How do organisms use energy?¹

1a. Why does your body need energy?

1b. What do your cells use energy for?

2. Why do you need to eat?

Digestion of your food produces glucose and other small organic molecules which travel in your blood to all the cells in your body. Your cells use these molecules for cellular respiration, a process that makes ATP. Then, your cells use ATP to provide the energy for many biological processes.

Making ATP
In cellular respiration, glucose or another small organic molecule is one input for chemical reactions that provide the energy to make ATP from ADP plus a phosphate (P).

Using ATP
The energy for many different cellular processes is provided by the reaction of ATP and water to form ADP plus a phosphate. This reaction is called the hydrolysis of ATP.

3. Give one reason why energy input is needed to combine ADP and P to make ATP. (Hint: Notice the charges of the molecules in the top figure.)

¹ By Dr. Ingrid Waldron, Univ Pennsylvania, © 2018, but freely available for classroom use. A Word file, Teacher Notes with instructional suggestions, background information, and alignment with NGSS are available at http://serendipstudio.org/exchange/bioactivities/energy.
4a. Inside each cell, there is a constant cycle of synthesis and breakdown of ATP. Add to this diagram to show:
   - how cellular respiration contributes to the production of ATP
   - how the hydrolysis of ATP to form ADP + P is useful.

4b. Why does a cell need to constantly break down and synthesize ATP?

Cellular Respiration to Make ATP
These chemical equations summarize the multiple steps of cellular respiration. The curved arrows indicate that the two chemical equations represent coupled reactions. This means that the reaction of glucose and oxygen to make carbon dioxide and water provides the energy to combine ADP and P to make ATP.

5. Write the names of each of the molecules in the top chemical equation.

6. How do the cells in your body get glucose for cellular respiration?

7. Why do we need to breathe all day and all night?

8a. If you search for "cellular respiration equation" on the web, some of the most popular sites give the following chemical equation for cellular respiration of glucose.

   \[ C_6H_{12}O_6 + 6 \text{ O}_2 \rightarrow 6 \text{ CO}_2 + 6 \text{ H}_2\text{O} + \text{ATP} \]

What is wrong with this chemical equation? (Hint: Think about where the atoms in an ATP molecule come from.)

8b. Write a corrected version of this chemical equation that gives a more accurate summary of cellular respiration. (Hint: This corrected chemical equation should combine the two coupled reactions shown in the middle of this page.)
Using ATP to Provide Energy for Biological Processes

The hydrolysis of ATP provides the energy for many biological processes. For example, these coupled reactions summarize how hydrolysis of ATP provides the energy for a muscle protein to change shape and contract the muscle a tiny bit. Many repeats of this process result in muscle contraction.

9a. Explain why the top reaction is called the hydrolysis of ATP. (Hint: Hydro means water and olysis means breaking down or separating.)

9b. What do the curved arrows represent?

10a. The reaction, \( \text{ATP} + \text{H}_2\text{O} \rightarrow \text{ADP} + \text{P} \) occurs in all the cells in your body____ only in muscle cells ___

10b. What reasoning supports your answer?

Two important general principles about energy are:

- Energy can **not** be created or destroyed by biological processes.
- Heat is produced whenever energy is transformed from one type to another (e.g. chemical energy is transformed to the kinetic energy of muscle contraction.) For example, the energy for muscle contraction is provided by the hydrolysis of ATP, but only about 20-25% of the energy from this chemical reaction is captured in the kinetic energy of muscle contraction. The rest of the energy is converted to heat.

11. Cellular respiration takes place primarily in organelles called mitochondria. Some textbooks claim that "Mitochondria make the energy needed for biological processes." Explain what is wrong with this sentence and give a more accurate sentence.

12. Explain why your body gets warmer when you are physically active.