

Activity 3.2.6: In Search of Energy

Introduction

Lost in the desert, Mauro Prosperi searched for the energy to survive. Food was scarce, but he knew if he did not find something to nourish his cells, his body would give out. Food is our primary cellular fuel, and the macromolecules we ingest are the raw material needed to create the body’s energy currency, the amazing molecule, adenosine triphosphate (ATP). ATP is to cells what gasoline is to your car. This molecule provides the usable energy needed to carry out all body processes. One of the most amazing things about the body is its ability to create, store and recycle ATP. It is one of the most efficiently used compounds in nature. Your body breaks down the food you eat and stores the energy released in a form that can be utilized by the cells to do work.

Some people might think recycling is a relatively new concept. In actuality, cells have been recycling substances since the beginning of time. ATP is one of those recycled substances. As you might imagine, creating all the ATP you need from scratch is not very efficient. The body needs a quick and easily accessible source of ATP all the time. In fact, 10 million molecules of ATP are used and regenerated per second per cell! Now that’s a lot of energy. So how does food provide us with ATP and what does it really mean when we say this molecule is recycled? In this activity, you will explore the structure of ATP and delve deeper into how this powerful molecule functions in our cells.

Equipment

* Computer with Internet access
* *CellZone* Molecular Puzzles kit
* Colored markers or pencils

Procedure

1. Use the Internet to research the structure and function of the molecule ATP and complete the exercises below. The following websites may be helpful, but you may search the Internet for additional reliable resources.
* Dr. Leif Saul’s Biology in Motion (try the animations) <http://biologyinmotion.com/atp/index.html>
* Bristol University - ATP: Molecule of the Month <http://www.bristol.ac.uk/Depts/Chemistry/MOTM/atp/atp.htm>
* ATP – Adenosine Triphosphate <http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/A/ATP.html>
* Adenosine Triphosphate <http://hyperphysics.phy-astr.gsu.edu/hbase/biology/atp.html>
1. With your partner, use information you find to complete the tasks and answer the questions described below. Think about how the structure of ATP is related to its ability to supply energy.
2. Note that ATP is a nucleic acid. Think about what you know about the structure of nucleic acids such as DNA. Remember that the basic structure of each nucleotide consists of a nitrogenous base, a sugar and a phosphate group. The building block of ATP takes this same structure. List the sugar and the base found in molecules of ATP in the space below.

Sugar\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Base \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Draw a diagram of the ATP molecule. Each of the three components of the molecule should be a different color and each part should be clearly labeled.
2. Where is the energy located in the ATP molecule? Indicate on your drawing in Step 4 where the energy is being stored.
3. Review the equation for the breakdown of ATP and the release of energy shown below.

ATP + H2O 🡪 ADP + Pi + energy

1. What do we call the type of chemical reaction that occurs in #6? Explain how the name of this type of reaction relates to a key resource other than food.
2. What is ADP and how is it generated?
3. We have said before that ATP is recycled. What do you think is the simple equation for reforming ATP?
4. Name the process human cells use to generate more ATP. Where in the cell does this process occur?
5. The general chemical equation for the ATP generating process in cells is listed below. If necessary, research the identity of each item. Write the common name underneath each reactant (what goes in to the reaction?) and product (what comes out of the reaction?).

C6H12O6 + 6O2 🡪 6CO2 + 6H2O + ATP

1. The process of cellular respiration shown in #11 produces ATP by rejoining a phosphate group with the ADP molecule. Where do you get the C6H12O6 and O2 that is required for this process?
2. What happens to the CO2 that is produced in the reaction?
3. Which types of cells in the body would you expect to require the most ATP? Support your answers with evidence.
4. Obtain a bag of molecular puzzle pieces from your teacher or move to the designated building area. Remember the following when working with the puzzles.
* Oxygen and hydrogen atoms can bond with anything they fit with. Remember that each snap represents a covalent bond.
* A molecule is stable (complete) only if it has no available pegs or slots.
1. Use the pieces to assemble a molecule of ATP. Refer to your drawing in step #4.
2. Assemble a molecule of water. Use your molecule puzzles to complete a hydrolysis reaction and to convert ATP to ADP, releasing energy. Demonstrate this process to your teacher.
3. Use your puzzle pieces to show how ATP is reformed. Demonstrate this process to your teacher.
4. Read the article “Lighting up the Heart” found at <http://www.bristol.ac.uk/news/2006/5067.html> and answer the following:
* How has a process in nature been used as a medical intervention?
* What does the level of ATP tell scientists about the functioning of the heart?
* What are potential applications of this research? How can this type of test help patients?

Conclusion

1. Based on what you learned in PBS, what are three foods that would be considered good energy sources? Explain your choices.
2. Name three specific body processes that require energy in the form of ATP.

1. You hear someone mention the molecule “AMP.” Based on what you learned about the structure of ATP and the way in which energy is released, what do you think AMP stands for and how do you think it would be created?
2. Explain how the recycling of ATP helped save Mauro Prosperi. Why is the ability to recycle this molecule an advantage?
3. Based on what you have read in this activity, explain the role food, water and oxygen play in the creation of ATP or the release of energy from this molecule.