Before Breathable Air

Model the steps from nonliving molecules to oxygen-using cells.

BIO.4.1 "Use models to differentiate between organic and chemical evolution, illustrating the steps leading to aerobic heterotrophs and photosynthetic autotrophs."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline the nonliving process and circle each living cell type in the passage, then draw a line in the table where the model shifts from chemical evolution to organic evolution.

How Oxygen Changed Early Life

1. Imagine an early Earth shoreline with no plants or animals. Energy from sunlight, lightning, and geothermal heat could drive reactions among nonliving substances, producing simple organic molecules. Scientists call this proposed buildup chemical evolution. Organic molecules contain carbon, but they are not necessarily alive. These molecules may have supplied ingredients for the first cells, though their exact origin remains uncertain.

2. Once cells existed, inherited changes in cell populations across generations became organic evolution. A common model proposes early anaerobic heterotrophs that obtained food from available organic molecules and released energy without oxygen. This is a model, not a confirmed account of the first cells. It shows a transition from nonliving chemistry to evolving living populations.

3. Later, oxygen-producing photosynthetic autotrophs evolved. They used sunlight and carbon dioxide to make food and released oxygen. Oxygen gradually accumulated in water and air. Aerobic heterotrophs could then use oxygen to release energy from food. In the model below, the order matters: an oxygen source must appear before cells that depend on abundant oxygen can spread.

A MODEL OF EARLY CHANGES

Stage	What happens	Oxygen
Chemical evolution	Organic molecules form without cells	Not required
Early heterotrophs	Cells consume available organic molecules	Not used
Photosynthetic autotrophs	Cells make food using light	Released
Aerobic heterotrophs	Cells consume organic food	Used

2 ANSWER WITH EVIDENCE

Use the passage

1. Why does the model place the shift from chemical to organic evolution between its first and second rows?

2. Which modeled cells could obtain energy before oxygen built up, and where did their food come from?

3. Use the model to explain why oxygen-producing autotrophs come before widespread aerobic heterotrophs.

4. How did oxygen use differ between the two heterotroph stages, and what changed between them?

3 YOUR TURN

Your own words

Make two arrow paths, one with oxygen-producing photosynthetic autotrophs and one with photosynthetic autotrophs that release no oxygen; assume there is no other oxygen source. Show whether aerobic heterotrophs could spread on each path, then explain the difference in one sentence.

ANSWER KEY

Before Breathable Air

HIGH SCHOOL · BIO.4.1

PART 1 · READ AND MARK

Underline the nonliving process and circle each living cell type in the passage, then draw a line in the table where the model shifts from chemical evolution to organic evolution. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	Why does the model place the shift from chemical to organic evolution between its first and second rows?	**The first row describes molecules forming without cells. The second describes living cells, whose populations can change across generations.**
2	Which modeled cells could obtain energy before oxygen built up, and where did their food come from?	**Early anaerobic heterotrophs could release energy without oxygen. They consumed available organic molecules.**
3	Use the model to explain why oxygen-producing autotrophs come before widespread aerobic heterotrophs.	**The autotrophs released oxygen. Aerobic heterotrophs needed that oxygen to release energy from food, so abundant oxygen had to become available before they could spread.**
4	How did oxygen use differ between the two heterotroph stages, and what changed between them?	**Early heterotrophs did not use oxygen; aerobic heterotrophs did. Oxygen-producing photosynthetic autotrophs evolved between those stages.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

Oxygen-producing autotrophs → oxygen builds up → aerobic heterotrophs can spread.
Autotrophs that release no oxygen → oxygen does not build up → aerobic heterotrophs cannot spread.
Aerobic heterotrophs need available oxygen to release energy from food.

Accept arrow paths with equivalent labels. The explanation must link the spread of aerobic heterotrophs to an available oxygen source.