Global Warming
Should We Sweat this Environmental Response?

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Introduction

What is global warming and why are there so many conflicting views as to its implications? Weather patterns are shifting and natural disasters are seemingly everywhere on our planet. But are these effects of modern man's dependency on fossil fuels or is global warming a phenomenon of Earth's natural rhythms?

There can be no doubt as to the climatic changes of our planet and what its inhabitants are dealing with. The hottest five years of the 20th century occurred during the late 1990's. Desertification is occurring at the rate of about 60,000 square kilometers per year, and record snowfalls have created devastating floods. Tropical diseases are migrating and droughts are killing crops and creating famine. Environmental refugees are headlined as the media capitalizes on these tragic circumstances.

Global warming skeptics argue that these climatic changes are a natural part of Earth's cycle. Ice core samples indicate dramatic and sudden changes in the Earth's climate. However, in comparison with earlier paleo-climates, Earth's past 12,000 years have been stable. The current warming trend may be enhanced by our dependency on fossil fuels, but skeptics are quick to point out that Earth also has climate cycles, as we see every year with the changing of the seasons.

As the subject of global warming has so many political, social and environmental ramifications, this curriculum unit will examine the greenhouse effect and the resulting climatic changes that will impact the inhabitants of our planet.

The goals of this unit are to present the environmental and social implications of global warming. Students will also examine both sides of the global warming controversy: Is human activity responsible for the acceleration of the greenhouse effect? Or is our planet experiencing a normal, cyclic warming trend? Students will also look at solutions to environmental problems through creative problem solving activities. This careful examination of all points of view may help students with their own decision-making processes that are often not well examined and can lead them into trouble with their personal lives.

Academic Setting

This unit in global warming is targeted towards high school students who may have special academic needs, but it is also applicable to all secondary students. My students are above average in intelligence but are academically challenged as their behaviors impede their ability to learn material at their current grade levels. Their

reasoning and problem solving abilities are strong but not always used in appropriate ways. This unit could last up to three weeks, depending on student behavior and capability to comprehend and participate.

Albuquerque High School is comprised of 2020 students. Sixty eight percent of these students are Hispanic, 20% are Anglo, 5% are African American, 5% are Native American, and the remaining are a mixture of Asian, African, and Russian. The ethnicity rates are higher at Albuquerque High School as compared to the other ten high schools in the city of Albuquerque. Tweny-five percent of the students attending Albuquerque High School receive free or reduced lunches. The percentage of students who receive free or reduced cost meals is considered an indicator of socio-economic status. The higher the percentage, the more likely a school is to have a larger percentage of students with special needs related to poverty.

Global Warming

History of Global Warming Awareness

The theory of global warming is not new. Since the time of Napoleon, scientists had known about the greenhouse effect. The mathematician and scientist, Jean Baptiste Fourier (who first coined the term 'greenhouse effect') noted the principles of global warming in 1827. He observed that certain gases trapped sunlight in the atmosphere, similar to the glass in a greenhouse. The Swedish chemist, Svante Arrhenius, first predicted global warming in 1896. He attempted to measure carbon dioxide in the atmosphere and predicted that doubling the concentration of CO_2 would increase temperatures between 9° and 11°F. This 100-year-old prediction is close to scientists' current calculations.

In the 1938, G.S. Callender, a British meteorologist, declared that global warming was already taking effect. He had gathered information from over 200 weather stations around the world and demonstrated that average temperatures had increased between the 1880s and the 1930s. His hypothesis was not well received by the scientific world and began a long running controversy of global warming. In 1955, a young geo-chemist named Charles Keeling began monitoring CO_2 levels in the atmosphere from the top of Mauna Loa, Hawaii. Keeling's careful measurements have shown an increase in CO_2 levels over the past 45 years. In 1979, Mrs. Margaret Thatcher became Prime Minister of the United Kingdom, and she helped to elevate the global warming hypothesis to the status of a major international policy issue.

Modern technology has elevated these scientific predictions into political and social controversies. Paleo-climate data gathered from core samples of ice sheets, tree rings, and sea floor sediments indicate wild extremes in Earth's ancient climate. Paleo-climate data also suggest extreme variations in carbon dioxide levels that coincide with the temperature variations. The lower the carbon dioxide

levels, the cooler Earth will be.

The Atmosphere and the Greenhouse Effect

The atmosphere of our planet can be divided into several layers with differing temperature structures. The atmosphere is composed as follows:

1) Troposphere -is closest to Earth's surface and contains ~ 90% of the atmosphere's mass
-reaches up about seven miles from the surface of Earth
-holds the oxygen we breathe
-clouds are formed here (most water vapor is in troposphere)
-most air pollution is found in the troposphere, where it may be moved about by the wind or returned to earth in rain or snow

2) Stratosphere -second layer of Earth's atmosphere
-is about 20 miles thick
-upper layer of the stratosphere reaches 30 miles above the earth
-contains the ozone layer which help block ultraviolet rays.

3) Mesosphere -third layer of earth's atmosphere
-is about 25 miles thick
-upper layer of the mesosphere reaches 55 miles above Earth
-may have extreme winds and cold temperatures (-165° F).

4) Thermosphere -fourth layer of Earth's atmosphere
-may be 550 miles thick
-upper layer of the troposphere blends with space
-air in the thermosphere is very thin and has little protection from the scorching heat of the sun.
-temperatures can reach 2000° F.

Greenhouse Effect

The greenhouse effect is what allows for the proliferation of life on Earth. Like a greenhouse, Earth' s atmosphere allows sunlight to enter and penetrate all the way to the surface in the form of short-wave radiation. The heat that is radiated back from the rocks and oceans is at a different wavelength from the incoming sunlight. This longer wavelength has more active atmospheric absorption than the incoming short-wave radiation. This difference accounts for the natural greenhouse effect that makes life on Earth possible in the first place.

The long-wave radiation does not travel back out through the atmosphere like the sunlight coming in because much of it is absorbed by clouds and naturally occurring trace gases in the atmosphere. The main long-wave absorbing gas is water vapor, mostly in the form of clouds. Then there is carbon dioxide, methane, nitrous oxide and ozone. These gases are more efficient at absorbing outgoing

long-wave radiation than incoming short-wave radiation. Therefore, they trap heat and there occurs a natural greenhouse effect. The trapped heat is then distributed around the planet by direct radiation (as from the rocks), air currents, evaporation, cloud formation and rainfall. Scientists calculate that without the naturally occurring greenhouse effect, Earth would be about 60° F cooler than the global current average of 59°F (Easterbrook 1995). Our planet would be frozen (0° F) without the greenhouse effect.

Enhanced Greenhouse Effect

The enhanced greenhouse effect is largely caused by the addition of fossil fuel emissions into the atmosphere. These emissions come from a variety of sources including industries, trains, plains, automobiles, coal-burning utility companies, and even lighter fluids for outdoor cooking. Seven to eight billion tons of carbon dioxide are pumped into the atmosphere each year by these human activities. (Nature produces 200 billion tons). Pre-industrial levels of CO_2 were 280 parts per million. The present concentration is 370 parts per million. Future levels are predicted to reach 555 parts per million around 2100. (Gutzler 2000) As humankind becomes accustomed to convenience and luxury, our dependence on fossil fuel grows and soon society will be forced to examine the consequences of our desired lifestyles.

Careful measurements of other greenhouse gases indicate increasing levels of methane, nitrous oxide and ozone. Methane (CH_4) is estimated to have thirty times the warming potency of carbon dioxide. Methane is a waste product of the biological activity of certain bacteria. Major contributors of methane include cattle, sheep and rice paddies. As our world population burgeons at 6 billion (10 billion by 2100 Gribbin, 1990) there will be more demands placed upon these food sources and consequently, more methane production trapping more heat. Nitrous oxide (N_2O) is also increasing but at a slower rate than methane. The increase in N_2O is mainly a result of the use of nitrogen-based agricultural fertilizers, but can also be attributed to the burning of fossil fuels, lightning, and biological activity in soils. Ozone (O_3) is a form of oxygen and is very efficient at absorbing infrared radiation. Most of the ozone in the atmosphere is in the stratosphere where it is both created and destroyed by photochemical processes in a series of reactions. These reactions are roughly in balance but are now being disturbed by human activities. Ozone production is increasing with the population, as are the other greenhouse gases.

The most prevalent greenhouse gas and the one most responsible for global warming is water vapor. It has a concentration thirty times greater than carbon dioxide and is responsible for nearly 99% of the natural greenhouse effect. (Easterbrook, 1995). Unfortunately, even the slightest warming caused by an increase in CO_2 levels will cause more evaporation of ocean waters, which in turn, creates more heat trapping water vapor in the atmosphere. This is a positive

feedback in the climate system.

An Overview of the Effects of Global Warming

Melting of Polar Ice

The break up of polar ice shelves may be the most dramatic manifestation of global warming. Glacial ice that has been frozen for twenty thousand years is breaking up and melting at rates far greater than anticipated by scientists. (Gelspan 1997) The surface of ice acts like a mirror and reflects most of the sunlight back into the atmosphere. When ice shelves break up, exposed rocks absorb heat and further warm the ice cap. The earth will reflect less heat and retain more of it, perpetuating the process.

Recent data show that the Arctic ice cap has thinned in the last decade. The melting of this polar ice sheet will destroy the algae that grow on its underside and form the basis of the food chain which vast numbers of fish, seabirds, and mammals depend. Algae also produce oxygen and consume carbon dioxide, a global bonus we do not want to lose.

Plankton, which thrives in cold seas, is also under threat both from rising ocean temperatures and from increased exposure to ultraviolet radiation due to ozone depletion. Plankton also plays a key role in absorbing carbon dioxide from the atmosphere by incorporating it into their cells. Certain plankton (phyto-plankton) also produce oxygen. A reduction in plankton productivity could therefore dramatically accelerate global warming and destroy ocean food chains.

Rising Sea Levels

As carbon dioxide builds up and traps heat in our atmosphere, the oceans absorb some of this heat and sea levels rise due to thermal expansion. The resulting warmth expands ocean waters, just as the level of water heated on the stove expands in its pan. The rising of sea levels will result in serious environmental and social problems for human kind. These include:

1. Island nations and coastal communities will be gradually inundated by ocean waters and habitable land will shrink (Kiribati, Maldives, Bangladesh, Egypt, Holland, Louisiana, etc.).

2. Sea walls can be built, but at a cost that may not be attainable by developing nations (hundreds of billions).

3. As people are forced to move inland, animal habitats will be infringed upon, further stressing fragile bio-systems.

4. Rising sea levels will breach coastal habitats that are vital for providing protein to poor communities. Animal such as shrimp, crawdads, and oysters that breed in estuaries, (bays, etc. where

fresh and salt water mix) will be killed off as oceans rise.

5. Animals at the top of the oceanic food chain may become endangered as warmer sea temperatures disrupt algae and plankton production.
6. Coral reef production will be challenged as the careful balance between sea levels, sea temperatures, and wave action is disrupted by global warming.
7. Rising sea levels will have serious economic consequences for island nations and coastal communities that are dependent on tourism.
8. Island nations and coastal communities will experience deadlier and more frequent storms and storm surges.
9. Coastal flooding by storms will result in the loss of crucial wetlands and mangrove swamps that act as barriers between the land and the sea.
10. Fresh water will be harder to attain as rising sea levels inundate inland water supplies.
11. Agriculturally productive delta areas will diminish due to rising seas. (Egypt, Mississippi)
12. Croplands may become salty and nonproductive due to rising water tables from infiltration of the seas.

Changing Patterns of Precipitation

One of the ironies of global warming is that a warmer Earth would probably mean more rain and flooding in some areas. As temperatures rise there is more evaporation, which in turn puts more water vapor into the atmosphere. Global warming will also induce higher temperature differences between the land and sea surfaces, causing an increased transport of precipitable water to the continents and increased rainfall.

As global temperatures increase and precipitation patterns change, there will also be a shifting of plant and animal habitats. Ecological zones will shift toward the poles in an attempt to escape rising temperatures. Many plant and trees species will not be able to migrate fast enough, some perhaps only 1.2 miles a year. If ecological zones shift 60 to 95 miles or more over the next 40 years as some researchers predict, then there may be a widespread extinction of plants and the animals dependent on them. Animals that can not keep up with shifting zones may become extinct.

Desertification

Desertification is the degradation of drylands and is caused by climate change and unsustainable land use. The most common forms of unsustainable land use are over-cultivation, over-grazing, deforestation, and poor irrigation techniques. These practices result in the loss of productivity in croplands, pastures and woodlands. Drylands can be defined by having modest water supplies: less rainfall than forests, but more rainfall than a desert. Pampas, steppes, plains, grasslands, and savannas are all considered drylands. Hyper-arid areas, such as the great deserts, are not considered drylands. Drylands are one of the most productive of the ecosystems (Milich 1997) and serve as the world's breadbaskets for grain production. The people living in drylands are particularly resilient and have mastered their ecosystems in sustaining and maintaining life in harsh areas.

Desertification is a worldwide phenomenon, affecting two-thirds of the countries in the world and one-third of Earth's livable surface, on which one billion people live. The consequences of desertification are broad in spectrum, with the most serious of these being the social costs. As drylands are degraded by climatic changes, malnutrition and starvation can lead to famine, typically in areas that are also experiencing poverty, civil unrest or war. In Africa, many people have become internally displaced or forced to migrate to other countries due to war and drought. The environmental resources in and around the cities and camps where these people settle come under severe pressure. Difficult living conditions and loss of cultural identity further undermine social stability.

The environmental consequences of desertification are perhaps more difficult to rectify as the imbalances set in motion by either climate changes or human activities are slow to recover. As native soils are subjected to harsh climatic conditions and human influences, its physical and bio-chemical composition is changed, rendering it less productive. Exposed and eroded topsoil can be blown or washed away by infrequent rainstorms. Gullies and cracks may appear and wind or water can remove vital nutrients. If the water table rises due to inadequate drainage and poor irrigation practices, the soil can become waterlogged, and salts may build up. When soil is trampled and compacted by livestock, it can lose its ability to support plant growth and to hold moisture, resulting in increased evaporation and surface run-off. These are several of the factors responsible for degrading drylands.

Another consequence of desertification at the local and global level is the destruction of animal and vegetative species, resulting in a reduction in bio-diversity. This loss of biodiversity affects the health of local people who rely on a large number of different animal and vegetable species. It also encourages genetic erosion of local livestock and plant varieties. The loss of genetic strains of cultivated and indigenous plants can affect the possibility of producing botanically based medicines to treat or prevent disease. The loss of vegetation also results in a loss of oxygen production and carbon dioxide intake.

Insect Infestations and the Spreading of Tropical Disease

Insects are "cold blooded" and populations are kept in check by freezing and cold temperatures. With the rise of global temperatures over the past ten years, many countries are experiencing infestations that are ruining crops and homes and spreading disease where none have existed. The Intergovernmental Panel on Climate Change (IPCC) declared that "Climate change is likely to have wide ranging and mostly adverse impacts on human health with significant loss of life."

The health effects from global warming are being experienced in many forms. As so often happens, poor people are being hurt the most. Direct health effects from a warmer climate include death by starvation, heat stroke and drowning. Indirect health effects include cholera, malaria, dengue fever, typhoid, salmonella and bubonic plague.

Environmental Refugees

Today there are over 25 million environmental refugees roaming the world, squatting on other people's land, migrating to over-crowded cities, sneaking under cover of darkness across borders, and scrambling to survive (Gelspan, 1997). Their numbers exceed all other types of refugees — political, economic, and religious. Most of these refugees are in sub-Saharan Africa, India, China, Mexico, and Central America—all at a comfortable distance from North America.

The number of environmental refugees is expected to grow exponentially with the growth rate of the human population. By 2050, the following countries are predicted to contribute millions of environmental refugees to an increasingly homeless world:
Bangladesh ~26 million refugees
Egypt ~12 million refugees
China ~85 million refugees
India ~20 million refugees (Myers, 1995).

As water, food, and shelter availability continue to become less accessible, these ~150 million environmental refugees will be forced to exist anyway possible, even if it means further damage to an already challenged biosphere. Will these overwhelming numbers compromise our ability for compassion and capability to help?

Global Warming Skeptics and Imagined Risk

Most global warming skeptics do not agree with the latest finding of the IPCC. The research done by this group of 2500 scientists indicate that planetary warming is occurring, that it is separate from the natural variability of the climate, and that it is caused by the build up of greenhouse gases—notably emissions from the burning of coal and oil (Gelbspan 1997). Many of these skeptics are found in industries that will have something to lose if society were asked to reduce their use of fossil fuels. The fossil fuel industries are large and very powerful and want to maintain their trillion-dollar-a-year commerce in oil and coal as long as they can.

However, skeptics of global warming do have some convincing arguments. Perhaps their biggest argument is that there is a pervasive ‘imagined risk’ being generated by global warming believers who claim that human activity is causing increased global temperatures. These believers of global warming allegedly manipulate their facts and figures and use natural disasters (floods, drought, hurricanes) to fuel their allegations. The media tend to capitalize on these disasters, further fueling alarmist views by comparing human grief and tragedy with changing weather patterns.

Imagined Risk: Arguments of Global Warming Skeptics

"The efforts to fix the imagined problem could be worse than the problem imagined" (Heartland Institute 1998). This summarizes the biggest argument of global warming skeptics. Other arguments include:

1. Imagined risk has become a real risk in the form of proposed governmental policies to inhibit CO_2 emissions. Developing nations will be hurt; the poorest nations will suffer the most from suppressed economic development.

2. Renewable sources of energy such as wind, solar, water and biomass will not be able to meet the demands of the developed world.

3. Climate models consistently over-estimate global warming. Oceans and clouds are not accurately factored into the calculations. Oceans trap heat and clouds reflect a percentage of entering sunlight back into space.

4. In the West many forms of pollution have begun to decline in the very period that environmentalists declared them to be growing worse (Easterbrook 1995).

5. Temperature increases will be beneficial to the coldest latitudes. Crop production may increase as more land is available and carbon dioxide levels increase.

6. The emphasis on increased abnormal weather patterns is unfounded. Abnormal weather and natural disasters are within the normal range of climatic variations.(Gutzler 2000).

7. The "heat island effect" (increased temperature readings from urban areas) and lack of ocean readings give inaccurate measures of heat. These readings do not detect small variations in temperatures.

8. Global warming is impacted by solar insolations. These variations in energy output from the sun has shown to

(naturally) increase or decrease global temperatures.

Another very intriguing argument from global warming skeptics is that humankind is incapable of creating a change in the weather, as the mass of the atmosphere is so great. Global warming skeptics also say that over time our planet has the ability to cleanse itself from pollutants. Nature has repelled forces of a magnitude many times greater than the worst human malfeasance. Nature will continue to rule the earth, even as humankind exerts its presence.

Possible Solutions to Environmental Problems

Potential environmental ramifications are hard to deny and harsh scenarios must be addressed to help society prepare for our changing climate, whether it is naturally induced by the rhythms of our planet, or brought about by a dependency on fossil fuels. The following solutions are but a few of the many possibilities in helping our fragile ecosystems.

1. Simplify life by consuming fewer material goods. This will be difficult in capitalistic countries that are swayed by media to have the biggest, the fastest, and the most of everything possible. The current era of ‘instant gratification’ is fueled by credit card and loan companies that have made consuming appear easy and painless. If people were less materialistic, fewer natural resources would be consumed, allowing for less of an environmental impact.
2. Control growing global populations, the greatest factor impacting the environment. As population grows exponentially (and food crops, arithmetically) there will be huge demands placed on our natural resources. Fossil fuel emissions will also escalate the greenhouse effect and increase global temperatures. Many countries are working hard to educate women (and men) as to their family planning options. Education appears to be the one factor that is helping to manage a growing population.
3. Halt deforestation and replace vegetation. This process will help to decrease soil erosion, increase oxygen levels, rebuild animal habitats and provide potential food sources for growing populations. Halting deforestation would reduce atmospheric carbon dioxide by acting as a "sink" to store carbon. Maintaining present forests and planting new forests is also necessary in the movement towards atmospheric remediation. The American Forestry Association points out that "for every ton of new wood that grows, about 1.47 tons of CO_2 are removed from the air."
4. Depend less on fossil fuels for transportation. Use of mass transit systems, car-pooling, riding bikes, and walking to our destinations will help in reducing fossil fuel emissions. Concentrated efforts will be needed to preserve our finite reserves of coal and oil and reduce CO_2 levels.
5. More use of energy efficient appliances, windows, lighting, heating & cooling systems, vehicles, etc. The technology to increase efficiency in all of

these areas is available if we are willing to make the changes and pay the prices.

6. More use of sustainable forms of energy. Solar, wind, geo-thermal and hydropower are renewable, alternative sources to coal and oil. More technological improvements have helped increase the viability of these energy sources.
7. More efforts toward recycling of newspaper, paper, cardboard, glass, metals and plastics are needed to preserve natural resources and reduce landfills. Recycling these materials takes energy and commitment, but will help preserve current natural resources.

Vocabulary for Global Warming

aerosol- A suspension of liquid or solid matter in air. Some are produced mechanically, such as dust, sea salt or soot and some are produced chemically through the conversion of gases into solids or liquids, such as the conversion of sulfur dioxide gas into sulfuric acid. These increase albedo and act to cool the surface of Earth.

albedo- The fraction of light reflected by a surface, often expressed as a percentage. Snow covered surfaces have a high albedo level; vegetation-covered surfaces have a low albedo because of the light absorbed for photosynthesis.

anthropogenic effects- Effects which result from human activities such as the burning of fossil fuels or deforestation.

carbon cycle- The exchange of carbon in various chemical forms between the atmosphere, the land and the oceans.

carbon dioxide- An important greenhouse gas consisting of one carbon atom and two oxygen atoms. Plants use it during photosynthesis to make carbohydrates. CO_2 is released back into the atmosphere during the processes of combustion or decay.

carbon sink- The techno-term for whatever absorbs carbon dioxide as part of the carbon cycle. Sinks include oceans, trees and tundra.

climate- The average or predicted weather conditions in a particular region. Climate is quantified by measures such as the monthly mean temperature or precipitation averaged over a number of years.

climate model- Computer programs designed to represent atmospheric, dynamic and chemical processes that occur in nature.

cloud condensation nuclei- Aerosol particles on which molecules of water vapor may condense to form cloud droplets or ice particles.

deforestation- Cutting down forests; one of the causes of the enhanced greenhouse effect, not only when the wood is burned or decomposes, releasing CO_2, but also

because trees take in CO_2 from the atmosphere in the process of photosynthesis.

desertification- The process of land degradation that involves loss of nutrients in soil, loss of topsoil, loss of native and cultivated vegetation, and lack of rainfall. These effects are human-made, but are being enhanced by global warming.

drylands- Land that has a modest water supply (less than a forest, more than a desert). Plains, pampas, steppes, grasslands and savannas are all considered drylands.

feedback- A process in which one event affects another, which then affects the original event. In climate, warming is causing more evaporation which increases water vapor in the atmosphere which amplifies the initial warming and causes still more evaporation.

fossil fuels- Fuels such as oil, coal, or natural gas, made by decomposition of ancient plant and animal remains which give off carbon dioxide when burned.

GCM- An anacronym derived from "general circulation model", which is a computer model that calculates the detailed large scale motion of the atmosphere or the oceans explicitly from the equations of physics.

global warming- The idea that increased greenhouse gases cause Earth's temperatures to rise globally.

greenhouse effect- A natural process in which solar radiation is transmitted through the atmosphere and heats the surface of Earth. Thermal infrared radiation emitted by the surface cannot easily pass through the atmosphere, so the surface heats up to achieve an energy balance.

halocarbons- A family of industrial gases containing halons, such as chlorine, bromine and carbon. They are manufactured for use in refrigeration units, as cleaning solvents, and in the production of insulating foams. These gases are destructive of the stratospheric ozone layer and are long lived in the atmosphere.

hydrological cycle- The exchange of water between the atmosphere, the land and oceans.

infrared radiation- Radiation with wavelengths between 4 and 200 microns. It is emitted by all objects with temperatures close to that of the surface of Earth. It is invisible to the human eye, but the heat from it can be felt by human skin. Earth cools by emitting infrared radiation to space.

insolation- Incoming energy from the sun. The first two parts of the word come from "in=in" and "sol=sun".

methane- An important greenhouse gas (also known as natural gas) consisting of one carbon atom and four hydrogen atoms. It is produced during decay in the absence of oxygen, such as takes place under water, within our planet, or in the

guts of animals. It is an important energy source whose concentrations in the atmosphere have more than doubled since pre-industrial times.

nitrous oxide- Another important greenhouse gas consisting of two nitrogen atoms and one oxygen atom. This gas is created by lightning and from agricultural fertilizers.

ozone- A form of oxygen primarily present in the stratosphere and responsible for blocking ultraviolet radiation.

solar radiation- Radiation emitted by the sun, consisting of ultraviolet radiation, visible radiation, and near-infrared radiation. Of the total energy emitted by the sun, about half is visible and half near infrared, with ultraviolet being a small, but important constituent. Much of the ultraviolet radiation is absorbed by ozone in the stratosphere, which prevents it from harming life at the surface of Earth.

sulfur dioxide- A gas consisting of one sulfur atom and two oxygen atoms. It is produced by volcanoes, during the combustion of fuels containing sulfur, and by life processes. In the atmosphere it is converted into sulfuric acid aerosol, which may form hazes and serve as a mechanism for cloud condensation nuclei and acid rain.

stewardship- The attitude that human beings should see the earth as a garden to be cultivated rather than a treasury to be raided.

sustainable development- Development which meets the needs of the present without compromising the ability of future generations to meet their own needs.

weather- The short-term events of the atmosphere in terms of minutes, hours, or days.

Teaching Strategies

The following instructional strategies are designed for students who are in a full inclusion classroom to meet their academic needs. Instructors of this unit may modify or eliminate lessons as needed.

Science

Drawing of Earth's Atmosphere

Materials: White drawing paper; pastels; diagram of the layers of Earth's atmosphere

Objectives: To give students a visual representation of the layers in the atmosphere.

Procedure: First model the drawing of the atmospheric layers (troposphere, stratosphere, mesosphere, thermosphere) and describe the qualities of each. Students are to take notes as the layers are being described. Have students repeat the drawing process, and encourage students to use a different pastel for each layer. Remind students to blend their pastel colors, as the atmospheric layers blend into

one another. Have students orally review the qualities of each atmospheric layer.

2) *Fossil Fuel Creation and Destruction*
Materials: Earth science book, etc. that describes the geologic time periods and the formation of fossil fuels; students' science note books, pencil colors, adding machine paper, rulers.
Objectives: To help students understand the extremely long process of fossil fuel formation, as well as the short period in which society is using up these finite resources.
Procedures: Read with students the process of fossil fuel creation (ancient plant and animals buried and exposed to great pressure that changed them into coal, oil and natural gas). Discuss the ancient time period in which this process took place (Triassic, Jurassic, Cretaceous, etc.) and the very short time period in which we have begun to burn these off. Students are to take notes during the reading and discussion of this information. Students will also demonstrate this new knowledge by drawing and labeling a time-line of the geologic eras up to present day. Give each student about ten feet of adding machine paper to use as their time line. Explain that students are to divide up the geologic eras into periods of 100 million years. Each 100 million years is equal to 3 inches. Students are encouraged to draw what was alive during these eras on their adding machine paper. Make sure students label each geologic time period. Discuss with students the correlation between production and destruction of fossil fuels using their time lines as evidence.

3) *Earth's Carbon Cycle*
Materials: Earth science book, etc. with good explanation and graphics that explain the carbon cycle. (See p.23-29 of *Global Warming: The Complete Briefing* by John Houghton), students' science journals, pencil colors
Objectives: To teach students about the movement of carbon dioxide throughout our planet and its atmosphere. Carbon dioxide is a vital greenhouse gas for plants and marine plankton. Earth has a mechanism for balancing excess amounts, but human activity is producing amounts that may be disrupting this balance.
Procedures: Read the carbon cycle with students. On the board, sketch and diagram the exchange of CO_2 between the land and oceans. Include the additional CO_2 production from human activities. Discuss carbon dioxide sinks (oceans, forests, tundra) and how deforestation and rising global temperatures are melting the tundra and causing the release of CO_2 back into the atmosphere, challenging a delicate balancing. Have students take notes and reproduce diagrams in their science notebook. Encourage students to be creative and colorful with their drawings.

4) Greenhouse Effect
Materials: Earth science book, etc. with explanation of greenhouse effect. (See student & teacher reading list), student's science journals, pencil colors
Objectives: To help students learn about Earth's greenhouse effect that allows for

life to proliferate. Students will also examine the increase of greenhouse gases caused by human activities that are leading to global warming.
Procedures: Read with students the information on greenhouse effect. Draw and diagram the process of incoming short wave radiation that hits the surface of our planet. Explain that our planet returns this radiation back into the atmosphere in the form of long wave radiation. Review the atmosphere and that helps to trap and circulate the heat emitted from Earth's surface. Review the gases that are enhancing the greenhouse effect (CO_2, N_20, CH_4, O_3) and their heat carrying capacity. Have students take notes and recreate the drawing from the board or their science book. Discuss the potential problems, solutions, and benefits associated with global warming.

Creative Writing

1) *Science Fiction Story Based on Catastrophic Effects from Global Warming*
Materials: lined paper or students' journals, a written review of the effects of global warming (on the board), present and future, pencil colors
Objectives: To have students write a creative story based on their knowledge of the impacts of a warmer Earth, and to practice their written language skills. Students should be encouraged to illustrate a section of their science fiction story to help stimulate creativity and allow for another learning modality to be manipulated.
Procedures: Lower the classroom lighting if possible, to help create a somber mood. Review the social and environmental impacts of global warming. Explain to students that they are to write a creative story that should be at least two to three pages in length. Encourage students to be as dramatic as possible, using worst case scenarios. (Remember the movie, *Soylent Green*?) Students' writing should be done in 2 drafts to allow for corrections in grammar, punctuation, spelling, and accuracy of directives.

2) *Science Fiction Story Based on Simpler Life Styles*
Materials: lined paper or students'journals, a written review of simpler life style changes and options (on the board), pencil colors
Objectives: To have students write a creative story about our society choosing to greatly simplify our life styles to help preserve natural resources and reduce rising global temperatures. Students are to give specific examples of solutions (more use of mass transit, less materialism) in their story. Students will practice their written language skills. Students will also practice future problem solving skills.
Procedures: Review with students the many solutions for simplifying life in order to preserve natural resources. Explain to students they are to write a story of at least two to three pages in length. Encourage students to think critically of our many options and to be creative in their writing. Students' stories should be done in two drafts to allow for corrections in grammar, punctuation, spelling, and accuracy of directives.

Critical Thinking Skills
1) Scientific Debate Between Global Warming Skeptics & Believers

Materials: A written review of arguments on both sides of the global warming controversy on the board. (A warmer planet will mean more crop production in colder latitudes; a warmer climate will cause the seas to rise).
Objectives: To help students think critically about the global warming controversy. Students will also practice their public speaking skills by defending their view points.
Procedures: Divide students into two groups (skeptics & believers) and have them review the arguments they will be debating. Students should be given basic ground rules of debating an issue (One person speaks at a time, no put-downs or name calling). Have students debate one issue at a time

Future Problem Solving

1) *Renewable Energy Sources*

Materials: Earth science book, etc. that discusses renewable energy sources (see p.88-95 of *Our Fragile Planet: Global Warming* by Jenny Tesar); lined paper or students' journals, computers, CD-ROM encyclopedias, access to the internet
Objectives: To help students critically think about the environmental problems our planet may soon be facing. Students will review energy alternatives that may help to reduce CO_2 emissions and lessen the potential for global warming. Students will also practice their written language skills, as well as their computer & internet research skills.
Procedures: Review and discuss renewable, alternative forms of energy that may potentially reduce CO_2 emissions (wind, solar, biomass, nuclear, geothermal, etc.). Ask students to select one alternative energy form and research its potential viability to sustain energy for societies across the planet. Students are to explain how their chosen energy form produces power. Have students research where their chosen energy form would be the most geographically successful. Students can also be challenged to develop a new form of energy and explain its process for producing energy.

2) *Atmospheric Remediation*

Materials: A written review (on the board) of the greenhouse effect, greenhouse gases, atmospheric layers, and consequences of a warmer planet; paper or students' journals, pencil colors.
Objectives: To help students critically think of methods to remediate our atmosphere, and to practice critical and creative thinking skills. Students will also practice their written language skills.
Procedures: Review and discuss the information on the board. Challenge students to write about a way of cleaning the air in the layers of our atmosphere. They are to be creative as possible, and may also illustrate their inventions. Accept all suggestions and encourage students to detail the technology that will be needed to construct their ideas.

Geography (this could be an on-going lesson, lasting all year)

Where in the World is the Natural Disaster or Environmental Problem?

Materials: large, current world map (National Geographic magazine is a good source); high school student atlases of the world, daily newspaper, or weekly magazine articles on natural disasters & environmental concerns, a pocket folder for each student, colored thumb tacks or push-pins that are, color-coded by classification of natural disaster or environmental concern
Objectives: To help students learn world geography by following media articles on natural disasters & environmental concerns; and to enhance student awareness of environmental issues around the world.
Procedures: Make copies of the articles for each student as you can get them. Give each student an atlas, and a pocket folder to keep articles in. Each day (or less often) read the articles with students and discuss the social and environmental ramifications of the event. Have students locate in their atlas where the problem has taken place. Design a color-coding system for your pins or tacks that indicate the type of disaster or problem that has occurred (black: petro-chemical spill; green: hurricane, storm surge, typhoon; orange: wild-fire; red: drought or famine; purple: spread of tropical disease or insect infestations, etc.). Then have a student place the color-coded pin or tack into the map where the problem has occurred. Discuss which continent the event has taken place; review the form of government and what the country's economy is like. Would this be a place the students would wish to travel to? How would they get there? What places and cities would they want to visit in this country? Use student atlases to answer these questions.

New Mexico State Standards

This unit addresses the following state standards as appropriate for students in grades 9 – 12.

Science: Unifying Concepts and Processes
1) Student will interpret evidence to understand changes in natural and artificial systems.
2) Student will evaluate specific hypotheses, models, laws, theories, principles, and paradigms as explanatory tools.
3) Student will analyze models for limitations, strengths, and basic assumptions.
4) Student will evaluate the contribution of external and internal forces to change in the form and function of objects, organisms, and natural systems.

Science: Science as Inquiry
1) Student will develop causal functional questions to guide investigations.
2) Student will use evidence to understand data and to develop consistent arguments to logically explain data.
3) Student will explain and interpret the results of investigations to teachers, parents, and others.
4) Student will explain that science distinguishes itself from other bodies of knowledge through the use of empirical standards, logical argument, and skepticism as scientists strive for certainty in proposed explanations.
5) Student will explain that scientific ideas depend on experimental and

observational confirmation, and that theories and ideas are refined or discarded as new evidence becomes available.

Science: Life Science
1) Student will predict the impact humans might have on species and environmental systems.
2) Student will analyze the impact of resource depletion in over populated areas on social and cultural norms.
3) Student will predict the impact on recycling on resource depletion and environmental degradation.
4) Student will evaluate the interaction of multiple factors such as risk, environment, and desire on choices for meeting basic human needs.

Science: Earth and Space Science
1) Student will evaluate information about Earth's materials, energy of the Earth's systems, and geo-chemical cycles.
2) Student will model the interaction between the Earth's internal and external energy sources indicating that these energy sources create heat.
3) Student will model weather patterns and other natural cycles related to the movement of matter driven by the Earth's internal and external sources of energy.
4) Student will use fossils and other evidence to investigate how the Earth has changed or remained constant.
5) Student will explain the evolution of the Earth in terms of the interactions among the geosphere, hydrosphere, atmosphere and biosphere.

Science in Personal, Social, and Environmental Perspectives
1) Student will predict the risks and benefits associated with natural and social hazards.
2) Student will evaluate human activities for the potential they have for increasing or decreasing environmental risks.
3) Student will develop models for tracking changes in social risk factors and natural hazards.
4) Student will develop cost-risk benefit analysis in the context of natural hazards and environmental issues (ozone depletion, carbon dioxide reduction and global warming).

Social Studies: People, Cultures, Places and Environments
1) Student will evaluate the relationships among various regional and global patterns of geographic phenomena such as land forms, soils, climate, vegetation, natural resources and population.
2) Student will evaluate and predict how environmental changes and crises impact society and the economy around the world.
3) Student will evaluate information from different theories using a wide range of philosophies to explore diverse uses of land and resources.

Social Studies: Global Connections and Technology
1) Student will analyze the influence of science and technology upon society.

2) Student will evaluate how science and technology have transformed the physical world and human society.
3) Student will analyze how science and technologies influence core values, beliefs and attitudes of society, including public policies.
4) Student will analyze and assess the causes, consequences, and evaluate possible solutions to persistent contemporary and emerging global issues.
5) Student will evaluate the concerns, standards, issues, and conflicts related to universal human rights and their impact on public policy.
6) Student will compare and evaluate relationships and tensions between national sovereignty and international interests in such matters as territory, economic development, use of natural resources, nuclear and other weapons, and concerns about human rights.

Language Arts: Speak and Write
1) Student will express facts, ideas, and opinions clearly, articulately, and appropriately for a specific purpose or audience.

Language Arts: Appreciate and Respect
1) Student will recognize, analyze, and respond critically to propaganda, marketing campaigns, and other persuasive messages.

Language Arts: Access, Analyze, and Inform
1) Student will evaluate the usefulness of information for specific purposes.
2) Student will use available technology to locate information and create quality products.

Reading List for Students

Atmospheric and Environmental Science

Earth at Risk: Global Warming, by Burkhard Bilger, 1992.
Examines the global warming phenomenon, discussing the greenhouse effect in its positive, life-giving configuration, and again as this system is knocked out of balance by increased levels of carbon dioxide.

Environments of the Western Hemisphere, by John C. Gold, 1997.
Examines the different environments in North and South America and how people have modified and threatened the biosphere to improve their standards of living.

Global Warming: Assessing the Greenhouse Threat, by Laurence Pringle, 1990
Explores the climatic, ecological and economic effects from the burning of fossil fuels. Also examines possible solutions to environmental threats.

Government and the Environment: Tracking the Record, by Thomas G. Aylesworth, 1993.
Describes the many aspects of environmental pollution, the growing awareness of the problem, and the role of the federal government in formulating a policy to protect the environment.

Hazy Skies: Weather and the Environment, by Jonathan D. W. Kahl, 1998.
Describes the connections between pollution and weather, the destruction of the ozone layer, global warming, efforts at pollution control, and alternative energy forms.

Our Endangered Planet: Atmosphere, by Mary Hoff and Mary M. Rodgers, 1995.
Explains how atmospheric gasses work and how mankind has upset the natural balance thereof.

Our Fragile Planet: Global Warming, by Jenny Tesar, 1991.
Discusses the gradual warming of our planet, its possible causes and effects, and some solutions.

Protecting Our Air, Land and Water, by Gary Chandler and Kevin Graham, 1996.
Presents examples of successful efforts to protect natural resources and includes names and addresses of organizations that are involved with these endeavors.

Saving Planet Earth, by Rosalind Kerven, 1992.
Presents the advantages and drawbacks of various actions being taken by people and the governments to save and protect the Earth's resources, wilderness areas, plants, animals, and tribal peoples.

Working In The Environment, by Corinna Nelson, 1999.
Profiles twelve people whom have careers related to the environment including a park ranger, lab technician, and environmental lawyer.

Using and Understanding Maps: The Endangered World, by Scott E. Major, 1993.
Eighteen map spreads highlight the damage pollution has done to our world.

Bibliography and Suggested Reading List for Teachers

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