Global Warming: Is the Earth Like A Greenhouse?

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INTRODUCTION

Climate change and global warming are well up on the current political agenda. There are urgent questions everyone is asking: are human activities altering the climate? Is global warming a reality? How big are the changes likely to be? Will there be more serious disasters; will they be more frequent? Can we adapt to change or can we change the way we do things so that we can slow down the change or even prevent it occurring? Because the Earth's climate system is highly complex, and because human behavior and reaction to change is even more complex, providing answers to these questions is an enormous challenge to the world's scientists. As with many scientific problems, only partial answers are available, but our knowledge is evolving rapidly.

Global warming and ozone depletion are examples of global pollution – pollution in which the activities of one nation can affect all people and all nations. It is only during the last thirty years or so that human activities have been of such a kind or on a sufficiently large scale that their effect can be significant globally. And because the problems are global, all nations have to be involved in their solution.

All life on Earth owes its existence to the greenhouse effect. Large quantities of greenhouse gasses in the Earth's early atmosphere kept the temperature within tolerable limits for life to flourish.

Since we control the climate to a certain extinct, it is uncertain what long-term effects human actions in the biosphere will have on the world as a whole. It is becoming more apparent, however, that as man continues to use the Earth's resources, the climate could change in such a way that it is no longer benevolent to mankind. There also is a consensus among scientists that atmospheric concentration of average temperatures can be attributed to atmospheric concentrations of greenhouse gasses. Thus, while much is known about greenhouse warming phenomena, there remain great uncertainties.

OBJECTIVES

I teach a very unique group of students. My classes consist of students with lower mathematics background. It is my responsibility to teach the students basic concepts of chemistry and physics and simultaneously to teach the students math skills. My goals are to provide support and create a structural environment whereby my students can reach their individual capabilities. The assignments are designed to meet the individual needs of my students.

I am designing a one semester project-based unit to identify and model the greenhouse effect. This session will allow students an opportunity to build and test a physical model analogous to the atmospheric greenhouse effect and provide students practice in setting controlled experiments, accurately recording data, graphing, and interpreting the results. By the time the students complete this unit, they will be able to identify the major greenhouse gases and identify the human activities that are changing the Earth's atmosphere.

This unit will recall what is known about the greenhouse effect, and order and classify information about the greenhouse effect. The students will identify main ideas about how the earth 's atmosphere produces the greenhouse effect and will identify relationships between solutions to global warming and their results. They will elaborate and summarize possible solutions to global warming while engaging in metacognative thinking. The students will predict how the earth may be compared to a greenhouse. Students will make models of a greenhouse and compare it to the Greenhouse Effect. The physical model will be constructed out of familiar materials. The students will have an opportunity to build and test a physical model. Analyze and give students practice in setting up controlled experiments accurately, recording data, graphing and interpreting the results. The students will answer the following questions.

1. Why do we need a model of the atmosphere?

2. What things were different in this experiment and the real Earth's at the atmosphere?

3. How high does the atmosphere go?

4. What is the equilibrium temperature?

The students will use the HOBO (Heat Operation Based Option) temperature logger, which has its temperature sensor, a device whose resistance changes inversely by large amounts with temperature changes, inside the box. This HOBO temperature logger has an internal calendar and clock, and you can set this calendar and clock to match your computer. My students will use the temperature logger to collect data for this unit.

In connection with this project, my students will observe how different Earth materials heat up differently due to color. The students will touch the pavement, parking lot, grass areas, rocks and building to feel the difference.

BACKGROUND INFORMATION

Global Warming

The temperature of the earth is kept warm due to gases, such as carbon dioxide, in the atmosphere. The atmosphere gases trap warmth from the sun, just as glass traps warmth in a greenhouse effect. Scientists think the earth's atmosphere is getting warmer because of the increase of carbon dioxide production. We can find out more about greenhouse effect. The burning of fossil fuels is considered the major cause of the increase in carbon dioxide , but other factors contribute to the increase of this gas. What are they? If the earth's atmosphere is getting warmer, how much warmer is it? What effect does this extra heat have on the earth's environment? Can the warming be stopped?

Some rays from the Sun never reach the Earth. They bounce back into space off the clouds. About 50% of the rays reach the earth and bounce off sand, ice or snow. About half of all rays are absorbed by things on the ground such as fields, pavement, houses, and lakes. Dark places like roads and plowed fields get very hot in the Sun. The warmed places of the Earth give off heat like warmed flowerpots in a greenhouse. Some of the heat passes into space, but the air surrounding the Earth traps some of the heat. This raises the temperature of the Earth about 60 degrees Fahrenheit (35 degrees Celsius) higher than it would be without an atmosphere. The above factors create a temperature balance, and living things have adjusted to it.

The blanket of air surrounding Earth is called the atmosphere. There are four major layers of the atmosphere. Two gases make up almost all of the lower atmosphere where we live. These gases are nitrogen, oxygen and water vapor a greenhouse gas is also an important component. The other gases are trace gases are trace and they trap heat and keep it from going immediately back into space. These gases are called greenhouse gases. Some greenhouse gases are produced by human activities.

Global warming could alter rainfall, wind, and heat patterns around the world. If the earth warms, polar ice caps could melt; resulting in sea level rises, which would endanger many people since some of these areas are heavily populated.

The agricultural belts of the world could be altered, severely disrupting the economy of food-exporting nations which may not be able to adapt. They might have moved to a more suitable environment, but migration could be blocked by urban development and other human activities that destroy habitats. Global warming might improve some areas. Cold uninhabited places could become warmer. Dry uninhabited places could become wetter, making farming possible where it is not now.

Students will identify lifestyles and local and international strategies for dealing with potential global warming. The reason the students will complete this unit is to obtain a better understanding and gain knowledge of facts about global warming as it is compared to the greenhouse effect. It is important that the students are aware of the causes of and sources of the Greenhouse Effect. The amount of carbon dioxide in the atmosphere has been increasing rapidly. Human activities are also releasing other “greenhouse” gases such as methane, chloroflurocarbons that intensify the heat trapping properties of the atmosphere as a whole. Chloroflurocarbons also rise into the upper layer of the atmosphere, the stratosphere, where they destroy the protective layer of the ozone, a gas that forms a shield against ultra violet rays that can harm many forms of life. There is growing concern about the effects of these atmospheric changes, which could bring on rapid and profound changes in climate.

The unit will begin by identifying reasons for concern about the atmosphere changes. More and more people are using energy, by driving cars for example. Increasing the use of fossil fuels has been part of the process development and industrialization. Deforestation is in part caused by pressure to meet the needs of the increasing population. According to estimates made by The Food and Agricultural Organization of the United Nations, during the periods 1981-1990 dense tropical forest through out the world disappeared at a rate of over 40 million acres a year. This figure represents an area the size of the state of Washington.

What do a car idling in city traffic and a smoke stack a on an electric power plant have in common with rice plants standing in a wet Chinese field and a herd of cattle on South America range land? Although this riddle may seem difficult, the answer will be clear after this unit. How does the greenhouse effect work as seen through the eyes of Jack Williams. The sun’s energy warms the Earth. The Earth radiates away heat as infrared energy. Molecules of carbon dioxide and other greenhouse gases interrupt some out going infrared energy, and radiate it back toward the Earth. Humans activity especially burning fossil fuels, add greenhouse gases to the atmosphere. Many scientist fears that added greenhouse gases will send too much heat back, warming the Earth and changing the climate.

Usually the term greenhouse effect has a negative connotation. It’s usually associated with global warming and as a one of the dire consequences of industrial growth. But without the greenhouse effect, life as we know it would not exist on Earth. Our planet’s average temperature would be closer to 0^{o} F than 59^{0}F it now enjoys. Heat and cold air balance out. This is what the debate over the “greenhouse effect” is all about. Many scientist fear that pollution is changing the atmosphere in ways that will reduce the amount of infrared energy being sent into space. If that happens the Earth will warm up before a new balance between incoming and outgoing energy is struck.

There is no doubt that the so-called greenhouse gasses absorb energy-this can be demonstrated in the laboratory. According to R. Coppock, scientist also agrees that these gasses can trap energy when present in the atmosphere. Without the naturally occurring greenhouse gases, mostly water vapor, carbon dioxide, and methane, the planet would be about 33^{o} C colder than it is. The trapping of energy by trace gasses-the greenhouse effect-thus is not necessarily bad. There is widespread, but not unanimous, agreement that global means temperature has $0.3\text{-}0.6^{0.}$ cover the last 100 years. There is contentious debate, however, about whether this global average temperature can be attributed to atmospheric concentrations of greenhouse gasses. There are two main issues. First, carbon dioxide (CO_2) is the dominant atmospheric greenhouse gas, but the location of more than 40 percent of the carbon dioxide emitted into the atmosphere is unknown. Thus, while much is known about greenhouse warming, there remain great uncertainties.

See Illustration 1 below.

The 1990 concentrations have been estimated on the basis of an extrapolation of measurements reported for earlier years, assuming that recent trends remained approximately constant. Net annual emissions of CO_2 from the biosphere not affected by human activity, such as volcanic emission, are assumed to be small. Estimates of human –induced emissions from the biosphere are controversial. In Table 1, ozone has not been included because of the lack of precise data. Here ppmv = parts per million by volume, ppbv = parts per billion by volume, and pptv = parts per trillion by volume. The source of this table is the Committee on Science, Engineering, and Public Policy.

So back to the question—Is the world getting hotter? This question was first studied in the 1890's by Nobel Prize-winning Swedish scientist Svante Arrehnius. He tried to bring what he then termed the greenhouse effect to the public's attention. His concerns were prompted by the simple premise the world was then burning a lot of coal and oil. His studies lay dormant until the late 1930's, when a British meteorologist cautioned that a warming induced by carbon dioxide was in fact already taking place. His opinion was rejected by scientists who were convinced that there were plenty of room in the ocean to absorb any increase in the amount of atmospheric gases

Causes of Global Warming

The causes of global warming are widespread. If one cause had to be singled out as the leader, it would be simply the number of people now crowding this planet. This growing mass of human beings-now just over 5 billion, and expected to double in the next 60 years-spews increasingly more greenhouse gases into the air every year. We do it by using more energy, driving more miles, and producing more garbage. Because global warming is fueled by so many different gases, it may turn out to be the most difficult to cure of all the world's environmental ills. Ridding the world of the multitude of activities that fuel the greenhouse buildup is impossible. Just getting up in the morning starts the cycle: when you turn on the bathroom light, it probably uses electricity generated by the burning of fossil fuels, which pump pumps carbon dioxide into the sir. The refrigerator that keeps your orange juice cold is lined with another contributor to the greenhouse shield-chlorofluoro-carbons. Driving to work burns gasoline, which sends millions of particles of carbon dioxide into the atmosphere. The mahogany desk that you work at may have come from a tree in the rain forest, and that tree once helped absorb carbon dioxide from the atmosphere. Even the rice on your plate at lunch time contributed, by giving off methane gas when it was grown.

Albedo Effect

While thinking about global warming, life on Earth owes it existence to the greenhouse effect. Large quantities of greenhouse gases in the Earth's early atmosphere kept the temperature within tolerable limits in order for life to flourish. The phrase "global warming" has become familiar to many people as one of the important environmental issues of our day.

Surface temperatures were maintained at high levels due mostly to the greenhouse effect. Greenhouse gases, mostly carbon dioxide and methane along with water vapor, held in much of the heat received from the sun. Opposing the greenhouse effect were thick clouds of condensed water vapor that completely surrounded the planet. The clouds reflected the Sun's rays back into space by what is called the albedo effect (fig 1). The clouds also kept some of the surface heat from escaping into space by reflecting it back to the ground.

When sunlight strikes very small objects, such as air molecules and dust particles, the light itself is deflected in all directions—forward, sideways, and backward. The distribution of light in this manner is called *scattering.* Because air molecules are much smaller than the wavelengths of visible light, they are more effective scatters of the shorter (blue) wavelengths than the longer (red) wavelength. Hence, when we look away light strikes our eyes from all directions, turning the daytime sky blue. At midnight midday, all the wavelengths of visible light from the sun strikes our eyes and the sun is perceived as almost white. At sunrise and sunset, when the white beam of sunlight must pass through a thick portion of the atmosphere, scattering by air molecules removes the blue light, leaving the longer wavelengths of red, orange, and yellow to pass through, creating the image of a ruddy or yellowish sun.

See Illustration 2 below.

The percent of radiation returning from a surface compared to that which strikes it is called the *albedo* of the surface. Albedo, then, represents the reflectivity of the surface. We have seen that clean white snow reflects up to 95 percent of the solar radiation that reaches it. Such snow can have an albedo as high as 95 percent. The albedo of water surface depends upon the angle at which the sun strikes it and whether the surface is smooth or rough.

According to Donald Ahrens (1991), most grassy fields, plowed fields, and rocky areas have albedos of between 10 and 30 percent (see Table 3 below). Thick clouds have a higher albedo than thin clouds. On the average, the albedo of clouds is near 60 percent while the albedo of the moon is about 7 percent. This means that out of all the solar radiation that hits the moon's surface, only 7 percent is reflected. What does this fact tell us about the surface color of most moon rocks? It indicates that, because moon rocks reflect so little sunlight they must be good absorbers. That is, they tend to be dark in color.

See Illustration 3 Below.

We can see that on an annual global average, the Earth and its atmosphere redirects about 30 percent of the sun's incoming radiation back to space. This gives the Earth and its atmosphere a combined albedo of 30 percent of the sun's incoming radia*tion back to space. This* gives the Earth and its atmosphere a combined albedo of 30 percent. Of the remaining solar energy, the atmosphere and clouds absorb about 19 percent, and about 51 percent reach the lower atmosphere to warm the surface. The surface, in turns, warms the air above it.

In order to determine which materials absorb more heat, students will use white or black tempera paint or construction paper paced close to an incandescent light or direct sunlight. Monitor the temperatures using thermometers or touch. Students while observing how different Earth materials heat up differently due to color, can touch the parking lot, grass areas, rocks, and buildings to feel the difference.

Balancing Act

All life on Earth owes its existence to the greenhouse effect. Large quantities of greenhouse materials in the early atmosphere kept the temperature within tolerable limits in order for life to flourish. The phrase "global warming" has become familiar to many people as one of the important environmental issues of our day.

Surface temperatures were maintained at high levels due mostly to the greenhouse effect. Sunlight was still about 10 percent less than it is today, but greenhouse gasses, mostly carbon dioxide held much of the heat received from the Sun.

If the Earth and all the things on it are continually radiating energy, why doesn't everything get progressively colder? The answer is that all objects not only radiate energy; they absorb it as well. If an object radiates more energy than it absorbs, it gets colder; if it absorbs more energy than it emits, it gets warmer. On a sunny day, the earth's surface warms by absorbing more energy from the sun and the atmosphere than it radiates, while at night the Earth cools by radiating more energy than it absorbs from its surroundings. When an object emits and absorbs energy at the same rate, its temperature remains constant.

The rate at which something radiates and absorbs energy depends on its surface characteristic, such as color, texture, and moisture, as well as temperature. For example, a black object in direct sunlight is a good absorber of radiation. It converts energy from the sun into internal energy, and its temperature ordinarily increases. Good absorbers are also good emitters of radiation.

Lesson 1: Modeling the Greenhouse Effect

The objectives of this session are to; (1) provide basic information about the Earth's atmosphere and how scientists use models to study it; (2) provide students with an opportunity to build and test a physical model analogous to the atmospheric greenhouse effect; (3) introduce the concept of energy transfer and thermal equilibrium; and (4) give students practice in setting up controlled experiments, accurately recording data, graphing, and interpreting the results.

Materials

White chalk and chalk board	marking pen and butcher paper
A piece of string, 41/2 feet long	scissors

Each Group Needs

2 two-liter plastic soda bottles	2 thermometers
3 strips of thin cardboard 11/2X1"	2 markers (one red, one green)
1 rubber band	6 cups of potting soil
1 100 watt light bulb	1 piece of plastic wrap (6X6")
1 clip on lamp	1 plastic 8oz cup
2 graphing data sheets	

Procedures

1. Tie a piece of chalk to a length of string. Place your foot on the loose end of the string, and draw an arc on the board, with radius of about four feet. Tell the students that the arc represents the surface of the Earth.

2. Invite the students to suggest how far the Earth's atmosphere would extend above the surface in this drawing.

3. Tell the students that scientist have found that over 90% of the Earth's atmosphere lies within about 10 miles of the Earth's surface. The scale of this drawing is about 1 foot = 1,000 miles.

4. Add that the space shuttle orbits well above the Earth's atmosphere. (Draw a little space shuttle about 2" above the chalk-line).

5. Explain that another way of understanding how far out the atmosphere extends is to imagine the Earth shrunk to the size of an apple. At that scale, the atmosphere is only the thickness of the skin of the apple.

Before Day of Activity

1. Collect 2-liter plastic soda bottles (two for each team of four). Cut them off at the point where they begin to narrow at the neck.

2. Tagboard or manila folders can be used to make a strip of thin cardboard,1/2 inch wide by 1" long, to be used as a spacer, to locate the two bottles exactly ½ inch from the light bulb. Cut two squares of the cardboard to cover the bulb of the thermometer so that they are shaded from the rays of the light bulb.

Day of Activity

1. Tie the chalk onto one end of the string and practice drawing an arc with a four foot radius.

2. Make copies of he graphing data sheet. (one copy for every two students).

3. Close windows, window shades, and doors so classroom is free of draft and direct sunlight.

4. Assemble the clip-on lights, bulbs and stands. Each bulb should be standing upright between two bottles.

5. Tape the thermometers and cardboard strips inside the bottles.

6. Using a cup to measure, pore about 12 ounces of dry soil into each bottle.

7. Place clear plastic wrap over the bottle, securing it with a rubber band.

Discuss the homework

Before you began to build your model, you need a clear idea of what the atmosphere is like.

The Greenhouse Experiment

1. Assemble students into groups of fours. Do not distribute equipment yet. Explain that the air in the bottle is going to "model" the Earth's atmosphere when it is exposed to rays from the Sun. Ask the class "What is going to model or represent the Sun? (The light bulb)

2. Explain that because the experiment is going to measure the temperature of the air when exposed to light rays each bottle needs a thermometer inside.

3. One of these bottles will be the "control" and nothing more will be done to this.

4. Pass out the equipment. Have each group cover one cover one of the bottles with plastic wrap.

5. Obtain the students attention and demonstrate how to set up the experiment.

    a. Arrange bottles on either side of the light with thermometer facing outward, so you can read it.

    b. Space the bottles equally distance from the light, using a half inch strip of paper as a spacer. The light should be turned off at this time.

6. Hand out the data sheet entitled "The Greenhouse Effect," and explain that this is what each group will use to record their results. When everyone is ready, take thermometer readings and record it with a pencil mark on the graph once every minute for 15 minutes.

7. After data has been collected, graph it on the graph paper and compare the results.

Lesson 2: The HOBO Activity

This activity uses technology to determine the amount of heat different substances will hold. The students will be able to measure the amount of heat different substances will hold, make predictions and collect data to complete graphs.

As the name HOBO implies, like a real hobo, the data logger leaves the computer, goes out and does its job of data logging. Then it returns and the data is fed into the computer. The beauty of the HOBO (Heat Operation Based Option) is that one computer can be used with 20 or 30 data loggers for a class of students.

The Heat Operation Based option (HOBO) temperature logger will be connected to your computer at this time. Get two beakers; heat the water in one and chill the water in the other. Place a styrofoam cup into each beaker of water for insulation. Place a fourth cup of oil in two test tubes and place one in the hot water and the other in the chilled water. Tape the thermometer to the outside of the insulated container so it measures the temperature of the water. Place a temperature logger into each test tube and turn the loggers on. The temperature loggers should be synchronized with the computer.

The students will turn the logger on and collect the temperature and list the time for each container of water with oil in it every five seconds. The students will collect data for one hour. After collecting the data, the students will take the loggers out of the oil and connect the logger to the computer. The computer will collect the data and graph it instantaneously. The students will be able to observe the curves for the hot oil and the curves for the cold oil and make comparisons of the patterns or curves at different temperatures.

Repeat the whole process using a different oil, water or other liquid in the test tubes. By comparing the results from different substances it can be seen that different substances hold different amounts of heat.

Lesson 3: Absorption of Radiant Energy

Color affects the absorption of radiant energy. You can use the results of this experiment to better dress for the season—to keep cooler in the summer and warmer in the winter. Home designers and city planners use the principles being studied to design energy –efficient homes and cities.

In this experiment, you will: Use a computer to monitor temperature changes due to radiant energy absorption, calculate temperature changes, and interpret your results.

Materials

Macintosh or IBM compatible computer	piece of white paper
Serial Box interface or ULI	piece of black paper
Two Vernier Temperature probes	lamp and bulb

Procedures

1. Tape two temperature probes to the table surface.

2. Place a piece of white paper over Probe 1 and a piece of black paper over probe 2.

3. Prepare the computer for data collection by opening " Exp. 11" from the Physical Science with Computers experiment files of Logger Pro. The vertical axis will have temperature scaled from 20 to 45^0C. The horizontal axis will have time scaled from 0 to10 minutes.

4. Position a light bulb directly over the boundary between the two pieces of paper and about 10cm above the paper pieces. The bulb should be the same distance from both probe tips.

5. Click collect to begin data collection, then switch on the light bulb. Record the initial temperature measured by each probe.

6. When data collection is complete (data has been collected for 10 minutes), record the initial temperature measured by each probe. Turn the light bulb off and return all materials to the places directed by your teacher.

7. To confirm your data, click the Statistics button, then click ok to display a box for both probes.

8. Print copies of graph as directed by your teacher.

Have students enter their data in the chart seen in Illustration 4 below.

Processing Data

Give students the handout seen in Illustration 5 below. Have them record their answers on this worksheet.

ANNOTATED BIBLIOGRAPHY

Student Reading List

Ahrens, C. Donald, *Meteorology Today*: West Publishing Company, N.Y., PP60-69, 1991.

This book describes the Earth's atmosphere, layers, origin and composition It focuses on different pollutants in the atmosphere and how they can be controlled. It discusses the balancing act, absorption, emission and equilibrium.

Houghton, John et. al. *Global Warming*; Cambridge University Press, 1996.

It describes how half of the contribution of methane gas to the greenhouse effect is because of its direct effect on the out going thermal radiation. The other half arises because its influence on the over all greenhouse effect.

IPC Report, *The Earth In The Balance,* 1990.

This report encounters our endangered Earth and its problems with radiation pollution and too much heat. It gives some solutions for solving the problems of the greenhouse effect.

VanCleave, Janice, *A+ Projects In Chemistry*: Wiley & Son, Inc. N. Y., PP 164-169. , 1995.

It describes different Science Fair Projects including Carbon Dioxide its Production and Uses. It discusses how scientist believes that the Earth's atmosphere is getting warmer because of the increase in carbon dioxide. This warming is called the Greenhouse Effect.

Teacher Reading

Anonymous, "DuPont sets Ambitious Agenda of Greenhouse Gas Emission Cuts. Chemical Marker Reporter 256 (13): 22. 1999, Sept 27.

A report of the issues on greenhouse gasses emission problems that are caused when gasses are trapped in the atmosphere by the sun's heat.

Coppock, Bob, *Policy Implications of Greenhouse Warning*, Panel of Policy Implications on Greenhouse Warming Committee on Science, Engineering Policy , "National Academy of Science," 1999.

The report examines relevant scientific knowledge and evidence about the potential effects of greenhouse warming, and assigned actions that could slow the onset warming (Mitigation Policy) or help human and national systems, plants and animals adapt to climatic changes (adaptation Policies).

Cretzen, P, J. & Leleweld, J. *Nature*, 355:122, pp339-41. 1998, Oct.

It discusses the roles of enhanced greenhouse effect of a molecule of methane compared to a molecule of carbon dioxide is known as global warming potential (GWP).

Hilemann, Bette, " Reducing Greenhouse Gases," *Chemical* Engineering *News*: 77 (39) 25-26, 1995, Sept 28. In 1995, the UN Intergovernmental Panel on Climate Change declared: The balance of evidence suggests a discernible human influence on global climate. This conclusion set off major battle among policy makers, scientist and industry over the connection between greenhouse gas emissions and global climate change.

Kerr, Richard, "Global Warming is Real" *Science: Vol 243:489, Feb, 1989, P.6003.*

This article contains information about how real the issues of Global Warming are.

Michaels, Patrick & Knappenberger, "*Greenhouse Effect," Chief Executive, Vol 145: 100, 1999.*

An alternative approach to this proposal would be to credit industry for expenses related to technological discoveries that reduce net ***greenhouse*** emissions. This incentive would punish one section favor of another, but merely cost-shares environmental stewardship.

APPENDIX OF ILLUSTRATIONS

Illustration 1 – Key Greenhouse Gases Influenced by Human Activity

	CO_2	Ch_4	CFC_11	CFC_12	N
Pre-industrial atmospheric Concentration	280 ppmv	0.8 ppmvg	0	0	288ppbv
Current atmospheric Concentration (1990)	353 ppmv	1.72 ppmv	280ppmv		310ppmb
Current rate of Annual Atmospheric Accumulation	1.8 ppmv	0.015 ppmv	9.5 ppmv	17 ppmv	0.8 ppmv
Atmospheric life Time (years)	50-200	10	65	130	150

Illustration 2 – The Albedo Effect

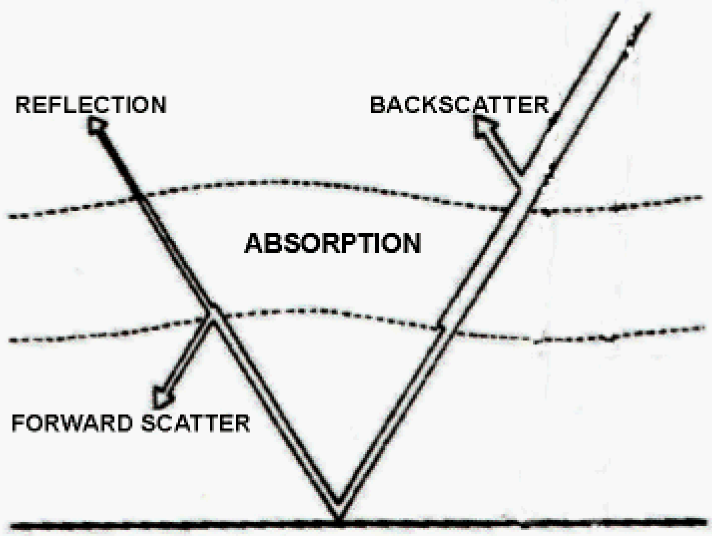

Fig. 1-1 *The effect of the albedo on incoming solar radiation*

Illustration 3 – Typical Albedo of Various Surfaces

Surface of object	Albedo (Percent)
Fresh snow	75 to 95
Clouds (thick)	60 to 90
Clouds (thin)	30 to 50
Venus	78
Ice	30 to 40
Sand	15 to 45
Earth and Atmosphere	30
Mars	17
Grassy Field	10 to 30
Dry, Plowed Field	5 to 20
Water	10 (daily avg.)
Forest	3 to 10
Moon	7

This table summarized the idea of reflectivity by showing the albedo of various surfaces.

Illustration 4 – Data Chart for Laboratory Activity 3

	Probe 1	Probe 2
	White	Black
Minimum temperature	________ ^{0}C	________ ^{0}C
Maximum temperature	________ ^{0}C	________ ^{0} C

Illustration 5 – Student Handout for Laboratory Activity 3

1. Calculate the temperature change for each color by subtracting the initial temperature from the final 5emperature.

2. Which color had the larger temperature increase?

3. Which color had the smaller temperature increase?

Solar collectors can be used to absorb the sun's radiation and change it to heat. What color would work best for solar collectors? Explain.

Extensions

1. Investigate the abilities of other colors to absorb energy.

2. Investigate the abilities of different materials, such as soils, concrete, asphalt, water, and grass, to absorb radiant energy.

Name ________________ **Date ___________**

Illustration 6 – Student Handout for *The Greenhouse Effect*