Science & Literacy Activity

GRADES 9-12

Common Core State Standards:
WHST.9-12.2, WHST.9-12.8, WHST.9-12.9
RST.9-12.1, RST.9-12.2, RST.9-12.7, RST.9-12.10

New York State Science Core Curriculum:
PS 1.2h

Next Generation Science Standards:
PE HS-ESS 2-7
DCI ESS2.E: Biogeology
The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual co-evolution of Earth's surface and the life that exists on it.

OVERVIEW

This activity, which is aligned to the Common Core State Standards (CCSS) for English Language Arts, introduces students to scientific knowledge and language related to Earth Science. Students will read content-rich texts, visit the David S. and Ruth L. Gottesman Hall of Planet Earth and use what they have learned to complete a CCSS-aligned writing task, creating an illustrated text about how Earth's systems and life on Earth co-evolved to create an oxygen-rich atmosphere.

Materials in this activity include:

- Teacher instructions for:
    - o Pre-visit student reading
    - o Visit to the Gottesman Hall of Planet Earth and Student Worksheet
    - o Post-visit writing task
- Text for student reading: "Footprints of the Air "
- Student Worksheet for the Gottesman Hall of Planet Earth visit
- Student Writing Guidelines
- Teacher rubric for writing assessment

SUPPORTS FOR DIVERSE LEARNERS: An Overview
This resource has been designed to engage all learners with the principles of Universal Design for Learning in mind. It represents information in multiple ways and offers multiple ways for your students to engage with content as they read about, discuss, view, and write about scientific concepts. Different parts of the experience (e.g. reading texts, or locating information in the hall may challenge individual students. However, the arc of learning is designed to offer varied opportunities to learn. We suggest that all learners experience each activity, even if challenging. We have provided ways to adapt each step of the activities for students with different skill-levels. If any students have an Individualized Education Program (IEP), consult it for additional accommodations or modifications.

1. BEFORE YOUR VISIT

This part of the activity engages students in reading a non-fiction text about investigating Earth's early atmosphere to learn how it changed over time. The reading will prepare students for their visit by introducing them to the topic and framing their investigation.

Student Reading
Have students read "Footprints of the Air." Have them write notes in the large right-hand margin. For example, they could underline key passages, paraphrase important information, or write down questions that they have.

Ask:

- The reading states that the scientists are "poring over their favorite Earth history book." What are they hoping to learn from the "book," and how are they "reading" it?
  (Answer: The "book" is a rock outcrop called the Huronian Supergroup. It formed about 2.2.–2.5 billion years ago [BYA], around the same time when oxygen began to accumulate in the atmosphere. The scientists are hoping that "reading" it will help them attach firm dates to the rise of oxygen in Earth's early atmosphere. The rocks are in sequence, like the pages of a book, and can be read from the bottom layer upward to learn how Earth's atmosphere underwent a transition from containing no free oxygen to containing some free oxygen.)
- What created the "footprints" that the scientists are investigating and how did they find them?
  (Answer: The "footprints" are traces of sulfur left behind by active volcanoes. They are able to find these by grinding up rocks from the Huronian Supergroup and other deposits around the world.)

- What information are they able to get from the "footprints"? Does this help them find the answer they were looking for?
  (Answer: In old rocks, before the buildup of atmospheric oxygen, the ratio of sulfur-33 to sulfur-32 varies; in young rocks it is constant and in the same ratio as today. The "footprints" helped them attach firm dates to the rise of oxygen in Earth's early atmosphere: free oxygen began to accumulate in the atmosphere about 2.45 BYA and was well established by 2.1 BYA.)

SUPPORTS FOR DIVERSE LEARNERS: Student Reading

- "Chunking" the reading can help keep them from becoming overwhelmed by the length of the text. Present them with only a few sentences or a single paragraph to read and discuss before moving on to the next "chunk."
- Provide "wait-time" for students after you ask a question. This will allow time for students to search for textual evidence or to more clearly formulate their thinking before they speak.

2. DURING YOUR VISIT

This part of the activity engages students in exploring the Gottesman Hall of Planet Earth.

Museum Visit & Student Worksheet

Let students know that they will be using worksheets to gather information about how Earth's systems and life on Earth co-evolved to create an oxygen-rich atmosphere. Explain to students that they will be focusing on three sections of the hall to gather this information: (1) "How has the Earth Evolved?", (2) "Why is the Earth Habitable?", and (3) "How do Scientists Read the Rocks?". You may want to provide students with a copy of the map from the Educator's Guide to help them find these areas more easily. To allow for easier data collection, you may want to break students into groups and have them start their exploration at different sections. Tell students that back in the classroom, they will refer to these notes when completing the writing assignment.

If students are able to take pictures of specimens in the hall, encourage them to do so. They can use the images to illustrate their writing assignment. If taking pictures is not possible, students can access digital images of the specimens on the Museum's website: amnh.org/rose/hope

SUPPORTS FOR DIVERSE LEARNERS: Museum Visit

- Review the Student Worksheet with students, clarifying what information they should collect during the visit.
- Have students explore the hall in pairs, with each student completing their own Student Worksheet.
- Encourage student pairs to ask you or their peers for help locating sources of information. Tell students they may not share answers with other pairs, but they may point each other to places in the hall where answers may be found.

3. BACK IN THE CLASSROOM

This part of the activity engages students in an informational writing task that draws on the pre-visit reading and on observations made at the Museum.

Writing Task

Distribute the Student Writing Guidelines handout, which includes the following prompt for the writing task:

> Based on the reading, your visit to the Gottesman Hall of Planet Earth, and your discussions, write an illustrated essay in which you describe how Earth's systems and life on Earth co-evolved to create an oxygen-rich atmosphere.
>
> Be sure to include:
> - how this evolution can be seen in the Huronian Supergroup
> - the role of black smokers, banded iron formations, and stromatolites in the oxygenation of the atmosphere
>
> Support your discussion with evidence from the reading and the information gathered using the Gottesman Hall of Planet Earth worksheet.

Go over the handout with students. Tell them that they will use it while writing, and afterwards, to evaluate and revise their essays.

NOTE: It may be helpful to review the "How do we know about the early atmosphere?" diagram with you students (as a class or in smaller groups during student sharing). This will help ensure that students have an understanding of the relationship between banded iron formations, stromatolites, and the oxygenation of the atmosphere. To access the diagram, go to amnh.org/rose/hope. On the left-side navigation, click on "How has the Earth evolved?" and then "A special planet."

Before they begin to write, have students use the prompt and guidelines to frame a discussion around the information that they gathered in the Gottesman Hall of Planet Earth, and compare their findings. They can work in pairs, small groups, or as a class. Referring to the writing prompt, have students underline or highlight all relevant passages and information from the reading, and their notes from the hall that can be used in their response to the prompt. Instruct each student to take notes on useful information that their peers gathered as they compare findings. Students should write their essays individually.

NOTE: If students would like to refer to photos of the specimens they examined in the hall, they can search for them on the Museum's website: amnh.org/rose/hope

SUPPORTS FOR DIVERSE LEARNERS: Writing Task

- Re-read the "Before Your Visit" assignment with students. Ask what they saw in the hall that helps them understand how Earth's systems and life on Earth co-evolved to create an oxygen-rich atmosphere.
- Allow time for students to read their essay drafts to a peer and receive feedback based on the Student Writing Guidelines.

Student Reading
Footprints of the Air

On a chilly October afternoon, Grant Young and Jay Kaufman stand along a busy roadside in northern Ontario, poring over their favorite Earth-history book. Young, a professor of geology at the University of Western Ontario, and Kaufman, a geoscientist from the University of Maryland, are among the leading scientists trying to attach firm dates to the rise of oxygen in Earth's early atmosphere — an event that, when it occurred more than 2 billion years ago, dramatically altered the planet's development.


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The Huronian Supergroup

The book they are reading is an ancient geological masterpiece: the Huronian Supergroup, a massive formation of rock laid down gradually between about 2.5 billion and 2.2 billion years ago, precisely the period when oxygen began to accumulate in the atmosphere. The Huronian Supergroup is 10 or 11 kilometers (six or seven miles) thick and extends well below ground. From atop a nearby outcrop, a viewer can survey the landscape for miles around. At the moment, however, Kaufman and Young are at road level, examining a segment of the outcrop that was exposed back when the highway was built. Individual layers of ancient sediment form horizontal stripes on the rock. From a few steps back, the rock wall looks like a cross-section of a giant, stone encyclopedia.

"When we look at a sequence of rocks, it's like the pages of a book," Young says. "The page at the bottom is the oldest and the page at the top is the youngest. We read history by starting at the bottom layer and working our way up. The Huronian Supergroup is particularly exciting and interesting because, by chance, these rocks were laid down at a period when the atmosphere underwent a transition from containing no free oxygen to containing at least some free oxygen."

It may seem at first like an odd strategy: studying rocks in order to understand the atmosphere. It's one thing to examine fossils, the solid remains of ancient, solid creatures. But what can rocks reveal about something as formless as air, much less air that existed billions of years ago? How does one study the ancient atmosphere when no samples of it are left to collect?

Fortunately, the geological record contains a history of more than just rock. The atmosphere, then as now, constantly interacts with Earth's crust. As exposed rock weathers, its composition is altered by compounds in the air. This alteration is apparent even billions of years later and reveals important details about the atmosphere at the time. By studying a shoeprint in the mud, a police detective can determine not only the kind of shoe that made it, but also critical details about its wearer: size, weight, gender, even age, and whether or not he or she walked with a limp. The ancient atmosphere left an equally telling signature in the rock record. By flipping backward through pages of rock, a geologist can begin to form a picture of that atmosphere and how it changed through time.

"I've often wished that I had a time machine to go back and collect a sample of ancient atmosphere or an ancient bit of seawater," says Kaufman. "But we can't. All we can do is collect rocks that were formed under those waters and under that atmosphere."


© AMNH

Jay Kaufman, of the University of Marylan, looking at Huronian stratigraphy.

Oxygen is a highly reactive element; it readily combines with other elements to form new compounds. As these compounds form, they become part of the geological record, leaving behind a trail of molecular "crumbs" that point to oxygen's whereabouts through history. One clue to the nature of the ancient atmosphere comes from rock formation known as "redbeds," the oldest of which date back about 2.2 billion years. Redbeds are sediments that were deposited on floodplains by water exposed to the atmosphere. They contain a mineral called hematite, a compound of iron and what must have been atmospheric oxygen. After 2.2 billion years ago, redbeds become increasingly common in the geological record.

"It's a very simple kind of test," says Young, who has studied redbeds extensively over the course of his career. "But it does give us at least a first-order idea as to whether there was free oxygen and whether there wasn't."

In recent years Kaufman's colleague James Farquhar, a geochemist at the University of Maryland, devised an even more precise method of dating the rise of oxygen. He collected rocks from the Huronian Supergroup and other deposits around the world, ground them to powder in the laboratory, and studied them for traces, not of oxygen, but of an entirely different element: sulfur. Sulfur compounds are emitted in vast quantities by volcanoes, which were especially active during Earth's youth. Like other airborne compounds, they undergo reactions in the atmosphere and eventually end up deposited in the geological record.

As it happens, there are four different kinds, or isotopes, of sulfur. By far the most common — about 95 percent of all atmospheric sulfur — is sulfur-32, or sulfur with an atomic weight of 32. The other isotopes are sulfur-34 (4.2 percent), sulfur-33 (0.75 percent), and sulfur-36 (0.02 percent). The relative proportion of these four isotopes has tended to remain steady over time. But Farquhar and his colleagues found that in rocks older than about 2.4 billion years, the proportion of sulfur-33 varied widely, whereas rocks younger than about 2.1 billion years showed no significant variation. What accounted for the variation, and for the change?

The answer, Farquhar and Kaufman believe, was oxygen. Early in the planet's history, before enough free oxygen had accumulated to form a protective layer of ozone (O3), Earth's atmosphere was scorched by intense ultraviolet radiation from the Sun. The UV radiation may have reacted with the atmosphere to produce some compounds with a high sulfur-33 to sulfur-32 ratio and other compounds with a low sulfur-33 to sulfur-32 ratio. Later, with the rise of oxygen and the formation of an ozone layer which blocked incoming UV radiation, that photochemical reaction stopped, and the ratio of sulfur-33 to sulfur-32 ceased to vary. Amazingly, these signatures of sulfur isotopes are recorded in the rocks. In old rocks, before the buildup of atmospheric oxygen, the ratio of sulfur-33 to sulfur-32 in rocks is variable; in young rocks it is constant and in the same ratio as today.

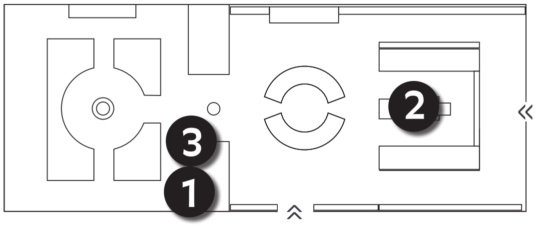
Farquhar's technique, though indirect, is remarkably exact: he has determined that free oxygen began to accumulate in the atmosphere about 2.45 billion years ago and was well established by 2.1 billion years ago. He also has been able, for the first time, to provide a rough measure of how much oxygen there was compared to today. "The sulfur research probably provides the strongest evidence for the buildup of oxygen in the atmosphere," Farquhar says. "The change from a large signature to a much smaller signature is a result of a large change in atmospheric oxygen content, from levels 100,000 times less than present to levels within about 100 times less than the present level."

"The most exciting thing to me about this research is that it quantifies amounts of oxygen in the atmosphere," Kaufman adds. "Before, we just had this qualitative sense of, well, it was low here, it must have risen here. But the signatures that we're seeing allow us to actually get at numbers — to get at the timing of this rise, so it's not just a fairytale. We can actually write some sentences on the pages of the book of atmospheric oxygen."

Student Worksheet

Today you will investigate how current conditions on Earth are the result of its biotic and abiotic systems co-evolving over long stretches of time.

Visit three areas in the Gottesman Hall of Planet Earth to explore the rise of oxygen in Earth's atmosphere.



1 How has the Earth Evolved?

a. Observe specimens #17, #18, and #19, layers of the Huronian Supergroup.
Explain what the color variations and composition of each of these layers tells us about how the atmosphere has changed over time.

- Specimen #17, pyrite-bearing conglomerate:

- Specimen #18, gray-white quartz:

- Specimen #19, red quartzite:

What clues about the conditions on the early Earth are found in rocks like the Huronian Supergroup?

b. Observe specimen #16, the oldest fossil.

What was the Age of Microbes and what was its importance to the evolution of life on Earth?

Describe the specimen and explain how the presence of fossil bacteria supports the idea that the Earth's atmosphere was evolving. How does the presence of these fossil bacteria support the idea that Earth's atmosphere was evolving?

2 Why is the Earth Habitable?

One of the simplest definitions of a life-form is: anything with the capacity to reproduce and regulate itself. Before life began, the complex organic, or hydrocarbon-bearing, molecules that make up RNA and DNA, the building blocks of life, must have formed. No one knows exactly how life formed from these molecules, but many ideas have been put forward.

As you enter this area, go toward the large video screen on the right and explore the "Life at the Hydrothermal Vents" label deck.

Some scientists theorize that life begin at deep-sea vents. Find three lines of evidence to support this claim.

Explain how sulfide chimneys can support life without the presence of sunlight.

3 How has the Earth Evolved?

a. Observe specimen #14, stromatolite and the illustrated label deck "How Do We Know About the Earth's Early Atmosphere?"

What are stromatolites?

What was their role in the oxygenation of Earth's early atmosphere?

Why did they flourish when shallow seas became more extensive?

b. Observe specimen #15, banded iron (also see specimen #23 around the corner) and the illustrated label deck "How Do We Know About the Earth's Early Atmosphere?"

Describe the bands and explain how they formed.

When and why did banded iron formations stop forming?

What does the presence of banded iron formations tell us about conditions in the early atmosphere and oceans?

NOTE: Photos of the specimens that you examined in the hall are available at amnh.org/rose/hope.

ANSWER KEY

Student Worksheet

Today you will investigate how current conditions on Earth are the result of its biotic and abiotic systems co-evolving over long stretches of time.

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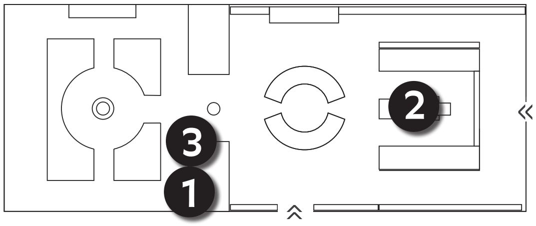


1 How has the Earth Evolved?

a. Observe specimens #17, #18, and #19, layers of the Huronian Supergroup.
Explain what the color variations and composition of each of these layers tells us about how the atmosphere has changed over time.

- Specimen #17, pyrite-bearing conglomerate:

(Answer: This quartz-pebble conglomerate is from one of the oldest layers of the Huronian Supergroup. It formed as a gravel bar in a river, perhaps during a flood. The rock contains the heavy minerals pyrite [called "fool's gold"] and uraninite [a uranium mineral], which were originally particles carried by the river. These minerals could not have survived in the presence of oxygen. They are part of the evidence for an oxygen-poor atmosphere 2.5 billion years ago.)

- Specimen #18, gray-white quartz:

(Answer: This quartzite formed in a riverbed, as indicated by the well-developed cross-bedding [sedimentary layers at angles to the main horizontal layers]. Its buff to gray color is typical of the oldest rocks of the Huronian Supergroup. The color suggests deposition when the atmosphere contained no free oxygen.)

- Specimen #19, red quartzite:

(Answer: The rocks in the upper part of the Huronian Supergroup are red-brown, like this quartzite specimen. The color is due to the presence of small quantities of iron oxide minerals (rust), and indicates deposition when the atmosphere contained oxygen.)

What clues about the conditions on the early Earth are found in rocks like the Huronian Supergroup?

(Answer: Many geologists believe that this sequence of rocks records a change from an oxygen-free to an oxygen-bearing atmosphere.)

b. Observe specimen #16, the oldest fossil.

What was the Age of Microbes and what was its importance to the evolution of life on Earth?

(Answer: From 3.9 to about 1.2 billion years ago, life was confined to microbes, or single-celled organisms. During this time, the microbes prospered, gradually altering their surroundings. The conditions they created made the environment hospitable for the emergence of more complex life-forms, beginning about 1.2 billion years ago. Geochemical evidence, in the form of traces of organic carbon in rocks, suggests that life existed nearly 3.9 billion years ago.)

Describe the specimen and explain how the presence of fossil bacteria supports the idea that the Earth's atmosphere was evolving. How does the presence of these fossil bacteria support the idea that Earth's atmosphere was evolving?

(Answer: This 3.5-billion-year-old black chert from the Warrawoona Group of Western Australia contains microscopic forms believed by some scientists to be fossil bacteria. If these are actually fossils, they are the oldest-known examples of life. The microfossils resemble modern light-sensitive bacteria, and the rocks in which they are found formed near the surface of a shallow sea. It is thus likely that organisms employing photosynthesis — the use of sunlight for food and energy — were providing oxygen for an evolving atmosphere.)

2 Why is the Earth Habitable?

One of the simplest definitions of a life-form is: anything with the capacity to reproduce and regulate itself. Before life began, the complex organic, or hydrocarbon-bearing, molecules that make up RNA and DNA, the building blocks of life, must have formed. No one knows exactly how life formed from these molecules, but many ideas have been put forward.

As you enter this area, go toward the large video screen on the right and explore the "Life at the Hydrothermal Vents" label deck.

Some scientists theorize that life begin at deep-sea vents. Find three lines of evidence to support this claim.

(Answer: Some of the thermophilic, or heat-loving, vent microbes are the most primitive organisms known on Earth. They include Archaea, which belong to a third domain of life and are as different from bacteria as bacteria are from all other organisms. Second, complex organic molecules, the building blocks of life, are found at the vents. Third, the deep ocean was one of the few places on the early Earth that was protected from frequent meteorite bombardments and lethal radiation.)

Explain how sulfide chimneys can support life without the presence of sunlight.

(Answer: Hot, mineral-rich fluids supply nutrient chemicals. Microbes, some of which eat these chemicals, form the base of the food chain for a diverse community of organisms. These vents are the only places on Earth where the ultimate source of energy for life is not sunlight but Earth itself.)

ANSWER KEY

3 How has the Earth Evolved?

a. Observe specimen #14, stromatolite and the illustrated label deck "How Do We Know About the Earth's Early Atmosphere?"

What are stromatolites?

(Answer: Mats of bacteria that trap and precipitate sediments or colony of microbes piled on one another over time, forming semi-rigid, upward-pointing, and branching columns).

What was their role in the oxygenation of Earth's early atmosphere?

(Answer: These bacteria produced oxygen through photosynthesis.)

Why did they flourish when shallow seas became more extensive?

(Answer: Because the atmosphere during much of the Precambrian had little oxygen, there was no protective ozone layer, and life could prosper only in water of just the right depth — shallow enough for sunlight to penetrate, but deep enough to block out the Sun's harmful ultraviolet radiation.)

b. Observe specimen #15, banded iron (also see specimen #23 around the corner) and the illustrated label deck "How Do We Know About the Earth's Early Atmosphere?"

Describe the bands and explain how they formed.

(Answer: The dark layers are mainly composed of magnetite (Fe_3O_4) while the red layers are chalcedony, a form of silica (SiO_2) that is colored red by tiny iron oxide particles. Some geologists suggest that the layers formed annually with the changing seasons.)

When and why did banded iron formations stop forming?

(Answer: About 1.7 billion years ago, banded iron formations — sedimentary rocks consisting of iron-rich layers alternating with iron-poor ones — stopped forming. By this time, photosynthesis had supplied enough oxygen to entirely deplete the oceans of their iron.)

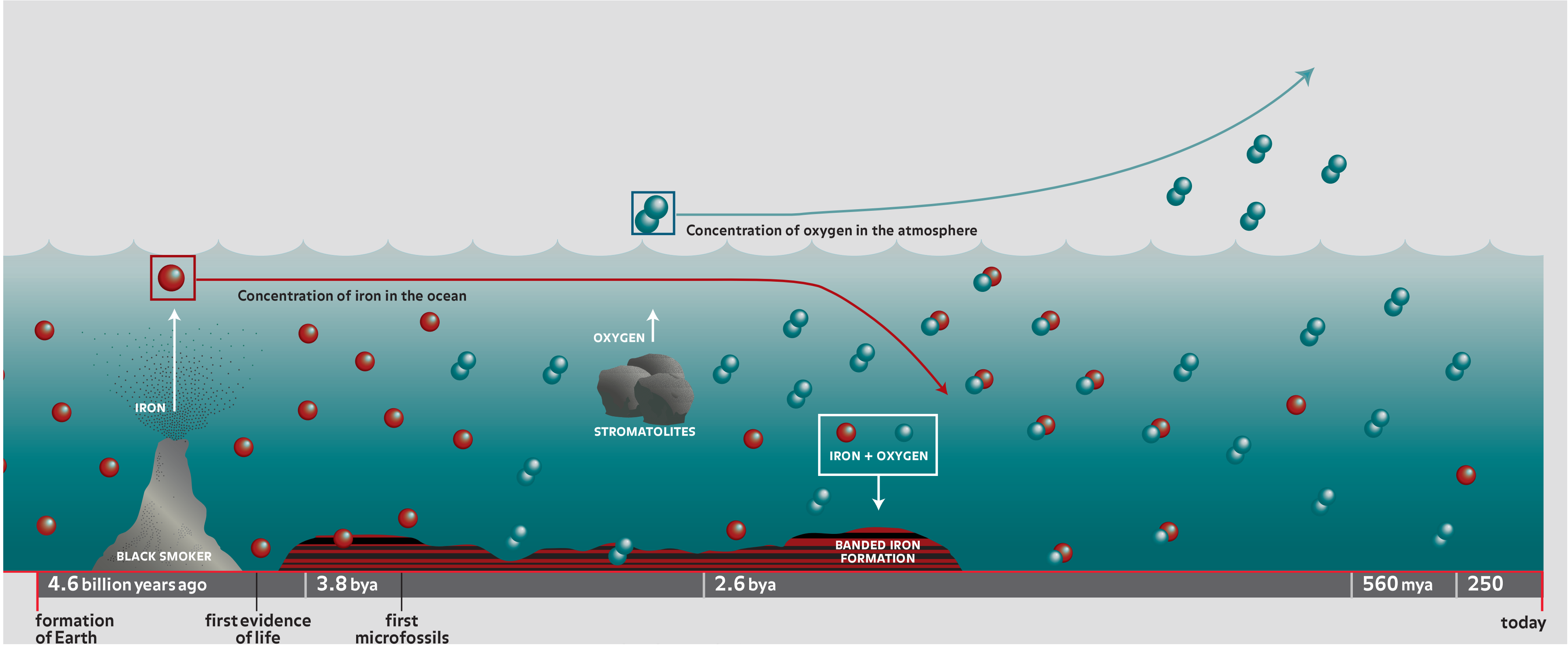
What does the presence of banded iron formations tell us about conditions in the early atmosphere and oceans?

(Answer: They show that the atmosphere and ocean once had no oxygen. Photosynthetic organisms were making oxygen, but it reacted with the iron dissolved in seawater to form iron oxide minerals on the ocean floor, creating banded iron formations.)

NOTE: Photos of the specimens that you examined in the hall are available at amnh.org/rose/hope.

Student Handout

How do we know about the early atmosphere?



Student Writing Guidelines

Based on the reading, your visit to the Gottesman Hall of Planet Earth and your discussions, write an illustrated essay in which you describe how Earth's systems and life on Earth co-evolved to create an oxygen-rich atmosphere.

Be sure to include:
- how this evolution can be seen in the Huronian Supergroup
- the role of black smokers, banded iron formations and stromatolites in atmospheric oxygenation

Support your discussion with evidence from the reading and the information gathered using the Gottesman Hall of Planet Earth worksheet.

Use this checklist to ensure that you have included all of the required elements in your essay.

☐ I introduced the topic of Earth systems and life on Earth co-evolving to create an oxygen-rich atmosphere.

☐ I clearly described how Earth's systems and life on Earth co-evolved to create an oxygen-rich atmosphere.

☐ I only included relevant information about the role of black smokers, banded iron formations and stromatolites in atmospheric oxygenation.

☐ I used information from "Footprints of the Air" to explain the topic in detail.

☐ I used information from the Gottesman Hall of Planet Earth to explain the topic in detail.

☐ I used academic, non-conversational tone and language.

☐ I included a conclusion at the end.

☐ I proofread my essay for grammar and spelling errors.

Assessment Rubric

	Scoring Elements	1 Below Expectations	2 Approaches Expectations	3 Meets Expectations	4 Exceeds Expectations
RESEARCH	**Reading**	Attempts to present information in response to the prompt, but lacks connections to the texts or relevance to the purpose of the prompt.	Presents information from the text relevant to the purpose of the prompt with minor lapses in accuracy or completeness.	Presents information from the text relevant to the prompt with accuracy and sufficient detail.	Accurately presents information relevant to all parts of the prompt with effective paraphrased details from the text.
	AMNH Exhibit	Attempts to present information in response to the prompt, but lacks connections to the Museum exhibit content or relevance to the purpose of the prompt.	Presents information from the Museum exhibit relevant to the purpose of the prompt with minor lapses in accuracy or completeness.	Presents information from the Museum exhibit relevant to the prompt with accuracy and sufficient detail.	Accurately presents information relevant to all parts of the prompt with effective paraphrased details from the Museum exhibit.
WRITING	**Focus**	Attempts to address the prompt, but lacks focus or is off-task.	Addresses the prompt appropriately, but with a weak or uneven focus.	Addresses the prompt appropriately and maintains a clear, steady focus.	Addresses all aspects of the prompt appropriately and maintains a strongly developed focus.
	Development	Attempts to provide details in response to the prompt, including retelling, but lacks sufficient development or relevancy.	Presents appropriate details to support the focus and controlling idea.	Presents appropriate and sufficient details to support the focus and controlling idea.	Presents thorough and detailed information to strongly support the focus and controlling idea.
	Conventions	Attempts to demonstrate standard English conventions, but lacks cohesion and control of grammar, usage, and mechanics.	Demonstrates an uneven command of standard English conventions and cohesion. Uses language and tone with some inaccurate, inappropriate, or uneven features.	Demonstrates a command of standard English conventions and cohesion, with few errors. Response includes language and tone appropriate to the purpose and specific requirements of the prompt.	Demonstrates and maintains a well-developed command of standard English conventions and cohesion, with few errors. Response includes language and tone consistently appropriate to the purpose and specific requirements of the prompt.
SCIENCE	**Content Understanding**	Attempts to include science content in explanations, but understanding of the topic is weak; content is irrelevant, inappropriate, or inaccurate.	Briefly notes science content relevant to the prompt; shows basic or uneven understanding of the topic; minor errors in explanation.	Accurately presents science content relevant to the prompt with sufficient explanations that demonstrate understanding of the topic.	Integrates relevant and accurate science content with thorough explanations that demonstrate in-depth understanding of the topic.