

The Air Is Full of Nitrogen, and Almost Nobody Can Eat It

Learning target: I can explain, with evidence from a passage, how nitrogen atoms move from the air into living things and back, and why the same atoms can become a problem when too many arrive at once.

Reading with evidence

About 35 min

Individual

MS-LS2-3 · practice

MS-LS2-4 · supports

reading

writing

Name _____

Date _____

Period _____

Directions

Read the passage once straight through. Read it a second time with a pencil, numbering the paragraphs 1 to 7 and underlining every place where nitrogen changes from one form to another. 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, Scrap paper for the forms strip

The Air Is Full of Nitrogen, and Almost Nobody Can Eat It

[1] Take a breath. About four-fifths of what just entered your lungs was nitrogen gas. Your body needs nitrogen badly: every protein in your muscles and every strand of your DNA contains nitrogen atoms. Yet the nitrogen you breathed in will leave on your next breath exactly as it came. The reason is that nitrogen gas is made of pairs of nitrogen atoms clamped together by one of the strongest bonds in chemistry. Almost no living thing has the tools to pull that pair apart. Animals cannot. Plants cannot. For most of life on Earth, the biggest supply of nitrogen on the planet might as well be locked in a safe.

[2] A few kinds of bacteria hold the key. They carry out nitrogen fixation: using a great deal of energy, they turn nitrogen gas into ammonia, which in damp soil quickly becomes a form called ammonium. Some of these bacteria live on their own in soil and water. Others live inside small lumps, called nodules, on the roots of plants such as peanuts, beans, clover and alfalfa. The partnership is a trade. The plant pumps sugar down to the bacteria; the bacteria hand back fixed nitrogen. Farmers noticed thousands of years ago that fields recover after a season of beans or clover, long before anyone knew bacteria were doing the work.

[3] Lightning is the only other natural process that fixes nitrogen. The heat of a bolt makes nitrogen gas react with oxygen gas in the air. The nitrogen oxides that form dissolve in raindrops and reach the ground as nitrate, a form that plant roots absorb easily. But it is a small contribution: across the whole planet, bacteria fix many times more nitrogen than lightning does.

[4] Once nitrogen is fixed, it begins to travel. Nitrifying bacteria in the soil change ammonium into nitrate. Plant roots take in both ammonium and nitrate and use them to build proteins and other

molecules. A rabbit that eats clover digests the clover's proteins into their building blocks, amino acids, and reassembles them into rabbit proteins. When the rabbit produces waste, and when any plant or animal dies, decomposers break the proteins down and release ammonium back into the soil. In wet, oxygen-poor soil, denitrifying bacteria convert nitrate back into nitrogen gas, which drifts up into the air. The safe is locked again.

[5] In 1909, the German chemist Fritz Haber showed that nitrogen gas could be forced to combine with hydrogen in the laboratory, and by 1913 the engineer Carl Bosch had turned the method into a working factory. The process needs very high pressure and temperature, which take a lot of energy. Today fertilizer plants fix more nitrogen than all the lightning on Earth, and scientists estimate that about half of the people alive are fed by crops grown with factory-made nitrogen. The nitrogen atoms in your last meal may well have passed through a steel reactor before they passed through a plant.

[6] There is a catch. Nitrate dissolves completely in water and does not stick to soil particles. When a farmer spreads more fertilizer than the crop can take up, or when a storm arrives soon after spreading, the extra nitrate washes into streams, ponds and the sea. Algae in the water use it the way crops do and multiply into thick green blooms. When the algae die, decomposers feed on them and use up the water's oxygen through cellular respiration. Fish suffocate. Most summers, a 'dead zone' with too little oxygen for fish forms in the Gulf of Mexico near the mouth of the Mississippi River, fed by nitrogen washed off farms upstream.

[7] Notice what did not happen in that story. No nitrogen was destroyed, and none was created. The same atoms that were in the air were fixed by a factory, spread on a field, washed into a river, built into algae, released by decomposers and, eventually, returned to the air by denitrifiers. A nitrogen atom in your muscle right now has probably been part of the air, a bacterium, a plant and an animal, and it will be again. Matter on Earth does not get used up. It gets used again.

Questions: cite the passage

1. According to paragraph 1, why can't you use the nitrogen you breathe in, even though your body needs nitrogen? Quote the phrase that gives the reason.

2. Paragraph 2 calls the relationship between a bean plant and its root bacteria 'a trade.' What does each partner give, and what does each get?

3. Paragraph 3 says lightning fixes nitrogen. In what **form** does that nitrogen reach the ground, and how does the paragraph compare the amount with what bacteria fix?

4. Using paragraph 4, list in order the forms a nitrogen atom takes from ammonium in the soil to ammonium in the soil again, passing through a clover plant and a rabbit. Name the organism or process responsible for each change.

5. Paragraph 1 says about four-fifths of air is nitrogen gas. The air in a typical classroom has a mass of about 240 kg. Estimate the mass of nitrogen gas in the room. Then explain in one sentence why a houseplant in that room still needs fertilizer.

6. What problem did Haber and Bosch solve, and what does paragraph 5 say it costs to run their process?

7. Paragraph 6 explains why extra nitrate can kill fish. Describe the chain of events in order, and explain why the fish die **after** the algae bloom rather than during it.

8. The passage ends: 'Matter on Earth does not get used up. It gets used again.' Using evidence from at least two different paragraphs, explain how the dead-zone story supports that claim even though it describes a serious problem.

Track the forms

On scrap paper, draw six boxes in a row and label them: nitrogen gas, ammonium, nitrate, plant protein, animal protein, ammonium again. As you read the second time, write above each arrow between boxes the organism or event that causes the change (for example, 'nitrifying bacteria' between ammonium and nitrate). Questions 3, 4, 7 and 8 can all be answered from this strip.

A nitrogen budget for one field

Suppose a farmer spreads 120 kg of nitrogen on a field. The crop takes up 65 kg, denitrifying bacteria return 18 kg to the air, and the rest washes toward a river. Calculate how much nitrogen reaches the river. Then design two changes to the farmer's practice that would shrink that number, and explain for each which process or reservoir in the passage it works on. One change should involve timing and one should involve a plant from paragraph 2.