

Chemical Energy

FIGURE 20: When an elk eats plants, energy in the plant molecules is released through a series of chemical reactions.



Model Draw a simple flow chart to show how energy is transferred from the sun to the elk's cells.

Your cells need energy to perform essential cell processes. This energy comes from food, but not directly. First, the food must be digested. Digestion breaks food into individual molecules, and some of these molecules store energy in their bonds. This chemical energy is only usable after biomolecules are broken down by a series of chemical reactions known as cellular respiration.

Chemical Energy and ATP

Cellular respiration transfers energy from organic molecules such as glucose to a molecule called **ATP**, or adenosine triphosphate. ATP is known as the energy currency of the cell. It provides the energy necessary for cell processes such as pumping molecules across the cell membrane and driving chemical reactions. ATP also provides energy for mechanical processes, such as the contraction of muscle cells.

Cellular respiration is complementary to another process called photosynthesis. In this process, organisms such as plants and algae absorb energy from sunlight and use it to help make high-energy sugars. When an animal such as an elk eats a plant, the plant matter is digested, and individual molecules are transported to cells. Cellular respiration converts energy from some of these molecules to a form cells can use.



Energy and Matter

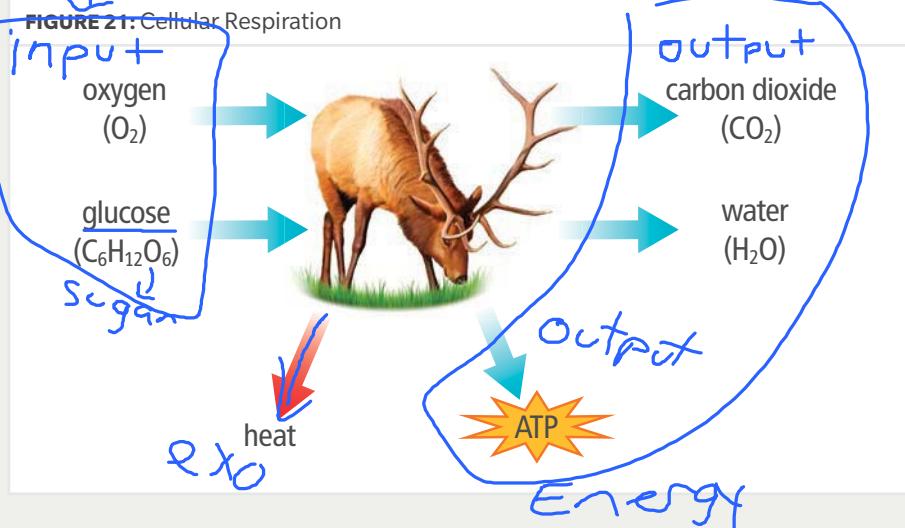
Cellular Respiration



Collaborate With a partner, answer the following questions.

- What is the energy input for cellular respiration, and what are the energy outputs?
- According to this model, is cellular respiration an endothermic or **exothermic** process? Explain your answer.

Cellular respiration is a multistep process that transfers chemical energy from glucose to ATP, which provides energy for cell processes. In addition to glucose, cellular respiration requires oxygen as a reactant. The products are ATP, carbon dioxide, and water. Heat is also released as a product of cellular respiration.



ATP is a molecule made up of subunits called adenine and ribose, as well as three phosphate groups. The bonds between the phosphate groups are high-energy bonds that store chemical energy in a form that cells can use.

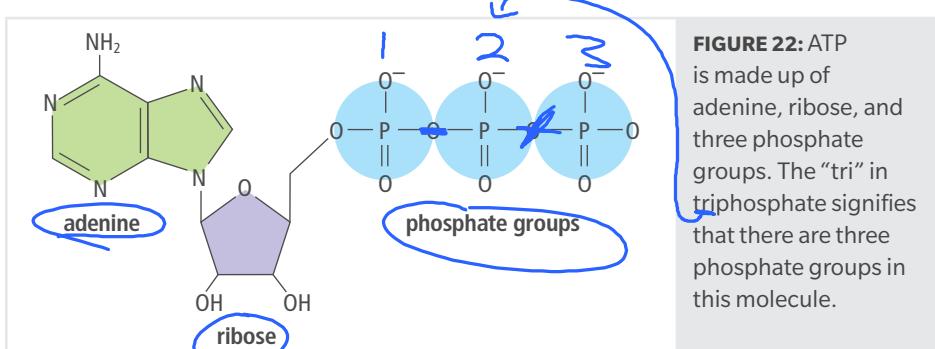


FIGURE 22: ATP is made up of adenine, ribose, and three phosphate groups. The “tri” in triphosphate signifies that there are three phosphate groups in this molecule.

ATP is generated when cells carry out cellular respiration. In this process, energy from the breakdown of biomolecules is used to add a phosphate group to adenosine diphosphate, or ADP. The energy carried by ATP is released when a bond between two phosphate groups is broken. A phosphate group is released, and ATP becomes ADP, a lower-energy molecule. The energy released can be used to power cell processes such as transporting materials, carrying out reactions, and producing new molecules.

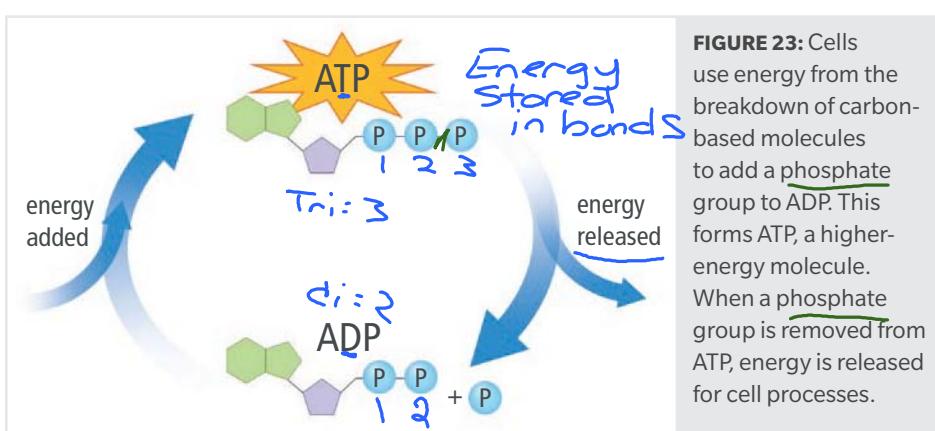


FIGURE 23: Cells use energy from the breakdown of carbon-based molecules to add a phosphate group to ADP. This forms ATP, a higher-energy molecule. When a phosphate group is removed from ATP, energy is released for cell processes.



Language Arts

Connection Make an analogy to explain the role of ATP in storing energy and releasing energy for cell processes.

Analyzing Energy Content in Food $|C_g| = 1000 \text{ cal}$

The energy in food is measured in Calories. One Calorie from food equals one kilocalorie, or 1000 calories. Proteins and carbohydrates have 4 Calories per gram, and fats have 9 Calories per gram. The number of Calories in food is indirectly related to the amount of ATP that can be produced from the food. The number of ATP molecules produced depends on the type of molecule that is broken down—carbohydrate, lipid, or protein.

Carbohydrates are the molecules most commonly broken down to make ATP, but they are not stored in large amounts in your body. The body uses fat for energy storage instead because it is more Calorie-dense and can yield greater amounts of ATP per unit mass. Proteins store about the same amount of energy as carbohydrates, but they are less likely to be broken down to make ATP. The amino acids in proteins are needed to build new proteins more than they are needed for energy.



Explain A common misconception is that proteins are a good source of energy. Explain which types of foods are the best energy sources and how this relates to the amount of ATP made by your cells.

Carbohydrates are the easiest source of energy for organisms to eat to get energy.