Name: _____

Date: _____ Hour: _____

Molecular Modeling of Photosynthesis and Cellular Respiration

Introduction

Photosynthesis is the process by which green plants capture energy from sunlight and use it to make food molecules like glucose. Cellular respiration is the process used by plants and most animals, to convert the energy stored in food molecules into energy of adenosine triphosphate (ATP). ATP has high- energy bonds that store energy in a form that is directly useable by plants and animals for conducting life processes such as growth, maintenance, and reproduction.

Photosynthesis and cellular respiration are the fundamental processes in the flow of energy and the cycling of matter. Energy cannot be recycled because it is used. Matter, in the forms of carbon, oxygen, and hydrogen, is continually recycled.

Photosynthesis

Photosynthesis is the process by which plants convert carbon dioxide into their food, by using the energy derived from the Sun. The essential materials for this process are sunlight, water, carbon dioxide, and chlorophyll. The leaves and stem of a plant have microscopic holes, known as stomata, through which the carbon dioxide enters the plant. While carbon dioxide is absorbed by leaves, water enters the plant through its roots. After being absorbed by the roots, water travels all the way through the stem to reach the leaves where photosynthesis takes place. Water is combined with carbon dioxide and used by the plant to produce oxygen and the energy-rich molecule, glucose. Oxygen is released into the atmosphere through the stomata. The chemical reaction for photosynthesis is: $6\ CO_2 + 6\ H_2O + \text{Light Energy} \rightarrow C_6H_{12}O_6 + 6\ O_2$

Cellular Respiration

Energy is defined as the ability to do work. The cells of both plants and animals require a continuous supply of energy for the performance of their life activities. Carbohydrates, especially glucose, generally provide this energy through the process of cellular respiration. The chemical reaction for cellular respiration is: $C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O + \text{Energy of ATP}$

In this activity, you will:

(a) learn to interpret the molecular and structural formulas of water, carbon dioxide, glucose and oxygen.

(b) construct molecular models to illustrate the processes of photosynthesis and cellular respiration.

Materials

Parts of the Model Set:

6 black atoms = carbon (C)	24 small white links = single covalent bond
12 white atoms = hydrogen (H)	24 large white links = double covalent bond
18 red atoms = oxygen (O)	1 ATP
1 diagram of plant cell	1 diagram of animal/plant cell

Part I Modeling Molecules

1. A molecule is a group of atoms held together by chemical bonds. The atoms important for photosynthesis and cellular respiration are carbon, hydrogen, and oxygen. Using the molecular models, build a single molecule of water. The molecular formula for water is H_2O.

   The structural formula for water is 

   You need: _____ hydrogen atoms

   _____ oxygen atom and

   _____ single bonds

   Draw your water molecule in the box.

2. Carbon dioxide, CO_2, has two double covalent bonds as shown in the structural formula, O = C = O.

   Build a single molecule of carbon dioxide.

   You need: _____ carbon atom

   _____ oxygen atoms

   Draw your carbon dioxide molecule.

Part II Modeling Photosynthesis

The process of photosynthesis uses light energy, water, and carbon dioxide and produces glucose and oxygen. During the process of photosynthesis, light energy is converted into energy stored in the chemical bonds of glucose molecules. Chloroplasts, found in the cells of green plants and algae, are the sites for photosynthesis.

3. Place Diagram 1 in front of you on the desktop.

   a. What is the name of the green organelles in the cell? _____

   b. What is their function? _____

4. Place the water molecule and carbon dioxide molecule you assembled on the chloroplast.

   Keep in mind, from the balanced equation, there should be six of each of these molecules.

   Our model kits do not allow for us to make this many.

a. What types of organisms have cells that contain chloroplasts? _____

b. Without the beginning materials (reactants) for photosynthesis, plants could not survive. What is needed for the plants to survive?

_____

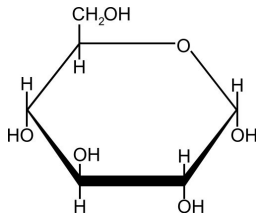
5. Complete the first column of Table 1 by counting the number of atoms in each model for the reactants in Photosynthesis. **Please account for the fact that there should be SIX of each of these Molecules.**

Table 1

Atoms	Number of Atoms in the Reactants	Number of Atoms in the Products
Black carbon atoms		
White hydrogen atoms		
Red oxygen atoms		

6. In photosynthesis light energy is converted into chemical energy in a series of reactions that produce glucose and oxygen molecules. "Break" the bonds in the carbon dioxide molecule and water molecules. Using these atoms (with additional H, C, and O's), reassemble the atoms to make one glucose molecule.

Hint: In constructing a molecule of glucose, it is best to first connect the one oxygen and five carbons atoms that form the central ring of the molecule.



To build the glucose molecule, you need:

_____ carbon atoms

_____ hydrogen atoms

_____ oxygen atoms

7. An oxygen molecule, O_2, is made of two oxygen atoms bonded together with a double bond. The structural formula for the oxygen molecule is O = O. Build one oxygen molecule. Keep in mind, the equation says you should build six.

8. Complete the second column of Table 1 above by counting the number of atom models for the products in photosynthesis. **Please account for six molecules of O_2.**

9. Which product of photosynthesis remains in the green plant for use as a building material or as a source of energy? _____

10. Which product of photosynthesis is released as a gas into the atmosphere by green plants?

_____

Part III Modeling Cellular Respiration

Both plant and animal cells contain organelles called mitochondria that are the principle sites for cellular respiration. In cellular respiration 1 glucose molecule combines with 6 oxygen molecules to produce 6 water molecules, 6 carbon dioxide molecules, and energy stored in ATP molecules.

11. Place Diagram 2 (animal/plant cell with mitochondria) in front of you.
    a. The organelle that is the principal site of cellular respiration is magnified.What is the name of this organelle? _____
    b. What types of organisms have cells with this organelle?_____

12. Place the glucose molecule and one oxygen molecule that you made during Part II Modeling Photosynthesis,
    on the diagram of the mitochondria. Without the beginning materials (reactants) for cellular respiration, plants and animals cells could not convert the energy stored in food molecules into energy of ATP and they would die. What reactants are required for cellular respiration?_____

13. Complete Column 1 of Table 2 by counting the number of atom models for the reactants in cellular respiration.

Table 2

Atoms	Number of Atoms in the Reactants	Number of Atoms in the Products
Black carbon atoms		
White hydrogen atoms		
Red oxygen atoms		

14. In cellular respiration, food molecules like glucose are converted through a series of chemical reactions into carbon dioxide, water, and chemical energy that is stored in ATP. “Break” the bonds in the glucose molecule
    and the oxygen molecule. Using only these atoms, reassemble the atoms to make a carbon dioxide and a water molecule. **Answer all questions as if you have made <u>six</u> of each of these!!**
    a. Which reactant contains the energy released during the process of cellular respiration?
    _____
    b. How many carbon dioxide molecules can you make? _____
    c. How many water molecules can you make? _____

15. Complete Column 2 of Table 2 above by counting the number of atom models for the products in cellular respiration. **Please take into account that <u>six</u> water and carbon dioxide molecules should be made.**

16. The energy released during cellular respiration is stored in the high-energy bonds of ATP. To model this,

place ATP on the mitochondria diagram. The energy stored in ATP is used to power the plant or animal's activities such as growth, repair, digestion, excretion, and movement.

Name two activities, not from the above examples, that you do which required energy stored in ATP.

_____ and _____

17. Carbon monoxide, CO, is a colorless, odorless gas that interferes with cellular respiration by significantly reducing the amount of oxygen molecules in the mitochondria. Carbon monoxide poisoning can cause brain damage and death because the process of cellular respiration is limited. When cellular respiration is limited, the organism does not make enough ATP and does not have enough _____ for its activities.
18. Which products of cellular respiration could be released into the atmosphere and used as the reactants of photosynthesis? _____ and _____
19. Are the atoms used in photosynthesis and cellular respiration recycled? Explain how the models you made illustrate your answer._____

_____

20. Is the energy obtained from sunlight during photosynthesis recycled? Explain your answer.

_____

_____

DIAGRAM 1 PLANT CELL

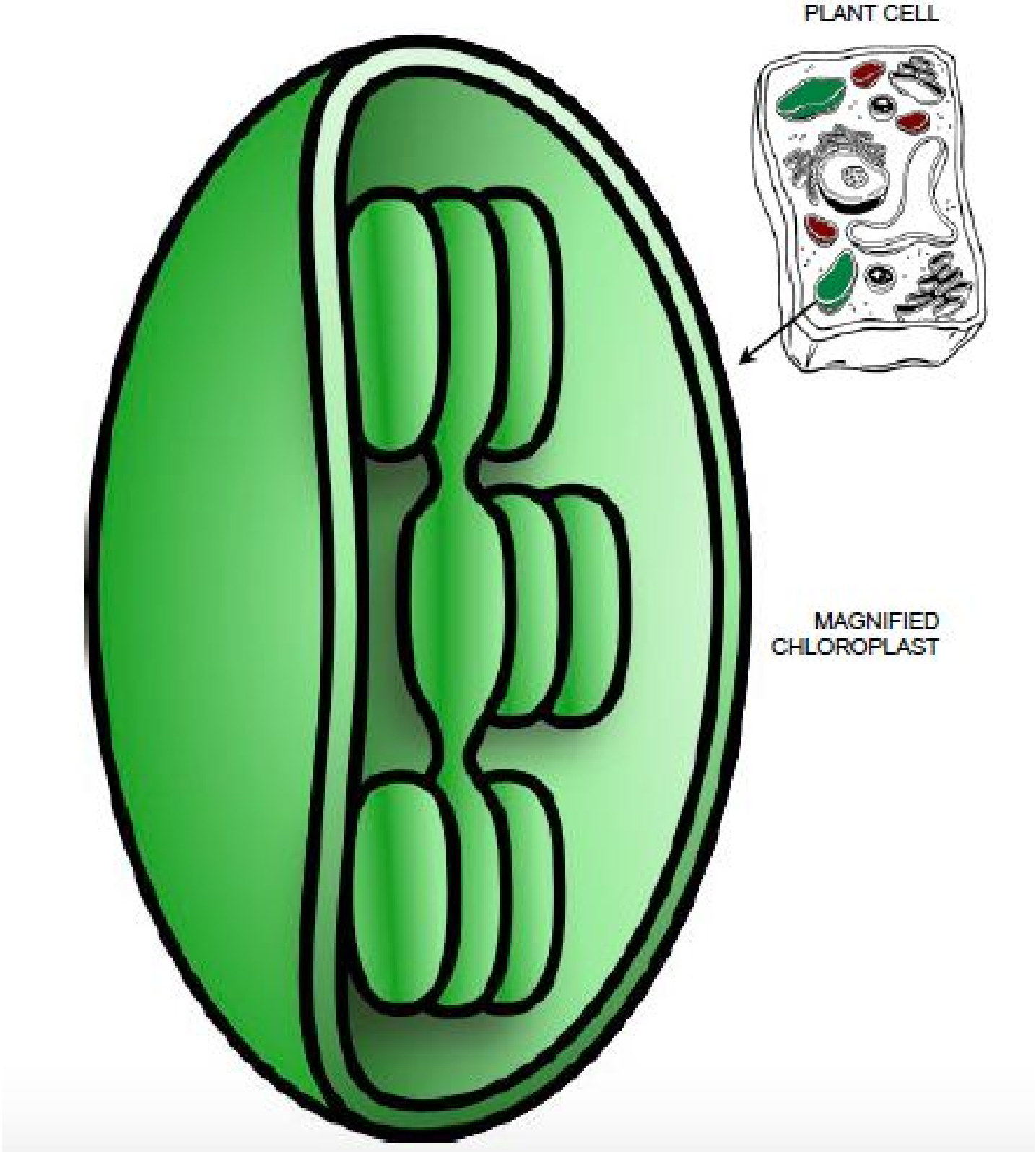
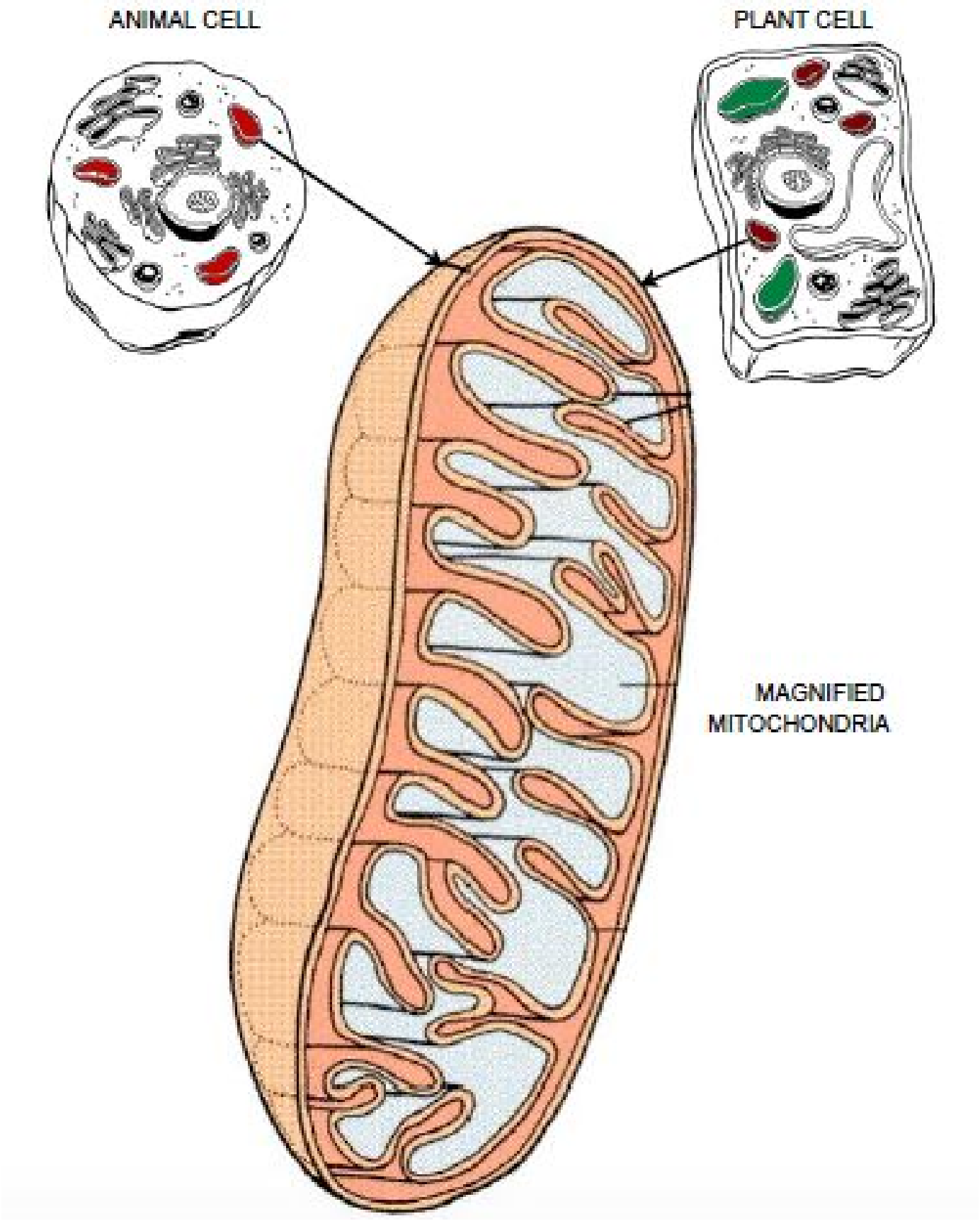
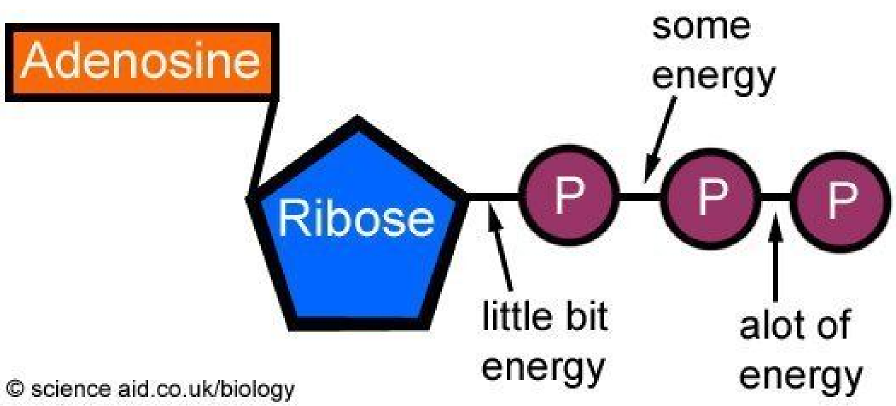


DIAGRAM 2 ANIMAL/PLANT CELL

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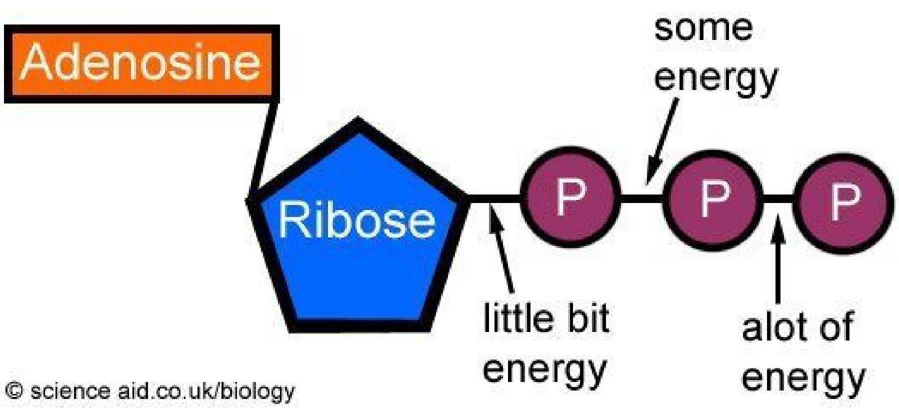
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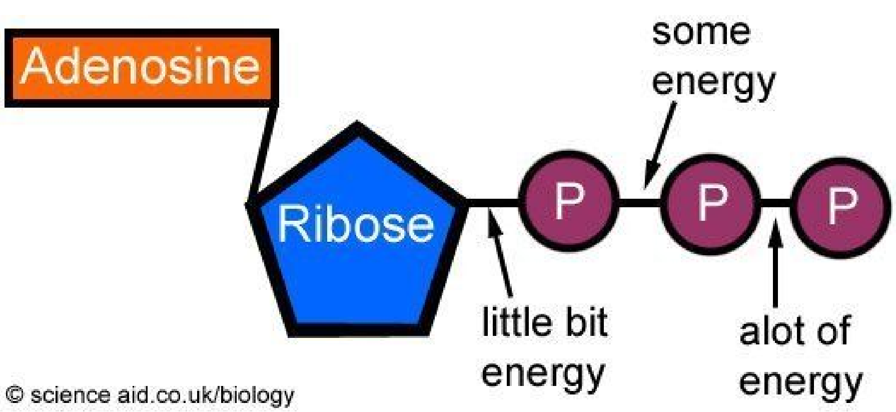
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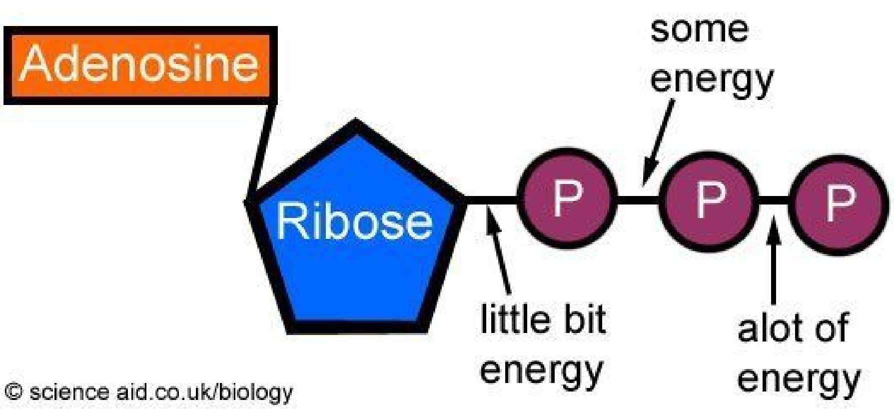
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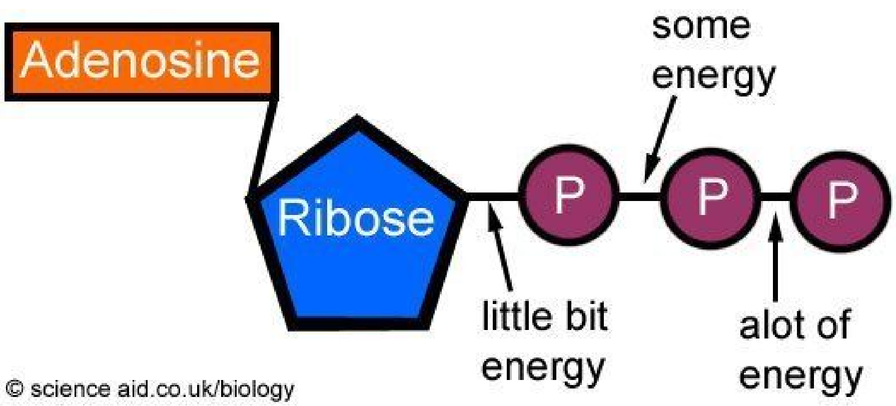
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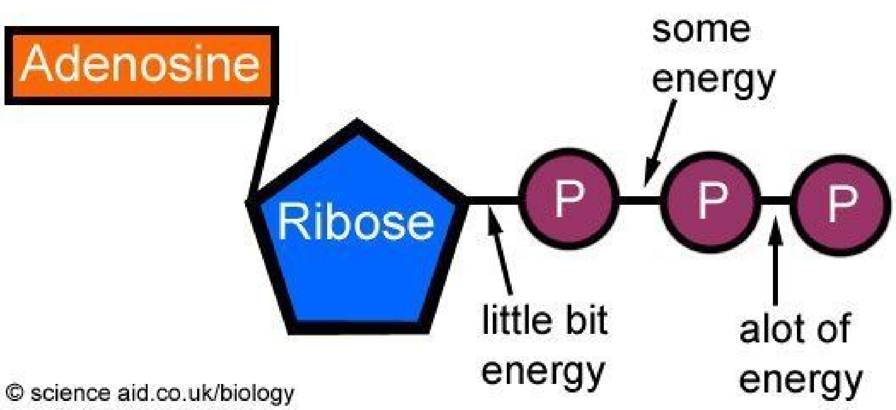
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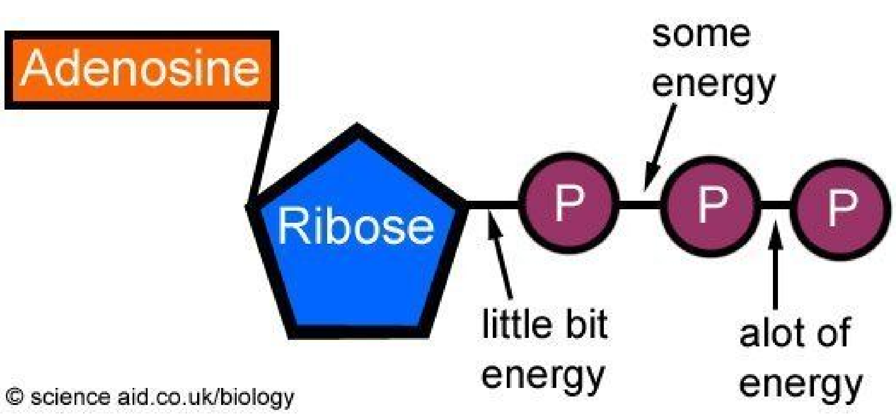
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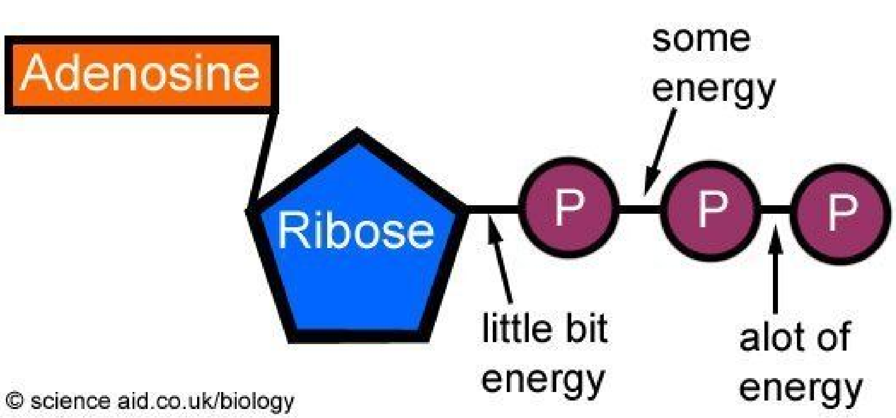
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