**How has the Atmosphere Changed over time, and what were the Causes of Those Changes?**

**Introduction**: The Earth is composed of a complicated, interdependent set of systems (the Hydrosphere, the Atmosphere, the Geosphere, and the Biosphere), and the formation and evolution of the Earth’s atmosphere is a beautiful example of the ways in which these 4 systems interact with each other to produce changes over time. Scientists know that the Earth’s present atmosphere is quite different from the way it was 4.5 billion years ago, and they also know that the atmosphere has continued to change in many ways since the Earth was born 4.5 billion years ago. Some evidence for this change has been collected through drilling for ice cores in the arctic. Gases become trapped in ice over time, and as more ice accumulates, a record of the percentages of each type of gas becomes preserved in the ice.

Current scientific theory explains that while the surface features of the Earth developed, volcanic activity and other processes injected large amounts of gaseous materials into the atmosphere. These events determined the reflectivity and the heat absorbing properties of the early Earth (that is, the Earth’s ability to absorb heat energy from the Sun has changed through time). Somehow, the basic components of life-- carbon, hydrogen, oxygen, and nitrogen-- were synthesized into simple organic molecules from which the first life forms emerged. Or perhaps the first molecules of life appeared from beyond the Earth, arriving in debris from a comet or meteor. Scientists aren’t sure, but they think that this event occurred in the first half billion years of the Earth’s history in an atmosphere with practically no oxygen. One example of atmospheric changes due to the influence of other Earth systems (in this case, the Biosphere) can be seen in the rise of Archaea and cyanobacteria (the first primitive photosynthetic organisms) in the primitive Earth. They evolved to survive in an oxygen-free environment. These primitive ocean organisms apparently thrived in an atmosphere that was predominately water vapor and carbon dioxide. They evolved to use the process of photosynthesis, using the water and CO2 in their environment to live-- and they released oxygen gas in the process, producing the O2 found in our atmosphere today.

**Objectives**: You will be working with information about the Earth’s early atmosphere as well as important events that took place over the course of Earth’s history. Using this information you will:

* make a prediction about the plot percentages of atmospheric gases;
* create a cumulative graph depicting changes in the atmosphere over time;
* identify geological events during the same time period;
* interpret the graph by relating events to the changes in the atmosphere.

In the table below, make predictions about what you think might have happened to certain gases in the atmosphere over time. Think about whether a certain gas might have become more prevalent over time, or if perhaps the amount of that gas in the atmosphere has decreased.

|  |  |
| --- | --- |
| **Gas** | **Predicted change since Earth’s beginning to present** |
| Carbon Dioxide |  |
| Nitrogen |  |
| Hydrogen |  |
| Oxygen |  |
| Other Gases |  |

**Procedure:**

1. The first data table below illustrates the composition of the Earth’s atmosphere at different times in the planet’s history. You will be making a line graph of the information in the Data Table. Place “Billions of Years Ago” on the x-axis and “Percentage of the Atmosphere” on the y-axis. Be sure to give your graph an appropriate title and label each axis. Also be sure to **BE NEAT!!!!!!!!!** The graph that you are making is called a CUMULATIVE GRAPH. On this graph, you will be plotting the SUM of the percentages, rather than the actual percentage of the gas itself. For example, 4.5 Billion years ago carbon dioxide made up 80 % of the atmosphere. So on your graph put a dot at 80 for carbon dioxide at 4.5 bya. Nitrogen made up 10% of the atmosphere: 80 + 10 = 90%, SO PUT A DOT FOR NITROGEN AT 90 for 4.5 bya. Hydrogen made up 5% of the atmosphere at that time, and 90 + 5 = 95%, so put a dot at 95 for hydrogen gas at 4.5 bya. Continue graphing in this way for the remainder of the data, up to the present time.

* Plot the information for each gas by placing a dot with a colored pencil for each data point.
* Use a different color for each gas.
* Connect the dots for a specific gas with the same color you used to make your data points.
* Create a key indicating the color and type of gas each line represents.

5. The second data table lists some important events in the Earth’s history. Write each event beneath the graph next to the time that it occurred.

6. When you have completed the graphing part of the activity, complete all of the questions on your report sheet.

**Data Table #1: Composition of Earth’s atmosphere from the Earth’s Formation to the Present**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Billions of Years Ago (BYA) | | | | | | | | | |
| Gas | 4.5 | 4.0 | 3.5 | 3.0 | 2.5 | 2.0 | 1.5 | 1.0 | 0.5 | Present |
| CO2 | 80 | 20 | 10 | 8 | 5 | 3 | 1 | 0.07 | 0.04 | 0.025 |
| N2 | 10 | 35 | 55 | 65 | 72 | 75 | 76 | 77 | 78 | 78 |
| H2 | 5 | 3 | 1 | 0.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| O2 | 0 | 0 | 0 | 0 | 0 | 1 | 5 | 10 | 15 | 21 |
| Other | 5 | 42 | 34 | 26 | 23 | 21 | 18 | 13 | 7 | 1 |

**Data Table #2: Major Events in Earth History**

|  |  |
| --- | --- |
| Geological Event | Billions of Years Ago (BYA) |
| Origin of Earth | 4.5 |
| Formation of oldest known bedrock | 3.9 |
| First evidence of organic matter in rocks | 3.7 |
| Photosynthesis evolves in plants | 3 |
| Limestone deposits become common | 1.8 |
| Earliest land plants | 0.44 |
| Earliest land animals | 0.4 |
| Dinosaurs dominate | 0.17 |

Names: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Report Sheet: Changing Atmospheric Gases and the Causes of Those Changes**

1. How old is the earth? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2. What gas has made up the largest portion of the Earth’s atmosphere for most of Earth’s history?

\_\_\_\_\_\_\_\_

3. What gas has gone from virtually non-existent to abundant over the Earth’s history? \_\_\_\_\_\_\_\_

4. Which gas has been virtually nonexistent in the atmosphere since about 3.0 BYA? \_\_\_\_\_\_\_

5. Which gas appeared in the atmosphere just before limestone deposits became common? \_\_\_\_\_\_\_

6. For about how long was CO2 the dominant gas in the atmosphere? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**III. Conclusion**

Using your graph, Data Tables 1 and 2, and the information in statements a-f below, answer the following conclusion questions. Be sure to relate each of your answers to the amounts of gases present in the atmosphere, as well as major events in Earth’s history.

a. Plants use carbon dioxide and produce oxygen gas in the process of photosynthesis.

b. Small sea animals create shells made of calcium carbonate which is the main component of limestone.

c. From about 4.4 BYA to 4 BYA, oceans were formed from water that was released by volcano venting and water-containing comets that bombarded the earth.

d. Gaseous carbon dioxide from the atmosphere can dissolve in water.

e. Hydrogen is much less dense than other gases.

f. The early earth had a lot of ammonia which contains nitrogen. Ammonia can be broken down by sunlight to release nitrogen gas.

1. Why do you think that the concentration of hydrogen Earth’s atmosphere decrease so early in the Earth’s history? Note: hydrogen is the smallest and least massive atom.

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2. Why did the level of carbon dioxide decrease so dramatically from 4.4 BYA to 4 BYA?

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3. Why do you think that the percentage of oxygen in the atmosphere began rising when it did?

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4. Why do you think that limestone deposits began showing up around 1.8 BYA? What is limestone made out of?

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