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Energy, Climate, Environment: What's Plastic Got To Do with It?

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Introduction and Rationale

I teach Enrichment Math and Language Arts to the high achieving students selected primarily on the basis of their MAP test scores (NWEA - Measurement of Academic Performance). Our Enrichment program is structured as a pullout program with allocated class times ranging from 30 to 60 minutes for students in grades K-5. The premise that we operate on is, high achieving students often do not meet their expected target growth goals in the regular classroom particularly in subjects of their academic strength. In the regular classroom we often teach to the middle achievers and give that extra time and or focus to the lower achieving students.

Even with the expectations that we differentiate in our classrooms for all ability levels, high achieving students often get the short end of the stick. They tend to be able to work on their own or in a small group with little or no interaction with the teacher. Of course, this is not true in all cases but it is definitely a situation that exists and that we have recognized in our school district. The current approach is not always enough to get these students to move significantly beyond where they start at the beginning of the year. Our goal is to provide challenging material that will help them to meet or exceed their target growth goal.

As we implement a new Math curriculum this upcoming school year, I plan to integrate the content of this unit into the math curriculum in order to provide relevance to the math students are learning. This unit provides the opportunity for my students to have a practical application for the math they will be learning and understand how professionals use it in the field of science. Often my students have asked why they have to know how to do this or how they will use the math concepts and skills in the real world. The curriculum does not address this directly. This unit will address those questions as I integrate it into my math curriculum, using math as a quantitative and forecasting tool.

Part of our Language Arts curriculum involves being able to decode words for meaning using Latin or Greek roots and affixes. Specific words relevant to the topics of this unit lend themselves nicely to decoding according to their Latin or Greek origin. Another focus of our Language Arts curriculum is to read informative text which we don't do enough of in the regular classroom.

Content reading material from this unit will be used to address the informative text requirement of our enrichment curriculum. The academic focus of this unit will be geared toward my enrichment students in grades 5. However, I plan to adapt it for grades 3 and 4. The focus will be on math and language arts. The

math focus will involve computation, recognizing patterns in number and predicting/forecasting, data gathering, generating graphs, interpreting data as it relates to an authentic situation, and evaluating data to determine the likelihood of an event or outcome becoming a reality. The language arts focus will be on reading informative text material; extrapolating key information to answer questions, draw conclusions, and make decisions; and decoding words for meaning.

Objectives

Recently there has been an increase in the number of initiatives started at our schools and in our communities to recycle solid waste materials. At the school where I teach recycling is an ongoing effort. There are recycling bins in the teacher's lounge, classrooms collect aluminum can tabs, and the cafeteria now has recycling bins to collect solid waste materials. There is a thrust on recycling and it is a word that the students use frequently. They do not hesitate to remind a teacher or fellow student to recycle his/her plastic water bottle. Most, if not all, of their knowledge of why we recycle is associated with pollution of the environment. The level of pollution that they are aware of is basically what they see locally or are exposed to on television. Very few of my students understand pollution beyond their local community or environment.

This unit will be divided into three major topical sections focusing on the specific areas potentially impacted by plastic bottles and plastic bags. The three topical areas of focus for this unit include: Energy, Environment, and Climate. There are four major questions to be answered during the course of the learning and exploration activities for each section. The four questions for each of the topical areas are: 1) What is happening? [The problem] 2) Why is it happening? [The causality] 3) What does plastic have to do with it? [The contributing factors of Global warming] and 4) How are we contributing to the problem? [Choices]. Answers to each of the four major questions will be facilitated through direct teacher instruction, interactive Internet websites, informative text reading material, and group work.

Acknowledging that locally and globally there is an emphasis on recycling, conserving energy, and using alternative and renewable energy resources, my goal is to have students take a step back and ask themselves why. Why is there such an emphasis on these things now? I want them to be able to look at the bigger picture that encompasses this emphasis.

I want this unit to enable students to become knowledgeable, or more knowledgeable, of the significant impact and effect that solid waste materials can have on health, the environment, and climate. With this in mind, the focus of this unit will be on plastics as a [recyclable] group of products. A particular emphasis will be on plastic bottles and bags (LDPE or PET, polyethylene). Their relationship to fossil fuel combustion, impact on the environment, potential impact on health, and contribution to global warming via CO_2 emissions will be areas of focus. Students will recognize that they make choices and the choices they make can potentially have a negative or positive impact on helping to mitigate the effects of global warming.

In order to develop higher levels of thinking in my enrichment program students, this unit will incorporate a variety of activities. Students completing this unit will gain knowledge of what is currently happening as a result of global warming. They will apply what they learn about plastics, relate it to global warming, and determine the extent of plastic's contribution to global warming. Additionally they will analyze the life cycle of plastics, determine at what stage(s) green house gases are emitted into the atmosphere, and synthesize the

information compiled to either propose policy changes, promote changes in behavior to minimize green house gas emissions, or conclude and support that nothing needs to be done. My students will also be challenged to evaluate the three R's - Reduce, Reuse, and Recycle and identify which of the three they consider to be the most beneficial with regard to plastics and its impact on the Earth and support their decision.

Since my students are often inquisitive about why something happens and are always willing to hypothesize about it and then generalize, this is a unit that I am convinced will capture their interest and utilize their skills. It addresses things they are exposed to on a daily basis but never really observe or give a lot of thought to. For these reasons, much of this unit will be inquiry based with students conducting research to find answers, using math as a quantitative tool, writing to explain and/or inform, and generating products that demonstrate what they've learned.

The Essence of the Earth

The Earth, Animals, and Humans are truly spectacular creations that exist with a perfect electro-chemical balance within and a harmonious symbiotic relationship among them. One depends on the other with a natural order that keeps a balance that is a major factor of sustaining life on earth. Our senses [see, hear, feel, smell, and taste] allow us to enjoy the beauty of the earth in its entirety as it was created and intended to endure. Take a moment to think about the glistening beauty of the lakes; the colors and sparkle of the morning, evening, and midnight skies; the graceful fluttering of our feathered friends; the purposeful flight of insects, the bumble bee in particular, as they travel from one plant to another to feed on its nectar while facilitating pollination; the fresh smell of the ocean breeze; the soft rumbling of the ocean waves as the outer reaches come to greet the sandy coast; the gentle breeze that cools the summer evening; the chirping that melodiously wakes us from our slumber; and the pure white frozen polar ice caps that serve as homes for polar bears and penguins. All of this is what the earth has to offer and more. In order for this to be a reality there has to be a natural order. What we often don't realize is that energy is what makes this all happen, and more than that, it is the perfect natural balance of energy that sustains life and the symbiotic relationships on earth. First, we need to understand what our natural systems are and how they function when in perfect natural balance.

The Natural State of Affairs

Everything is a system with a set of parts or components that are linked in an organized way to serve a specific purpose. Everything that does work or performs a function can be considered to be a system in one form or another. The components operate as a complex whole and result in some observed behaviour. [1]

The earth has a natural climate system that regulates its temperature. There are 5 components of the climate system that include the atmosphere, hydrosphere, cryosphere, biosphere, and lithosphere. Each of these components is affected by the other. The natural warming process of the earth is referred to as the green house effect because it acts similarly to how a botanical greenhouse works. [2]

Each of the components of the climate system has a set of variables. When the equilibrium of the variables is disturbed the system is considered to be in transition from one state to another state. The state of the system is reflected by the value of the set of variables at a given point in time. A 'discrete system' is a how system that jumps from one state to another but can only exist in one state at given point in time would be described; a 'continuous system' is one that gradually moves from one state to another. The climate system is a good example of a Continuous System that can be classified as an Open System describing how it interacts with its surrounding environment. An Open System exchanges energy and mass with its outside environment. It can be further categorized as a cascading system made up of a series of subsystems. The mass and energy involved with the Open System is passed [or cascades] from one subsystem to another. The result is that the output from one subsystem is the input to another subsystem. In the climate system the individual subsystems, as mentioned above, are the atmosphere, hydrosphere, cryosphere, biosphere, and lithosphere. The natural interaction among these subsystems can be explained by the water cycle, carbon cycle, and green house effect. [3]

The Natural Green House Effect

The atmosphere is the most variable component of the climate system. [4] As we examine this subsystem further we will see why. The Earth's natural green house effect is a balance between the energy from the sun and the loss of that energy back into space. Approximately 1/3 of the energy that hits the earth, received in the form of solar short-wave radiation, is reflected back to space. The atmosphere absorbs some of the remaining energy, however the land and oceans absorb most of it. The Earth's surface becomes warm and consequently emits long-wave radiation toward the atmosphere. The naturally occurring green house gases that include water vapor, carbon dioxide, ozone, methane, and nitrous oxide trap and re-emit the long-wave radiation warming the atmosphere. These greenhouse gases act collectively to create a blanket effect that warms the earth by approximately 35Â°C (95Â°F). Clouds cool the surface by reflecting solar radiation and also warm it by absorbing and re-emitting outgoing long-wave radiation. [5] Globally the net effect is a balance between incoming solar radiation, illustrated numerically as +100, loss of short-wave radiation to space, illustrated numerically as -30, and loss of long-wave radiation to space, illustrated numerically as -70 resulting in a net effect of zero. [6] This illustrates our climate system working in perfect balance with equilibrium of the variables of its subsystems.

The composition of the earth's atmosphere includes 78% nitrogen, 21% oxygen and 1% other gases. It is the 1% of other gases that is of concern when we discuss the greenhouse effect, and ultimately global warming due to climate change, because this 1% is comprised of the greenhouse gases. The two most important greenhouse gases according to Maslin are carbon dioxide and water vapor. Without the natural greenhouse effect produced by water vapor and carbon dioxide the average temperature of the earth would be approximately -20Â°C (-4Â°F). [7]

The greenhouse gases in the atmosphere act similarly to the glass panes in a botanical greenhouse. Sunlight enters the Earth's atmosphere, passing through the blanket of greenhouse gases. As it reaches the Earth's surface, land, water, and biosphere absorb the sunlight's energy. Some of the energy passes back into space, but much of it remains trapped in the greenhouse gases, similarly to how the panes of the botanical green house traps the heat inside, causing the earth to heat up. [8] When the atmosphere is in balance, and not saturated with greenhouse gases, enough energy passes back into space preventing the earth from being overheated and resulting in a rise in temperature. Without the greenhouse effect, the Earth wouldn't be warm enough for humans to live on.

Carbon dioxide and water vapor are variables in the atmosphere, a component or subsystem of the climate system. As variables, their value or amount can change. Therefore, the amount of carbon dioxide and water vapor in the atmosphere can vary on Earth. Consequently, the natural greenhouse effect has created a climate system that is naturally unstable and can be somewhat unpredictable. [9]

The Water Cycle

The hydrosphere includes all water in the liquid phase consisting primarily of oceans but also including lakes and rivers. [10] The cryosphere encompasses all frozen water, including seasonal snowfalls, glaciers, the polar ice caps and permafrost. [11] Both are involved in the water cycle, an example of a closed system transferring only energy across its boundary.

The Earth has a finite amount of water that is stored in oceans, rivers, and lakes as well as underground between rock and soil. It is also stored as solid ice in glaciers at the north and south poles and as snow on top of mountains. Ice crystals are another form in which water is stored in clouds and as vapor in the atmosphere. It is the same water that moves from the different storage areas to the atmosphere via the water cycle.

Evaporation occurs when the sun heats up the water in the oceans, rivers, and lakes changing it from a liquid to a gas causing it to rise as vapor to the atmosphere. Transpiration is another process by which vapor is released back into the atmosphere, occurring when plants release water through their leaves. Collectively the two are referred to as evapotranspiration. When the water vapor in the atmosphere cools it condenses back to liquid form and forms clouds.

Precipitation in the form of rain, sleet, snow, or hail occurs when the air can no longer hold the current amount of water. When the precipitation reaches the ground it either remains as snow and/or ice in frigid locations; is received as water back into the oceans, rivers, or lakes; or falls onto land. On land, the water either penetrates into spaces in the ground, which is the process called infiltration, or it can flow over the ground in a process called runoff ending up back into a body of water. Water that infiltrates becomes groundwater that either stays in place or moves underground until it too joins a body of water. From there, the cycle starts all over again with the same finite amount of Earth's water.

The Carbon Cycle

The biosphere includes plants on land and in the sea and all animals. [12] The carbon cycle, a closed system transferring only energy across its boundary, is the natural recycling process of carbon atoms. Without the balanced functioning of the carbon cycle, life as we know it today, could drastically change. The carbon cycle involves the movement of carbon and carbon dioxide (CO_2) throughout the environment. CO_2 is one of the greenhouse gases and the one that is most influenced by the activities of humans.

Carbon is found everywhere. It is stored in the ground, found in fossil fuels, the air, certain rocks and animals' shells, and all living things. Carbon is part of the soil, is dissolved in ocean and lake waters, and is stored in plants and trees. Plants and trees use carbon dioxide from the atmosphere through photosynthesis and store the carbon as they grow. Plants release carbon into the atmosphere through a process called respiration. Decomposed plant matter becomes part of the soil and over time compacts and transforms into fossil fuels such as oil and coal.

Through the diffusion process, gases containing carbon move between the ocean's surface and the atmosphere. Ocean plants use carbon dioxide from the water for photosynthesis in the same way land plants

use it. The ocean animals eat the plants to get the carbon and release carbon dioxide into the water through respiration. Decomposed water plants and animals either sink to the ocean deep or settle on the ocean floor and get buried. Water moving between the deep ocean and the surface carries carbon, some of which moves from the surface to the atmosphere. [13]

There lies the natural order of our continuous open cascading climate system. When all of the variables and exchange of energy and mass are in balance, life and the surrounding environment is just fine. Now lets take another look to see what is happening, what has already happened, and question whether our earth is still in perfect balance. Is all the beauty we visualized earlier and once enjoyed still there for us to enjoy now and for generations to come? When we look again we see that there have been significant changes to our planet. We can observe changes in our weather patterns. The quality of both land and oceans has been diminished due to pollution. Our forests have been considerably depleted. There is an increase in the occurrence of infectious and terminal diseases. Animals and insects are becoming extinct while others are growing in number. What has happened and is continuing to happen to the beauty and balance that the earth once had to offer?

When Things Go Awry and Upset the Natural Balance

Greenhouse Gases and Global Warming

The Earth is constantly changing. There are natural cycles, as described above, that balance and regulate earth and its atmosphere keeping it in perfect balance [14] . Since the onset of the Industrial Revolution human activities have caused changes to these natural cycles resulting from an increase in the amount of greenhouse gases in the atmosphere. The greenhouse gases that are worth discussing in this unit are carbon dioxide CO_2, methane CH_4, water vapor H_2O, and Chlorofluorocarbons CFCs. An increased amount of ant of these greenhouse gases accelerates the greenhouse effect.

Global warming, described as an increase in heat energy trapped by CO_2 in the atmosphere, enhances the water cycle. The evaporation of water from the surface back into the atmosphere is accelerated. Condensation of water vapor in the atmosphere is increased and precipitation, in the form of rain, sleet, hail, or snow, back to the surface is intensified. The increase in greenhouse gases in the atmosphere, CO_2 in particular, causes the atmosphere to be warmer resulting in a higher capacity to hold water causing an enhanced greenhouse effect. In areas that are near a water source, a warmer atmosphere holds more water characterized by more clouds and an increase in precipitation. More precipitation results in higher amounts of ground water causing a rise in sea level due to increased runoff. If there is no increase in runoff, the ground becomes more saturated resulting in increased flood conditions. The increased availability of water vapor in the atmosphere also leads to a significant increase in the energy available to drive storms and associated weather fronts, affecting rainfall rates, precipitation amounts, storm intensity, and related runoff. [15]

In areas that are not near water sources, intensified evapotranspiration causes the soil and vegetation to dry out resulting in fewer clouds and less precipitation. The result is drought conditions, shallower rivers and lakes, and a decreased amount of ground water. These results of flooding and drought conditions can significantly impact the decline of food crops and world food supply.

As part of the biosphere, humans participate in the natural carbon cycle. However, by extracting fossil fuels

from the ground and burning fossil fuels such as coal, oil, and natural gas for energy to power cars and factories, humans are adding CO_2 to the atmosphere faster than carbon is released through natural processes. The pace at which the natural carbon cycle works is in sync with the natural processes through which carbon is released. The carbon cycle is ill equipped to handle the unnatural human induced releases of carbon into the atmosphere. Therefore, the concentration of carbon dioxide in the atmosphere has been disrupted and is consequently out of balance. The carbon cycle is additionally overloaded when trees are cut down because they can no longer take carbon dioxide out of the atmosphere. When the wood is burned, organic carbon becomes carbon dioxide and is released into the atmosphere. When the concentration of CO_2 is upset the carbon cycle, which is a closed system, works to return to its natural state but the natural processes involved work so slowly that they cannot keep up with the rapid pace that CO_2 is being released into the atmosphere. The additional carbon dioxide released into the atmosphere, overloading the carbon cycle, has contributed to global warming. [16]

Evidence of Global Warming and Climate Change

The greenhouse gas of particular focus, when discussing global warming and climate change, is CO_2 because it is the greenhouse gas whose concentration in the atmosphere is influenced most by human activities. Measurements from tree rings, ice core boreholes, and retreating glaciers provide sufficient evidence that the surface temperature of the Earth in the last few decades of the 20th century was higher than any comparable period for the past 400 years. The global average surface temperature has risen by approximately 1.5 degree Fahrenheit since 1900 and is projected to rise another 2 to 11.5ºF by 2100. [17]

Scientists have been engaged in studying our past climate in order to confirm that carbon dioxide in the atmosphere is indeed an important factor in controlling global climate. One way they have accomplished this is from drilling ice cores in both Antarctica and Greenland. Ice cores help tell the historical story of the atmosphere in the following way. When snow falls to the ground it is light and fluffy containing a lot of air, some of which becomes trapped as the snow slowly compacts to ice. Scientists extract these air bubbles and measure the percentage of greenhouse gases that are present. These measurements represent the percentage of greenhouse gases that were in the atmosphere at the particular time of the dated ice core. By drilling over two miles down into Greenland's and Antarctica's ice sheets, scientists have been able to determine the amount of greenhouse gases that were present in the atmosphere over the last half a million years. In addition, they were able to estimate what the temperature was when the ice was formed. This information gave rise to the discovery that carbon dioxide (CO_2) and methane (CH_4) co-varied with temperatures over the last 400,000 years. [18]

Information gathered from the study of the ice cores in addition to the study of the concentration of carbon dioxide in the atmosphere at the top of Mauna Loa Mountain in Hawaii helped establish carbon dioxide as a greenhouse gas that has a direct impact on global climate and therefore climate change. We need to distinguish between weather and climate to understand the phenomenon of climate change.

Weather is the day-by-day occurrences of the atmosphere near the earth's surface. Meteorologists and/or forecasters predict weather conditions each day, which may include a mix of events like temperature, humidity, cloudiness, precipitation, or the onset of a storm. Basically weather is the state of the atmosphere at a particular location at a given point in time, it is what you experience.

Climate is the long-term average temperature and/or weather conditions of a particular region over a period of

time. It is the average weather in a place over many years. While the weather can change in just a few hours, climate takes hundreds, thousands, even millions of years to change when the natural cycles are working under normal, balanced conditions. It is the type of weather conditions one expects to experience in a particular region during a certain time of year. In other words, because of its climate, someone would expect it to be very cold and snowy in Buffalo, New York in the winter months of January and February. Climate can also determine the type of plant and animal life one would expect to find native to a particular area. Temperature and precipitation are the two primary factors that climatologists rely on to determine climate.

Climate Change refers to changes in the long-term trends in the average climate like changes in average temperatures. It is natural or human induced change in the average global temperature of the atmosphere near the Earth's surface. This is the condition that climatologists are most worried about because it poses significant dangers around the world, potentially causing disasters like flooding, drought, and disease. Observations undeniably illustrate that warming of the climate exists. [19] The cryosphere was once considered a passive responder to the climate but is now believed to be an active player in climate change. [20] The amount of sea ice in the Arctic has decreased severely over the last 50 years as the ice melts. Our glaciers are melting in response to warming.

What's Happening to Our Environment?

Damaging change has already occurred and is most likely going to continue to get worse in the future. Anthropogenic greenhouse gas emissions continue to rise and increase the concentration of greenhouse gases in the atmosphere. Global warming and climate change will undoubtedly continue even if all anthropogenic contributions to atmospheric greenhouse gas concentrations were to cease. The focus at this point must be on finding ways of adapting to the changes that have already occurred and will continue to occur in the not too distant future. As we continue to explore what is happening to our environment, we must also examine and evaluate ways we can effectively change our use of energy and other natural resources to help mitigate the impact on global warming and global climate change. Our up and coming generations need to be considering ways to build a sustainable society, locally and globally, by making and promoting wise choices today.

Sea Level Rise and Water Quality

The Queen of England is afraid. International C.E.O.'s are nervous. And the scientific establishment is loud and clear. If global warming isn't halted, devastating sea-level rises will be inevitable by 2100. [21] Coastal regions, Manhattan, and parts of Washington, D.C. are among the areas that could find themselves under water. Sea level has risen by approximately 8 inches over the past century after practically no rise in 2000 years. Satellite data available over the past 15 years has shown sea level rising at a rate approximately double the rate observed over the past century. [22]

As stated in the Global Climate Change Impacts in the United States report, the Earth's major ice sheets on Greenland and Antarctica are currently losing ice volume by increased melting and calving of icebergs, another contributing factor to sea-level rise. The Greenland Ice Sheet has been experiencing record amounts of surface melting, and a significant increase in the rate of mass loss in the past decade. If the entire Greenland Ice Sheet melted, it would raise sea level by about 20 feet. The Antarctic Ice Sheet consists of two portions, the West Antarctic Ice Sheet and the East Antarctic Ice Sheet. The West Antarctic Ice Sheet, which is

more vulnerable to melting, contains enough water to raise global sea levels by approximately 16 to 20 feet. If the East Antarctic Ice Sheet melted entirely, it would raise global sea level by about 200 feet. [23]

About 45 percent of the carbon dioxide emitted by human activities in the last 50 years is now stored in the oceans and vegetation. The rest remains in the air. As the ocean absorbs carbon dioxide from the atmosphere, seawater becomes less alkaline and more acidic through a process referred to as ocean acidification. The pH of seawater has decreased significantly and is projected to drop much more dramatically by the end of the century if carbon dioxide concentrations continue to increase. Such ocean acidification is essentially irreversible over a period of centuries. [24] What this means is that sea animals and coral reefs are experiencing survival difficulties.

Pollution - Is Plastic the Culprit?

Our oceans have been treated as waste systems swirling our trash in the Subtropical Gyre as if getting it ready to be emptied down the drain, but where is the drain? Did we even think about that before we dumped our waste into the oceans? According to one estimate, plastic constitutes 90 percent of all trash floating in the world's oceans. Plastic particles floating in the Great Pacific Garbage Patch is six times the mass of plankton and twice the size of Texas. Many ocean animals eat the plastic particles mistaking it for plankton, which is their natural food. Millions of sea turtles, whales, and birds die because of plastic bag pollution. Because plastic bags do not degrade, when the animals die and decompose the plastic is released back into the environment, either on land or in the water. The largest predators accumulate the highest concentrations of persistent chemicals that stay in the body because they bond with body fat. Plastics have entered the lives and bodies of most people on the planet as early as 1950. One contribution to this fact is that humans eat some of the larger predators in the form of fish or other seafood and some land animals. This can be explained further by the concept of bioaccumulation. Bioaccumulation is the increase in the concentration of a particular substance in a living organism as it ingests contaminated air, water, or food. As bigger animals feed on smaller animals, the level of contamination exposure is increased is as the level in the food eaten is added to the level already in their body from other sources.

Plastic bags also release poisonous materials into the soil damaging water sources. This is seen more frequently in landfills where un-recycled plastic bags are thrown. Plastic bags photo degrade in landfills and in the oceans, which means that sunlight breaks the bags into tiny pieces. Each fragment of the bag releases extremely toxic chemicals into the soil that then contaminate water sources. Plastic bags can then take up to 1000 years to biodegrade. When not disposed of properly they fly away with the wind. They can end up clogging sewers and waterways leading to a potential increase in the risk of flooding, particularly in small towns. [25]

In 2007, more than 830 million pounds of plastic bags and film were recycled nationwide, up 27 percent from 2005. It takes about 430,000 gallons of oil to produce 100 million plastic bags, and the U.S. goes through 380 billion of them a year. More than 1.6 billion gallons of oil are used each year for plastic bags alone. Of the 380 billion plastics used in a year 1 percent is recycled. The average household generates 17 pounds of PET bottles annually. When buried some plastic material may last 700 years blocking the natural flow of oxygen and water through the soil. When burned, they release dangerous toxins and carcinogens into the air. The damage is even more severe when the bags end up in the ocean, where thousands of sea turtles and other marine life die each year after mistaking plastic bags for food. [26]

Health - Is Plastic the Culprit?

Bisphenol A (BPA) is classified as a synthetic estrogen or an 'endocrine disruptor'. It is used to harden polycarbonate plastics and epoxy resin. There is growing concern that it can cause serious and occasional irreversible damage to health. It has been estimated that 6 billion pounds of BPA are produced annually. BPA is used in the manufacture of water and beverage bottles among other products. According to the Environmental Working Group (www.ewg.org/chemindex/chemicals/bisphenolA), laboratory tests have shown that trace BPA exposure can disrupt the endocrine system and trigger such disorders as chromosomal and reproductive system abnormalities, impaired brain and neurological functions, cancer, cardiovascular system damage, adult-onset of diabetes, early puberty, obesity, and resistance to chemotherapy. It was also hypothesized by Theo Colborn in the late 1980s that reproductive and development disorders might be caused by 'endocrine disrupting' chemicals. [27] In 1997, the FDA found that BPA seeped from polycarbonate water containers into the the bottled water at room temperature and further reported from another study that boiling water increased the rate of seepage. [28]

What's Plastic Got to do With Climate Change?

We hardly ever think about how something as simple as a plastic bottle or plastic bag can play a bigger role in our world beyond the convenience for which it was intended. Let's take a look at plastics in our environment. We are inundated with plastics.

Because our existence depends on our planet and its climate, it is important to understand how what we do and the choices we make impacts the Earth. Below are the facts about CO_2 emissions during the lifetime of plastic bags and plastic bottles that will be helpful for students to know as they engage in the unit's activities.

As of 2008, 70 percent of the synthetic industry was comprised of plastic. Plastic is made from oil and natural gas. Petroleum is drilled and transported to a refinery, involving the release of greenhouse gases into the atmosphere. It is a mixture of various kinds of molecules that are easily separated. The molecules in petroleum are made from two kinds of atoms, carbon (C) and hydrogen (H). A common type of molecule in petroleum is called hexane. Scientists believe the hexane molecule is a string of Hydrogen atoms bonded to the four bonding points of Carbon. Carbon is a particularly useful atom for building molecules because it has four bonding points. Crude oil and natural gas are refined into ethane, propane, hundreds of other petrochemical products and vehicle fuel. Ethane and propane are "cracked" into ethylene and propylene, using high temperature-furnaces that give off heat. A catalyst is combined with the ethylene and propylene in a reactor, resulting in "fluff" which is a powdered material or polymer that resembles laundry detergent. The polymer is fed to an extruder where it is melted. Melted plastic is cooled then fed to a pelletizer that cuts the product into very small pellets. [29] These pellets also find their way into our oceans contributing to the massive amounts of plastic waste swirling around in the Gyres.

Polymers are chains of molecules made up of many units. Each link is usually made up of carbon, hydrogen, oxygen and/or silicon. To make the chain many links are hooked or polymerized together. To create polymers, petroleum and other products are heated under controlled conditions and broken down into smaller molecules called monomers that are the building blocks for polymers. Different combinations of monomers produce plastic resins with different characteristics, such as strength or molding capability.

Between 1997 and 2005, the annual sales of bottles of water holding less than one liter increased from 4 billion to approximately 30 billion bottles. When giving consideration to the energy used for pumping, processing, transporting and refrigerating bottled water the annual fossil fuel footprint calculated for bottled water consumption in the United States is equivalent to more than 50 million barrels of oil. There is no information regarding ingredients on the labeling of plastic products or packaging. The American Plastics Council estimated that somewhere around 5 percent of all plastics manufactured are recycled. Today, most recycled polyethylene bottles are exported to China. China is now the largest destination for plastic waste. When we consider recycling, we should also consider what is involved in the recycling process. In addition to the combustion of fossil fuels required during the recycling process there is the issue of collecting and transporting the recyclable materials to the recycling plant. All of these steps contribute to CO_2 emissions into the atmosphere. [30]

The production of plastic requires huge machinery, lots of fuel and large amounts of energy involved in drilling to acquire the oil and transporting it to refining facilities where fuels and plastics are produced. Electricity is the main source of energy needed to make plastic. The electric energy needed in the production and manufacturing processes of plastic usually comes from coal-burning power plants. [31] It is important to keep this in mind when attempting to assign numbers for the calculation of CO_2 emissions of plastic bags and plastic bottles during their lifetime. The carbon footprint of plastic (LDPE or PET, polyethylene) is about 6 kg CO_2 per kg of plastic. Take the weight of your plastic bags or bottles, multiply it by the number of plastic bags or bottles you use [per year]. Then calculate the carbon dioxide emitted by your own usage of plastic bags or bottles.

The production of 1 kg of polyethylene (PET or LDPE) requires the equivalent of 2 kg of oil for energy and raw material. Polyethylene PE is the most commonly used plastic for plastic bags. Burning 1 kg of oil creates about 3 kg of carbon dioxide. So, for every 1 kg of plastic (which requires 2 kg of oil), about 6 kg carbon dioxide is created during production and incineration (because burning 1 kg of oil creates 3 kg of CO_2).

A plastic bag has a weight in the range of approximately 8g to 60g depending upon its size and thickness. According to estimates provided, a common plastic carrying bag weighs between 25 g and 40 g, the average weight being 32.5 g. To simplify the calculation, take the above 1 to 6 relation between kg plastics and kg of carbon dioxide, and you get 195 g carbon dioxide for 32.5 g of plastic, which is the equivalent of the average plastic carrying bag in the household evaluated. So the calculation for 5 plastic bags would be as follows:

5 (plastic bags) X 32.5 g (avg. weight) = 162.5 g of plastic

162.5 g of plastic X = 975 g of CO_2. [32]

One million plastic bags are used every minute around the world. Over 100 billion plastic bags are used in the United States annually. The total cost of these bags is approximately $ 4 billion. In the U.S. less than 5 percent of plastic bags are recycled and only 1 percent of plastic bags are recycled worldwide.

So, the question to ponder is can something as simple as plastic in its many forms, but focusing on plastic bags and plastic water bottles, contribute to the problems we are experiencing today? Is its contribution significant enough for us to consider making different choices? Is it significant enough to promote alternatives to petro-based plastics? Is it significant enough to care at all? What we want to consider is that the rise in surface temperature, that has already taken place, is going to have irreversible effects on the Earth. The actions we take from this point on, knowing what has happened, can only serve to mitigate the consequences

of global warming and climate change by reducing our contributions to CO_2 emissions into the atmosphere. According to Auden Schendler, "cutting CO_2 emissions is difficult . . . because we live in an energy-based society." [33]

Strategies Employed During Implementation

Direct Teacher Instruction. This will involve a whole group presentation, demonstration or discussion of a key concept. While employing this strategy general information will be imparted to the entire class with the completion of an assignment.

Interactive Internet Websites

Students will use websites to gain further knowledge on a particular topic that is either assigned to a pair or self-selected from the menu for independent work. Some suggested websites have been included but there are others available that you may also find as you browse the Internet.

- http://eo.ucar.edu/kids/green/warming6.htm
- http://epa.gov/climatechange/kids
- http://earthobservatory.nasa.gov/iotd/archive.php
- http://earthguide.usc.edu/earthguide/diagrams
- www.pewclimate.org/global-warming-basics/facts_and_figures

Informative Text Reading - Students will participate in reading, comprehending, analyzing, and responding to informative text material. The content of the material will be related to the unit content and structured toward helping to answer one of the four major questions for each of the topical areas.

Independent Self-Selected Menu Assignments - Students will select topics to research further from a menu of choices. They will also select the process for investigating the topic further engage in hands-on activities; interpreting graphs and drawing conclusions; metric conversions; or interpreting documented statistical material and presenting a summary of it in an alternate format.

Think-Pair-Share - Students will be introduced to the unit through visual imagery accompanied by music. A plastic bottle will be visible on the desk at the front of the room. Students will be paired up to discuss what they think the unit will be about.

Whole Class Group Work - During the Whole Class group lesson content will be presented with the entire class engaged in the same activity and involved in group discussion, my intent is that these whole group lessons will involve an appropriate demonstration, presentation, or reading. Often this may be a math lesson.

Small Group Work including the completing activities that may result in a product or discussion and group decision or conclusion.

Self-Selected Menu Choice Activities - The Menu Activity lessons will provide students with choices of independent tasks that when completed will present written documented information, supporting statistical data, graphic representations, and/or illustrations that further answer the essential questions for a particular

section

After completing the learning activities in this unit, the students will be prepared to and will begin to evaluate some things that can be done as responsible consumers. They will focus on identifying behaviors that would have the biggest impact and make the greatest contribution to controlling and/or minimizing our negative impact on the earth's atmosphere, with the intent of averting the maximum consequences of global warming.

Independent Research

At the conclusion of key segments of the unit or the entire unit, students will select from an annotated list of grade level appropriate independent [research] projects that will illustrate their evaluation of an alternative to a problem agent or approach. These projects might result in sponsoring a school-wide event, a letter to a congressman, a letter to the editor of the local newspaper, an informational brochure to be distributed, participation in a kid focused effort sponsored by EPA or other organization etc. The final decision will include input from the students to promote ownership and maximum participation.

At the conclusion of this unit I envision an accumulation of student work that can be displayed in a progressive sequence that will illustrate to viewers the effect of global warming, contributing factors, and the role that plastics may play in it. Hence the display should depict what is happening, why it is happening, choices we have and considerations for making those choices, and what we can decide to or not to do to help.

Classroom Activities

Sample Lesson I (may take two to three class sessions)

Provide instruction on the natural green house effect and how an increase in the concentration of green house gases impacts the green house effect causing global warming.

Have each student examine a graph that shows the concentration of the three greenhouse gases most affected by human activities, carbon dioxide, methane, and nitrous oxide for a period covering the past 800-1000 years. Engage students in a discussion of how to interpret what the graph represents with regard to the concentration of greenhouse gases during the period covered.

After providing instruction on how a mean (average) is derived and what it represents, provide each student with a copy of the Mauna Loa Monthly Mean Carbon Dioxide graph. Discuss the reason for the fluctuation of the yearly monthly means as reflecting the seasonal differences of the amount of carbon dioxide in the atmosphere because of the amount of vegetation available to absorb carbon dioxide through photosynthesis. Have students read the graph and come up with a monthly mean for each ten-year period. It might be a little difficult for fifth graders to identify the mean for each year within the ten-year period. However, for those capable students, and I did have some in my fourth grade from the previous year, challenge them to go further after completing the assignment for each decade.

After they have recorded the mean concentration for each decade, have them calculate the percent of change from the previous decade. Discuss their calculations and their results. Engage students in what the information they calculated represents and how it might be used in anticipating future changes. Have them calculate an average mean for the next decade using the information from their previous calculations. Allow students to work in pairs as desired.

Sample Lesson II (may take two class sessions and for completion)

After teacher instruction of the concepts of global climate change and its relationship to trash, students will work in groups of four with pairs reading different sets of informative text readings. After reading, each student will generate a 'fortune teller' that teaches the information for the piece of text they've read. Students will generate the questions and formulate the answers. Students will be provided with the specifics of what type of information must be gained by the individuals playing their 'fortune teller' game through their questions and answers. They will then exchange their 'fortune tellers' with other pairs of students in order to facilitate an exchange of information learned.

As students work in groups of four they can organize themselves in any way they choose for the generation of the 'fortune tellers'. They can choose to work as a group and specialize, work as an assembly line or work individually with everyone completing their own 'fortune teller' from beginning to end. My students participate in an annual Meaningful Economics competition that involves a production component that involves producing a product with a specific set of materials. This is a perfect opportunity to integrate production practice into this assignment.

Anyone playing the game with their 'fortune teller' should be able to ascertain, from the information included on the 'fortune teller', what the problem or issue is that is being addressed, what is causing it or the contributing factors, and what some alternatives and/or solutions to the problem or issue are. (See Appendix B for folding instructions)

Sample Lesson III (may take two class sessions and possibly some work done at home for completion)

After instruction on Greek and Latin root words and affixes and modeling the decoding of a sample word, students will be assigned a word of their own. Using a glossary of terms and any additional words that you may choose to add, students will be assigned a specific word. Two of the variety of methods I use for making assignments include selecting a word that has been written on an index card from a box or other receptacle or students obtaining a number as they enter the classroom that matches a word that has been assigned the corresponding number.

Students will generate a quality vocabulary word booklet for their assigned word. The word booklet will have three panels including a front cover, an inside left panel and an inside right panel, and a back cover. An 8 ½ by 11 inches piece of plain white paper is folded in half from an initial landscape position. The cover will include the word in bold letters and an illustration that visually depicts the word. The inside left panel will include the word decoded into its component parts including the root word, suffix, and/or prefix that they have decoded for meaning using Latin and Greek roots and affixes, the definition of the word, part of speech, and other correctly spelled forms of the word. Students must identify the Greek or Latin origin(s) and their meanings. The inside right panel will include an illustration with a caption that demonstrates how the word is related to the content of the unit. The caption must include the word or some form of the word assigned. The back cover will have a list of 3-5 other words that are derived from the same Latin or Greek origins identified

for this word.

The vocabulary booklet will be graded according to a predetermined rubric that is shared with the students during the initial assignment. Students will have the opportunity to grade their own booklet according to the rubric upon completion prior to turning it in for teacher evaluation.

A selection of words suggested for this activity include Anthropogenic, Atmosphere, Biosphere, Carbon, Dioxide, Chemical, Combustion, Consumption, Condense, Cryosphere, Equilibrium, Emission, Fossil, Fuel, Cycle, Hydrosphere, Methane, Ozone, Petroleum, Sequestration, Stratosphere, Teleconnections, Troposphere, Cyclones, Polymer, Polyethylene, Mitigation, Biogenic, Deforestation, Permafrost, Glacier, Depletion, Radiation, Evaporation, Transpiration, Recycle, Symbiosis, Precipitation, Respiration, Variable, Bioaccumulation, Infiltration, Photosynthesis, Compose, Decompose, Compact, Transform, Discreet, and Organic. Online sources for unit related glossaries are:

- http://www.pewclimate.org/global-warming-basics/full_glossary/glossary.php
- http://www.eia.doe.gov/kids/glossary/index.html
- http://nsidc.org/arcticmet/glossary/

Sample Research Projects

Research and identify the specifics of Delaware's Bottle Law. (or other relevant state of choice)

Research methods of recycling that are available to consumers.

Evaluate the effectiveness of current recycling methods.

Examine current recycling efforts and identify ways to increase consumer participation.

Identify alternative methods of producing plastic materials that would reduce the use of petroleum as a raw material.

Identify alternative products consumers can use that would lead to reducing the use of plastics.

Explain the aspects of the Industrial Revolution that could be viewed as contributors to global warming.

Teacher Resources

How are plastics made? Michigan Reach Out. (accessed 07/30 2009). http://www.reachoutmichigan.org/funexperiments/quick/plastic.html. Explanation of how plastics are made from petroleum. Appropriate for student reading material.

Plastic bags and plastic bottles - CO_2 emissions during their lifetime. (accessed 07/30 2009) Time For Change Newsletter. http://timeforchange.org/plastic-bags-and-plastic-bottles- CO_2-emissions. Provides data and calculations for linking plastic production and incineration to CO_2 emissions.

Plastic bag fact sheet - Action Club, 2008 - Lincoln Academy. A Series of slides with photos and information about plastic usage and

impacts on environment and wild life. PowerPoint presentation.

Anastas, Paul, and John Warner. 2000. The twelve principles of green chemistry. In Green chemistry., 30. New York: Oxford University Press Inc. This book is an introduction to the topic of green chemistry. It introduces the reader to what green chemistry is, the tools and principles of green chemistry, and the evaluation of green chemistry. A good introductory resource.

Archer, David. 2007. Global warming: Understanding the forecast. Global warming: Understanding the forecast. Malden, MA: Blackwell Publishing Ltd This book provides a fundamental understanding of global warming by presenting it as the problem of assessing the risk of climate change caused by man.

Bates, B.C., Z.W. Kundzewicz, S. Wu and J.P. Palutikof, Eds., 2008: Climate Change and Water. Technical Paper of the Intergovenmental Panel on Climate Change, IPCC Secretariat, Geneva, 210 pp.

Cowens, John. 2007. Paper or plastic? Teaching Pre K - 8. April 2007, www.teachingk-8.com/archives/integrating_science_in_your_classroom/paper_or_plastic_by_john_cowens.html. Provides activities for finding mass and volume of paper and plastic bags.

David, Laurie, and Cambria Gordon. 2007. The down-to-earth guide to global warming. New York, NY: Orchard Books, Scholastic Inc. A comprehensive resource for understanding why global warming happens and the ways it impacts our planet. Presents ways to work together to help prevent the full consequences of global warming.

Drake, Frances. 2000. Global warming: The science of climate change. New York: Oxford University Press Inc. This book concentrates on the climate related aspects of global warming and how the science is being used to inform policy-makers. It provides the basic concepts behind global warming. It helps the reader place global warming within the context of climate change.

Hertsgaard, Mark. 2006. While Washington slept. Vanity Fair, www.vanityfair.com/politics/features/2006/05/warming200605. Article discussing the potential impact of sea level rise due to global warming.

Imhoff, Daniel. 2005. Paper or plastic. San Francisco, CA: Sierra Book Clubs This book presents the dilemma of the supermarket choice of paper or plastic in today's society. The problem with packaging is unfolded giving consumers, product designers, and policymakers information needed to take necessary steps toward a more sustainable future.

IPCC. Climate Change 2007: Synthesis Report, IPCC Plenary XXVII (Valencia, Spain, 12-17 November 2007. Provides an integrated view of climate change.

Jackson, Lisa P. A. 2006. Climate change kids site - the carbon cycle. Environmental Protection Agency, (accessed 07/30 2009). www.epa.gov/climatechange/kids/carbon_cycle_version2.html. An animated diagram of the Carbon Cycle. Appropriate for kids.

Jackson, Lisa P. A. Climate change kids site - the greenhouse effect. Environmental Protection Agency. (accessed 07/30 2009). www.epa.gov/climatechange/kids/greenhouse.html. An informative and illustrated page of the greenhouse effect with an animated diagram of an enhanced greenhouse effect. Appropriate for kids.

Karl, Thomas R. 1997. Global warming and the earth's water cycle: What do the changes mean and why be concerned? Suite 250, 1717 Pennsylvania Ave., NW Washington, DC: US Global Change Research Program. (accessed 07/30 2009) www.usgcrp.gov/usgcrp/seminars/971105DD.html (Updated Oct. 12, 2003). November 5, 1997 seminar presentation on the Earth's Water Cycle and Global Warming. Appropriate for student reading material.

Maslin, Mark. 2004. Global warming: A very short introduction. New York: Oxford University Press Inc. This book, published in 2004, is an easy read that predicts the impacts of global warming and what could be in store beyond 2004. Identifies the controversies

around global warming and presents the findings of the then current Intergovernmental Panel on Climate Change (IPCC) Report to the general readership.

Millennium Ecosystem Assessment, 2005. Ecosystem and Human well-being: synthesis. Island Press, Washington, DC. World Resources Institute

Rasmusson, E., Alley, R., Fisher, A., Mahlman, H., Tans, P. and Wallace, M. J. Global warming facts & our future - the earth's carbon cycle. Marian Koshland - Science Museum of the National Academy of Sciences. Washington, D.C., (accessed 07/30 2009). www.koshland-science-museum.org/exhibitgcc/carbon01.jsp. Discusses the natural balance of the Earth's carbon cycle and human's impact on that balance.

Richardson, Annie. 2008. Plastic bags and oil consumption. Food democracy. (accessed 7/30/2009) http://fooddemocracy.wordpress.com/2008/07/16/plastic-bags-and-oil-consumption/ ed.

Schendler, Auden. 2009. Getting green done - hard truths from the front lines of the sustainability revolution. First ed. New York, NY: PublicAffairs member of Perseus Books Group. This book looks at the difficulty of going green and the urgency to go green. It highlights the issues surrounding the green movement and the reality of climate change.

Thomas, Karl R., Jerry M. Melillo, and Thomas C. eds Peterson. 2009. Global climate change impacts in the United States. New York, NY: Cambridge University Press, 9780521144070, (accessed 7/30/2009) www.globalchange.gov/usimpacts. Report summarizes the science of climate change and the impacts of climate change on the United States.

Wargo. John, A Quiet Revolution in Plastics. An excellent resource providing information about how the use of different types of plastics, exposure to plasticizer chemicals, and inadvertent consumption of plastics has an impact on human health and the environment at large. Chapter of book.

Student Resources

Brice, Raphaelle. 1987. From oil to plastic. Ossining, NY: Young Discovery Library. This is a simple kid friendly explanation of the production life cycle of plastic drilling to end product.

David, Laurie and Cambria Gordon. 2007. The down-to-earth guide to global warming; New York, NY; Orchard Books, Scholastic Inc. Comprehensive resource for understanding why global warming is happening and the impact it has on the planet.

Hall, Julie. 2007. A hot planet needs cool kids. Bainbridge Island, WA: Green Goat Books This book provides an easily understood explanation of the greenhouse effect. It presents current information about the causes and effects of climate change and how people are working to reduce it. Offers suggestions as to how parents and their children can join the fight to minimize the increase in climate change by making different choices.

Thornhill, Jan. 2007. This is my planet - The kids' guide to global warming. Maple Tree Press Inc., Toronto, Ontario. Explains the natural cycles of the Earth and how they are impacted by global warming.

Interactive Websites for Students

http://epa.gov/climatechange/kids

Informational and illustrated website on Climate System and global warming.

http://www.epa.gov/epawaste/education/pdfs/k00-001.pdf

An informational booklet that explains the reasons to reduce, reuse, and recycle. It makes the connection to trash and climate change. Students in grades 4-5 complete puzzle activities and use their math skills to learn about how reducing, reusing, and recycling affect climate change.

http://www.epa.gov/osw/conserve/materials

A section of the Environmental Protection Agency's website that contains information on a variety of non-hazardous materials recovered for recycling in the United States.

http://www.wildwildweather.com/

This site offers sources for learning activities and interaction regarding weather that lead to studying Science, Math, Language, and Geography.

http://www.pewclimate.org/global-warming-basics/kidspage.cfm

An informational global warming kid's page aimed at helping kids better understand global warming with links to other related sites.

http://www.epa.gov/safewater/kids/flash/flash_watercycle.html

This is an animated diagram of the water cycle.

http://earthguide.ucsd.edu/earthguide/diagrams/greenhouse/

Animated diagram of Global Warmng and the Greenhouse Effect.

http://earthguide.ucsd.edu/earthguide/diagrams/energybalance/index.html

Animated diagram of Global Energy Balance.

Appendices

Appendix A

DE ELA #1 Use written and oral English appropriate for various purposes and audiences.

DE ELA #2 Construct, examine, and extend the meaning of literary, informative, and technical texts through listening, reading, and

viewing.

DE ELA #3 Access, organize, and evaluate information gained through listening, reading, and viewing.

DE ELA #3.2a Be able to organize, manipulate, and express information and ideas relevant to a defined need by using technology to synthesize information into a meaningful format to express ideas and experiences and to create text, drawings, graphs, diagrams . . .

DE Math # 4 Develop Quantitative Reasoning and an understanding of Data analysis . . . by solving problems in which there is a need to collect, appropriately represent, and interpret data; to make inferences or predictions and to present convincing arguments . . .

DE Sci # 3 Energy and its Effects

Ess Ques A What happens to energy in a system - where does this energy come from, how is it changed within the system, and where does it ultimately go? How does the flow of energy affect the materials in the system?

Ess Ques B What is a 'responsible' use of energy? Are there alternative forms of energy that will serve our needs, or better ways of using traditional forms of energy?

GLE 3 Investigate and describe how moving water and air can be used to make objects and machines, such as a waterwheel and windmill, move.

GLE 4 Using books, computers, and other resources, search for ways that people use natural resources to supply energy needs for lighting, heating, and electricity. Report results by making a poster, written report, or oral presentation.

Appendix B

Fortune Teller Folding Instructions

(adapted from EPA's Trash and Climate Change publication)

1. Start with a square piece of paper. Put the letters 'UP' to distinguish one side from the other side of the square, this could be the darker colored side of a two-tone piece of paper.

2. With the 'UP' side facing up fold the paper neatly in half and then in half again in the opposite direction to form 4 equal squares.

3. Unfold the square and flatten out the paper with the 'UP' side still facing upwards.

4. Fold in each corner so that the four points meet in the center.

5. Flip the paper over. Again, fold in each corner so the four points meet in the center.

6. Fold the square in half, making a rectangle, with the open flaps facing down.

7. Slide both index fingers and thumbs under each of the four outer flaps.

8. Pinch your fingers together and push the top corners to help form the shape.

9. Open the 'fortune teller' up and proceed as instructed to write your information in the appropriate sections.

Endnotes

[1] Frances Drake, Global Warming: The Science of Climate Change p 6

[2] Mark Maslin, Global Warming-A Very Short Introduction, 4-6

[3] Frances Drake, Global Warming: The Science of Climate Change, 6-8

[4] Frances Drake, Global Warming: The Science of Climate Change, 31

[5] Mark Maslin, Global Warming-A Very Short Introduction, 4

[6] Frances Drake, Global Warming: The Science of Climate Change, 24-25

[7] Mark Maslin, Global Warming-A Very Short Introduction, 6

[8] EPA, Climate Change Kids Site - The Greenhouse Effect,

[9] Mark Maslin, Global Warming-A Very Short Introduction, 6

[10] Frances Drake, Global Warming: The Science of Climate Change, 39

[11] Frances Drake, Global Warming: The Science of Climate Change, 54

[12] Frances Drake, Global Warming: The Science of Climate Change, 58

[13] EPA, Climate Change Kids Site Carbon Cycle Movie, adaptation

[14] Jan Thornhill, This Is My Planet-The Kid's Guide to Global Warming

[15] Thomas R. Karl, Global Warming and the Earth's Water Cycle: What Do the Changes Mean and Why be Concerned?

[16] Marian Koshland, Global Warming Facts and our Future, http://www.koshland-science-museum.org/exhibitgcc/carbon02.jsp,

[17] Thomas R. Karl, Jerry M. Melillo, and Thomas C. Peterson, (eds.), Global Climate Change Impacts in the United States,

[18] Mark Maslin, Global Warming, 6-7

[19] Global Climate Change Impacts in the U.S.;U.S. Global Change Research Program

[20] Frances Drake, Global Warming: The Science of Climate Change, 54

[21] Hertsgaard, Mark. 2006. While Washington Slept

[22] Global Climate Change Impacts in the United States, Thomas R. Karl, Jerry M. Melillo, and Thomas C. Peterson, (eds.). Cambridge University Press, 2009, 18

[23] Global Climate Change Impacts in the United States, Thomas R. Karl, Jerry M. Melillo, and Thomas C. Peterson, (eds.). Cambridge University Press, 2009, 18

[24] Global Climate Change Impacts in the United States, Thomas R. Karl, Jerry M. Melillo, and Thomas C. Peterson, (eds.). Cambridge University Press, 2009, 16-17

[25] Action Club, 2008;Plastic Bag Fact Sheet, Lincoln Academy

[26] Richardson, Annie. 2008. Plastic bags and oil consumption

[27] John Wargo, The Quiet Revolution in Plastics, 269

[28] John Wargo, The Quiet Revolution in Plastics, 273

[29] How are plastics made? Michigan Reach Out

[30] John Wargo, The Quiet Revolution in Plastics, 267

[31] John Cowens, Paper or Plastic?

[32] Plastic bags and plastic bottles - CO_2 emissions during their lifetime

[33] Auden Schendler, Getting Green Done, 18