

Section 3.2: ATP: Energy Currency of the Cell

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1. (a) Answers may vary. Sample answer: An example of chemical work using ATP is supplying energy for non-spontaneous, endergonic reactions, including protein synthesis and DNA replication.

(b) Answers may vary. Sample answer: An example of mechanical work using ATP energy is the beating of cilia or movement of flagella, contraction of muscle fibres, or movement of chromosomes during mitosis/meiosis.

(c) Answers may vary. Sample answer: An example of transport work using ATP energy is pumping substances such as Na^+ or K^+ ions across membranes against their concentration gradient.

2. The universality of ATP as an energy source for every type of cell in every living organism supports an argument that all species have evolved from one original organism.

3. (a) ATP can be described as a phosphorylated sugar. It has a triphosphate group attached to a ribose sugar molecule, which is attached to a molecule of adenosine.

(b) The structure of an ATP molecule allows it to contain large amounts of free energy. The unique feature that allows ATP to do this is its triphosphate tail. The triphosphate tail is the location of several high energy bonds that can be recycled using the cellular machinery.

4. ATP hydrolysis is the process by which ADP and P_i are formed and water is consumed. The process releases free energy.

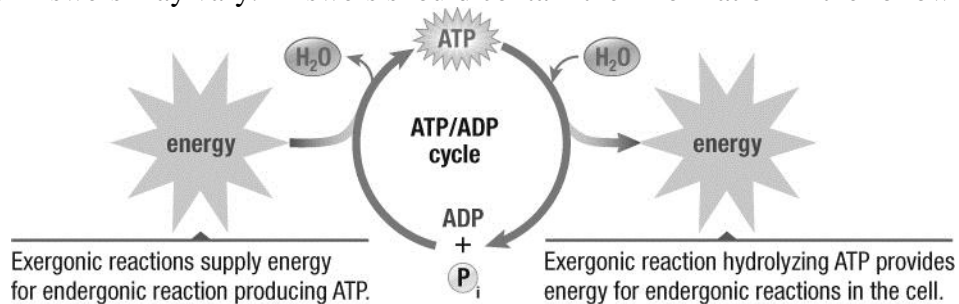
5. During the hydrolysis of ATP the ADP is retained and recycled. This is in contrast to the oxidation of glucose, in which the entire molecule is catabolized. When a cell uses glucose during cellular respiration the entire molecule is oxidized and converted into water and carbon dioxide.

6. Answers may vary. Sample answer: ATP is formed when ADP is coupled to an exergonic process, usually involving energy released from the metabolism of food. Then ATP transfers free energy to an endergonic process by phosphorylating other molecules. By doing this it becomes ADP again and is available to begin a new cycle.

7. The first group (glutamic acid, NH_3 and ATP) has more free energy than the second group (glutamine, ADP, and P_i). This because group 2 is only formed when group 1 is catabolized, therefore group 2 must have less overall free energy. This can be confirmed as follows: When the molecules in group 1 react, producing the molecules in group 2, the process is exergonic.

8. There is very little ATP in the diet and it is a relatively large and energy-rich molecule. It would be extremely wasteful and inefficient to use an “entire ATP” and discard it just to obtain the energy released by a single hydrolysis reaction.

9. Answers may vary. Answers should contain the information in the following diagram.



10. The phosphorylation reaction is the addition of an inorganic phosphate group to a molecule resulting in the formation of a high-energy bond.

11. (a) Reactions ii and iii are spontaneous.

(b) Combinations of i & iii, ii & iv, and iii & iv would be spontaneous.

12. The use of ATP as an energy source allows for large amounts of energy to be transferred and recycled without the production of waste gases or molecules. It does not require the complete catabolism of the molecule. The use of ATP also allows energy to be stored and released relatively easily unlike the metabolism of other macromolecules that require very intricate pathways to capture their energy, thus resulting in longer lag times from when the energy is required to when it is available.

13. Answers may vary. Answers should include the following: Fireflies combine ATP with luciferin to form luciferyl adenylate and inorganic pyrophosphate. The luciferyl adenylate then combines with oxygen to form oxyluciferin and adenosine monophosphate (AMP), which releases light energy. The reaction is catalyzed by the enzyme luciferase and is between 80 and 90 % efficient.