Reading 1 for Activity 4.3
Energy and Reactions

This reading reviews energy changes in an important reaction that takes place in living cells. The reading refers to some common molecules in biology that have large names. Do not worry about the terms, instead, focus on the energy changes during this reaction and how that relates to what you have been learning about energy, bonding, and reactions in class.

In the lab, you saw that the hydrogen peroxide had to be heated up to observe bubbles forming. Placing the test tube of hydrogen peroxide in warm water meant more energy could be transferred from the surroundings (the warm water) into the system (the tube filled with hydrogen peroxide) to start breaking apart hydrogen peroxide molecules. Energy needs to be transferred into the system to start a reaction because when atoms are bonded they are at a stable, low potential energy point. Therefore, when bonds break, the atoms are in a less stable state and have higher potential energy.

In order to break a bond and separate atoms, energy must be transferred into the system. This is always true because bonds always form at stable low potential energy points. However, it is common to hear about energy being "released when bonds break." Even many science textbooks have these inaccurate statements.

For example, in our society we burn a lot of fuel as a source of energy. Fuel is usually made of molecules that have several carbon and hydrogen atoms bonded together. When the fuel is burned, it reacts with oxygen, the molecules of the fuel break apart, and rearrange and bond with oxygen atoms to form carbon dioxide and water. Sometimes you may hear fuel molecules referred to as "high energy" molecules. It is also common to think about energy being "released when the fuel breaks apart." However, as you have seen in class, these statements are both inaccurate simplifications. All bonds form at stable low potential energy points. Also, the reaction of burning fuel will not start without transferring some energy into the system. This initial spark or flame is necessary to start the reaction by breaking some bonds.

There are also reactions that are common in biology that often get discussed in simplified and inaccurate terms--in particular, the reaction when a molecule called ATP breaks.

ATP Reaction

ATP stands for adenosine triphosphate. ATP is a large molecule found in cells. ATP is a really important molecule for life. ATP reacts with water and other components in cells. The products of this reaction are ADP (adenosine diphosphate) and hydrogen phosphate, shown in Figure 1.

Analyze Figure 1. How are ADP and ATP similar and different?

The Interactions Project materials are being developed and researched with funding from the National Science Foundation (DRL-1232388) in partnership with Michigan State University.

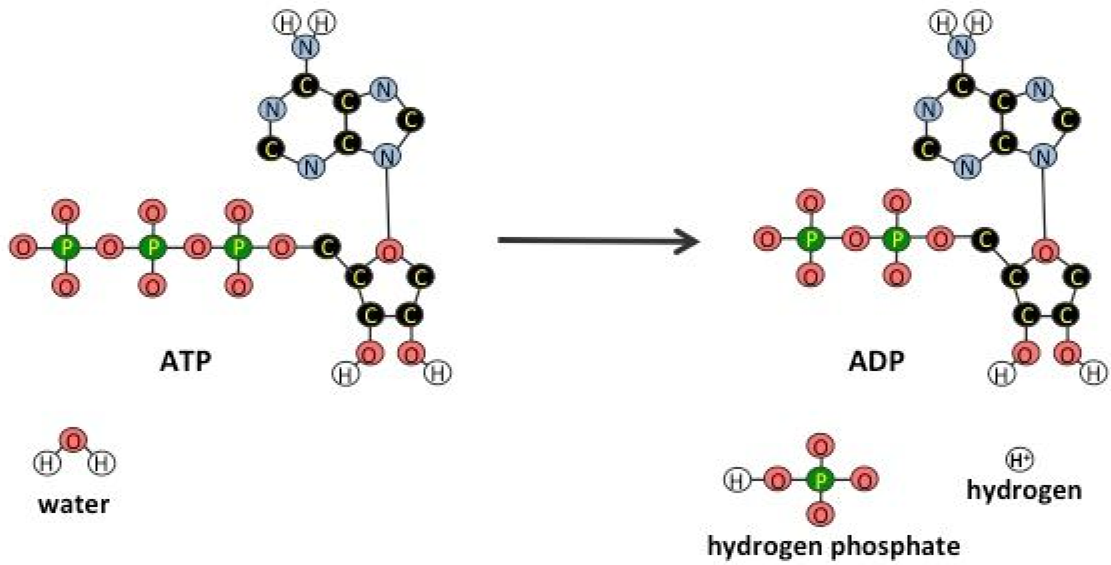

Figure 1: The ATP reaction

Energy and ATP → ADP reaction

During this reaction, a lot of energy is transferred from the molecules involved in the reaction to the rest of the cell. This energy allows the cell to do all of the work necessary to maintain life, including building new cell parts, moving parts around, and getting rid of waste.

This is an essential reaction for all living things and therefore is discussed in Biology textbooks. These textbooks often talk about how the ATP bond is broken to make ADP. They also often suggest that breaking the ATP bond "releases energy" to the surroundings. However, as you have seen in class, breaking a bond cannot transfer energy out to the surroundings. In fact, the opposite is true, breaking bonds means that energy must be transferred ***from*** the surroundings into the system.

Energy must be transferred from the surroundings into the system in order to break the bond in ATP. However, it is also true that the reaction, overall, transfers more energy out to the surroundings than is needed to break the bond in the ATP. If you compare the molecules in Figure 1, what else is happening in the reaction in addition to breaking a bond in ATP?

What do you think might be happening to transfer energy out to the surroundings in this reaction?

You will be exploring energy transfers during reactions more as you continue Activity 4.3.

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