Fuel for the Climb

Model how muscle cells turn food energy into ATP.

BIO.2.3 "Develop models of the major reactants and products of cellular respiration (aerobic and anaerobic) to demonstrate the transformation of the chemical energy stored in food to the available energy of ATP..."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline the reactants and circle the products named in each overall route, then write "ATP" beside each step that makes ATP to trace where the energy goes.

Two Routes for Muscle Fuel

1. During a long bike climb, muscle cells need a steady supply of ATP, the molecule that powers contraction. Glucose from food holds chemical energy in its bonds, but cells cannot use that stored energy directly for most work. They transfer some of it into ATP by joining ADP to a phosphate group. Both routes of cellular respiration begin in the cytoplasm with glycolysis: one six-carbon glucose molecule becomes two three-carbon pyruvate molecules. Glycolysis makes a net gain of two ATP and transfers high-energy electrons to NAD^+, forming NADH. What happens next depends partly on how much oxygen reaches the cells.

2. When oxygen is available, pyruvate enters mitochondria. Its carbon atoms leave as carbon dioxide, while electrons from NADH move through an electron transport chain. Oxygen accepts electrons at the end of that chain and helps form water. The energy released by these linked reactions drives the joining of ADP and phosphate to make much more ATP. In a simplified overall model, glucose, oxygen, ADP, and phosphate enter; carbon dioxide, water, and roughly 30 to 32 ATP per glucose leave. Glycolysis provides two of those ATP. The carbon dioxide carries the carbon from glucose, while oxygen helps complete the energy-releasing transfer of electrons.

3. If oxygen delivery cannot keep pace with a sudden burst of effort, muscle cells can keep glycolysis running by converting pyruvate to lactate. This fermentation step uses NADH to restore NAD^+, which glycolysis needs. No additional ATP comes from turning pyruvate into lactate; the route yields only the two ATP made during glycolysis per glucose. In an overall model, glucose, ADP, and phosphate enter, while lactate and ATP leave. Breaking chemical bonds requires energy, but forming new bonds releases energy; across the entire process, more energy is released than used. Some released energy is captured when ATP forms, and the rest escapes as heat.

2 ANSWER WITH EVIDENCE

Use the passage

1. Build an arrow model of the oxygen-using route. Show what enters, what leaves, and the approximate ATP yield per glucose.

2. Build an arrow model of the lactate route when oxygen delivery cannot keep up. Show what enters, what leaves, and the ATP yield per glucose.

3. In the lactate route, why must pyruvate become lactate even though that step makes no ATP? Link your answer to the step that does make ATP.

4. Why is it inaccurate to say that breaking glucose bonds alone releases the energy stored in ATP? Describe both bond changes.

3 YOUR TURN

Your own words

A runner changes from a steady jog to a hard sprint. In the box, draw two labeled arrow models: one emphasizing the oxygen-using route and one showing how the lactate route supports ATP production when oxygen delivery cannot keep up. Include reactants, carbon products, water where it forms, ATP yields, and one sentence explaining how bond changes transfer energy to ATP.

Fuel for the Climb

PART 1 · READ AND MARK

Underline the reactants and circle the products named in each overall route, then write "ATP" beside each step that makes ATP to trace where the energy goes. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	Build an arrow model of the oxygen-using route. Show what enters, what leaves, and the approximate ATP yield per glucose.	**Glucose + oxygen + ADP + phosphate → carbon dioxide + water + about 30 to 32 ATP.**
2	Build an arrow model of the lactate route when oxygen delivery cannot keep up. Show what enters, what leaves, and the ATP yield per glucose.	**Glucose + ADP + phosphate → lactate + 2 ATP.**
3	In the lactate route, why must pyruvate become lactate even though that step makes no ATP? Link your answer to the step that does make ATP.	**Converting pyruvate to lactate restores NAD^+, which lets glycolysis continue making two ATP per glucose.**
4	Why is it inaccurate to say that breaking glucose bonds alone releases the energy stored in ATP? Describe both bond changes.	**Breaking bonds requires energy. Forming new bonds releases more energy across the process, and some of the net release is captured when ADP joins phosphate to form ATP.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

Steady jog, oxygen-using route: glucose + oxygen + ADP + phosphate → carbon dioxide + water + about 30 to 32 ATP per glucose. Hard sprint, lactate route: glucose + ADP + phosphate → lactate + 2 ATP per glucose; pyruvate → lactate restores NAD^+ for glycolysis. Breaking bonds costs energy, but forming new bonds releases more, and some of the net energy is captured in ATP.

Accept word labels or correct chemical formulas in arrow models. The sprint model may also show the oxygen-using route continuing alongside lactate production.