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Teaching Science and Global Warming

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Introduction

What will happen to the Earth in the future? What is global warming and how does it affect us? This is by far the most critical environmental problem we face. We must do something before it is too late. We must take an active role and it should start with our children.

According to two of New Haven Public Schools science curriculum standards, students must understand the process of scientific inquiry (1.0) and students must understand the dynamics of the Earth (4.0). This unit will touch upon these two science standards and the fourth grade unit on the Earth's oceans and atmospheres. The principal objective of this unit is to have creative, critical thinkers who are able to understand the basics of global warming. This unit will provide elementary school teachers with hands-on activities that will integrate science, mathematics, language arts, and art. This unit will be used in a fourth or fifth grade classroom in New Haven, Connecticut, but it may be adapted to other grade levels or areas.

In the third grade science curriculum, students learn about the Solar System. They study the basics, the Sun, the planets, and their position in the Solar System. In fourth grade we build on this knowledge and focus closely on the Earth, particularly the oceans and atmospheres. Unfortunately, I have noticed that students do not know very much about the Sun and its relationship to us on Earth. Therefore, as an introduction to this unit, we will focus on the Sun, as a main source of energy, and the Earth. Then, we will discuss the greenhouse effect, the consequences, and ways we can help.

The Students

My students for this unit will be fourth or fifth graders. My classroom is comprised of 20 to 26 students, about half of them male and half female. We are a very diverse classroom made up of students from different ethnic backgrounds such as, Hispanic, African American, and Caucasian. My students vary in levels, from proficient to intervention.

In New Haven, Connecticut the school population is comprised mainly of African American and Hispanic

students. The population is as follows: African American students represent about 55%, Hispanic students about 30%, Caucasian students about 11%, and 4% other. The particular school that I teach at is a low socioeconomic school in which most, if not all, students receive free breakfast and lunch. It is also among the low performing schools, as measured by the state CMT (Connecticut Mastery Tests).

Throughout the year, we study science through literacy and language arts activities. We also focus on the science curriculum. The New Haven science department issues science kits for each grade level. In the fourth grade, students completed a science unit on motion and force. Students also studied the Earth and its atmospheres and oceans. Therefore, this unit will serve as a supplement for the Earth unit.

Students really enjoy science units. The science kits are very thorough and full of hands-on activities. The most difficult part for the students seems to be the vocabulary because most of my students are LTSS students (they receive Language Transition Support Services). Therefore, vocabulary is a key factor in this unit.

My goals for this unit are to teach children to reason and think on their own. Children will use the scientific method, make connections, and think critically. My unit will touch upon many concepts but most importantly it will focus on "the basics." For example, students will learn about the Sun and Earth. The Sun is vital for life on Earth, without its light and warmth life as we know it would not exist. Students will also learn about greenhouse gases and the greenhouse effect. Students will do hands-on experiments. Most importantly, students will learn about the consequences of global warming and what we can do to help.

The purpose of this unit is to teach students about the most important environmental problem of the 21 st century, global warming. The unit will focus on many key concepts. It is important that students learn about this topic, global warming, because it relates to life. As teachers, it is our duty to make students aware of such pressing issues like global warming. My students will be given the facts. My hope is that students will not only understand what global warming is, but also want to help. I hope I motivate my students to make immediate changes in their homes and community, simply starting by educating and encouraging their family.

Through my experience, readings, and knowledge from this seminar, *The Science of Global Warming,* I will create a unit that will provide elementary school teachers with activities about the Sun, Earth, and global warming. These activities will match district wide goals and will fit in perfectly with the science curriculum. After learning about these topics, I hope students will be excited and curious about all aspects of science. Most importantly, I hope students will understand the consequences of global warming and be ready to help and make a difference in the world.

For many of the facts about the Sun and Earth, I relied on my reading of *Universe* by William Kaufmann and Roger Freedman. For the facts about global warming, I have used many reliable websites and the book titled, *An Inconvenient Truth* by Al Gore. All of my sources opened my eyes to new ideas.

There are many ideas that should be discussed in this unit. The topics that I suggest are as follows:

The Sun

The Earth

Greenhouse Gases/Greenhouse Effect

Global Warming

Consequences

Ways to Help

The Unit

The Sun

The Sun is the most important part of the Solar System. The Sun is the closest star to us. The Sun is much bigger than the Earth. It would take about 1,300,000 Earths to fill the Sun. It looks small because it is so far away. It is 93 million miles or 150 million kilometers away. Its light reaches us in about 8 minutes. The surface temperature of the Sun is about 10,000 degrees Fahrenheit. The center of the Sun reaches a temperature of 27,000,000 degrees Fahrenheit (3).

The center of the Sun is called the core. All of the Sun's energy comes from the core. The energy moves slowly toward the Sun's outer surface. The energy radiates, or travels in waves, away from the Sun as heat and light energy. After it leaves the Sun, the energy moves very fast (3).

The dark patches on the Sun are called sunspots. Although they look like dark patches, if they were extracted they would glow bright red. Sunspots are low-temperature regions in the photosphere. The number of sunspots on the Sun varies from year to year. Every eleven years, the number of sunspots increases to a very large number and then decreases again. When sunspots are at the maximum, the Sun is in an active period. Solar flares generally erupt near sunspots. Flares sometimes send large streams of glowing gas into space, releasing lots of energy (3).

There are three main layers of the Sun's atmosphere. These are the photosphere, chromosphere, and the corona. The photosphere is the layer of the Sun we see. It is sometimes called the surface but it is not solid. The chromosphere is a thin blanket of gas that glows pink. It is impossible to see this layer because the photosphere is much brighter. The corona is a layer of gas that surrounds the Sun. It looks like a glowing halo. We can only see the corona when the rest of the Sun is blocked, like when there is a total eclipse (3).

The Sun gives off energy. A small part of the Sun's energy travels to Earth. It gives us heat and light. Without the energy of sunlight, the Earth would be frozen and lifeless. The Sun warms Earth's air, helping to create wind. Wind is an energy source (windmills) and helps move rain. The Sun's heat creates a water cycle. The Sun warms water from oceans and lakes, causing it to rise as vapor. Vapor forms clouds. When the clouds cool, the vapor condenses and falls back to Earth as rain or snow (3).

The Earth

The Earth is the fifth biggest planet. The diameter of the Earth is 12,756 km or 7,926 miles. The Earth's mass is 5.974×10^{24} kg. The Earth is tiny compared to the Sun. If the Sun were the size of a beach ball, the Earth would be smaller than a pea. The Earth is very wet; about 71% of the Earth's surface is covered by water. The Earth is the only known planet that has life on it (3).

The Earth is made up of four layers. The thin outer shell is called the crust. It is divided into pieces called plates, which fit together like a puzzle. The crust forms the land and the ocean floor. Next is the mantle, which is hot, partly molten rock. At the top, the mantle is made of solid rock. Deeper down it is so hot that the rock becomes molten. The rock in the mantle is made of mainly iron and magnesium. Beneath the mantle there is a layer of liquid metal called the outer core. The outer core is a mixture of very hot liquid iron and nickel. In the center of the Earth, there is a ball of very hot solid metal called the inner core (3).

The Equator is the imaginary line around the middle of our planet. It divides the Earth in half and is half the distance from the poles. The two halves are called hemispheres. Most of the continents, land mass, are in the Northern Hemisphere. Hence, the vast majority of the Earth's vegetation is also north of the Equator (1).

The Earth is always turning. It never stops. It travels, or revolves, around the Sun once every year. The Earth spins on its axis. The axis goes from the North Pole to the South Pole. It makes one turn on its axis once every 24 hours. As the Earth spins on its axis, the side that faces the Sun warms up in the daylight and the side that is hidden cools down in the darkness. As the Earth spins we move from day, to night over and over again. It is the Earth's spinning that causes this to happen. The change in temperature causes winds to blow, clouds to form, and all other weather conditions (3).

The Earth is wrapped in a thin layer of air called the atmosphere. The original or "primitive" atmosphere consisted of hydrogen, helium, methane, ammonia, nitrogen, neon, and a small amount of argon. But this primitive atmosphere escaped. Our current atmosphere is influenced by volcanic eruptions, which contain nitrogen, carbon dioxide, and water vapor.

Scientists have divided the atmosphere into five invisible layers. These layers are made up of a mixture of gases, such as oxygen and nitrogen. These layers are the exosphere, thermosphere, mesosphere, stratosphere, and troposphere. The height of the troposphere is up to 10 miles. This layer contains nearly all the water vapor and most of the other gases in the atmosphere. It gets colder with height. Weather also occurs in the troposphere (3).

Greenhouse Gases/Greenhouse Effect

The atmospheres of both Mars and Venus consist almost entirely of carbon dioxide, whereas carbon dioxide accounts for only 0.03% of the Earth's atmosphere. Our atmosphere is a 4-to-1 mixture of nitrogen and oxygen, two gases that are found in only small amounts on Mars and Venus. Carbon dioxide is also abundant on Earth, but not in the atmosphere. It is dissolved in the oceans and chemically bound into carbonate rocks (3).

The Earth has gaseous species that are transparent at optical wavelengths, which is light, and opaque at infrared wavelengths, which is heat. This means that light can get through the atmosphere but heat is trapped. The greenhouse gases are water vapor, carbon dioxide, methane, and ozone. The most abundant gas is water vapor.

When explaining the greenhouse effect to younger students, I would begin by discussing a greenhouse. A greenhouse is a glass enclosure. Because the glass is transparent to sunlight, the enclosure will let most solar radiation in. The solar energy that reaches the greenhouse is partly reflected and partly absorbed. The reflected part acts as visible light so it will be able to leave the enclosure just as it came in. The absorbed part acts as infrared radiation or heat, so it becomes thermal radiation at the temperature of the greenhouse. Glass traps heat. Therefore, the absorbed solar radiation becomes trapped in the greenhouse, raising the

temperature.

The same thing occurs on Earth. The atmosphere acts as a filter for the Sun's radiation. Sunlight arrives at the Earth. 39% of sunlight is reflected by clouds and the surface. Sunlight that is not reflected is absorbed by the surface. 61% of sunlight is absorbed by the surface, heating it. This heated surface emits infrared radiation (heat). Some of the infrared radiation is trapped by the atmosphere, heating both the atmosphere and the surface. The remaining infrared radiation "leaks" into space (3).

The fraction of radiation reflected is called albedo. Albedo may be illustrated by discussing the color clothing we wear when it is hot and when it is cold outside. For example, we wear white or light colored clothing when it is hot outside (summer) to reflect the radiation from the Sun and keep us cool. When it is cold outside (winter), we wear black or dark colored clothing to absorb the Sun's radiation and keep us warmer. Without an albedo, Earth would absorb all of the Sun's radiation and reflect absolutely nothing. The albedo depends on clouds, snow, and ice.

Greenhouse gases allow light from the Sun to come into the atmosphere, but trap a portion of the outward-bound infrared radiation and warm up the air (1). The greenhouse gases act like a blanket or like the glass roof of a greenhouse keeping some of the heat from the Sun in. Greenhouse gases are beneficial, without them the average temperature of the Earth's surface would be -25 degrees Centigrade. The Earth would not be a very nice place to live; in fact it would be frozen over. Instead, due to the greenhouse effect, the average temperature of the Earth is 10 degrees Centigrade. Therefore, greenhouse gases keep the Earth's surface at a more hospitable average temperature. The evil is not the greenhouse effect; the evil is that humans are messing with it.

The problem that we face is that our thin layer of atmosphere is being "thickened" by huge quantities of human-caused carbon dioxide and other greenhouse gases. To help students get a visual of this, I would compare a glass of milk to a milkshake. As it "thickens", it traps a lot of the infrared radiation that would normally escape the atmosphere and continue out into space. So the Earth is heating up. It means the Earth now absorbs and holds more heat than it radiates back into space. As a result of this, the temperature of the Earth's atmosphere and oceans is getting dangerously warmer (1).

Because the amount of human-caused greenhouse gases is increasing, we are raising Earth's average temperature and creating dangerous changes in the climate. Carbon dioxide (CO_2) accounts for 80% of total greenhouse gas absorption. When we burn fossil fuels (oil, natural gas, and coal) in our homes, cars, factories, and power plants, we release carbon dioxide into the atmosphere. CO_2 is also released when we cut or burn down trees or when we produce cement (1).

As for the other greenhouse gases, 60% of the methane in the atmosphere is produced by humans. It comes from landfills, livestock farming, fossil-fuel burning, wastewater treatment, and other industry. We have also added 17% more nitrous oxide (N_2O) to the atmosphere. It comes from fertilizers, fossil fuels, and the burning of forests, and crop residues. Finally, water vapor is a natural greenhouse gas that we cannot control. It increases in volume with warmer temperatures, which magnifies the impact of all artificial greenhouse gases (1).

The fact is that the greenhouse effect is real. But there are many myths that go along with this. There have been many different projections about what will happen. The details of these projections (consequences) are uncertain. These projections are possible but not fact. We are noticing these things but there are

uncertainties. We are noticing the rise in sea-level, melting of polar ice caps, increase in the Earth's mean temperature, and the increase and magnitude of storms. We need more understanding.

Global Warming

The term global warming refers to the increasing average temperature of the Earth. This increase may be due to many processes, but the principal cause is the increasing levels of greenhouse gases, mainly carbon dioxide. These rising levels of greenhouse gases are due to human activities, mainly the burning of fossil fuels. Because of human activities, the amount of greenhouse gases has increased much faster that the Earth can absorb them.

About 150 years ago, when the industrial age began, all the new engines that drove the new machinery started to burn fossil fuels in enormous quantities that far surpassed the wood fires that civilizations had previously used for warmth. All this new burning poured and still pours greenhouse gases into the atmosphere. Especially carbon dioxide, which spews from chimneys and exhaust pipes (http://abcnews.go.com). One hundred and fifty years ago, our atmosphere had about 280 parts per million of carbon dioxide. Now that figure has reached 380 parts per million, an increase of 35 percent. Methane has more than doubled in the same amount of time and nitrous oxide has increased by 15%. The numbers for methane and nitrous oxide are significantly lower than carbon dioxide, so carbon dioxide is the greenhouse gas that is scrutinized most.

We have relied on oceans and trees to absorb our CO_2 emissions. But as rate of emission increases, they cannot absorb all of that carbon dioxide. The oceans can absorb less CO_2 as they warm, and as they become more acidic. Trees absorb carbon dioxide through photosynthesis. But when forests are burned, more carbon dioxide is released into the air. Carbon dioxide is also released when trees die or decompose. So planting more trees will not solve our problem.

The average surface temperature of the Earth has increased by about 1°F in the past 50 years. At the present rate, carbon dioxide levels are expected to double in the next 50 years. In greenhouse emissions continue to increase, within the next 50 years the average temperature is expected to increase between 2° to 8°F. This doesn't seem like a big difference or something we should worry about. But that's not true. The average increase would not be the same everywhere on Earth. This average temperature change means great changes in the average daily temperatures for cities. There may be a 1°F increase at the Equator but up to a 12°F difference at the poles. This means some areas will have extended "heat waves" while others will have extended cold periods.

Consequences

There are many serious consequences of global warming. The increase in global temperatures is expected to result in other climate changes including a rise in sea level. As the global temperature increases, the water in the oceans expands in volume, and additional water enters them which had previously locked up on land in glaciers and polar ice caps. The last time the Earth was five degrees warmer was three million years ago, when sea level was about eighty feet higher. Jim Hansen, Director of the NASA Goddard Institute for Space Studies, describes what this would mean. In that case 50 million people in the United States would be below sea level (east coast and Florida). China would have 250 million displaced people. Bangladesh would lose their entire nation (120 million people). And India would lose the land of 150 million people.

Climate changes would also lead to changes in the amount and pattern of precipitation. There will be more

rain on the coasts and droughts everywhere in between. These changes may also increase the frequency and intensity of extreme weather events such as floods, droughts, heat waves, and hurricanes.

If you look at the 21 hottest years measured, 20 of the 21 have occurred within the last 25 years. The hottest year recorded during this entire period was 2005. These temperature increases are taking place all over the world, even in our oceans. And as our oceans get warmer, storms get stronger. These storms include not only hurricanes, but also cyclones and typhoons (depending on the ocean in which they originate). Greg Holland, director of the Mesoscale and Microscale Meteorology Division at the National Center for Atmospheric Research says, "The hurricanes that we are seeing are indeed a direct result of climate change and that the wind and warmer water conditions that fuel the storms are increasingly due to greenhouse gases." In 2004, the all-time record for tornadoes in the United States was broken. In 2005, hurricanes hit the Caribbean and Gulf of Mexico causing significant damage (1). This extreme weather will also be very costly. Insurance companies all over the world are feeling this drastic blow.

Almost all the mountain glaciers in the world are now melting, many of them quite rapidly (1). Glaciers in Greenland and Antarctica are melting into the ocean at up to double the speed of just a few years ago. The loss of glaciers not only directly causes landslides, flash floods, and glacial lake overflow, but also increases annual variation in water flows in rivers. By drilling into the glaciers, scientists analyze the air bubbles trapped under layers of snow. Scientists can measure the levels of each gas in the atmosphere hundreds and thousands of years ago. They can measure the average temperature of past centuries.

Rising global temperature might cause forest fires to occur on larger scale, and more regularly. This releases more stored carbon into the atmosphere than the carbon cycle can actually re-absorb. Fires also reduce the overall forest area on the planet.

Since climate directly affects agriculture, water supplies, and human health, these changes could be disruptive to civilization and security. Global warming may cause significant destruction of several crops. The region likely to be worst affected is Africa, both because its geography makes it vulnerable, and because seventy percent of the population rely on rain-fed agriculture. Areas in the world that usually get two rainfalls in the year will probably get one, and those that get only one rainy season will get far less. Sea level rises threaten to contaminate groundwater, affecting drinking water and agriculture in coastal zones. In some areas, shrinking glaciers threaten the water supply. Rising temperatures have two opposing direct effects on mortality: higher temperatures in winter reduce deaths from cold; higher temperatures in summer increase heat-related deaths. "Heat waves" kill lots of people; the European heat wave in 2003 is a perfect example of that. Global warming is expected to affect the spread of disease such as malaria. In poorer countries this may lead to higher incidence of such diseases (http://en.wikipedia.org).

Rising temperatures are beginning to impact ecosystems. Butterflies have shifted northward in Europe and North America. Plants lag behind, and larger animals' migration is slowed down by cities and highways. In Britain, spring butterflies are appearing an average of six days earlier than two decades ago. In the Arctic, the waters of Hudson Bay are ice-free for three weeks longer than they were thirty years ago, affecting polar bears, which do not hunt on land (http://en.wikipedia.org).

Half of all plant and animal species are showing impacts of the warming. The Bering Sea (between Russia and Alaska) is getting warmer and the heat is having a huge impact on marine wildlife there. There is a declining food supply for populations of walrus, gray whales, and sea ducks. These animals have to compete with fish populations that have moved into their territory.

Animals are trying to adapt to the changes. But there is a limit to how far north the whales and other mammals can go. In some cases, they are becoming extinct. We are facing what biologists are beginning to describe as a mass extinction crisis. The destruction of the Amazon rain forest not only drives many species to extinction but also adds more carbon dioxide to the atmosphere. It is like a double edged sword. Coral reefs are being killed in large numbers by higher ocean temperatures due to global warming.

Ways to Help

Any solution could run into the millions or billions of dollars, but scientists say the cost of no action is much higher. We have to take action now. We need to decrease our use of fossil fuels so that there is less carbon dioxide that is released into our atmosphere. We must make serious cuts in the greenhouse emissions that are warming the Earth and melting the polar ice caps.

This is not a simple problem to fix. The first thing that we need to do is publicize this problem, not to scientists, but to everyone. Next, we need to work vigorously in refining the science of global warming, so we know what is likely to be ahead of us. Finally, we must develop technology and the industrial infrastructure to actually solve the problem.

There are many things that can be done in the U.S.A. We could expand the generation of power by nuclear, wind, or hydroelectric means. We could optimize efficiency of energy use. We could sequester greenhouse gases in energy production plants. Lastly, we could develop the capability to mass produce biodiesel fuels. By developing automobiles that use biodiesel, we would have cars that emit much lower amounts of carbon dioxide.

It is important for students to understand the simple things that they can do at home. Al Gore discusses ways to help solve the climate crisis in his book, *An Inconvenient Truth.* So many things we do in our day-today lives (driving, cooking, heating our homes, and working on computers) result in greenhouse gas emissions. It is impossible to eliminate our personal contributions but we can reduce our contributions (1).

First, he discusses ways to save energy at home (great ways to get students and their families involved). We can substitute conventional incandescent light bulbs with super-efficient compact fluorescent lights (CFLs). They use 66% less energy and reduce household emissions up to 10 %. We can buy energy-efficient appliances to reduce household emissions up to 50%. It is also important to properly operate and maintain appliances (run only full loads in the dishwasher and washing machine and use a clothesline to dry clothes instead of the dryer). We can heat and cool the house efficiently. By lowering the heat a few degrees in the winter and setting the air conditioner a couple of degrees higher in the summer, you can save energy. It is also important to insulate your house so that energy does not "leak out." We can conserve hot water by taking showers instead of baths and by washing clothes in cold water instead of hot. Most importantly, reduce standby power waste by unplugging appliances that are not being used (1).

Outside of our homes, we can also "get around on less"(1). We can reduce the number of miles we drive by walking, biking, carpooling, or taking mass transit wherever possible. If we are driving, we should drive smarter by driving the speed limit and by combining different errands into one trip. We can also purchase vehicles that are more energy efficient. Hybrid cars run on a mix of gasoline and electricity and some get 50 miles or more per gallon. There are also alternate fuels for cars, derived from renewable plant materials like corn, wood, and soybeans. The most commonly used renewable fuels today are biodiesel and ethanol. Finally, we can reduce air travel by taking vacations closer to home. Flying is another form of transportation that produces large amounts of carbon dioxide (1).

"Reduce, reuse, and recycle." It is important to recycle things like paper, glass, steel, aluminum, and plastic at home, school, work, and everywhere. While it does take energy to gather, haul, sort, clean, and reprocess these materials, recycling takes far less energy than sending recyclables to landfills and creating new paper, bottles, and cans from raw materials. One way to conserve is to bring a reuseable tote when shopping for groceries and other items. Another way to conserve is to carry your own refillable bottle for water or other beverages, instead of buying single-use plastic bottles (1).

We must continue to learn about the state of the environment and what is being done about it. We should share our knowledge with others. Tell family and friends about climate change and what they can do to participate in the solution. We must inform and inspire others to take action. We can bring awareness to our neighborhoods and schools, and find ways to implement programs in our community (1).