Powering a Tomato

Trace how a plant stores energy and uses it for cellular work.

BIO.2 "Students will explain that cells transform energy through the processes of photosynthesis and cellular respiration to drive cellular functions..."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline the substances entering each equation and circle the substances leaving it. Number the sentences beginning "When a transport protein" and "The cell can then" to show the order of the ATP cycle.

From Sunlight to Growing Roots

1. On a sunny afternoon, a tomato leaf takes in carbon dioxide from the air and water from its roots. Chloroplasts capture light energy and use it to rearrange atoms: $6CO_2 + 6H_2O$ + light energy → $C_6H_{12}O_6 + 6O_2$. The sugar glucose stores some of the captured energy in its chemical structure. Making glucose requires breaking old bonds, which takes energy, and forming new bonds. The light-driven process stores energy overall. Oxygen leaves the leaf, while glucose can travel to cells that need fuel, including cells in the tomato plant's growing roots.

2. At night, a growing tomato root still needs energy to move minerals into its cells. With steps in the cytosol and mitochondria, aerobic cellular respiration rearranges atoms: $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ + energy. Breaking bonds in glucose and oxygen requires energy; forming bonds in the products releases energy. Overall, this process makes energy available to build ATP from ADP and phosphate. When a transport protein moves a mineral ion, ATP transfers energy and becomes ADP and phosphate again. The cell can then use energy from respiration to rebuild ATP.

3. If a root sits in flooded soil, oxygen may run low. The root can make a small amount of ATP by glycolysis, which splits glucose, and then use alcoholic fermentation to keep glycolysis running. Yeast in rising bread dough can do the same: glucose becomes ethanol and carbon dioxide, while glycolysis supplies ATP. In a sprinting person's muscle, low oxygen can lead to lactic acid fermentation instead; this makes lactate, not ethanol. Fermentation does not provide the large ATP yield of aerobic respiration. In both cases, ATP can still power cell activities, but the fuel yields less usable energy per glucose.

2 ANSWER WITH EVIDENCE

Use the passage

1. Use the first equation to explain how a tomato leaf stores light energy and rearranges atoms.

2. During aerobic respiration, what happens to energy when old bonds are broken and new bonds form? How does the cell use the energy made available overall?

3. Trace the ATP and ADP cycle as a root cell moves a mineral ion.

4. Compare what a tomato root can do with glucose when oxygen is available and when flooded soil limits oxygen.

3 YOUR TURN

Your own words

Imagine a tomato seedling moves from sunlight and well-drained soil into darkness and flooded soil. Write a short model predicting what happens to its glucose supply and ATP production, using both balanced equations, the ATP to ADP to ATP cycle, and one product of fermentation.

Powering a Tomato

PART 1 · READ AND MARK

Underline the substances entering each equation and circle the substances leaving it. Number the sentences beginning "When a transport protein" and "The cell can then" to show the order of the ATP cycle. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	Use the first equation to explain how a tomato leaf stores light energy and rearranges atoms.	**Light energy helps rearrange carbon dioxide and water into glucose and oxygen. Some captured energy is stored in glucose.**
2	During aerobic respiration, what happens to energy when old bonds are broken and new bonds form? How does the cell use the energy made available overall?	**Breaking bonds requires energy, while forming bonds releases energy. The process makes energy available to build ATP from ADP and phosphate.**
3	Trace the ATP and ADP cycle as a root cell moves a mineral ion.	**ATP transfers energy to the transport protein and becomes ADP and phosphate. Energy from respiration rebuilds ATP from ADP and phosphate.**
4	Compare what a tomato root can do with glucose when oxygen is available and when flooded soil limits oxygen.	**With oxygen, the root uses aerobic respiration to produce carbon dioxide, water, and energy for a larger ATP yield. With little oxygen, glycolysis and alcoholic fermentation allow a smaller ATP yield; ethanol and carbon dioxide are produced.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

In light, $6CO_2 + 6H_2O$ + light energy → $C_6H_{12}O_6 + 6O_2$. In darkness, photosynthesis stops, so the seedling uses stored glucose without replacing it through photosynthesis. With oxygen, $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ + energy. Flooding limits oxygen at the roots. Glycolysis and alcoholic fermentation can continue, producing ethanol, but they yield much less ATP per glucose than aerobic respiration. ATP transfers energy to a mineral transport protein and becomes ADP and phosphate. Energy from glucose breakdown can rebuild ATP from ADP and phosphate.

Accept equivalent descriptions of the balanced reactions and ATP cycle. Students should distinguish ATP supplied by glycolysis from the fermentation step that keeps glycolysis running.