

Slow Fire: How Scientists Learned That Living Things Burn Their Food

Learning target: I can explain, with evidence from a passage, how cellular respiration resembles burning, where in the cell most of it happens, and why plants carry it out too.

Reading with evidence

About 35 min

Individual

MS-LS1-7 · supports

reading

writing

Name _____

Date _____

Period _____

Directions

Read the passage once all the way through. Read it a second time with a pencil: number the paragraphs 1 to 6 and underline every date, name and number. Then answer the questions in complete sentences. When a question asks for evidence, quote or closely paraphrase the passage and give the paragraph number.

You will need: This worksheet, Pencil

Slow Fire

[1] Hold your hand a safe distance from a candle flame and you feel warmth. Watch for an hour and the candle is shorter. The wax has not vanished. It has reacted with oxygen from the air and left as two invisible gases, carbon dioxide and water vapor. A burning candle is a chemical reaction: a fuel and oxygen go in, new molecules come out, and energy leaves as heat and light. People long suspected that a living body's warmth came from a fire inside it, but nobody could test the idea until chemists learned to measure gases and heat.

[2] The test came in the winter of 1782 to 1783, in Paris. The chemist Antoine Lavoisier and the mathematician Pierre-Simon Laplace built an ice calorimeter: a chamber surrounded by a jacket packed with ice. Anything warm inside melted some ice, and the water that dripped out could be weighed to measure the heat. They kept a guinea pig in the chamber for about ten hours and collected the melted ice and the carbon dioxide it breathed out. Then they burned charcoal until it had produced the same amount of carbon dioxide, and measured the heat from that. The two amounts of heat were close. Lavoisier concluded that breathing animals carry out a slow form of combustion, a burning without flame.

[3] Why no flame? In a candle, the reaction runs fast and hot in one place. In a living thing, the same overall change, food plus oxygen becoming carbon dioxide and water, happens in many small steps at body temperature, inside cells. Energy is released a little at a time. The cell captures part of it to power its work, such as building new molecules or moving, and the rest spreads out as heat, which is why a guinea pig, a person and even a pile of sprouting seeds feel warm. One detail matters for later classes: the reaction releases energy because the molecules it forms, carbon dioxide and water, hold less chemical energy than the sugar and oxygen that went in. Energy is not created in the cell; it is converted from one form to another.

[4] Where inside the cell does this happen? In 1890 the German scientist Richard Altmann described tiny grains in stained cells and guessed they were important to the cell's life. In 1898 another German scientist, Carl Benda, named them mitochondria, from Greek words meaning thread and grain. During the twentieth century, researchers showed that most of the steps of cellular respiration take place inside these structures. Mitochondria are found in plant cells, animal cells and many single-celled organisms such as amoebas. Not every cell has them: your mature red blood cells do not. A heart muscle cell, which contracts every second of your life, is packed with them.

[5] Here is the part that surprises many students: the slow fire burns in plants too. A seed sprouting in dark soil, a root growing underground, and a leaf at midnight are all releasing energy from sugar in their mitochondria, using oxygen and giving off carbon dioxide. A bag of sprouting seeds in a closed, insulated container warms up by several degrees. Plants have no lungs or gills. In an animal, breathing moves air or water across a surface where oxygen enters the blood and carbon dioxide leaves; that is a transport job, not the reaction itself. Plant cells get oxygen from the air through tiny openings in their leaves and from air pockets in the soil. When a field stays flooded for days, those air pockets fill with water and the roots can die for lack of oxygen.

[6] Lavoisier's guinea pig and the candle on your table run the same overall reaction at different speeds. In both, the atoms are conserved. The carbon in the gas the guinea pig breathed out had arrived in its body as carbon in its food; the carbon in the gas above the candle had been part of the wax. More than two hundred years later, the central idea has not changed: living things get the energy they need by combining the molecules in their food with oxygen, a controlled burn that happens, in tiny steps, inside almost every cell.

Questions: cite the passage

1. According to paragraph 1, what goes into a candle's reaction and what comes out? Name the two gases, and say what happens to the energy.

2. Explain how the ice calorimeter in paragraph 2 measured heat. Why was melted ice a useful thing to weigh?

3. Lavoisier and Laplace compared the guinea pig with burning charcoal. In your own words, explain what they matched between the two, what they measured, and what result let Lavoisier conclude that breathing is 'a slow form of combustion.'

4. Paragraph 3 gives two differences between burning in a candle and the reaction in a cell. State both. Then quote the sentence that says what happens to the energy that the cell does **not** capture.

5. Paragraph 3 says energy 'is not created in the cell.' According to the passage, why does the reaction release energy at all?

6. Using paragraph 4, write a short timeline: what happened in 1890, what happened in 1898, and what was shown later. Then give one example from the paragraph of a cell with many mitochondria and one with none.

7. A classmate says, 'Plants don't do cellular respiration; they don't even breathe.' Using at least two pieces of evidence from paragraph 5, explain which part of the statement is true and which part is false.

8. The passage calls cellular respiration a 'controlled burn.' Using evidence from at least two different paragraphs, explain what the candle and the guinea pig have in common and why the word 'controlled' is needed.

Mark the margins

After your first reading, write one of these labels in the margin beside each paragraph: FIRE, EXPERIMENT, WHY NO FLAME, WHERE IN THE CELL, PLANTS TOO, SAME ATOMS. Every question names or hints at a paragraph; find the matching label, reread only that paragraph, and underline the sentence you will quote before you start writing.

Redo the experiment with a plant

Lavoisier used a guinea pig. Design a version of the ice calorimeter experiment that would test whether a bag of sprouting seeds also produces heat and carbon dioxide in the dark. Describe what you would put in the chamber, what you would measure, what comparison you would need (think about Flask B in Worksheet 1), and what result would support the claim in paragraph 5. Then explain one reason the seeds would melt less ice per hour than the guinea pig did.