

Cell Energy

10

Energy within a cell exists in the form of chemical energy. A source of this chemical energy is a compound called adenosine triphosphate (ATP). ATP when changed to a compound called adenosine diphosphate (ADP) releases energy for biological work in a cell. ADP can be changed to ATP, but this reaction requires energy. During cell respiration, energy made available from the breakdown of glucose is used to change ADP to ATP.

In this investigation, you will

- use paper models to construct molecules of adenosine triphosphate (ATP) and adenosine diphosphate (ADP).
- determine similarities and differences between ATP and ADP.
- illustrate energy release when ATP is changed to ADP.
- study the ATP-ADP cycle.

Materials

tracing or typing paper
light cardboard (optional)

scissors
paste (optional)

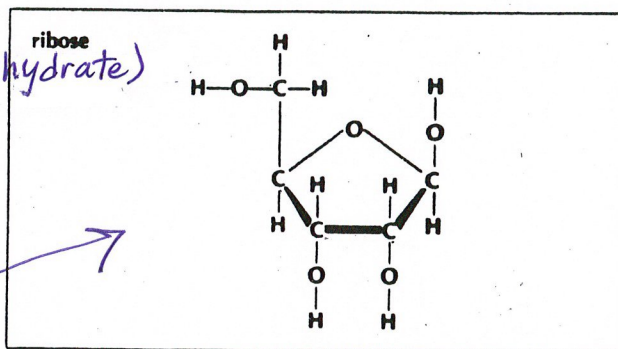
Procedure

Part A. The Chemical Structure of Adenosine Triphosphate

ATP is made up of smaller molecules or subunits—ribose, adenine, and phosphoric acid or phosphate groups.

Ribose Molecule

- Examine the structural formula of ribose.



1. What is the molecular formula of ribose? (Fill in

the appropriate subscripts.) C⁵H¹⁰O⁵

2. How does the number of hydrogen atoms compare to the number of oxygen atoms in

ribose? (double) 2x's

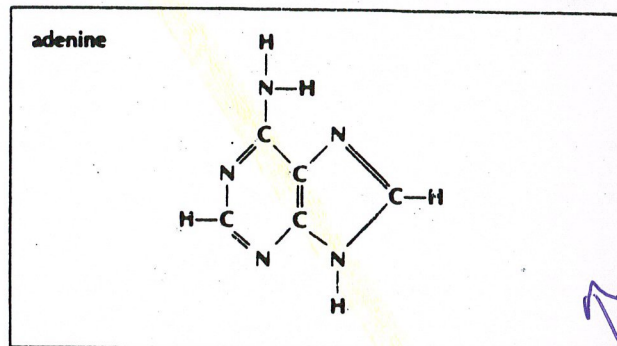
hydrogen

Ribose is a carbohydrate. It is different from glucose in one very important way. Glucose has six atoms of carbon in each molecule.

3. How many carbon atoms are in ribose? 5

Adenine Molecule

- Examine the structural formula of adenine.



4. What is the molecular formula of adenine? (Fill

in the appropriate subscripts.) C⁵H⁵N⁵

5. (a) What element is in adenine that is not in carbohydrates? Nitrogen

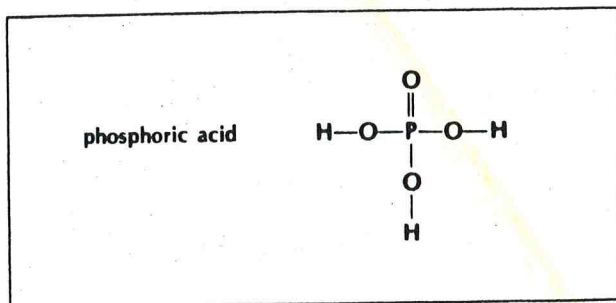
(b) What element is in carbohydrates that is not in adenine? Oxygen

- (c) What name is used to describe the H-N-H group? amine (NH₂)
- (d) Is adenine an amino acid? YES

Phosphoric Acid

- Examine the structural formula of phosphoric acid. Phosphoric acid is much like the phosphate groups in ATP.

NOTE: The letter P represents the element phosphorus.



6. What is the molecular formula of phosphoric acid? (Fill in the appropriate subscripts.)



Constructing an ATP Molecule

An ATP (adenosine triphosphate) molecule is made up of one ribose molecule, one adenine molecule, and three phosphoric acid groups joined.

7. What does the prefix tri- in triphosphate

mean? 3

8. Adenosine is a word made up of a combination of letters from two different words. Part of the word comes from ribose (the letters "os"). Where do the letters "aden" and "ine" come

from? adenine

- Trace the models in Figure 10-1 onto a separate piece of paper.

- Cut out the models of adenine, ribose, and phosphoric acid you just traced. CAUTION: Always be careful with scissors. You may want to paste the page on lightweight cardboard before cutting out the models. Cut along solid lines only.

- Attempt to join the adenine and ribose molecules much as you would pieces of a puzzle.

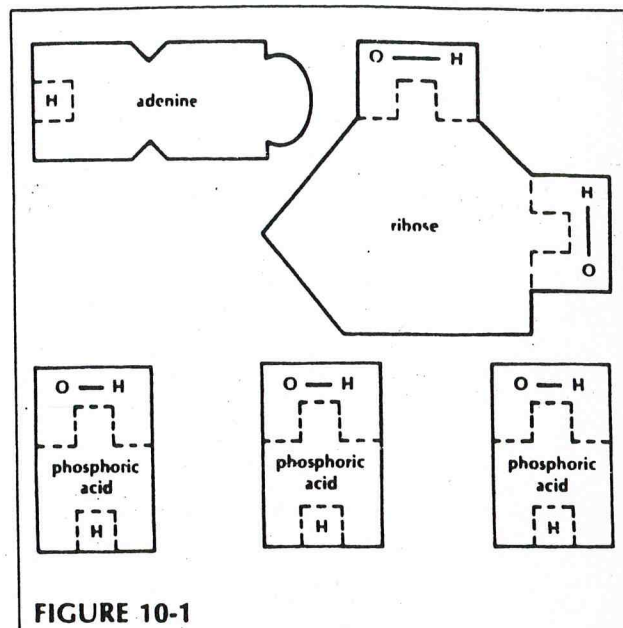


FIGURE 10-1

9. What end parts must first be removed from each molecule in order for adenine and ribose

to fit together? H + OH

- Remove these parts. The adenine and ribose molecules can now be chemically joined. New points of attachment or chemical bonds are formed.

10. What molecule is formed from the parts that are removed? water

- Examine the phosphoric acid models.

- Attach one of the three phosphates to the ribose molecule by removing an H from the phosphoric acid molecule.

- Attach the remaining phosphoric acid molecules one at a time to the phosphate group already attached to ribose.

11. What did you remove to make these connections?

H + OH ends

You have now built an ATP molecule.

12. List the five "building blocks" that are needed

to form one ATP molecule. 1 ribose, 1 adenine + 3 phosphoric acid molecules

13. What is required for the chemical combination of these parts? (HINT: See introduction.)

energy

Part B. Gaining Energy from ATP as It Changes to ADP

- Remove one phosphate group from the end of your ATP model.

14. How many phosphate groups are still attached to the original molecule? 2

15. This new compound with one fewer phosphate groups than before is called adenosine diphosphate (ADP). What does the prefix di-

mean? 2

16. List the four "building blocks" that are needed to form one ADP molecule. ribose

adenine, 2 PO₄

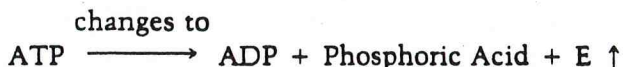
17. Explain how an ATP molecule is changed to an

ADP molecule. ATP broken down, losing PO₄, making ADP + releasing energy.

18. What is released when ATP is changed to

ADP? (HINT: See introduction.) energy

So far we have seen that ATP can be changed to ADP with energy given off. This change can be written using a type of shorthand. For example, this change may be written as follows:



19. What might the letter E in the above equation

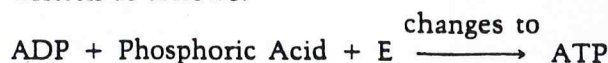
be an abbreviation for? energy

Part C. Changing ADP to ATP

ATP can be formed within living organisms if the correct raw materials are available. These raw materials are ADP, phosphoric acid, and energy. We can again use models to help show how ATP is formed.

- Construct an ADP molecule.
- Attach a phosphoric acid molecule to the ADP model. If necessary, remove any H or OH ends to provide the point of attachment. This combination forms an ATP molecule.

Energy is needed to change ADP back to ATP. Using a type of shorthand, this change can be written as follows:



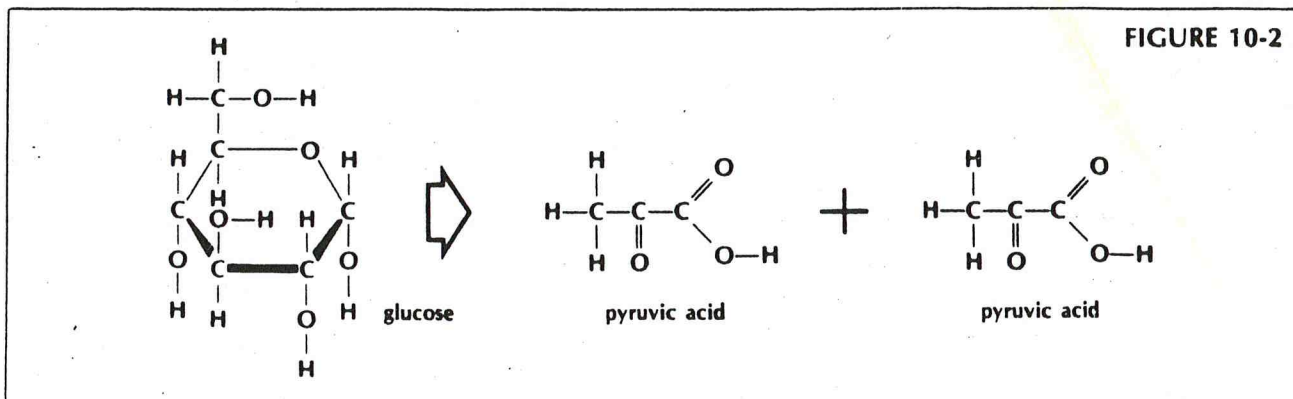
20. What might the letter E in the above equation

be an abbreviation for? energy

Part D. An Energy Source for Converting ADP to ATP

From where does the energy to form ATP from ADP come? It does not come from the energy released when ATP changes to ADP. The energy comes from a different source. Energy is "stored" in all compounds. Food such as glucose contains much energy. Glucose is the major source of energy for ATP formation. Energy is released from food during cellular respiration.

- Examine the structural formula for glucose shown in Figure 10-2. In respiration, glucose is broken down into two identical molecules of a chemical called pyruvic acid. This step is called glycolysis ("glyco-" = glucose, "-lysis" = break apart). Glycolysis is the first step in cellular respiration (Figure 10-2).



The lines which connect one atom to another represent chemical bonds. (A double line like this // represents two bonds.)

21. Count and record the number of bonds in

(a) one molecule of glucose. 24

(b) two molecules of pyruvic acid. 22

NOTE: Be sure to count double lines as two bonds.

22. Is the amount of energy in one glucose molecule the same as the energy in both

pyruvic acid molecules? no

23. How is some of this extra energy used?

energy for cells, cellular respiration.

Pyruvic acid is broken down further to yield more energy. Energy released from glucose during respiration is used in building more molecules of ATP.

Analysis

1. List the name and number of each molecule forming ATP.

1 adenine 1 ribose + 3 phosphates

2. List the name and number of each molecule forming ADP.

1 adenine + 1 ribose + 2 phosphates

3. How do ADP and ATP differ in

(a) number of phosphate groups? 2 in ADP, 3 in ATP or 1

(b) number of ribose molecules? 1 same

(c) number of adenine molecules? 1 same

(d) amount of potential chemical energy? more in ATP than ADP

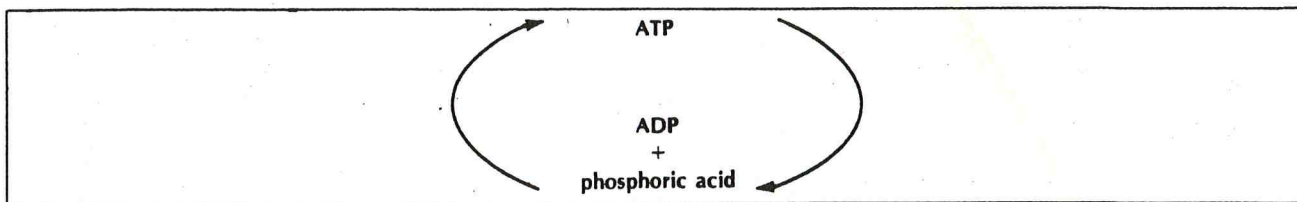
4. Your muscles require energy to move your body. What chemical directly supplies your muscles with

energy? glucose or ATP/ADP

5. What process directly supplies your body with the energy it needs to change ADP back to ATP?

cellular respiration

6. Changes from ATP to ADP and back again are often said to occur in a cycle. One change follows the other in this manner:



Energy is both given off and used for work. Energy is also supplied during cellular respiration. Complete the diagram below by writing in the words "energy given off" and "energy supplied from respiration" in the correct spaces.

