# Atoms on the Move

Trace how stars make elements and send them into space

**ESS.1A.4** "Research and explain how nuclear fusion in stars and supernova lead to the formation of all other elements."

NAME _____ DATE _____

## 1 READ AND MARK

Read it twice

**YOUR JOB** As you read, underline processes that build new atomic nuclei, circle events that send material into space, and number the steps that bring star-made atoms to Earth.

### Where Earth's Atoms Began

1. Imagine tracing the oxygen in a breath back through space. Soon after the universe began, it contained mostly hydrogen and helium, with tiny amounts of lithium. Stars later built many other elements from this starting supply. In a star's core, gravity squeezes matter so strongly that nuclei can fuse, releasing energy. A Sun-like star fuses hydrogen into helium and, later in its life, helium into carbon and oxygen. Those oxygen atoms did not arrive on Earth already assembled at the beginning of the universe. Their story includes long periods inside stars and a journey through space.

2. Massive stars can continue the chain. After using much of one fuel, a massive star contracts, heats up, and begins fusing new nuclei. This produces elements such as neon, silicon, and eventually iron in different layers. Ordinary fusion of lighter nuclei releases energy only up to the iron region. Building heavier nuclei this way requires energy rather than supplying it. Once the core can no longer gain energy from fusion, it may collapse. In some massive stars, that collapse triggers a supernova, an explosion that throws newly made elements into surrounding space.

3. A supernova does more than scatter what its star already made. During some explosions, extreme conditions produce additional elements, and neutron-rich material can build nuclei heavier than iron through rapid neutron capture. Not all heavy elements come from supernovae: collisions of neutron stars also create many, and some form by slow neutron capture in aging stars. Expelled gas and dust can later gather into new stars and planets, carrying atoms from earlier generations. Earth's rocks and living things contain some of these atoms. Explaining an element's origin means tracing both how its nuclei formed and how the material reached Earth.

## 2 ANSWER WITH EVIDENCE

Use the passage

1. Why did the oxygen in a breath have to form after the early universe, and how could a star make it?

2. Why does a massive star's production of iron matter to the chain of events that can lead to a supernova?

3. How can a supernova both make some nuclei heavier than iron and spread elements that formed earlier?

4. Trace how silicon could form and later become part of an Earth rock.

## 3 YOUR TURN

Your own words

Write a six-sentence museum label narrated by a grain of dust that becomes part of a planet. Trace carbon and gold, which is heavier than iron, from their different formation processes into the planet, and explain why a supernova is not the only possible source of gold.

# Atoms on the Move



## PART 1 · READ AND MARK

As you read, underline processes that build new atomic nuclei, circle events that send material into space, and number the steps that bring star-made atoms to Earth. Accept any marking that follows this job and points at the right text.

## PART 2 · ANSWERS

| # | QUESTION | ANSWER |
|---|---|---|
| 1 | Why did the oxygen in a breath have to form after the early universe, and how could a star make it? | **The early universe contained mostly hydrogen and helium, not oxygen. Later, a Sun-like star could make oxygen by fusing helium in its core.** |
| 2 | Why does a massive star's production of iron matter to the chain of events that can lead to a supernova? | **Fusion stops supplying energy near iron. Without energy from core fusion, the core may collapse and trigger a supernova.** |
| 3 | How can a supernova both make some nuclei heavier than iron and spread elements that formed earlier? | **Neutron-rich material can build heavier nuclei through rapid neutron capture during some explosions. The explosion also throws elements made earlier in the star into space.** |
| 4 | Trace how silicon could form and later become part of an Earth rock. | **Fusion in a massive star can make silicon. A supernova can expel it into space, where it can join material that forms a planet, including Earth's rocks.** |

## PART 3 · YOUR TURN (SAMPLE ANSWER)

I began as a grain of dust drifting through space. Carbon nuclei formed when helium fused inside an aging star. Gold could have formed when neutron-rich matter rapidly captured neutrons in some stellar explosions or in a neutron-star collision. Ordinary fusion could not build gold while releasing energy because that process stops supplying energy near iron. Material expelled from stars and explosions carried these atoms into the cloud where I formed. As that cloud formed a new planetary system, its carbon and gold became part of my planet.

Accept other accurate paths from stellar material to a planet. The label should distinguish fusion from the processes that can make elements heavier than iron and should not claim that every heavy element forms in a supernova.