Activity C Student Guide

Why is Carbon an Important Element?

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Overview

The Earth's atmosphere plays a large role in making the Earth habitable by helping to keep the surface of the planet warm. As you already learned, the atmosphere is made up of matter. So which types of matter in the atmosphere contribute to this warming effect? Atmospheric scientists have studied the different molecules of matter found in the atmosphere in order to determine the answer to this question. Many of these molecules that have the potential to warm the atmosphere are in a gaseous state. They are known as **greenhouse gases**.

Greenhouse gases are more effective at absorbing the heat escaping from the Earth's surface than other gases found in the atmosphere. Remember Earth's surface is warmed by the radiant energy from the sun. This re-radiated energy in the form of heat that is absorbed by the atmosphere helps produce the global temperature of our planet. Because in some ways this process behaves similarly to a real greenhouse, it is known as the greenhouse effect. However, the analogy is not completely representative; there are differences important fully understand how the greenhouse effect works. A greenhouse used for growing plants is generally warmer inside than outside because the glass walls trap heat inside the greenhouse. In the case of the atmosphere, the heat is actually absorbed by the molecules, not trapped. A number of the heat-trapping greenhouse gases contain the element carbon. Two of the most well known are carbon dioxide (CO_2) and methane (CH_4).

Not only does carbon play a crucial role in making the planet warm enough to support life, carbon is also an essential molecule in the tissues of living organisms. Carbon is considered the 'backbone' of larger molecules that make up the cell structures of all living organisms. DNA, RNA, proteins, fats and sugars are all carbon-based molecules. So as you can see carbon is an important element of life.

In addition many living organisms release carbon as a by-product of energy production. As energy is produced by cells of living organisms from the breakdown of sugars, these cells can then sustain life, and in so doing, allow the organism itself to sustain life. This process is called respiration. By exhaling this by-product of respiration, every person in the room is adding to the carbon content of our atmosphere.

So there is carbon in the atmosphere, carbon in the make up of living cells, tissues and organisms and carbon is produced by organisms as they create energy to live. But how does carbon move around through all of these structures and processes? Is there a way for carbon to get from the atmosphere into the tissues of living organisms? Yes. This process is called photosynthesis.

During the process of photosynthesis, the carbon from the atmosphere, in the form of molecules of carbon dioxide, is combined with molecules of water in plant tissues to form the longer chained molecules of

carbon. These longer chained molecules eventually are used to make the molecules found in all living tissues. When you eat vegetables and fruits, you are consuming the carbon that was taken out of the atmosphere by the plants. And when you eat meat, you are eating carbon-based molecules that were first produced by plants from atmospheric carbon, and then converted into similar but different molecules by the animal that ate the plant to make animal tissues.

In this activity, your group will continue studying the carbon cycle, the importance of carbon-based molecules like carbon dioxide in the atmosphere and how the amount of carbon in the atmosphere changes. You will look at data on global temperature and atmospheric carbon dioxide levels obtained from a variety of meteorological stations to illustrate why carbon dioxide can be understood as one of the greenhouse gases.

Learning Objectives

- ✓ Understand the concept of a cycle
- ✓ Understand the effects of the atmosphere on global temperatures
- ✓ Review the importance of elemental carbon within Earth's carbon cycle

Relevance

Carbon is an essential building block of life. Scientists around the world are hard at work studying whether the unprecedented increase in human activities that produce atmospheric carbon dioxide emissions over the past century may be altering the carbon cycle.

As far back as 1896, Swedish chemist, Svante Arrhenius, hypothesized that growth in the world's population and industrial activities like the burning fossil fuels from coal, oil that produce Carbon Dioxide would produce a global warming of Earth's temperature. In affect, a global experiment was beginning whereby humans were emitting large amounts of atmospheric CO_2. What will the effects of this increase have on both biotic and abiotic factors around the globe? Additionally, the interrelated nature of the Earth system raises further questions to answer about how changes in atmospheric carbon levels (an abiotic factor) may impact other factors such as global and regional economies and human health.

Investigation – Part 1 Activity C

Temperature and Carbon Dioxide

Materials

- ✓ Data tables of Average Temperature at Mauna Loa, Atmospheric Carbon Dioxide
- ✓ Concentrations at Mauna Loa and Global Temperature over time
- ✓ Graph paper or computer program to create graphs from the data
- ✓ Global Vegetation Map (Used in Topic 2, Activity A)
- ✓ Atmospheric Wind Circulation diagram

Period 1 – How are Temperature and Carbon Dioxide Concentrations Related?

In this activity you will be asked to create a variety of graphs of real world data from meteorological stations located in different places around the globe. Your graphs will then be used as evidence for the discussion and conclusions that you will make in responding to the question: How are temperature and CO2 concentrations related? You can create the graphs by inputting data to Microsoft® Excel spreadsheets or using the pencil and graph paper method.

Preliminary Activity – The Carbon Cycle

Using the terms list below, create a diagram (mind map) that shows how each of the words or phrases is related to one another. Use arrows to connect and show the flow of one concept to another. Then show your diagram or mind map to the rest of the class and explain your connections. On Data Sheet 1: Mind Mapping, draw a revised map based on everyone's ideas.

Terms List: a) Carbon in Plant Tissue b) Carbon in Fossil Fuels c) Carbon in Animal Tissue
d) Process of Respiration e) Atmospheric Carbon e)Process of Photosynthesis
f) Process of Combustion (Burning)

Methods

Data Analysis, Comparison and Consensus

1. Graph the Atmospheric Carbon Dioxide Concentrations at Mauna Loa versus the Time data set. Your teacher will provide the data to produce the graphs. Then interpret your results.
2. Graph the Average Temperature at Mauna Loa versus the Time data set to draw. Your teacher will provide the data to produce the graphs. Then interpret the graph.
3. Discuss with your group the observations that can be made. Remember to keep your conclusions specific to the results and record them in Data Sheet 2: Graphing CO2 and Temperature.

Data Sheet 1 Activity C

Mind Mapping

Using the terms list below, create a diagram (mind map) that shows how each of the words or phrases is related to one another. Use arrows to connect and show the flow of one concept to another.

Terms List:

1. Carbon in Plant Tissue
2. Carbon in Fossil Fuels
3. Carbon in Animal Tissue
4. Process of Respiration
5. Atmospheric Carbon
6. Process of Photosynthesis
7. Process of Combustion (Burning)

Data Sheet 2 Activity C

Graphing CO_2 and Temperature

Draw graphs for each of the data sets below, and then answer the questions that follow.

1. Atmospheric Carbon Dioxide Concentrations at Mauna Loa and Time data set

a) Describe two general trends using this result.

b) Explain why there are changes in the carbon dioxide concentrations each year.

c) If working on a computer, change the y-axis scale to start at 0 ppm of carbon dioxide. (If using pencil and graph paper, see teacher handout). Describe your result now with this change to scale of the y-axis.

2. Average Temperature at Mauna Loa and Time data set

a) Describe the general trend shown by the graph (hint – Compare January temperature in 1958 to 2002 values and compare July temperature in 1958 to the 2002 values)

b) Account for the differences of temperature in 1960 between the January and July data.

c) If the graph showed only the data points between 1966 and 1975, what might you have concluded? How do scientists keep from making these errors?

3. Record some of your conclusions comparing your number 1 and number 2 graphs.

Investigation – Part 2 Activity C

Think Globally

Period 2: How are local characteristics related to global conditions?

Preliminary Activity – Engagement

Examine the Global Vegetation Map and the Atmospheric Wind Circulation Patterns diagram. Answer the following questions. Be sure to write your answers down on paper.

1. Locate the Hawaiian Islands.
2. How do you think the trends observed in your graphs from the previous period may affect other places on the globe? Why?
3. How do you think that the Mauna Loa site may be affected by these global circulation patterns?
4. Discuss your ideas with your partner.
5. Be prepared to share their ideas with the class.

Methods

Now that you have an introduction to the relationship between Carbon Dioxide concentration at Mauna Loa and temperature, how does this compare with global changes in temperature?

Enter the data points for Global Temperature and time information onto the graph of Atmospheric Carbon Dioxide Concentrations at Mauna Loa and Time graph you made earlier You will now have two lines on this graph so be sure to label them clearly. This graph is representative of the global temperature and global carbon dioxide concentrations over this period of time.

Discuss within your group the observations that can be made at this point. Remember to keep your conclusions specific to your results. Record some of your conclusions and answer the Investigation Questions at the conclusion of this activity.

Investigation Questions Activity C

Think Globally

Graph the average global temperature data on to the Mauna Loa Atmospheric Carbon Dioxide Concentration and Time graph. Therefore, you will have two curved lines on the single graph so be sure to label them clearly, or use different colors for each line. This graph is representative of the global temperature changes and the global carbon dioxide concentration changes over a period of time.

1. What basic conclusions can you make comparing these two graphs?

a) It would not be scientifically valid to assume a relationship between these two data sets based only on this data. The relationship needs to be backed up or verified. Based on what you learned about the carbon cycle and atmosphere explain why scientists link these two sets of data.

b) The carbon dioxide concentration graph was used both for the local and the global graphs, but the temperature data sets were different. Why?

2. Do you believe there are any limitations in these data sets that should be consider? If so, explain.