Fuel to ATP

Trace matter and energy through two respiration routes

BIO.5.c "Use models of the reactants and products of cellular respiration (both aerobic and anaerobic) to illustrate how chemical energy is stored in the bonds of carbohydrates and lipids and converted to ATP and heat when the bonds are broken."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Circle the fuel in each arrow model and underline its ATP and heat products. Write A beside each model that uses oxygen and N beside the model that does not, so you can compare the routes.

What Powers a Run?

1. When a runner begins moving, muscle cells need ATP to power contraction. Cells can transfer chemical energy from glucose, a carbohydrate, to ATP. A simplified aerobic model is glucose + oxygen + ADP + phosphate → carbon dioxide + water + ATP + heat. Oxygen enters as a reactant, while carbon dioxide and water leave as products. ATP forms when phosphate joins ADP, and heat spreads to the surroundings. This route produces much more than two ATP per glucose. The arrow tracks changes in matter and energy, not the creation of energy. The model leaves out many steps inside the cell.

2. During a longer run, a cell may use a fatty acid from a lipid as fuel. Its simplified aerobic model is fatty acid + oxygen + ADP + phosphate → carbon dioxide + water + ATP + heat. Like glucose, the fatty acid contains chemical energy. Breaking fuel bonds takes energy, but forming new bonds in the products releases more energy overall. Some of that available energy helps make ATP from ADP and phosphate, and some becomes heat. The fatty acid model and the glucose model have different fuels, but both require oxygen and produce carbon dioxide and water.

3. During a hard sprint, a muscle cell may need ATP faster than oxygen can be supplied. It can use an oxygen-free route that includes glycolysis and lactate fermentation. A simplified net model is glucose + 2 ADP + 2 phosphate → 2 lactate + 2 ATP + heat. This route gives a net gain of two ATP per glucose, far fewer than the aerobic glucose route. Its carbon ends up in lactate rather than carbon dioxide. Lactate still contains chemical energy, so this route does not transfer as much of the glucose's energy to ATP and heat.

2 ANSWER WITH EVIDENCE

Use the passage

1. In the aerobic glucose model, identify the fuel and the products. Which products show where some of the fuel's chemical energy goes?

2. Compare the two aerobic models. What changes about the fuel, and which reactant and products do the models share?

3. Use the numbers in the oxygen-free model to explain the net ATP gain from one glucose. Where does the glucose's carbon end up?

4. A student says the arrows show energy being created. Use the models to correct that claim.

3 YOUR TURN

Your own words

A cyclist rides steadily, then sprints when oxygen cannot be supplied fast enough. Write a labeled arrow model for using a lipid-derived fatty acid during the steady ride and another for using glucose during the sprint. Add two sentences explaining where the fuels' chemical energy goes and why the fuel changes.

Fuel to ATP

PART 1 · READ AND MARK

Circle the fuel in each arrow model and underline its ATP and heat products. Write A beside each model that uses oxygen and N beside the model that does not, so you can compare the routes. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	In the aerobic glucose model, identify the fuel and the products. Which products show where some of the fuel's chemical energy goes?	**Glucose is the fuel. Carbon dioxide, water, ATP, and heat are shown as products; ATP and heat show where some of the fuel's energy goes.**
2	Compare the two aerobic models. What changes about the fuel, and which reactant and products do the models share?	**One uses glucose and the other a fatty acid. Both use oxygen and produce carbon dioxide, water, ATP, and heat.**
3	Use the numbers in the oxygen-free model to explain the net ATP gain from one glucose. Where does the glucose's carbon end up?	**One glucose leads to a net gain of two ATP. Its carbon ends up in two lactate molecules.**
4	A student says the arrows show energy being created. Use the models to correct that claim.	**The fuels already contain chemical energy. The routes transfer some of that energy to ATP and release some as heat; they do not create energy.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

Steady ride, aerobic: fatty acid + oxygen + ADP + phosphate → carbon dioxide + water + ATP + heat.
Sprint, oxygen-free: glucose + 2 ADP + 2 phosphate → 2 lactate + 2 ATP + heat.
In both routes, some chemical energy from the fuel is transferred to ATP, and some becomes heat. When oxygen supply cannot keep up, the cyclist's muscle cells can make ATP from glucose through the oxygen-free route rather than using a fatty acid in the aerobic route.

Accept equivalent arrow models that identify the correct fuels, oxygen requirement, carbon products, ATP, and heat. The oxygen-free model must show a net gain of two ATP per glucose.