ATP

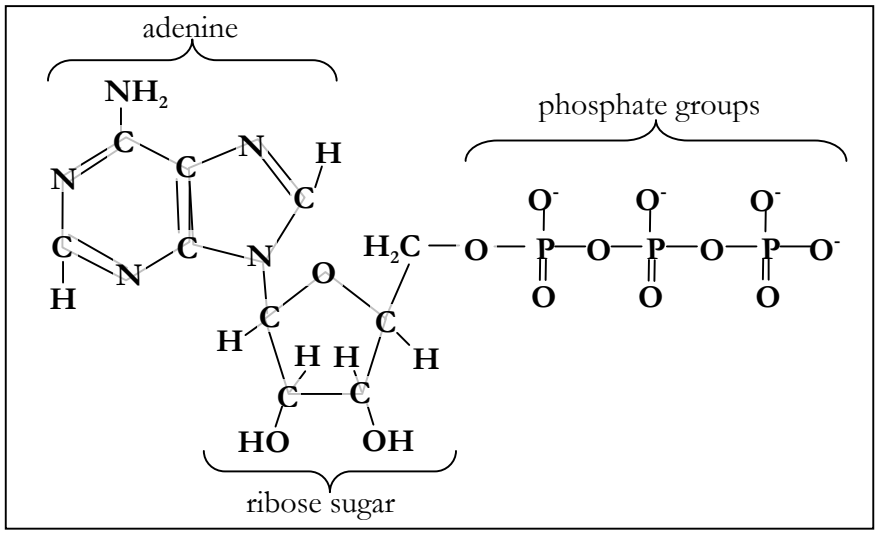
(How do cells capture, release and store energy?)

Why?

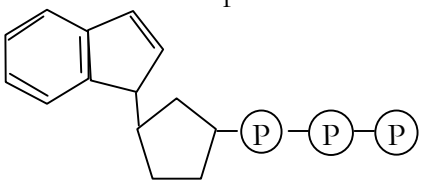
A sporting goods store might accept a $100 bill for the purchase of a bicycle, but the corner store will not take a $100 bill when you buy a package of gum. It is helpful to have smaller denominations in your wallet, to make everyday transactions easier.

The same concept is true for your cells. They need energy (their "currency") to take care of their everyday functions, and they need currency in many denominations. The largest denominations are the molecules in the food we eat, the source of all of our energy. These molecules are large, and harvesting the energy they hold requires work on the part of the cell. For quick cellular transactions, your cells store energy in the small molecule of ATP. This is the equivalent of a $1 bill for your cells' daily activities. As with money, this energy currency can be **earned, spent** or **saved**.

Model 1: The Structure of Adenosine Tri-Phosphate (ATP)



1. List the three parts of the ATP molecule and label each on the simplified molecule below.
   a.
   b.
   c.



2. Describe how you would be able to identify each part of the ATP molecule. Give yourself clues to identify each component.
   a.

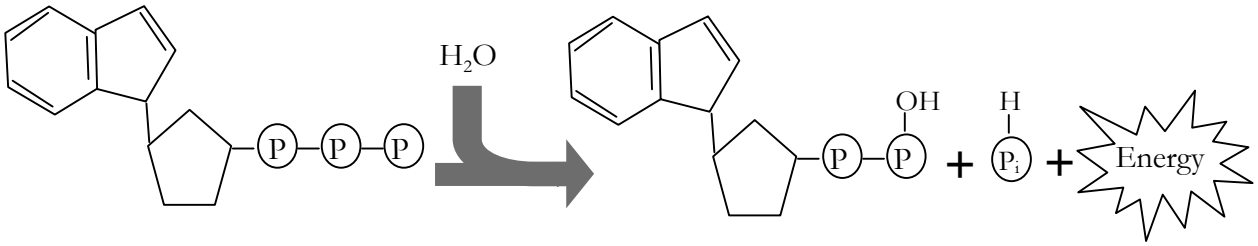
   b.

   c.

3. What is meant by *tri-* in adenosine triphosphate?

4. Discuss with your group what the structure of adenosine *di*phosphate and adenosine *mono*phosphate might be. Draw or describe your conclusions.

Model 2: Hydrolysis of ATP



5. Model 2 illustrates a chemical reaction. Write the reaction as an equation, using the name of each of the two reactants (input molecules) and each of the three products (outputs).

6. In the reaction in Model 2:
   a. Circle the bond that was broken in the ATP reactant.

   b. What happens to the water in this reaction?

7. The word *hydrolysis* has two roots: *hydro* and *lysis*.
   a. Describe how this term relates to the chemical reaction illustrated in Model 2.

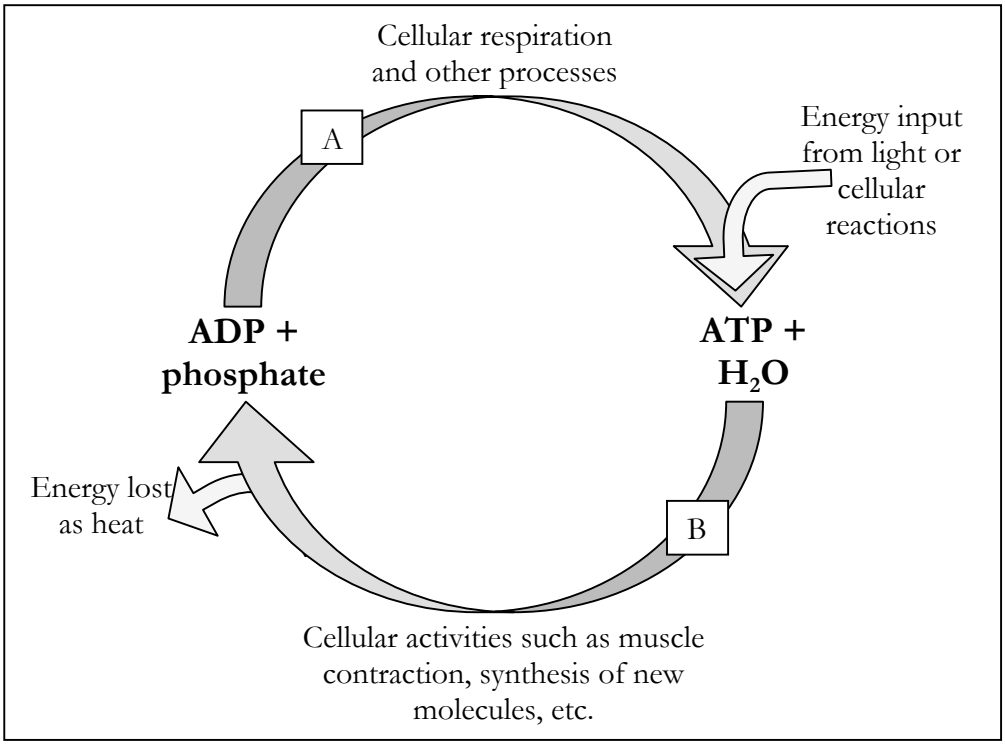
   b. Does the hydrolysis of ATP release energy or require energy input to occur?

8. If ADP were to be hydrolyzed in a similar manner, would you expect energy to be released or required? Explain your answer.

Read This!

All chemical reactions that occur in cells either require or release energy. **Endergonic** reactions are those that require energy input, while **exergonic** reactions release energy.

Model 3: The ATP Cycle



9. What happens to the ATP molecule during cellular activities such as protein synthesis and muscle contraction?

10. What component of the ATP molecule is removed during these processes?

11. What molecule(s) is produced by these activities?

12. Are these endergonic or exergonic reactions?

13. Use a complete sentence to describe at least two other examples of when a cell may need to use ATP as a source of energy.

14. The reaction to convert ADP back to ATP is called *phosphorylation*.
    a. Explain why this process is called phosphorylation

    b. Which arrow in Model 3 represents phosphorylation (A or B)?

    c. What process is represented by the other arrow?

15. Is the conversion of ADP to ATP an endergonic or exergonic process? Explain your answer in a complete sentence.

16. An analogy has been made between different dollar denominations and cellular energy (see the *Why?* box at the beginning of this exercise). To continue this analogy, is the production of ATP similar to earning, spending, or saving money? Explain your answer in a complete sentence.

17. Is the hydrolysis of ATP endergonic or exergonic?

18. Would this be compared to earning, spending or saving money?

19. What might be a cellular analogy to saving money?

Extension Questions

It is estimated that more than 2 x 10^{26} molecules or >160kg of ATP is formed in the human body daily. ATP is synthesized in two ways:

- **Substrate level phosphorylation** – energy released during a reaction, such as the breakdown of sugar molecules, is used directly to synthesize ATP. A small amount of energy is generated through this process.
- **Electron Transfer (Oxidative phosphorylation)** – energy from the movement of electrons from one molecule to another, via electron carriers, is used to synthesize ATP. Most cellular ATP is synthesized by electron transfer in the mitochondria.

Dinitrophenol (DNP) is an "uncoupler," which means it interferes with the flow of electrons. Fifty years ago, DNP was given as a drug to help patients lose weight.

20. Why would taking DNP make someone lose weight?

21. Why would taking DNP be dangerous?