

Bacteria Change Earth's Atmosphere– Grade Ten

**Ohio Standards
Connection:**

**Earth and Space
Sciences**

Benchmark C

Explain the 4.5 billion year history of Earth and the 4 billion year history of life on Earth based on observable scientific evidence in the geologic record.

Indicator 4

Describe how organisms on Earth contributed to the dramatic change in oxygen content of Earth's early atmosphere.

Lesson Summary:

The purpose of this lesson is to visually organize and understand the climatic change that occurred on Earth when photosynthetic bacteria began producing excess oxygen. Photosynthesis caused the concentration of oxygen in Earth's atmosphere to increase from less than one percent to the current 21 percent.

Estimated Duration: Two hours

Commentary:

Students will develop and explain a historical timeline in the form of a sequential storyboard. This storyboard will help to illustrate the events that influenced the composition of Earth's early atmosphere. Nonlinguistic representations help students think about and recall knowledge. Students will examine the significance and contributions of cyanobacteria to life on Earth.

Pre-Assessment:

Have students respond to the following questions:

1. What chemical was given off by the early cyanobacteria? (Hint: It is the same as the product produced by algae and green plants.)
2. If this chemical became more abundant in the Earth's early atmosphere, what would happen to the existing bacteria as a result of the change in atmosphere?

Scoring Guidelines:

1. Sample answers: Oxygen.
2. The ancient bacteria would die because there would be more oxygen in the atmosphere created by cyanobacteria. The death of the ancient bacteria would create space for more cyanobacteria which would lead to more oxygen.



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Post-Assessment:

- Print questions found in Attachment B, *Post-Assessment*, and distribute to students.
- Direct students to answer the questions provided.

Scoring Guidelines:

Use Attachment C, *Post-Assessment Answer Key* to assess student understanding.

Instructional Procedures:

Instructional Tip:

Students must have foundation knowledge of photosynthesis. Students should know that in photosynthetic organisms, carbon dioxide and water are united using sunlight as the energy source to produce organic molecules (sugars) and give off oxygen as a waste product.

1. Distribute foundational information (found in the Attachment A, *Storyboard Information*) that is most generally accepted by scientists based upon the data to date.
2. Divide the class into design teams of three to four students. Challenge them to make a storyboard that depicts how cyanobacteria changed the atmosphere on Earth.
3. Have each design team develop a storyboard that shows the seven steps found in Attachment A, *Storyboard Information*. The bulleted information should be included in one or more of the frames.
4. Conduct research for additional information for the storyboard. Keep it short and concise. The storyboards should be kept simple but complete. The drawings should be representative sketches not finished works of art.
5. If time permits, the storyboards can be shared with the class. Listed below are a variety of options.
 - Each team member can explain one or more panels of the storyboard.
 - Each team can choose a speaker to explain their storyboard.
 - Randomly select individuals from each team to explain one or more panels.
 - Randomly select individuals from the class to explain one or more panels.
6. Each student should be able to explain the storyboard. Some credit can be given for the completion and explanation of the storyboard but the focus is on student learning of the indicator. The concept of living organisms changing and maintaining Earth's oxygen concentration should be understood by all the students.
7. Assign the post-assessment.

Differentiated Instructional Support:

Instruction is differentiated according to learner needs, to help all learners either meet the intent of the specified indicator(s) or, if the indicator is already met, to advance beyond the specified indicator(s).

- Have advanced students research the actual geological evidence which scientists use to determine the early atmosphere of Earth and how it changed to support the life that exists today.



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- Divide the lesson into smaller steps or give more time to accomplish the task if necessary.

Extensions:

- Challenge students to complete a detailed study of the geology of the rocks from the earliest known examples. Include in this study of rocks the radioactive dating methodologies that use isotopes and oxides of iron which help determine the presence of oxygen.
- Invite students to explore information about stromatolites (fossils of cyanobacteria and algae) or archaeobacteria.
- Investigate the current NASA findings on the escape of hydrogen into space as a larger part of the picture allowing oxygen from photosynthesis to remain and increase.

Homework Options and Home Connections:

- Have students conduct a Web search on cyanobacteria to see its structure and location in the environment. After students have discovered where cyanobacteria can be found, have them take a real or virtual field trip to see cyanobacteria in nature.

Materials and Resources:

The inclusion of a specific resource in any lesson formulated by the Ohio Department of Education should not be interpreted as an endorsement of that particular resource, or any of its contents, by the Ohio Department of Education. The Ohio Department of Education does not endorse any particular resource. The Web addresses listed are for a given site's main page, therefore, it may be necessary to search within that site to find the specific information required for a given lesson. Please note that information published on the Internet changes over time, therefore the links provided may no longer contain the specific information related to a given lesson. Teachers are advised to preview all sites before using them with students.

For the teacher: Earth science textbooks, science journals and magazines, paper, pencils, pens, markers.

For the student: Earth science textbooks, science journals and magazines, paper, pencils, pens, markers.

Vocabulary:

- aerobic
- anaerobic
- archaeobacteria
- atmosphere
- bacteria
- chemosynthesis
- cyanobacteria
- photosynthesis



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Technology Connections:

Students can use software to create the storyboard and develop it for a video production.

Research Connections:

Marzano, R., Pickering, D., Pollock, J. (2001). *Classroom Instruction that Works: Research-Based Strategies for Increasing Student Achievement*, Alexandria, Va.: Association for Supervision and Curriculum Development.

Nonlinguistic representations or imagery modes help students think about and recall knowledge. This includes the following:

- Creating graphic representations (organizers);
- Making physical models;
- Generating mental pictures;
- Drawing pictures and pictographs;
- Engaging in kinesthetic activity.

General Tips:

The earliest mineral deposits known show there was minimal free oxygen (O₂) in Earth's atmosphere. Rocks from approximately two billion years ago show increasing amounts of oxygen until around 500 million years ago when the oxygen content leveled off at around 21 percent.

Attachments:

Attachment A, *Storyboard Information*

Attachment B, *Post-Assessment*

Attachment C, *Post-Assessment Answer Key*



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Attachment A Storyboard Information

A storyboard is a timeline of events that are visually displayed for use in movies, commercials and animations. Today you are going to create a storyboard for Earth's changing atmosphere. Your storyboard will consist of seven frames.

The background information below summarizes the transformation of the Earth's atmosphere. Your job will be to fill in the details. The seven bullets below will be the content of one or more frames of the storyboard. Feel free to investigate further but keep it short and concise. Be prepared to explain the events of Earth's changing atmosphere.

Background Information:

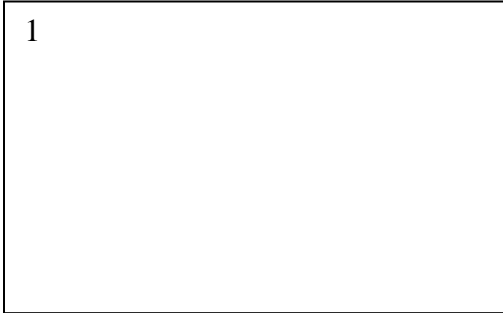
All living organisms must obtain a source of energy in order to carry out life processes. Bacteria are the simplest known life forms. The most ancient bacteria forms (archaeobacteria) can use the chemical energy in hydrogen sulfide or other inorganic molecules to provide that energy (chemosynthetic). Fossil evidence shows that cyanobacteria have existed on Earth for about 3 billion years. Cyanobacteria were able to use the electromagnetic energy of light to manufacture organic molecules through the process known as photosynthesis. The organic molecules contained chemical energy the cyanobacteria could use. The oxygen gas that was produced is poisonous to many of the anaerobic bacteria.

- Describe the composition of Earth's early atmosphere.
- Describe archaeobacteria and how they obtained energy.
- Describe cyanobacteria and how they obtained energy.
- Describe what cyanobacteria did to the atmosphere.
- Describe when the atmosphere began to change and how long the process continued.
- Describe what happened during this transition.
- Describe when the Earth's atmosphere began to stabilize.

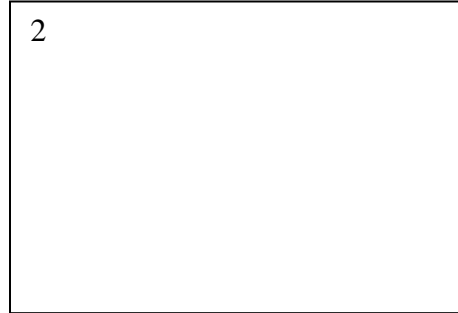
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Attachment A (Continued) Storyboard

1



2



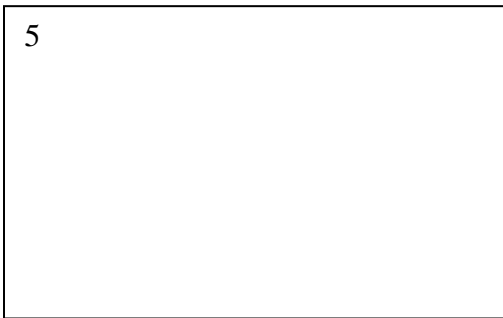
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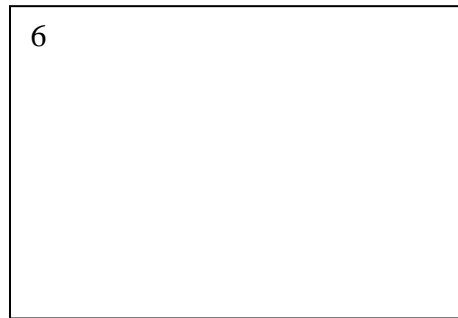
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6



7





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Attachment B Post-Assessment

1. Describe the composition of Earth's early atmosphere.
2. Describe archaeobacteria and how they obtained energy.
3. Describe cyanobacteria and how they obtained energy.
4. What did cyanobacteria do to the atmosphere?
5. When did Earth's atmosphere began to change and how long did that process last?
6. What happened during this transition?
7. When did the Earth's atmosphere begin to stabilize?



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Attachment C Post-Assessment Answer Key

Suggested answers:

1. The early atmosphere contained water, hydrogen cyanide, ammonia, methane, sulfur, iodine, bromine, chlorine and argon.
2. The earliest ancient bacteria are chemosynthetic. They can take in hydrogen sulfide as well as other inorganic molecules to manufacture organic molecules and give off some hydrogen in the process. These bacteria are thought to have become well established 3.5 billion years ago.
3. Cyanobacteria that appear around three billion years ago can use photosynthesis to produce food and give off oxygen as a waste product.
4. Earth's early atmosphere had very little oxygen (less than one percent). The level of oxygen started to increase three billion years ago and continued for the next two billion years.
6. As photosynthetic cyanobacteria increase, ancient chemosynthetic bacteria decrease. Oxygen is toxic to most chemosynthetic (anaerobic) bacteria.
7. Oxygen levels in the atmosphere become stable around 500 million years ago.