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# Earth’s Magnetic Field and Early Atmosphere

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# Earth’s Magnetic Field and Early Atmosphere

Earth’s magnetic field comes from moving metal in its outer core. Life changed the air by adding oxygen. **These are related parts of Earth’s history, but one did not simply cause the other.**



Stromatolites, layered structures built by ancient cyanobacteria, among the oldest fossil evidence of life on Earth. These early organisms modified Earth’s atmosphere. Photo: P. Carrara, U.S. National Park Service, via Wikimedia Commons, public domain.

At a Glance

Four facts to hold on to.

01
Field source

Moving liquid metal in the outer core.

02
Early air

Little free oxygen.

03
Oxygen rise

Great Oxidation Event, about 2.4 billion years ago.

04
Reversals

Irregular. Last full one about 780,000 years ago.

**Geodynamo**The process that makes Earth’s main magnetic field.
**Magnetosphere**The region shaped by the field and the solar wind.
**Solar wind**A flow of charged particles from the Sun.
**Stromatolite**A layered structure built by microbial communities.

## Earth’s Field and Early Air

Must Know

## What is Earth's magnetic field?

- It is an invisible field made by moving, electrically conducting metal in the outer core.
- It reaches far into space.
- A compass responds to it. So do charged particles from the Sun.
- The **solar wind** is a flow of charged particles from the Sun. Earth's field changes many of their paths.
- The region shaped by the field and solar wind is the **magnetosphere**. It reduces some space-weather effects near Earth.

## How was early air different?

- **Free oxygen was scarce** in Earth's early air.
- Early air changed over time. Volcanic gases, impacts, oceans, sunlight and life all played roles.
- Nitrogen and carbon dioxide were important gases. The amount of methane is still debated.
- Scientists do not know one exact gas mix for every early period.
- The claim that early Earth had 54% oxygen appears in a 2018 exam question. It is not a scientific estimate.
- Sources: NASA on early-air uncertainty and NASA Earth facts.

> **Quick check 1.** Free oxygen was scarce in Earth's early air, but its exact gas mixture changed and remains uncertain. *(True or False?)* See answer ↓

# How Oxygen Rose, and the Evidence

Good to Know

## Life changed the air

- Some microbes used sunlight to make food and released oxygen. Cyanobacteria are a well-known group.
- At first, much oxygen reacted with iron and other substances. It did not stay in the air.
- Later, oxygen built up. This is the **Great Oxidation Event**, about 2.4 billion years ago.
- Oxygen harmed organisms that could not tolerate it. Others later evolved ways to use it.
- It was a long chain of changes, not one sudden day.
- Source: NASA on early life and oxygen.

## Fossils and magnetic records

- Stromatolites are layered structures built by microbial communities.
- The Strelley Pool Chert in Western Australia has examples about 3.43 billion years old.
- Some older structures have been proposed, but their origin is debated.
- Rocks also record past magnetic directions. Repeated patterns show the field has reversed many times.
- A reversal swaps magnetic north and south. It does not turn Earth upside down.
- Reversals have no fixed schedule. The last full reversal was about 780,000 years ago.
- Sources: NASA on stromatolites and NOAA on reversals.

> **Quick check 2.** The Great Oxidation Event meant oxygen became abundant in the air in one day. *(True or False?)* See answer ↓

Exam Edge

## Previous Year Questions

UPSC 2018 tested three claims about Earth's field and early air.

> **Quick check 3.** The 2018 UPSC question's claim of 54% oxygen in early Earth's air is false. *(True or False?)* See answer ↓

## The Dynamo and Its Limits

Great to Know

### How does the geodynamo work?

1. Core heat drives motion in the liquid iron-rich outer core.
2. Earth's rotation helps organise the flowing metal.

3. Moving conductive metal makes electric currents.
4. The currents make the magnetic field.

- A reversal changes the field's direction, not the fact that Earth has a core.
- Sources: NASA Earth facts and NOAA geomagnetism guide.

## What can the field protect?

- The field diverts many charged solar particles.
- It is not an airtight cover. Some particles enter near the poles and help make auroras.
- Earth also loses some gas to space. Gravity, chemistry, sunlight and planet size matter too.
- Mars lacks a global core-generated field today. NASA's MAVEN mission shows solar-wind processes have removed some Martian air.
- Mars's small size and long climate history also matter.
- Venus lacks an Earth-like internal field yet has a very thick atmosphere.
- The field alone does not guarantee a habitable planet.
- Sources: NASA MAVEN, NASA Venus facts and NASA technical review.

> **Think it through: does a global magnetic field alone decide whether a planet keeps a thick atmosphere?**
>
> No. Mars lacks a global core-generated field, and solar-wind loss has mattered there. Venus lacks such a field but has thick air. Gravity, sunlight, chemistry and history also matter.

**Quick check 4.** Mars lacks a global core-generated magnetic field today, but it has local magnetic patches. *(True or False?)* See answer ↓

**Quick check 5.** Moving liquid metal in Earth's outer core helps generate its magnetic field. *(True or False?)* See answer ↓

**Quick check 6.** The Strelley Pool Chert contains stromatolite structures about 3.43 billion years old. *(True or False?)* See answer ↓

## Quick Q&A

Where does the field come from?

Moving metal in the outer core.

When did oxygen build up?

About 2.4 billion years ago.

Who released oxygen first?

Cyanobacteria.

Is the 54% oxygen claim true?

No.

Do reversals follow a clock?

No.

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**1. What organisms are credited with first releasing oxygen into Earth's atmosphere?**

**A.** Flowering plants

**B.** Cyanobacteria

**C.** Land mammals

**D.** Dinosaurs

See answer ↓

**2. What is the event called when atmospheric oxygen first built up significantly, around 2.4 billion years ago?**

**A.** The Younger Dryas

**B.** The Great Oxidation Event

**C.** The Cambrian Explosion

**D.** The Great Dying

See answer ↓

# Answer Key

1. **B.** Early photosynthetic cyanobacteria released oxygen as a byproduct, gradually building up atmospheric oxygen. ↑ Q1
2. **B.** This oxygen buildup, known as the Great Oxidation Event, occurred roughly 2.4 billion years ago. ↑ Q2

## Quick-check answers

1. **True.** ↑ 1
2. **False.** ↑ 2
3. **True.** ↑ 3
4. **True.** ↑ 4
5. **True.** ↑ 5
6. **True.** ↑ 6

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