4.2: How do Plants Get the Energy They Need to Move and Function? Reading

***Purpose for Reading**: As you read this text, work to make sense of how plant systems move matter and energy into, around, and out of a plant so that plants are able to move and function.*

Zooming into Plant Functions and Movement

Scientists work to explain things we can observe—like plants moving—by "zooming in" to the smaller systems that plants are made of—cells and the molecules that make up cells. Let's zoom into a plant to figure out how it moves.

Macroscopic scale: We observe plants moving at the macroscopic scale. Different plants can shift, tilt towards the light, or curl around surrounding objects. Plants also move materials around inside their bodies and carry out chemical processes that require energy. What is happening inside the plants at the microscopic and atomic-molecular scales to allow that movement to happen?

Cellular scale: Plants are made of cells that can change in size. Plant cells can grow or shrink in size in response to environmental or chemical signals. Plants move when a group of cells change in size by either absorbing water or by physically gaining mass. For example, if a plant causes the cells on the shady side of the stem to grow in size, it will cause the plant to lean towards the light.

Atomic-molecular scale: All of the plant's cells need energy to do their work. The cells all rely on the same process to get their energy: cellular respiration, a process that releases energy by combining glucose (or other small organic molecules) with oxygen.

Using Four Steps to Explain Cellular Respiration

We can explain cellular respiration—and how plants get energy to move—by answering the four numbered questions on the Three Questions handout:

1. How do molecules move to the location of the chemical change?

Cells need two kinds of molecules—glucose and oxygen—for cellular respiration. Here's how they get each.

Glucose In: All plants need a way to move glucose containing important matter and energy from the leaves (where glucose is produced) to every cell in the plant. Glucose is carried in the phloem to cells all over the plant.

Oxygen In: You had another kind of molecule on the reactant side of your chemical change placemat—oxygen. How did those six oxygen molecules get to the cell? The oxygen molecules in a plant are either absorbed from the surrounding air or produced by the plant during photosynthesis.

Remember, all plant cells need oxygen to carry out cellular respiration.

2. How are atoms in molecules being rearranged into different molecules?

Once the glucose and oxygen arrive in the cell they can go through a chemical reaction. Glucose reacts with oxygen to produce carbon dioxide and water. Here's the chemical equation for this reaction:

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6\ CO_2 + 6\ H_2O$$

3. What is happening to energy?

Cells transform the chemical energy in the glucose molecules into energy for cell functions, motion energy, and heat. Because of cellular respiration, plant cells have access to the energy necessary to swell or shrink in response to a signal from the environment. Every cell has a function; cellular respiration makes it possible for each cell to do its specific work.

4. How do molecules move away from the location of the chemical change?

Carbon Dioxide and Water Out: During cellular respiration, energy is released in the cell to enable the work of the cell to occur but what happens to the other products? The atoms found in glucose are rearranged into carbon dioxide and water, and are no longer needed by the cell so they are considered waste products. Cells have to get rid of unwanted waste products. Carbon dioxide and water are either used in photosynthesis to produce more glucose or are released into the atmosphere.

Plant movement we observe at the macroscopic scale is possible because cellular respiration is happening at the atomic-molecular scale.

Seeing Red and Feeling Blue

Because plants lack a central nervous system, they must rely on environmental and chemical signals to trigger movement. One of the most important environmental signals for a plant is light. Sunlight is made of red, blue, and green wavelengths of light, but only the red and blue wavelengths are absorbed by light receptor proteins in plant cells. The green light is reflected back (which is why plants generally look green).

Blue light receptors are what are responsible for most plant movement, such as when a plant bends towards the light. Red light receptors control plant responses such as germination and flowering. If you were to shine only a red light on a plant, it would not bend towards the light because the blue light receptors would not trigger the cells on the shady side to grow larger. Conversely, if you were to shine only a blue light on a plant, it would bend toward the light but it would be less likely to flower or germinate. For this reason, most high-efficiency LED grow lights in commercial greenhouses only use red and blue lights for plant growth. As a result, modern greenhouses often look purple when they are lit up at night.