Teaching Activity: The Development of the Atmosphere

Introduction: About 4 billion years ago, the Earth's atmosphere consisted mainly of two poisonous gases, methane and ammonia and some water vapor. During this period in Earth's history, organisms as we know them were nonexistent and the only life forms that inhabited the planet were simple single-celled *prokaryotes,* that were able to synthesize the chemicals in the air for food and energy. Over several hundred million years, chemical reactions triggered by sunlight dissociated the methane and ammonia and some of the water vapor, and caused nitrogen, hydrogen and carbon dioxide to form. The breakdown of water vapor and the introduction of green plant photosynthesis supported the development of the ozone layer and allowed life to develop above the surface of the ancient oceans and on the land. Over millions of years of evolution, the composition of the Earth's atmosphere has been altered by the life processes of the organisms that inhabit it, as well as by complex chemical and geological processes.

Objective:

- To describe the formation of the Earth' atmosphere;
- To explain how chemical reactions in the atmosphere produced nitrogen, hydrogen and carbon dioxide;
- To describe the formation of the ozone shield;

Important Terms: Atmosphere, dissociation, compounds, chemical reaction, solar energy, ultraviolet radiation, microorganism, bacteria, photosynthesis, ammonia, methane, chemical formula;

Materials: Copy of information sheet "Development of the Atmosphere", paper/pencil, colored pencils, copy of blank comic sheets;

Procedure:

**** Reading Selection" Development of the Atmosphere"**

Part I: Vocabulary:

1. Students should write one sentence definitions of the 15 words listed on the activity sheet.
    - Discuss the reading selection with them prior to beginning this activity; it will cover most of the questions that will come up.

Part II: Critical Thinking/Problem Solving:

1. Students should answer the questions in this section using information the acquired in the reading selection, "Development of the Atmosphere".

Part III: Sequencing:

1. Create sequence of events list with the class from the reading selection "Development of the Atmosphere" before telling them to begin the illustration part of this activity.
2. In the blank comic sheets, students should illustrate the development of the Earth's atmosphere over the period from 4.5 B years ago to about 600 M years ago.
    - They should give the finished product a title.
    - When they have finished with the illustrations, they should cut out the rectangles and connect them with tape or glue in order from #1 - 7.
    - The students should write a one sentence explanation of the illustrations in each section and attach it to the strip of illustrations.

Student Activity Sheet: The Development of the Atmosphere

Introduction: About 4 billion years ago, the Earth's atmosphere consisted mainly of two poisonous gases, methane and ammonia and some water vapor. During this period in Earth's history, organisms as we know them were nonexistent and the only life forms that inhabited the planet were simple single-celled *prokaryotes,* that were able to synthesize the chemicals in the air for food and energy. Over several hundred million years, chemical reactions triggered by sunlight dissociated the methane and ammonia and some of the water vapor, and caused nitrogen, hydrogen and carbon dioxide to form. The breakdown of water vapor and the introduction of green plant photosynthesis supported the development of the ozone layer and allowed life to develop above the surface of the ancient oceans and on the land. Over millions of years of evolution, the composition of the Earth's atmosphere has been altered by the life processes of the organisms that inhabit it, as well as by complex chemical and geological processes.

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- To describe the formation of the ozone shield;

Procedure:

Part I: Vocabulary: Define each of the terms below in a complete sentence.
Ex: ion ---- An ion is an electrically charged particle.

1. atmosphere	6. carbon dioxide	11.ultraviolet radiation
2. methane	7. hydrogen	12. microorganism
3. ammonia	8. gravity	13. bacteria
4. chemical reaction	9. oxygen	14. photosynthesis
5. solar energy	10. ozone	15. composition

Part II: Critical Thinking/Problem Solving: Use the information that you found in the reading selection to answer the following questions.

1. What chemical process would you identify as being responsible for the disappearance of methane and ammonia and the presence of nitrogen, hydrogen and oxygen in the Earth's atmosphere? Explain.

2. Could animals have lived on ancient Earth before green plants? Explain.

3. Scientists are concerned that certain chemicals when released into the atmosphere cause the level of ozone to decrease. Predict what might happen to living things on Earth is the ozone layer continues to decrease.

Part III: Sequencing: In the blank comic sheets, create a set of illustrations showing how the Earth's atmosphere changed over the period from 4.5 B years ago to about 600 M years ago. (HINT: Use the sequence of events list that we created in class as a guide!)

- Give the finished product a title.
- When you have finished with the illustrations, cut out the rectangles and connect them with tape or glue in order from #1 - 7.
- Write a one sentence explanation of the illustrations in each section and attach it to the strip of illustrations.

4 B Yrs Ago

3.8. B Yrs Ago

3.6 B Yrs Ago

3.5 B Yrs Ago

700 M Yrs Ago

600 M yrs Ago

350 M Yrs Ago

Development of the Atmosphere

When astronauts walk in space, they wear space suits for protective covering. The suits enclose the astronauts in an artificial environment, providing them with comfortable temperatures, moisture and oxygen. The suits also protect the astronauts from harmful *ultraviolet (UV) radiation* given off by the Sun. In a similar way, the Earth's atmosphere provides protection for living organisms on the surface of the planet as well as some of the materials necessary to support life.

Cameras and other instruments aboard satellites have provided scientists with much data about the structure and composition of the present atmosphere. From this information, and from other research, scientists have developed a *theory* of what the Earth's atmosphere may have been like millions of years ago. They are certain that the atmosphere has changed over time and that the present atmosphere is still evolving.

The Past Atmosphere

Scientists think that the Earth's atmosphere of 4 billion years ago contained sizable amounts of two deadly gases: methane (CH_4) and ammonia (NH_3). Methane is made up of the elements carbon and hydrogen, and ammonia is made up of nitrogen and hydrogen; both substances are poisonous. There was also some water (H_2O) in the early atmosphere of the Earth. Obviously, the atmosphere is no longer deadly; in fact, we could not live without it. How did this change in the atmosphere's composition come about?

Try to picture the atmosphere of the Earth 3.8 Billion years ago. At that time, complex *photochemical reactions* among the methane, ammonia and water vapor in the air were triggered by incoming solar energy. As a result of these and many other reactions, new materials formed in the atmosphere, among them, nitrogen (N_2), hydrogen (H_2) and carbon dioxide (CO_2). The methane and the ammonia were broken down, or *dissociated*, but the water vapor remained.

With the dissociation of the methane and ammonia molecules, atoms of hydrogen (H_2) and oxygen (O_2) were released into the air. Because hydrogen is such a light element, it escaped the Earth's gravitational pull, and disappeared into space. Nitrogen was left in greatest abundance, along with carbon dioxide and water vapor. Eventually, water vapor molecules also encountered solar energy, were broken down and release more hydrogen atoms into the atmosphere, as well

as atoms of oxygen. As before, the lightweight hydrogen atoms escaped to space, while oxygen atoms underwent reactions with one another to form a gas known as ozone (O_3). As the level of ozone in the atmosphere increased, a layer was formed in the stratosphere, about 30 km above the Earth's surface, known as the *ozone layer.*

The ozone layer is sometime referred to as an "umbrella" for life on Earth. Ozone absorbs most of the harmful ultraviolet (UV) radiation from the Sun, shielding the organisms on the surface from serious cellular damage. Before the ozone layer formed., the only living things on Earth were microscopic organisms living far below the surface of the oceans, where the sea water protected them from most of the UV radiation. After the ozone layer formed, some types of microorganisms began to appear on or near the surface of the water, and eventually ventured out onto land. The *blue-green bacteria* used the energy in sunlight to combine carbon dioxide in the air with water to produce food and release oxygen. These organisms were the first *photosynthesizers.*

As the by-product of photosynthesis, oxygen would change the planet forever. Unlike ozone, which formed high in the atmosphere, oxygen remained near the surface of the planet. It was this gas that the animals that developed later would breathe. In time, the blue-green bacteria were joined by more complex green plants on the surface; more carbon dioxide was taken in and more oxygen released, greatly increasing the O_2 content of the atmosphere. Around 600 million years ago, the amounts of oxygen and carbon dioxide began to level off and acquire their present atmospheric concentrations. Since then, the composition of the atmosphere has been fairly constant.