see the bottom figure on page 1). The following chemical equations summarize how ATP provides the energy for muscle contraction.

many ATP ----------> many ADP + many phosphate
\/
*energy*
\/
muscle relaxed ----------> muscle contracted

Question

**7**. When we are running, our muscles use a lot of glucose. During a long race, active muscles can use up most of the body's glucose stores, so a runner should consume some sugary beverage or food to make sure enough glucose is available. Explain how active muscles use glucose; be specific about the multiple molecules and processes involved.