AFTER THE WARMING

Teacher's Guide

Credits

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AFTER THE WARMING
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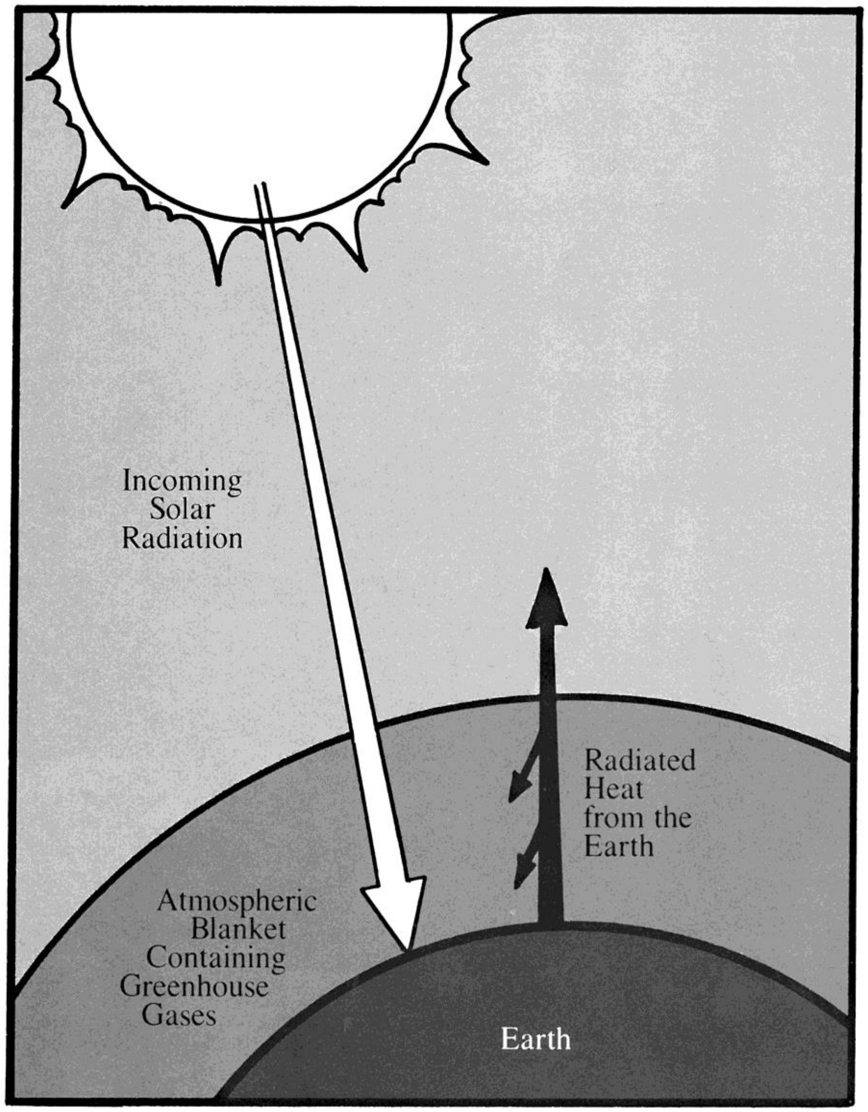
Table of Contents

The Greenhouse Effect



"The Greenhouse Effect" NASA: Goddard Institute for Space Studies.

INTRODUCTION

Imagine that it were possible to look back from the future at various global warming scenarios – at the momentous effects of environmental control choices made or not made. That is the premise of *After the Warming*.

Host James Burke uses innovative computer simulations by the "virtual reality generator" to transport students back through time and space from the year 2050. They can thus witness the impact that climatic change has had and will have on humankind. This high-tech approach to teaching such a complex topic helps global warming become realistic and relevant to students, while providing a logical presentation of the various hypothetical and actual issues and outcomes.

The two-hour *After the Warming* video, together with this instructional guide, will help students understand the complexities of global warming. It may also help them to see this global problem in very personal ways.

The purpose of this instructional guide is to facilitate the use of the PBS video, *After the Warming*, as a powerful teaching tool. The major goal of this guide is to provide teachers with ready-to-use lessons that will help students:

- understand the greenhouse effect and assess the past and future impacts that climatic change had and will have on the environment and its inhabitants (lesson one),

- recognize and assess the impacts of past, present, and future human activities on the environment (lesson two),

- make decisions about the severity of the problems and understand the difficulty of making policies on complex issues (lesson three), and

- suggest possible solutions and ways to take action to address the problem of global warming (lesson four).

ABOUT THE TEACHER'S GUIDE

This guide has been created as a ready-to-use mini-unit with reproducible pages of active involvement activities. It has been designed for both middle and high school teachers and can be used by social studies, geography, environmental education, and general science classes. Because of the multidisciplinary nature of the content, the lessons can be adapted to a team teaching approach. The guide has been organized into four lessons. Each lesson begins with a central question – an underlying theme, which corresponds to a specific segment of the two-hour television program, *After the Warming***.** Within each lesson the teacher will find a lesson overview, objectives, pre- and post-viewing activities, and a lesson summary. In addition to the comprehensive lesson plans, the guide contains useful background notes for the teacher, as well as a program synopsis, and bibliographies for the teacher and the students.

The lessons within this guide will provide students with ample opportunities to apply their critical thinking skills toward understanding the problem, and to weigh the possible solutions in terms of their social and economic impact on both a local and global scale. While completing various activities, students will be able to examine historical cause and effect relationships between climatic change and human activity. They then can use their understanding of the past to make predictions about potential future impacts. Additionally, students will analyze opposing viewpoints and form their own opinions regarding the nature and extent of the global warming problem. They will compare and assess the costs and risks of delaying actions to the costs and benefits of implementing preventive steps now.

PROGRAM OVERVIEW

From his vantage point of 2050 (the year in which the program begins), writer and host, James Burke, looks back to our present and examines the theories, current predictions, and solutions for global warming. Earth's atmosphere is the life-support mechanism of the planet. The 1990 that Burke examines shows how humans had been tampering with their environment for centuries, with little understanding of the extent to which their actions had already affected the earth's long-term health.

In *The Fatal Flower*, Part One of *After the Warming*, Burke reaches far back in history to show how past shifts in temperature drastically changed human society. He helps his audience understand why concern about any temperature change, either cooler or warmer, is valid. In the past, climate shifts had been brought about by the forces of nature. But with the onset of the Industrial Revolution (c. 1750), the forces of humans on nature began to become apparent. At this point, people began increasingly to abuse their home planet, not realizing their ultimate power to harm and perhaps destroy their planetary life-support system.

In *Secret of the Deep*, Part Two of *After the Warming* Burke tells the story of the next great revolution in human history, which will occur between 1995 and 2050. This ecological revolution – the Revolution of Planetary Management – has its roots in the past but will change every aspect of life in the future. For Burke, planetary management is seen as a prime opportunity to take out "planetary insurance" for a global strategic plan to develop a sustainable environment. Burke shows how that is possible while maintaining acceptable levels of economic viability among both the developed and developing nations.

After the Warming moves across both time and place, showing earth's past as well as its future. Using a combination of computer animation, models, and on-location footage from around the world, *After the Warming* will help audiences understand why they should care, at the same time setting out a series of prospective solutions to the serious problem now facing humankind – the health of our home planet.

ABOUT JAMES BURKE

James Burke has had a long and distinguished career in television in both Europe and the United States. Born in Northern Ireland in 1936, Burke received his education at Oxford University. He spent five years in Italy teaching at the Universities of Bologna and Urbino and directing the English Schools in Bologna and Rome. He made his television debut in 1965 as a reporter on a weekly current affairs program for Granada Television's Rome Bureau. In 1966 he became the co-host for a prime time weekly BBC science program, *Tomorrow's World*. Burke won critical acclaim for his interpretation of the US space program when he served as the chief BBC correspondent for all Apollo space flights. In 1972, Burke became the host of his own weekly prime-time science series, *The Burke Special*, which earned him a Royal Television Society Medal in 1972 and a Gold Medal in 1973. During 1975 and 1976, Burke co-hosted with Raymond Burr and co-authored with James Brabazon on NBC/BBC special, *The Inventing of America*.

In 1979, James Burke's ten-part television series, *Connections*, about the history of technology and social change, achieved the highest audience ever for a documentary series during its original PBS airing. In 1980, Burke wrote and presented *The Real Thing*, a six-part series on the brain and human perception. Another series, *The Day the Universe Changed*, was first broadcast in the United Kingdom in 1985. It is a personal view of the history of Western knowledge. A university credit course based on this series began in North America in the spring of 1988 and a special version of the series has also been produced for high school audiences in North America. James Burke is also a distinguished speaker and a regular contributor to such major magazines as *The Atlantic Monthly, New York Magazine, Vogue,* and *New Scientist*.

SYNOPSES

PART ONE: *THE FATAL FLOWER*

The year is 2050. James Burke is serving as host for the Global Information Network's special, *After the Warming*. Speaking to his audience, Burke explains how the Planetary Management Headquarters virtual reality generator, an electronic computer simulation of three-dimensional reality, will be used to re-run scenarios in human history. In the sequences that follow, Burke transports his audience back in time to see how shifts in climate drastically changed human society.

Burke begins by showing how human's descent from the African forest was triggered by a shift in the weather. From that moment on, human history is depicted as a series of life and death struggles with the climate.

Over the years, populations learned to adapt to the climate change through protective innovations. The invention of the chimney, for example, can be directly traced to this period of "global cooling."

In the 1750s, a new factor was introduced. England was experiencing excellent crop growing weather. Food production soared and so did the population. Demand for consumer goods accelerated, to be answered by the phenomenon now known as the Industrial Revolution. From this time on, Burke shows his viewing audience how the Industrial Revolution and its consequences radically and permanently altered the relationship between people and climate.

Powered by the steam engine, the Revolution took off. The Western inventions of interchangeable components and mass production led to a proliferation of technology. Industrialization meant the development of iron and steel manufacturing, heavy chemicals, shipping, textiles, mining, refining, and consumer goods. Many people left their farms and moved to the cities. Consumerism was born and the pace of the revolution escalated. Smokestacks belched carbon dioxide gas and other chemical dioxide gas and other chemical pollutants into the air. Modern patterns of industrial practice that still exist – the industrial research and development laboratory and mass production – were established.

Growing affluence fueled a population explosion among the industrializing nations. Demand and supply spiraled upward. A driving search for raw materials generated colonial expansion and growing markets. Railways were built to deliver the ever-increasing demand for coal to fuel the growing factories. Colonies with single product economies were spawned to provide the food and raw materials required to support the developing nations. Powerful nations were born during this period – nations dependent on massive new industries, using enormous quantities of fuel and electricity, the lifeblood of the expanding industrial age.

For 250 years, nature and the environment were thoughtlessly abused. In just two and a half centuries the Industrial Revolution, spreading like wildfire, burned fossil fuels that had taken millennia to lay down.

By the mid-1950s, some farsighted individuals were beginning to wonder if humans hadn't turned their back on nature with great risk.

Since the first measurements of atmospheric carbon dioxide (CO_2) were taken atop Mauna Loa, Hawaii in 1958, CO_2 has continuously increased. In the three decades that followed those initial measurements, climatologists and the models they produced painted grim scenarios for global environmental change. In essence, if we were to continue to release carbon dioxide and other industrial pollutants into the atmosphere, the earth's temperature might rise by an average of between 1.5ºC and 4.5ºC by 2050 A.D. This predicted rise forecast disastrous consequences for humankind.

By 1989, the models all agreed that some level of action was urgently necessary to prevent the worst of the predicted greenhouse effects. But politicians and a few scientists advised delay in the face of "speculative forecasts." Developing nations refused to accept that the growth rates they felt to be their due might be curtailed. Nothing, it was argued, could happen "that bad, that fast."

But the discovery of 10,000 year-old flower pollen, deep in a core drilled from the Greenland ice cap, revealed just how quickly climate could change. The pollen's presence showed that temperatures could change to full ice age, an overall change of 6ºC, in just a 70 year period.

It was time to act.

PART TWO: *SECRET OF THE DEEP*

The year is 1994. James Burke escorts his audience on a virtual reality computer-generated global tour to find out what the world is doing about the imminent threat of the greenhouse effect. In Western industrialized nations people are living the kind of energy intensive, conspicuously consumptive lifestyle that results in the creation of greenhouse gases in incredible quantities.

Not to be outdone, Eastern Europeans in 1994 are forsaking their central economies to leap after consumerism as fast as they can increase their industrial productions. Burning billions of tons of coal annually, their carbon readings are double the per capita level of Western nations.

And the Third World nations, also eager for industrialized-world conveniences, are anxious to catch up. This is made possible with the availability of Western financial aid. Because of this aid, major highway projects, hydroelectric dams, and other heavy industrial enterprises are undertaken at the expense of the fragile ecosystems, especially tropical forests. The effect of their industrial modernization is the creation of massive debt, paid, in part, by destroying more and more of their natural resources to sell for cash to service this debt.

The sum total of worldwide consumerism, industrialization, and deforestation in 1994 meant serious greenhouse pollution on a global scale. This was more than the doomsayers could handle. Their predictions became every bit as dramatic as the rise in atmospheric pollution: population – nine billion by 2027 and rising; economic growth – three percent a year; methane and carbon dioxide emissions – doubled. The computer models predicted dire consequences for life on earth: an average global temperature rise of up to 10 degrees at the equator and 25 degrees at the poles.

Reactions among the scientist, politicians, and industrial leaders regarding what actions to take, if any, were divided between panic and postponement. However, in 1994 a Dutch government report that had been prepared in 1989 caught the attention of some. It detailed a long-term strategy for dealing with the greenhouse crisis – a plan which would curtail the emission of carbon dioxide by portioning out a carbon budget among the nations of the world.

While the plan had merit, it was still considered unnecessary, since scientists at the time were unable to give the politicians a precise indication of when global warming would occur. What action did seem appropriate back then was to draft reports warning of a greenhouse possibility: some calling for action, and others for no action, reports noting the causes, and reports recommending a greenhouse organization. During the summers of 1997, 1998 and 1999 a series of devastating droughts hit the planet causing food shortages and deaths by riot and starvation. Suddenly, people started paying serious attention to the Dutch report.

Quickly the global carbon budget was established. How much greenhouse gas emission could the planet afford? What should be the emission ration of each country? Could the target be reached without destroying the world's economies? Early in 2000, the worldwide plan was established, administered by a new body – the Planetary Management Authority.

Around the same time, the latest forecast provided a grim prognosis of greenhouse aftermath – more droughts by 2015, massive forest loss by 2050, a 9ºF temperature rise moving natural habitats 800 kilometres (500 miles) north. During the first decade of the new century, industrialized countries worked aggressively to reduce these possibilities. Nations concentrated on renewable energy – hydroelectric power, the development of wind farms, solar thermal power and photovoltaics, and pulped biomass (corn and rice husks, sugar cane and animal dung) – anything but the forests to serve as a source of fuel. The result of this activity was no additional greenhouse gas.

Other energy-saving measures were also employed. Buildings were modified with new insulation materials; modularized environment control hardware was installed; windows had light sensitive film; and compact fluorescents, widely available around the year 2000, replaced the old incandescents of the 20th century.

As the effects from global warming began to be felt throughout the 2020s and 30s and as people were driven to stave off continued calamity, the world was being transformed. The end result in 2050: a new and remodelled world – a world **After the Warming.**

BACKGROUND

Throughout history, the earth has experienced periods of warming and cooling. Great Ice Ages have alternated with warmer periods, flooding coastlines, perpetuating deserts, and annihilating entire ecosystems. Over the course of human history, rising and falling temperatures have influenced the flourishing or perishing of civilizations. During the Little Ice Age (1500 – 1850), for example, when temperatures averaged only a few tenths of a degree Celsius cooler than today, Europe documented numerous years of famine and plague. Today, global warming, the rising of the earth's average temperature, is seen by some scientists as a very real possibility – not millions of years from now but as early as 2050. These scientists are predicting that by that date, a global warming of between 1.5 and 4.5 degrees Celsius (C) or 3 to 8 degrees Fahrenheit (F) will occur. To put these temperatures in perspective, consider that during the 10,000 year era of human civilization, the earth's average temperature has not been warmer by more than 1 to 2 degrees Celsius than it is today.

An increase of this amount could have devastating effects on some areas of the planet. Melting ice caps and glaciers might cause sea levels to rise, while increased heat might cause severe droughts to occur. For each 1º Celsius (1.8ºF) of global warming, a 160 kilometre (100 mile) shift poleward in temperature zones may occur. The repercussions from these environmental changes would have profound impact on agriculture, animal husbandry, forestry, recreation, industry, and many other human activities. The phenomenon that is responsible for producing a change in the earth's temperature is known as the greenhouse effect.

What is the Greenhouse Effect?

The greenhouse effect is the process by which the earth is warmed by the sun (see P3). Energy from sunlight warms the earth's surface. Some of this energy is absorbed by the surface, and some is re-radiated into space. Certain gases in the atmosphere trap some of this energy which continues to heat the atmosphere. These greenhouse gases, principally water vapour (which is concentrated near the earth's surface), carbon dioxide (CO_2), and methane, absorb heat and warm the planet to maintain an average global temperature of 15ºC (just over 59ºF). If not for this warming process, the earth would be uninhabitable, a virtual frozen wasteland at –15ºC (5ºF).

The greenhouse gases carbon dioxide and methane are released naturally by volcanoes, oceans, plants, and animals. But human industry and agriculture also account for their production, as well as for two other greenhouse gases, nitrous oxide and chlorofluorocarbons. Carbon dioxide is produced from the combustion of fossil fuels such as coal and oil, and from deforestation by the burning of trees and bush cleared from land. Methane is released from crops, livestock, and garbage.

Nitrous oxide is emitted by industry and fertilizers. Chlorofluorocarbons, or CFCs, come from aerosol spray cans, air conditioners, refrigerators, plastic foam, and solvents. The accretion of these and other greenhouse gases into the atmosphere through human activity has caused their concentrations to greatly increase since the beginning of the Industrial Revolution (1750–1914).

Many scientists worry that continued greenhouse gas increases with correspondingly higher temperatures will threaten the future of life on the planet. However, there could be some potential gains from increased levels of carbon dioxide, including an increase in plant growth and the warming of marginally productive northern regions which could enhance their habitation and stimulate growth of vegetation. Regardless of the impact, most scientists agree on one thing – that global warming will occur. The only questions that remain are "how much?" and "how soon?"

Climate change refers to long term shifts (decades in length) in normal climate. While there have been occasional variations in climate such as heat waves and cold spells, these are considered temporary occurrences, not true climatic changes. When the 1980s recorded four years of the warmest temperatures within the past 110 years, some scientists claimed that this marked the beginning of a period of climatic change; others claimed that it was too soon to tell.

Research conducted by Wallace S. Broecker, professor of geochemistry at Lamont-Doherty Geological Observatory at Columbia University, has led to an interesting hypothesis regarding how fast climatic change may occur. From his studies of records of pollen grains buried in Greenland ice cap samples, Broecker theorized that climate change may occur so suddenly and dramatically that people would have no opportunity to anticipate it or adapt to it. Broecker cites a period approximately 10,000 years ago when climate change occurred within a period of one century. Known as the Younger Dryas, this period occurred as a mini-ice age in northwestern Europe, Greenland, and maritime Canada.

The occurrence of any long-term climatic change involves complex natural processes. The greenhouse effect is but one of those processes. Others, like variation in the carbon cycle and oceanic circulation, along with overlapping cycles in the earth's orbit, tilt, and wobble (Milankovich cycles), combine to affect global climatic changes.

The Role of the Carbon Cycle

As a greenhouse gas, carbon dioxide makes up only .03 percent of the atmosphere's dry weight. Yet it is an essential ingredient for maintaining life on earth. During the carbon cycle, green plants absorb carbon dioxide from the air. In return, oxygen is given off as a waste product and inhaled by animals and humans. Springtime is the period of greatest plant growth and carbon dioxide absorption. In the autumn, carbon dioxide is released into the atmosphere as leaves fall and decompose. In addition to land plants, microscopic ocean plants called phytoplankton are also responsible for absorbing carbon and releasing oxygen. For millions of years the carbon cycle has helped to regulate the amount of carbon dioxide in the atmosphere. Unfortunately, given the rate at which carbon dioxide is presently being released and the rate of reduction in green plants due to deforestation, the right balance of carbon dioxide in the atmosphere that is needed to help maintain the present global average temperature is becoming more difficult to maintain.

Oceanic Circulation

The oceans maintain a pattern of circulation in which the flow of a deep current of salty water empties from the Pacific into the Atlantic. This is due in part to the nature of water evaporation in the North Atlantic. Surface waters in this region are warmer than those of the North Pacific. Warmer waters will evaporate more, leaving greater amounts of salt to flow through the sea from the Atlantic to the Pacific. It is hypothesized that any alterations in salt distribution caused by the transport of water vapour through the atmosphere from one ocean basin to another will affect climate change. Past climate records taken from ice and sediment cores indicate that climate changes have indeed occurred because of such reorganizations. It is hypothesized that an increase in the atmosphere's greenhouse gases may force yet another reorganization.

The Milankovich Cycles

These cycles refer to the studies of Yugoslavian scientist, Milutin Milankovich (1930), regarding the influence that changes in the earth's orbit have on glaciation. Three specific aspects of the earth's orbit comprise the Milankovich cycles: over 100,000 years the earth's orbit changes shape; over 41,000 years the earth's tilt on its axis changes; and over 19,000 years the earth has a wobble cycle.

Researching the Issue

Before the turn of the 20th century, some scientists expressed concern about the extent to which fossil fuel emissions could alter the composition of the earth's atmosphere. In 1896, Swedish chemist Svante Arrhennius predicted that if carbon dioxide doubled, the earth's surface would warm by approximately 5º Celsius. Many scientists today concur with that forecast. In 1958, David Keeling and Roger Revelle of the Scripps Institute of Oceanography in LaJolla, California began to record the atmosphere's concentration of carbon dioxide on the summit of Mauna Loa in Hawaii. Regular measurements of carbon dioxide taken since that time have indicated a steady rise in this greenhouse gas from 315ppm (parts per million) 30 years ago to 351ppm in 1988. These increases in carbon dioxide concentration have been contributed by human activities. Using the records at Mauna Loa, along with evidence from tree rings (which can depict periods of warming and cooling) and an analysis of air bubbles trapped in polar and glacial ice, scientists have estimated the pre-industrial carbon dioxide level to be about 280ppm. These statistics indicate that human activity has increased the level of carbon dioxide by approximately 25% since the start of the Industrial Revolution (c.1750).

An important research tool for modern scientists is the use of computer climate-change models of the global system. Powerful computers can examine interrelationships among many climatic features and mathematically factor in "what-if" scenarios. Given a set of climatic change variables, these computers output models which represent how the planet might look based on the provided data. Such modelling is extremely complex, requiring the adequate representation of feedbacks. Feedbacks are atmospheric and environmental conditions that may have an effect on global warming.

In computer modelling, positive feedbacks may hasten the process while negative feedbacks may slow it down. Examples of feedbacks are the effect that types of clouds, their altitude and brightness have on global warming; the effect that sunlight has on melting ice and snow, and the natural circulation of oceans; the rate at which plants and animals utilize carbon dioxide; and how and where carbon dioxide is deposited in sediments.

Debating the Issue

For the past several years, public concern – and scientific controversy – about the greenhouse effect have been growing. Throughout the 1980s, reputable scientists from all over the world have predicted numerous scenarios, many doomsday-ish in their projections. These predictions are based on steadily increasing measurements of carbon dioxide and other greenhouse gases in the atmosphere, coupled with the increase in populations, factories, and farms since about 1800. Many scientists and policy makers alike are deeply concerned about the continued increase of these gases, especially as nations like China and India take further steps toward industrialization.

Other equally reputable scientists have angrily disputed the doomsday predictions, likening the threat of worldwide devastation to a "Chicken Little" scenario. These scientists claim that despite the extensive research to date, too many uncertainties remain regarding the potential for global warming. One of their major concerns is the use of computer modelling as definitive evidence of a global warming threat. Their position is that, at present, there is no accurate way to incorporate the effects of atmospheric and oceanic feedbacks into the computer models.

Many climatologists predict that the greatest warming will occur at higher latitudes in the winter. According to computer models, areas within these latitudes are expected to be at least twice the global average temperature increase. However, according to Patrick J. Michaels, associate professor of environmental science with the University of Virginia, there has been no significant warming in the Northern Hemisphere since 1930. In fact, Michaels points out that although carbon dioxide measurements have been increasing, there is little evidence of any average temperature warming.

Tom Karl, a scientist with the National Oceanic and Atmospheric Agency (NOAA), claims that the National Aeronautic and Space Administration's 20th century U.S. temperature data, used in congressional testimony on global warming, are warm-measurement biased. He maintains that NASA's measurements indicating that temperatures over the United States warmed up nearly a degree during that century were not due to the greenhouse effect, but rather, to what he calls "artificial" warming, i.e., the trend for cities to grow up around NOAA's weather stations.

While the debate among scientists continues, the public and policy makers are asking a major question, "Can we afford to wait for absolute certainty regarding the timing and extent of the environmental impact of global warming?" Just as the calls for further research continue to be expressed, so do the calls for immediate action.

After the Warming: Part One *The Fatal Flower*

LESSON ONE
What impact does climate change have on human activity?

Overview

As students watch *After the Warming*, they will witness recreated scenes and events in human history that were shaped, in some way, by environmental change. This continuum of events will help students understand that climatic change has had a tremendous impact on how and where people live. The objectives and pre- and post-viewing activities for Lesson One focus on the events which occurred through the year 1580. Student viewing of the video should be stopped at that point, approximately 25-30 minutes into the first half. The second half of Part One, which begins with the Industrial Revolution (1750-1914), will be the focus of the objectives and activities included in Lesson Two.

Objectives

After viewing Part One of *After the Warming* (up to the Industrial Revolution) and participating in the previewing and post-viewing activities, the students will be able to:

1. **describe the greenhouse effect,**
2. **define global warming, and**
3. **explain the effects of climatic change on human activity.**

Vocabulary

Climate – A region's weather trends averaged over a long period of time.

Climatic Change – Long term (decades in length) shifts in regional climate.

Global Warming – The rising of the earth's average atmospheric temperature. The current average temperature is 15º C (just over 59º F).

Greenhouse Effect – The process by which the earth is warmed when certain gases in the earth's atmosphere trap heat that is radiated off the earth surface. An increase in these gases can produce an increase in the earth's average atmospheric temperature.

Greenhouse Gases – Gases in the earth's atmosphere which trap heat (from infrared radiation) radiated off the earth's surface. Those that occur naturally are nitrogen, oxygen, water vapour, carbon dioxide, methane and ozone. (Carbon dioxide and methane are produced by human activity as are nitrous oxide and chlorofluorocarbons (CFCs). Human contributions to the greenhouse effect are described in Lesson Two).

Ice Age – A very cold period during which polar icecaps and mountain glaciers increase in area. The great lakes are water filled depressions left from great glaciers that extended into Southern Ohio.

Reviewing Activities and Discussion Questions

1 *Define climate and introduce the concept of climatic change.*

You can give students a sense of what climatic change feels like by asking them if they have ever been in a greenhouse, a hot house, or a car that has been in the heat for a long period of time with the windows up. How did they feel? Tell the students that usually these feelings are temporary…but what if they were permanent? Review the definition of climatic change with the students.

Ask students to think of ways in which their environment might change if the temperatures where they live suddenly and permanently became very hot. You may wish to create a graphic web of their responses. Next, have the students work in small groups to generate lists of ways in which their lives and those of their family and neighbors might change given the environmental changes that they just mentioned. Ask each group to share their ideas with the entire class. Repeat the activities based on the climate suddenly becoming very cold.

2 *Introduce the concepts of greenhouse effect, greenhouse gases, and global warming*.

Note: This section may be team-taught by a social studies teacher and a science teacher.

Some students may already be familiar with the greenhouse effect, while others may confuse it with other air quality issues such as acid rain or ozone depletion. You may wish to check your students` prior knowledge and look for misconception. A brief explanation about the differences between acid rain, ozone depletion, and the greenhouse effect follow.

Acid Rain – Sulfur oxides and nitrogen oxides are commonly released from the smokestacks of power plants and industrial plants that burn coal and oil. As these emissions are transported through the atmosphere by winds, they often form secondary pollutants such as nitrogen dioxide, nitric acid vapour, and droplets containing solutions of sulfuric acid and sulfate and nitrate salts. These chemicals descend to the earth in acidified rain, snow, dew or fog popularly called “acid rain.” Dry forms are acidic gases or particulates. A number of harmful effects are derived from acid rain. Among them are damage to statues, buildings, metals, and car finishes; the killing of fish, aquatic plants, and microorganisms in lakes and streams; and the weakening or killing of trees by making them more susceptible to disease and insect attack.

Ozone Depletion – Human produced chemicals, chlorofluorocarbons (CFCs), are lowering the average concentration of ozone in the stratosphere. CFCs are used in air conditioners, refrigerators, and in aerosol spray cans propellants. When broken down by ultraviolet radiation, CFCs release chlorine atoms, which speed up the breakdown of ozone into oxygen gas. Ozone (0_3) is a form of oxygen found naturally which provides a protective layer shielding the earth from ultraviolet radiation’s harmful health effects on humans and the environment. Among these effects are basal-cell and squamous-cell skin cancers, eye cataracts, and decreased yields of important food crops such as corn, rice, soybeans and wheat.

Greenhouse Effect – This phenomenon is responsible for maintaining the average global temperature of the earth's atmosphere. When solar radiation reaches the earth's surface, some is absorbed, but some is re-radiated into the atmosphere. Carbon dioxide and other trace gases such as methane and nitrous oxide trap some of this re-radiation, preventing it from escaping into space. The result is the warming of the atmosphere by the trapped heat. Many scientists are concerned that a build-up of these gases caused by additional contribution of greenhouse gases from human activities will prevent sufficient radiation from escaping and cause warmer temperatures from excess heat. Among the proposed effects of this global warming would be melted ice caps and glaciers, a rise in sea levels, flooding, and drought conditions. A more detailed explanation of the greenhouse effect can be found in the background notes.

When explaining the greenhouse effect to your students, mention that some scientists predict a climatic change in the form of rising temperatures will occur possibly as early as the year 2050. Ask your students how old they will be in that year. Ask them which generation of people would be most affected by warming temperatures: their parents, themselves, or their children. Examine the graphic entitled, "The Greenhouse Effect" (P37). Using this graphic, along with information found in the "Background" section, explain the concepts of global warming and the greenhouse effect.

3 *Introduce the place names referred to in Part One of the video.*

Duplicate and hand out copies of the reference map (P17). Locations noted on the map correspond to many of the places mentioned in the first half of *After the Warming*, Part One. Review these place names with your students. Students should be made aware that some places on the map had an important role in history but no longer exist today. As they watch the first half of Part One, students can fill in the date when each place is mentioned in the program on the small line that appears next to its location on the map.

4 *Introduce the Virtual Reality Generator.*

Tell your students that *After the Warming* begins in the year 2050. Explain to them that they will see recreations and simulations of past, present, and future scenes and events made possible with the use of a "virtual reality generator." This is a fictional computer that has the ability to simulate three-dimensional reality. Ask your students to think of an example of a virtual reality generator that they might have seen in a movie, on television, or elsewhere. Perhaps they are familiar with the holodeck of Star Trek: The Next Generation or the time machine in Back to the Future I, II and III. Maybe they have seen simulators used in pilot training programs.

Post-viewing Recall and Discussion Questions

1 *Review the reference map exercise with your students.*

Ask them to recall some of the events that took place in the areas listed. Ask students which places no longer exist and why. Discuss how climatic change had an impact on the places mentioned.

2 *During the history of climatic change through 1580, were there any places mentioned which gained improvements to the environment and the manner in which people lived? How?*

Post-viewing Activities

1 *Have students turn to "Human Reactions to Environmental Changes"(P18-19) and "Looking for Trends" (P20).*

Ask your students to study the impact of climatic change on world populations. Have your students complete the second column of the worksheet "Looking for Trends" with actions that people took when the climate changed. Ask your students to complete the third column with reasons why they think that people reacted to climate change as they did.

Summarize this activity by asking the following questions:

* What climatic conditions contributed to an increase in population?

* What climatic conditions led to human migration?

* What climatic conditions led to the complete devastation (destruction) of some populations/ civilizations?

* How were some people able to adapt to climate change?

* Why do you think that some civilizations were able to adapt and others were not?

2 *In this cooperative learning exercise, your students will make predictions about the impact that climatic change might have on modern civilizations.*

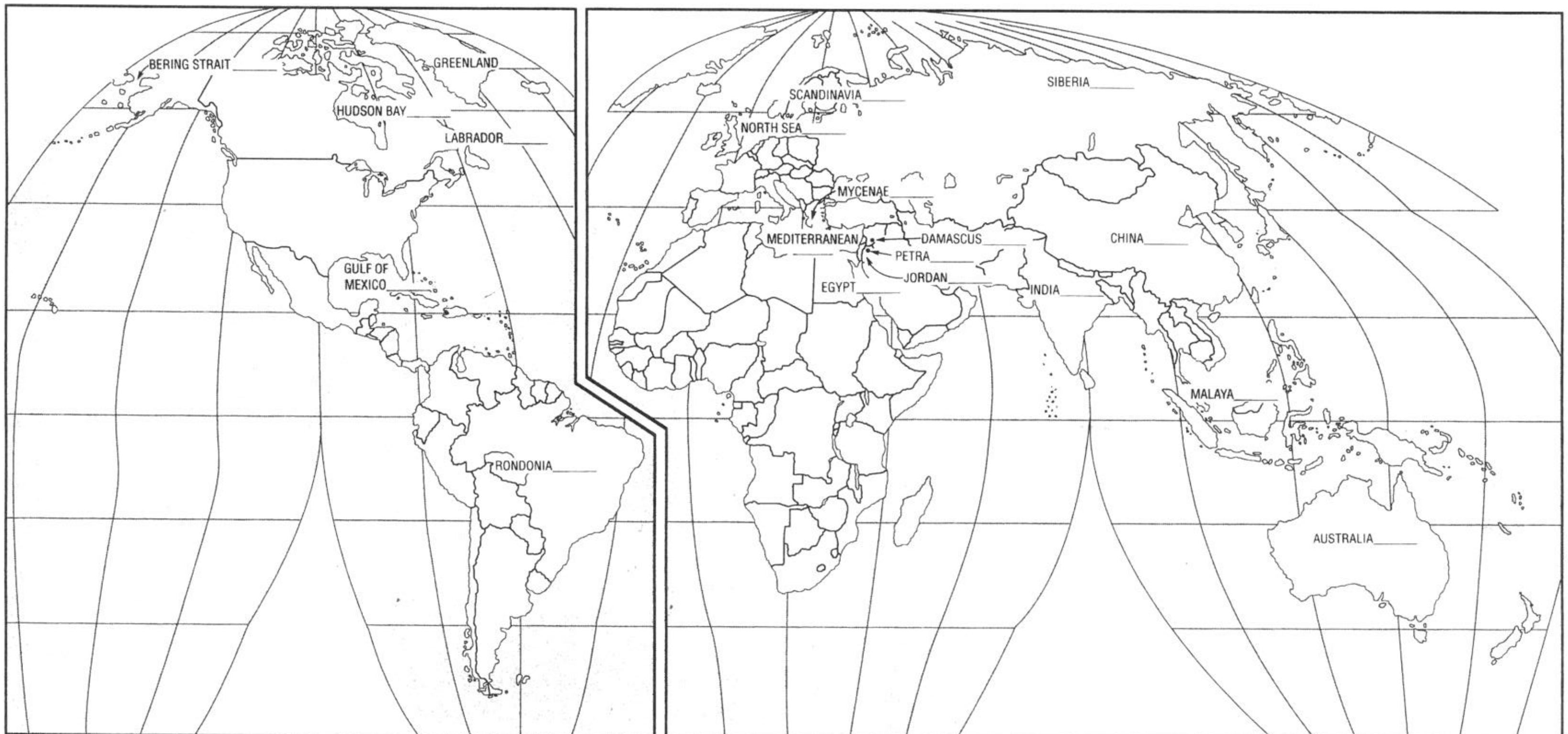
Group your students and hand out copies of the worksheet, "Can History Repeat Itself" (P21). Ask students to apply what they learned from the "Looking for Trends" exercise to make predictions about how people in different parts of the world would react today to similar changes in their environment. Ask each group to share their predictions. Summarize this activity by discussing specific differences regarding how people might react to climatic change today as opposed to the way they reacted during earlier times.

3 *Have students research and report on similarities and differences among the air quality issues, acid rain, ozone depletion, and the greenhouse effect.*

Lesson Summary

Through a replay of past events, your students have seen how climatic change has had an impact on the course of human history. You may wish to review these events with your students by rewinding the video and replaying any of the scenarios. To conclude, ask your students to come up with a general statement about the impact that climatic change has on people's lives. Write selected statements on the board. Have students select the best or combine parts of several to form a consensus statement.

Reference Map



Produced by University of Maryland Baltimore County Office of Cartographic Services and the Maryland Geographic Alliance.

Human Reactions to Environmental Changes

Environmental Change	Date	Human Activity
Drought dries up African forest	Several million years ago	People migrate onto grasslands
	70,000 BC	People migrate north out of Africa into cav from Killarney to Vladivostok.
Vegetation is stunted. Less food, animals and plants to eat. Sea water turns to ice; drops more tha 300 feet in some places.	Fourth Ice Age 50,000 to 15,000 years ago	People migrate in search of food, leaving caves of Siberia and crossing the Bering Straits to populate Americas all the way down to Chile. People migrate from Papua New Guinea to Australia across the Gulf of Carpentaria. Beginning of human communication, tool making with flint, and prehistoric art.
Global warming average 9º F. Ice begins to melt, flooding land bridges that link continents	15,000 BC	Americas are separated from Asia; Austral from Papua New Guinea
Sea levels rise. North Sea plain drowns. Gulf of Mexico created. England cut off. Hudson Bay filled Coastlines settle.		
Lush vegetation, abundant water supply	7000 BC	Humans run farming villages, especially in the Near East. Writing invented. Populatior begins to increase.
Massive droughts in Middle East-Egypt becomes a desert except fo the Nile	3000 BC	Civilisations start to organize to save wate Structured society run by rules. Calendar and mathematics described. Irrigation network. Surveying, engineering and brickwork to build canals. Geometry to measure reservoir volume. Metallurgy to make tools. Icons used for written communication.
Global average temperature drops 4º F. Westerly Mediterranean winc push further north than usual. Atlantic storm stalls in mid-Europe Major precipitation on Hungarian Plains creates flooding for several decades.	1200 BC	Hungarians migrate east for safety.
Western Greek mountains block o rain. Major drought in Mycenea.		Myceneans abandon their palaces and citie and disappear without a trace.

Climate becomes warm and moist Fruit and grain growing everywher Alpine mountain passes unfreeze.	300 BC	Europe: Roman Empire stretches from Portugal to the Black Sea, Scandinavia to the Sahara. Regular trade begins with China.
		Middle East: (Petra, along the European/China trade route.) Nabataeans develop irrigated terraces, factories, baths and theatres.
Global average temperature drops 7º F. Freezing drought in Central Asia.	450 AD	Sheep herding Huns migrate out of Asia across Roman Empire. Empire falls. Dark Ages begin.
		Petra experiences drought. Trade between Europe and Asia ends. Nabataeans disappear without a trace.
8º F rise in global average temperature. Pack ice in the Atlan melts.	800 AD	
	982 AD	Eric the Red moves to Greenland from Scandinavia.
	986 AD	Colonisation of Greenland begins.
Long warm summers in Greenlanc Plenty of pasture land for animals, but no wood.	1002 AD	6,000 people inhabit Greenland. Brisk trad with Scandinavia.
	1100 AD	Lief Erikson makes regular trips to 'Vinlanc (America) in search of timber.
'The Little Ice Age'. Temperature drops. Trade routes blocked by thick sea ice.	1300-1408 AD	Greenlanders isolated from needed resources. Inhabitants don't adapt to climate change. Freeze and starve to deat
	1580 AD	Europeans adapt to climate change. Inven 'weatherised manor house': stone walls; pitched roof and guttering; chimney; smal heated rooms; tapestries; plaster; panelin curtains and windows. Knitted clothing wit buttons. Economy improved.

Looking For Trends

Study the page “Human Reactions to Environmental Changes.” Complete the second column of the chart below by looking for tends and generalizing how people historically reacted to changes in their environment. Complete the third column by explaining why you think people reacted the way they did.

When the environment was:	People Would…	Because…
Warmer and drier		
Warmer and wetter		
Colder and drier		
Colder and wetter		
Pleasant		

Can History Repeat Itself?

Study the completed chart, "Looking For Trends." Predict how people in different parts of the world would react today to similar changes in their environment. Locate the countries mentioned below on a world map. Research their present environmental conditions and ways in which their populations live. Make predictions about how people would react to the environmental changes noted below and provide explanation for your predictions in the chart.

Environmental Change	People Will…	Because….
Global average temperature drops five degrees bringing snow and ice to Japanese cities and countryside.		
Global warming averages four degrees. Siberia experiences a warming trend.		
Global warming averages five degrees in Argentina causing drought conditions.		
Global average temperature drops four degrees. Major precipitation on the Sahara Desert.		
Major temperature increase or decrease (select one) in your community and its surroundings.		

LESSON TWO

What impact does human activity have on the environment?

Overview

As the students view the concluding scenes of Part One of *After the Warming*, they will observe the impact of Western civilization on the environment since the start of the Industrial Revolution in 1750. The students will learn how human contribution to the greenhouse effect heightened the threat of global warming. Charts and graphs will demonstrate evidence of increased concentrations of greenhouse gases in the atmosphere.

Objectives

After viewing the concluding segments of *After the Warming*, Part One (beginning with the Industrial Revolution), and participating in the previewing and post-viewing activities, the students will be able to:

1. explain the carbon cycle.
2. define and analyze the importance of the Industrial Revolution
3. define fossil fuels and deforestation
4. evaluate the impacts that human activities have had on the greenhouse effect
5. explain the influence that population growth has on the greenhouse effect
6. draw conclusions about relationships among elements on graphs.

Vocabulary

Carbon Cycle - Plants on land and microscopic plants in the ocean absorb carbon dioxide released by animals and decaying plants. These plants use carbon through the process of photosynthesis and release oxygen into the atmosphere. Animals, in turn, breathe in and absorb oxygen and release carbon dioxide when they exhale. In the autumn, leaves from trees fall and decay, releasing carbon dioxide back into the atmosphere.

Climate Change Model – Mathematical models that run on supercomputers and allows for the manipulation of variables related to the climate system. The most sophisticated models are three-dimensional general circulation models, which allow some regional differentiation of climate change.

Colonies – Land settled by people from another country or territory.

Consumerism – The demand for and purchase of products and services.

Deforestation – The removal of trees in major forests around the world. The slashing and burning method of removing trees causes the emission of carbon dioxide, methane, and nitrous oxide.

Fossil Fuels – Oil, coal and natural gas are examples. Fossil fuels account for 90% of the energy used in the United States. They are used in most areas of human activity: transportation, industry, utilities, and residences.

Greenhouse Gases (from human activities) – Carbon dioxide, nitrous oxide, methane and chlorofluorocarbons (CFCs) are all human contributions. Carbon dioxide and nitrous oxide are by-products of burning fossil fuels. Methane is produced by swamps, cattle, rice paddies, landfills, termites, and fossil fuel combustion. CFCs are used in aerosol sprays, freon from air conditioners, and plastic foam expanders.

Industrial Revolution (1750–1914) – Name for the shift from handmade items to the use of power-driven machinery for the production of goods. This period brought about dramatic changes in the way people lived.

Mass Production – The manufacture of large numbers of products, all exactly alike.

Rainforest – Dense green webs of plants and animals that occur along the earth's equator.

Western World – Industrialized nations of Western Europe and North America.

Previewing Activities and Discussion Questions

Note: The diagram of "The Carbon Cycle" (P28) will be used in the following three previewing activities. Additional information about the carbon cycle appears in the background section for teachers.

1 *Introduce the concept of the carbon cycle*.

Examine the diagram of the carbon cycle and human activities that contribute to the greenhouse effect (P28). After reviewing the information on the diagram, check students' understanding by having them explain the carbon cycle in their own words.

2 *Introduce the human contribution to the greenhouse effect*.

Review the concept of the greenhouse effect with your students. Explain that while the greenhouse effect is a phenomenon of nature, society since the mid-1700s has caused it to be enhanced by increasing the amount of greenhouse gases that are trapped in the atmosphere. Check your students` prior knowledge of fossil fuels. Have them write the four main types of fossil fuels on their handout. Define deforestation and explain why it is one source of the greenhouse gas, carbon dioxide. Have students look for other sources of greenhouse gases on the graphic, "Human Activities that Contribute to the Greenhouse Effect (P28)." Ask them to find sources for the four gases listed on the handout and to fill in the spaces with those sources. Provide students with the names of any additional sources that are not found in the graphic.

3 *Introduce information about the Industrial Revolution.*

Briefly review the Industrial Revolution (1750–1914) as the period during which major changes in the way people lived were brought about by the introduction of power-driven machinery. Describe mass production and the increased demand for consumer products. Ask students if they can draw any relationships between the industrial Revolution and the human contributions to the greenhouse effect.

Examine the diagrams "Past and Present Day Relationships of Carbon Dioxide and Temperature" on P26. Ask students to look at Chart A and determine the relationship of temperature change to carbon dioxide concentrations over the past 160,000 years. Then ask students to compare Chart B to Chart C and determine the relationship of global average temperature to atmospheric concentrations of carbon dioxide since 1880.

Analysis

Having analyzed the relationship between the increased in carbon dioxide and temperature changes which have occurred over thousands of years, ask students if they can determine the major problem regarding global warming as it relates to the carbon cycle and the added influence that human-produced greenhouse gases have had on the greenhouse effect. Your students should be able to conclude that the carbon cycle which helps regulate the earth's average temperature is being adversely affected by the rapid and heavy increase in carbon dioxide emissions since the Industrial Revolution and by the loss of plant life from deforestation. In other words, greenhouse gases are being produced in too great a quantity and at too rapid a rate for plants to absorb the right amount of carbon dioxide that would maintain the average global temperature. Have your students write a summary of their analysis of the problem at the bottom of the "Carbon Cycle" diagram.

Post-viewing Recall and Discussion Questions

1 *What evidence was cited to indicate that global warming could possibly occur within a period of one hundred years?*

2 *What effect does population growth have on the demand and use of energy?*

3 *How did the colonies contribute to the industrialization of the Western world?*

4 *What effects might climatic change have on industry?*

Post-viewing Activities

1 *Describe the impact that the Industrial Revolution has had on the greenhouse effect.*

Look at the table "How the Industrial Revolution Changed the Way We Use Energy" (P27). Students can work in groups to complete this exercise. Students should complete the first column with a list of ways that people in the 1600s used energy to perform daily activities. The categories listed give students some different aspects of daily life to think about. In the second column, the students will describe how energy is used today to perform an activity similar to one in the 1600s. In columns three and four, the students will list the advantages and disadvantages that have resulted from modern energy use. An example under transportation would be that in the 1600s people traveled by foot, horse, horse drawn car, wagon, or sleigh. Today we travel by car, truck, taxi, bus, train, aeroplane, jet, or subway/metro. Advantages of modern transportation include the speed at which we can travel; roads and highways that link us to more places; and relatively easy access to places around the world. Disadvantages include emissions of carbon dioxide and carbon monoxide from auto exhaust and fuel systems, and emissions of CFCs from air conditioning units that are installed in modern transportation. Additionally, trees have been removed and replaced with highways, thus reducing the environment's ability to absorb carbon dioxide. Have each group share their lists with the class. Ask students if, during the

Industrial Revolution, people were aware of the pollution problems that they were creating. What does current awareness of these problems mean to us today?

2 *Have students research the use of fossil fuels by different countries*.

Students might create a graph showing what proportions of various fossil fuels different countries use. Students might then use this graph to show a relationship between fossil fuel use and the amount of industrial growth among the countries being researched.

3 *Have students research and report on how electricity works, how it is generated, and the many ways in which it is used.*

4 *Have students research and write a report on Thomas A. Edison's development of electric lighting, including the challenges and problems that he met during his work.*

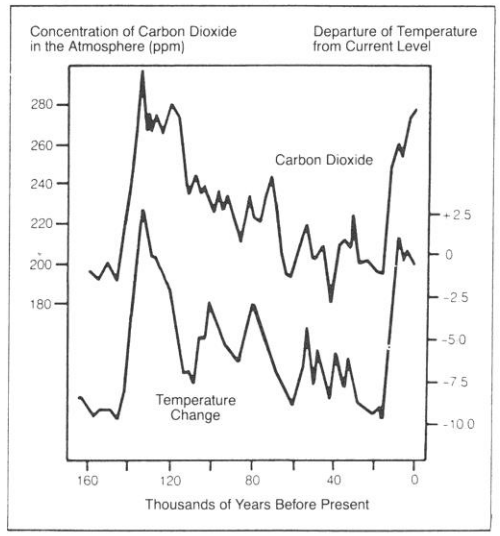
Lesson Summary

In Lesson Two, the students saw how Western societies industrialized at the expense of the environment. They analyzed charts and graphs that provided evidence of increased concentrations of greenhouse gases. To conclude this lesson, ask your students to form some general statements about the importance of the Industrial Revolution and the impact that energy use has on our environment today.

Past and Present Day Relationships Among Carbon Dioxide Concentrations and Temperature Change

A

Long-Term Variations of Global Temperature and Atmospheric Carbon Dioxide



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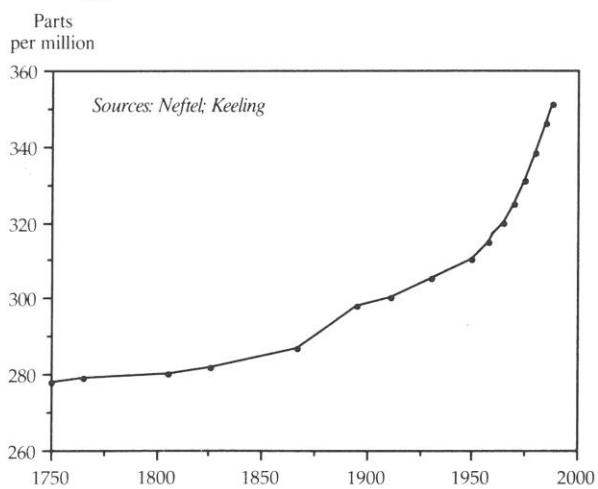
What is the relationship between temperature change and the atmospheric concentrations of carbon dioxide during the past 160,000 years?

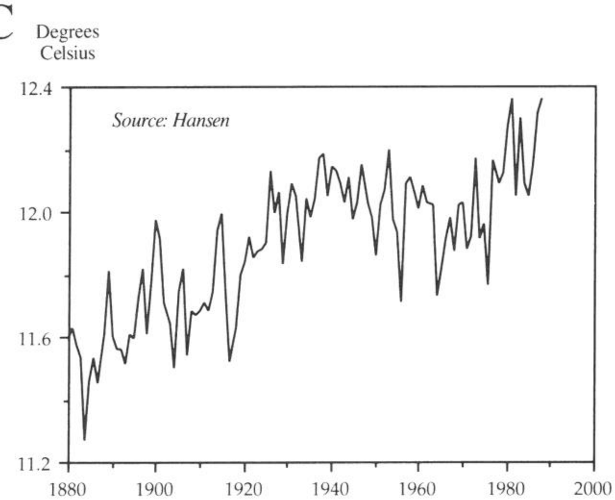
B



Atmospheric Concentration of Carbon Dioxide, 1750-1988

Reprinted from Worldwatch Institute

C



Global Average Temperatures, 1880-1988

Reprinted from Worldwatch Institute

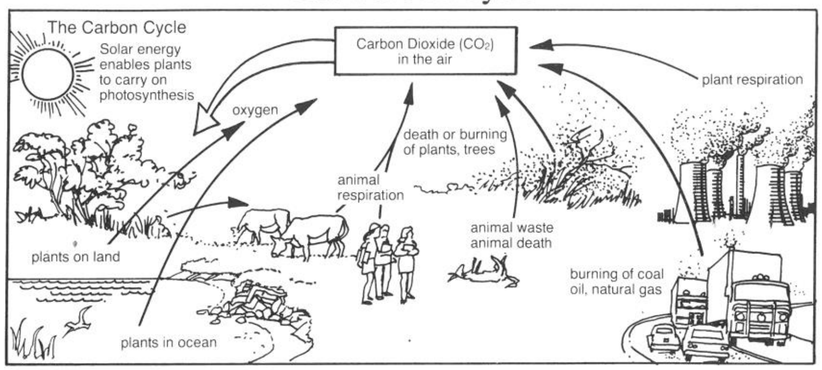
What is the relationship of global average temperatures to the atmospheric concentration of carbon dioxide since 1880?

How The Industrial Revolution Changed The Way We Use Energy

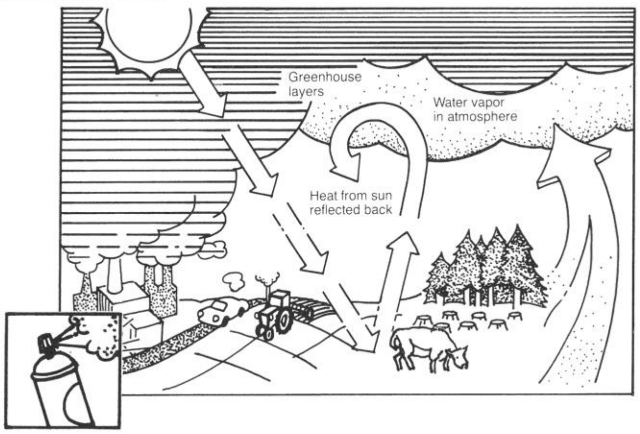
In the first column, under each category, make a list of the ways people in the 1600s used energy to perform daily activities. In the second column, list the ways that we use energy today to perform the same activities. In the third column, list the advantages that modern uses of energy have brought to our lives. In the last column, list the disadvantages that modern uses of energy have created.

Energy Use in the 1600s	Energy Use Today	Advantages	Disadvantages
Transportation			
Agriculture			
Industry			
Recreation			
Home Activities			

The Carbon Cycle



Human Activities That Contribute to The Greenhouse Effect



Fossil Fuels: ____ ____ ____ ____

Deforestation: ____

____

Carbon Dioxide:	Methane:	Nitrous Oxide:	Chlorofluorocarbons:
____	____	____	____
____	____	____	____
____	____	____	____

The Problem: ____

After the Warming: **Part Two** ***Secret of the Deep***

LESSON THREE

How do the risks of waiting for the results of further research on global warming compare to the costs and benefits of taking preventive measures now?

Overview

In Lesson Three, the students will see how Western nations continued to pollute the atmosphere despite evidence of increased concentrations of greenhouse gases. At the same time, Eastern Europe and the Third World were generating their own greenhouse gases. The program reveals that there were some calls for action. The Netherlands, for example, formulated a plan to control carbon emissions. The media produced a movie with doomsday predictions. Policy-makers, on the other hand, were lax in taking action and called for more research to reduce the uncertainties about the role the oceans had in controlling the greenhouse effect. Lesson Three focuses on the events leading up to the year 2000. Student viewing should be stopped at that point, approximately 25-30 minutes into the first hour. The last portion of *After the Warming*, Part Two, will be covered in Lesson Four.

Objectives

After viewing the first half of *After the Warming*, Part Two, and participating in the previewing and post-viewing activities, the students will be able to:

1. identify characteristics of a developing nation,

2. analyze the influence that the media has on public opinion,

3. evaluate the pros and cons of deforestation of the Brazilian rainforest and make policy decisions regarding its use,

4. form an opinion regarding the extent of the global warming threat after examining the uncertainties that still exist, and

5. evaluate the risks and costs of waiting for research results and compare them to the benefits and costs of taking immediate action to reduce the threat of global warming.

Vocabulary

Developing Nation – Many countries of Africa, Asia, and Latin America, which are characterized by a lack of capital goods such as appliances, furniture, vehicles of transportation and simple technology; low literacy rates; high unemployment; rapid population growth; and labor forces heavily committed to agriculture.

Single-Product Economy – A country whose economy relies primarily on the exportation of one or two products.

Third World – The economically developing nations of Africa, Asia, and Latin America. Many of these nations originally were colonies that gained independence from the developed nations. In their efforts to build their economies, they accrued massive debts from major lending institutions such as the World Bank and became "debt-dependent" upon the developed nations.

Previewing Activities and Discussion Questions

1 *Introduce the concepts of Third World and developing nations*.

Divide the class into groups and ask them to read "What is a Developing Nation?" (P34-35). Have each group review the profiles of the first three developing nations and compare them for similarities. In addition, ask your students to compare the first three countries to South Korea and look for differences and similarities. Have them formulate some general characteristics to describe a developing nation. For example, students may note that the three developing nations rely heavily on an agricultural economy, whereas South Korea's economy is much more industrialized. You may wish to have available some almanacs, atlases and additional references which the students might use to research other countries of their choice and to substantiate their findings.

Discuss:
a. If Third World nations were to begin a new Industrial Revolution, what impact do you think their activities would have on the greenhouse effect? Why?

b. What effect might rapid population growth by Third World nations have on the greenhouse effect? Of what significance would this effect be to global warming?

2 *Introduce the Dutch Government Report*.

This comprehensive report can be found in the document, *Energy Policy in the Greenhouse: Volume One – from Warming fate to Warming Limit: Benchmarks For a Global Climate Convention* by Florentine Krause, Wilfrid Bach and Jon Koomey. It is available from the International Project for Sustainable Energy Paths (IPSEP) El Cerrito, California 94530.

Explain to your students that in 1989, the government of the Netherlands introduced a global plan to cut greenhouse gas emissions. The plan recommends that the total global carbon budget from 1990 to 2100 be 300 billion tons. To put this in perspective, consider that the total global amount of carbon dioxide emissions in 1985 was 5.24 billion tons. If multiplied by the 110 year period as allowed by the plan, this would total 524 billion tons, 224 billion tons over the budgeted amount.

According to the plan, 50% of the budget would be allotted to developed nations while the other 50% would be allotted to the developing nations, Each half would then be divided proportionately based on each country's average carbon emissions and size of its adult population in 1990. The rate that each country took to use its share would be the rate of its emissions. Calculated out, some countries would have surplus emissions after 110 years while other countries would use up their allotted emissions in only a few years.

To adjust for this dilemma, carbon emissions trade rights would be allowed. This means that carbon emissions rights could be traded among countries in exchange for credits to be used to pay for reforestation, energy efficiency technology, and agricultural expertise. Thus, those countries with a surplus of carbon emissions for the 110 year period could trade off some of their allotted budget to countries that needed a larger allotment of emissions allowance to operate. A timetable was established for cutting emissions. Seventy-five percent of all carbon emissions would be cut by developed nations by 2030, while 25% of all carbon emissions would be cut by developing nations by 2050.

Ask your students to generate a list of actions that the United States would have to take in order to reduce its carbon emissions by 75%. Discuss what the costs of such actions might be.

Ask your students to note as they watch the program when the Dutch Government plan was accepted for implementation by the United States and what motivated the decision to accept the plan.

Post-viewing Recall and Discussion Questions

1 ***Why is the greenhouse effect considered a global problem?***

2 ***Which contributed more to the greenhouse effect: industrialization, consumerism, or deforestation? Support your conclusion.***

3 ***Why did the United States and other industrialized nations hesitate to take any action to curb their greenhouse emissions?***

4 ***What role did the media play in alerting the public to the threat of global warming?***

5 ***What effect, if any, did the media's strategy have on policy makers?***

Post-viewing Activities

1 ***Discuss the role of media in informing the public about important and sometimes controversial issues.***

Look at the editorial cartoon worksheet (P36). Divide your students into groups and assign a cartoon to each group. Ask your students to study the cartoon and to answer the questions on the worksheet.

2 ***Have the students create an editorial cartoon on any specific point of interest in "After the Warming".***

3 ***Review with your students how some Third World nations used the rainforest to improve their economy and to help overcome population problems.***

Divide your class into groups and go to "The Tropical Rainforest Connection" (P37-38). In this activity, each student will become a member of a special interest group.

Have your students research the current state of deforestation of Brazil's rainforest especially as it pertains to their chosen special interest. Students should work in their group to complete the decision-making chart. It is important to note that some groups may not reach consensus on the nature of the problem nor on what actions to take. In discussion, the students should realize that simple solutions to complex problems are often not available.

4 ***Divide your class into groups and go to "Debating the Issue" (P39)***

In the left hand column of this worksheet, have each group summarize the facts which they have gathered so far from watching *After the Warming*, which suggest that global warming is a threat to the environment. Next, ask students to look at "Research Contrary to Global Warming is Glossed Over" (P40-42). Ask your students to read the article and to complete the right hand column of the worksheet with the opposing viewpoints noted in the article. Then ask your students to complete the bottom portion of the worksheet.

Summarize this activity by asking your students to explain the uncertainties that exist regarding the greenhouse effect and global warming.

5 ***Have the students contact the local electric utility, the energy administration, a university scientist, or a federal department such as the CSIRO or the Department of the Environment and Energy to get their views on global warming and any available evidence to support those views. Once responses are gathered, discuss these views as they relate to the program.***

6 ***Have the students contact local, state, or national political leaders as well as foreign embassies to get their views and policies on global warming. Once responses are gathered, discuss these views as they relate to the program.***

7 As a culminating activity, discuss with your students the risks and costs that might be involved in waiting for research results to reduce the uncertainties on global warming.

Your students could brainstorm a list of those risks and costs in groups. Discuss how realistic these risks might be.

Review from Lesson Three's second previewing activity the students' lists of actions that the United States would have to take to reduce its carbon emissions. Discuss the possible benefits and costs in taking those actions. Your students could brainstorm a list of those benefits and costs in groups.

Ask your students to compare the risks and costs of delaying action to the benefits and costs of taking action now. Have your students take a stand on waiting for research results or taking some immediate action. Open the discussion for debate.

Lesson Summary

In this lesson, students saw how the threat of global warming increased in the 1990s as Western industrialized countries continued to pollute the atmosphere and developing nations began to generate their own contributions of greenhouse gases. Students examined evidence for uncertainties related to global warming and discussed the risks involved in postponing action in light of those uncertainties. Students also suggested specific actions that the United States might take to curb greenhouse gas emissions. The benefits and costs of taking these actions were discussed. To conclude, discuss with your students the kinds of decisions that policy makers must make before they formulate an action plan.

What Is A Developing Nation?

Study the brief profiles of the four countries described below. The first three countries are developing nations. Compare them to the industrialized nation of South Korea. Note some similarities among Morocco, Cuba, and Pakistan, and some of the similarities and differences with South Korea. Create a general description of what constitutes a developing nation.

Morocco

Morocco's economic activity is concentrated mostly in the cities. Its gross national product is the second lowest in Africa. Great differences exist in income, education, and living standards among the urban and rural areas. The Moroccan working class is mostly unskilled and illiterate. Unemployment in the cities is approximately 25% and as high as 50% in the rural areas. In the early 1980s nearly 50% of population was employed in agriculture. Morocco imports oil and small amounts of coal. Electrical current for power plants in and around the cities of Rabat and Casablanca is also imported. Oil accounts for only 3% of Morocco's commercial needs. Coal is the country's major energy source, and 54% of the nation's industrial needs are met by coal. Morocco's population has been growing very rapidly at an annual rate of 25%.

Cuba

Sugar exports represent nearly 80% of Cuba's total earning from trade. In exchange for sugar and Cuba's other exports, tobacco - coffee, and a few minerals - Cuba acquires machinery and equipment, mainly from the Soviet Union. Under the dictatorship of Fidel Castro and with the aid of the Soviet Union, Cuba has managed to increase its manufacturing capabilities to include production of cement, steel bars, fertilizer, tyres, refrigerators, baseballs, batteries, paper, shoes, toothpaste, small farm machinery, and rayon and other fabrics. While Cuba has been successful to some extent in diversifying its economy, it still depends on the Soviet Union for many necessities such as buses, trucks, spare parts, and most importantly, oil. Several basic foods such as rice, wheat, vegetable oils, and beans are also imported by Cuba. Cuba has a population of 10.3 million people. Three-quarters of its population live in urban areas, putting a strain on employment and housing for its city dwellers. However, unlike most other Latin American nations, Cuba's population is relatively stable.

Pakistan

Industry supplies 17% of Pakistan's gross national product. Textiles comprise the largest share of manufactured products, including both factory-made and hand-woven fabrics. Pakistan annually produces about 350,000 tons of ammonia-based fertilizers and manufactures large quantities of penicillin. Despite its industrial growth in certain areas, Pakistan is predominantly an agricultural country. Agriculture provides 30% of the nation's annual income. Pakistan is rich in minerals but lacks machinery, roads, and funds to develop large mining enterprises. Some foreign firms are providing machinery and expertise in exchange for rights to mine Pakistan's deposits of copper, iron ore, sulfur, gold, silver, and molybdenum (used to strengthen steel). Pakistan has some modern energy sources, hydroelectric power and natural gas, to provide its cities with household energy. However, residents in rural areas use wood and animal dung as fuel. To this end, much of Pakistan's landscape has been stripped of trees. Pakistan has a population of 107.5 million, of which 70% live in small rural villages and make a living as farmers or herders.

South Korea

Twenty-five per cent of South Korea's workforce is employed in industry that accounts for 35% of its gross national product. Since the 1950s this nation has developed heavy industry and chemical processing plants which together account for over half of the total manufacturing output. South Korea is among the world's top producers of ships. Textile and electronic goods are top among its exports. Production of automobiles has also increased, and cars have become the nation's third largest export. South Korea is one of the most densely populated countries in the world with about 42.6 million people. Sixty-five percent of its population lives in the cities.

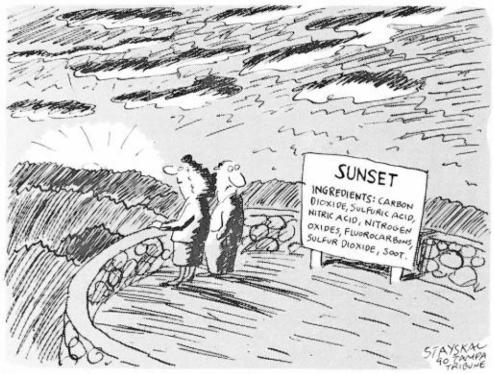
To curb its rapidly growing population, the South Korean government started a program in 1962 to limit the average family size. This effort has resulted in the nation's ability to cut its population growth rate in half.

General Description of a Developing Nation:

Interpreting Editorial Cartoons

On a separate sheet of paper, summarize the cartoonist's message. What symbols are used to convey that message? Are any of the characters recognizable? How are they depicted? What is the cartoonist's point of view? Do you agree or disagree with the point of view presented? Why/why not?

1.



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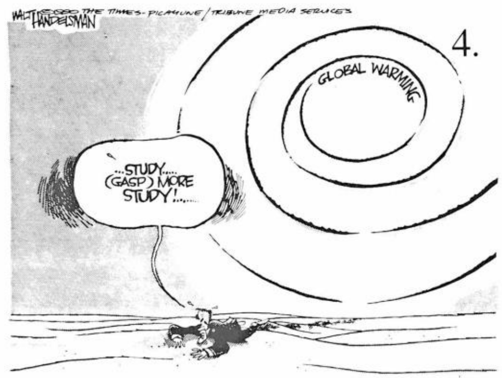

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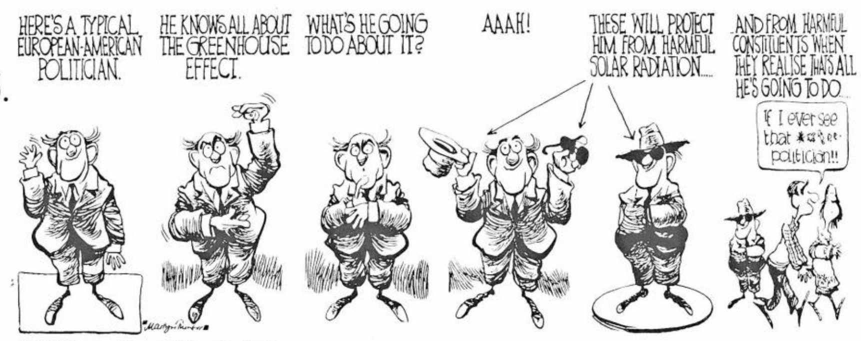

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The Tropical Rainforest Connection

As a member of one of the special interest groups below, carefully study your connection to the tropical rainforest in Brazil. Investigate the usefulness of the tropical rainforest and its special importance to your interest group. In small groups, complete the decision-making chart. Share your responses with the rest of the class when you have reached some conclusions.

Special interest groups

Japanese furniture maker
The industrialized nation of Japan is in short supply of hardwood used for timber, paper pulp, and other wood products. Japan is the largest importer, consuming 40% of the world's tropical hardwood. Deforestation is in Japan's best interest.

President of Brazil
Major cities in Brazil are vastly overcrowded. Jobs are scarce. Many people are poor and hungry. The Brazilian government encourages large-scale development projects and colonization of the tropical rainforest to relocate its peasants, to create jobs for them, and to raise their standard of living. Deforestation is in the Brazilian government's best interest.

Tropical rainforest native
Many people call the rainforest their home. They are independent and secure in their way of life. For them deforestation means upheaval and dislocation. Deforestation is not in their best interest.

Chairman of the board of a major hamburger fast food chain
Fast food chains use tremendous supplies of beef for hamburgers. This beef comes from cattle ranches which have taken over land that was once rainforest. It has been estimated that for each hamburger exported from Central America, a patch of forest the size of a kitchen must be cleared. De-forestation is in the United States fast food chains' best interests.

Environmentalist
The growth of trees plays an important role in battling global warming. Trees take in and store the greenhouse gas carbon dioxide (CO_2) while returning oxygen to the air. Trees have been a stabilizing force in helping to keep atmospheric CO_2 levels down. The destruction of the rainforest is harmful to human and animal populations in several ways. First, fewer trees means less ability for the earth to absorb harmful CO_2, allowing more of this greenhouse gas to escape into the atmosphere. Second, the method by which many of the trees are cleared, slashing and burning, actually creates additional CO_2 which is released into the atmosphere. To an environmentalist, deforestation is not in the best interest of people or animal populations.

The Tropical Rainforest Connection

Major Problem	Goal(s)	
Alternatives	Pros +	Cons -
	+ + - -	
	+ + - -	
	+ + - -	
Decision(s)	Reason(s)	

Debating The Issue

Is global warming a current or future threat to the environment? In groups, brainstorm a list of points made in *After the Warming* to suggest that the answer to this question is "yes." Then read the article entitled, "Research Contrary to Global Warming is Glossed Over" and list the major points made to suggest that the answer is "no."

Points made to suggest yes:	**Points made to suggest no:**

1 ***Examine the points made. Note the points which you consider to be facts with an 'F' and an 'O' those you consider to be opinions.***

2 ***Based on the information analyzed from both sources, what is your viewpoint? Is global warming a current or future threat to the environment? Why/why not?***

3 ***Discuss the different formats (television and newspaper) in which the information was presented. Did either format influence the viewpoint that you took? Explain.***

RESEARCH CONTRARY TO GLOBAL WARMING IS GLOSSED OVER
By Mark Hoske

Greenhouse Effect Disaster May Be Fiction

Chicago – Nations of the world may avoid global warming by doing nothing, except perhaps, investing in a little more money for research.

The Greenhouse Effect, recently publicized as a certainty, should still be regarded as theory based on questionable (computer) models, said researchers at the 17th Annual Illinois Energy Conference.

Three of four scientists speaking at the session on global warming suggested that visions of Midwestern deserts, tundra yielding to farmland and underwater coastal cities are a product of sensational media and political forces rather than sound scientific findings.

Surprised? So was a vast majority of the about 80 political, academic, research and utility personnel attending.

All four scientists speaking at the session did agree that more research – and research grants – is needed because of limits of current global climatic models. Additional research is needed prior to drastic and costly world-wide changes to avoid a disaster that may not happen, they suggested. The audience heard three of the four researchers say that:

- The drought of 1988 and surrounding years' low rainfall is well within the wide variance of climatic extremes exhibited within recorded history.
- The majority of the warming in the 20th century was prior to 1930, contrary to the dispersal of greenhouse gases.
- Computer models are limited in the scope of understanding of the significant roles of cloud cover and water vapour as factors to increased CO_2 equivalents.
- Energy efficiency and environmental proponents shouldn't rely on global warming as support for their programs because when global warming is again considered theory rather than threat, programs that have social value on many other points as well as global warming will lose political support.
- Doomsayers have been wrong before with popularly accepted theories on nuclear winter, a rapidly impending ice age, and supersonic aircraft depleting the upper atmospheric ozone layer.

Modelling, measurement dangers

Various global climatic models have their limits, says Kenneth E. Kunkel, Director, Midwest Climate Center. They won't show the ranges of environmental extremes, only average global temperature.
Richard S. Lindzen, Department of Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology explained that because of wide climatic variance in extremes, it's misleading to look at trends in a smaller period than the full 130-year climatic record and draw cause-and-effect conclusions. Further, within

that record, noted Patrick J. Michaels, Department of Environmental Sciences, University of Virginia, researchers must distinguish between naturally occurring and human-caused global warming. Unfortunately, it's a difficult distinction, he said. Lindzen added that more modern temperature measurements – unbiased by hotter readings near cities – show no record temperatures in the 1980s.

In terms of regional weather patterns, some computer models are contradictory, Lindzen explained. Also current models predict warming should be greater in the summer, which is not so.

Henry F. Diaz, Climatologist, National Oceanic & Atmospheric Administration, Air Resource Laboratory, agreed that unexplained temperature differences between hemispheres and over the land and oceans don't fit the models' predicted outcome.

Michaels seemed to sum up by saying, "When you model complex systems, you tend to get outlandish results."

Statistics can show anything

It's easy to generate catastrophic scenarios that are extremely unlikely, but difficult to disprove," Lindzen said.

Diaz said climate change is as much a problem of definition as detection since it depends on the time intervals. "Interpretation of data drives some of the current debate," he said. "Statistics can be used to show anything you want to show."

For instance, the summer of 1901 was similar to the heatwave of 1988, Diaz said. Other droughts were recorded in the 1950s and 1930s. Record wet years were recorded in 1973 and 1983. "It's more likely a part of climatic variability," he said.

Although recent satellite data is more accurate than that gathered from weather stations, Diaz said, the data available is from too short a period.

Michaels said that the change in hemispheric climate is counter to what should be happening – warming should appear first in the Northern Hemisphere, but there's been no change in the past 55 years.

Further, Michaels pointed out that new climatic models show virtually no change in U.S. summer temperatures since the doubling of CO_2-equivalent gases. "Where's the warming?" he asked.

Water vapour, other wildcards

Climatic feedbacks represent wildcards in the calculations and a point of contention.

Water vapour increases infrared absorption while decreased ice and snow cover caused by greenhouse heating will increase solar energy absorption, Kunkel said. Raising more uncertainty, Kunkel said little is known about the interaction of climate and the biosphere.

Michaels differed with the view that water vapour and cloud cover would increase warming.

Potential for large errors exist on the reflectivity and the amount and types of clouds. If clouds get just one percent brighter. Michaels said, it would counter all of the soothsayers' impending warming.

Clouds and water vapour are more important by two orders of magnitude than the so-called greenhouse gases, said Lindzen. The slightest error in cloud model will scrap the effect.

"Feedbacks – boy, are they at issue; they are the whole question." Lindzen said. "Water is the earth's thermostat."

"Almost certainly," Lindzen agreed with Michaels, "positive feedback in models are negative in nature," meaning that cloudiness creates cooling, not warming as in most models. "It's also uncertain how much CO_2 oceans will absorb," Lindzen added.

More study needed

Lindzen said some notable speakers at industry conferences contend that the time for study is over and the existence of the greenhouse effect is not to be debated – including Lord Marshall of Goring, one of Britain's most distinguished physicists and the chairman of the Central Electricity Generating Board at the World Energy Conference. "Why are people calling us to stop?" concluded Lindzen.

"We need to do more science on what has happened before we can say what may happen," Diaz added

Not confused, but convinced

Kunkel admitted that the media has had a difficult time presenting scientific findings. One of the many questions from the audience suggested that selective media coverage has confused the public on the global warming issue.

LESSON FOUR
What Steps Can be Taken to Combat Global Warming?

Overview

In Lesson Four, *After the Warming*, Part Two resumes in the year 2000. The students observe how the world is united in taking measures against global warming. While the heat is no longer preventable, it is providing the impetus to take important and effective steps in the fight against the changing climate. The final moments of *After the Warming* provide students with insight into what those steps were and the affect that they had.

Objectives

After viewing the last half of *After the Warming*, Part Two, and participating in the previewing and post-viewing activities, the students will be able to:

1. describe sources of renewable energy,
2. formulate a policy and develop an action plan to cut greenhouse gas emissions, and
3. take personal steps to save energy.

Vocabulary

Agroforestry – Extracting products from and growing crops inside tropical forests.

Feedback effect – The effect that certain environmental conditions have on global warming. Clouds, for example, have both negative and positive effects on global warming. An increase in cloud cover would reflect more solar radiation back into space producing a cooler planet (a negative feedback effect). On the other hand, a cloudier planet can trap more heat reflected from the planet and cause a warmer planet (a positive feedback effect).

Renewable energy – Energy sources which are replenishable. These energies are relatively pollution free. Examples of renewable energy resources are solar radiation, wind power, solar sea power, hydroelectric power, geothermal power, photosynthesis, power generated from organic wastes, and tides.

Telecommuting – Using a computer networking system to conduct business from home. This results in a decrease of carbon dioxide emission and reduction in fossil fuel use since fewer cars are used to commute to work.

Previewing and Discussion Questions

1 *Introduce the concept of renewable energy.*

Explain to your students that the earth does not contain an inexhaustible supply of fossil fuels. These fuels, which account for 90% of the energy used in the United States and which took millions of years to form, can be used up.

Discuss:

a. What can we do when we run out of fossil fuels?
b. What effects will running out of these sources of energy have on our lifestyles?
c. How can we slow down the consumption of these fuels?

Check your students' prior knowledge of alternative energy sources. Define renewable energy and ask the students to generate a list of resources that could be used as renewable energy.

2 *Have students design the energy efficient home of the year 2050. They can write, draw, or make a model of this home. Ask students if such a home could be designed using fossil fuels only? Why or why not?*

3 *Ask students to describe some possible positive side effects to global warming.*

4 *As students watch the last segment of "After the Warming," have them note the two general ways in which greenhouse gases can be cut without creating problems in the economy or changes in peoples' lifestyles.*

Post-viewing Recall and Discussion Questions

Discuss the following questions related to the students' viewing of the last part of *After the Warming*:

1 *What actions were taken in the first half of the 21st century by developed and developing nations to cut greenhouse gases?*

2 *What actions were taken to adapt to global warming?*

3 *What effect did global warming have on the environment during the first half of the 21st century?*

4 *How does energy use in the year 2050 compare to energy use in the 1990s?*

5 *How does the environment of the year 2050 compare to environment of the 1990s?*

Post-viewing Activities

1 *Have the students research and report on the use of renewable energy sources, their costs and their efficiency.*

2 *In small groups, have the students develop policies that could cut and control greenhouse gas emissions on a local, state, or national level.*

Have the students determine the impact that these policies would have on subgroups of the population such as farmers, commuters, plastics industries and coal miners. The students could write letters to officials and to the newspaper to seek support for their policies. Students could also create posters and radio or TV announcements that support their policies.

3 Form a class energy conservation committee.

Have students survey the current use of energy in the school and report on their findings. Next, have students generate a classroom or schoolwide energy usage policy and action plan to conserve and make energy use more efficient. Points to consider include the type and amount of lighting in offices, classrooms, and other areas: temperature levels; heating and air conditioning; use of energy when school is not in session or during extracurricular activities; and the use of natural light, blinds, and drapes. Have the students present their policy to the principal, school board, P and C, or student council. After the policy has been implemented, have the students determine the effectiveness of their action plan by comparing utility costs before and after implementation. Ask students to create a graph that charts their findings.

4 *Have students implement a personal energy conservation action plan.*

Ask students to review the list "How to Save Energy and Money" (P49) and choose one thing to implement for one month or longer. Ask the students to discuss the benefits that they will derive from their plan. After one month, ask students to report on how they conserved energy during that period.

5 *Have students contact local utility companies to inquire and report on the methods these companies use to encourage homeowners to conserve energy.*

6 *Conduct a tree planting around your school to absorb greenhouse gas.*

7 Have students design a mural of their community as it might look in the year 2050.

8 *Ask the students to create a timeline of the events which occurred in "After the Warming" from 1990 to 2050.*

Lesson Summary

In Lesson Four, students learned that greenhouse gases could be cut by using renewable energy and by increasing energy efficiency. The students made predictions about how the world of 2050 might look if renewable energy was used. They also formulated policies and suggested steps to take now that would create a more energy efficient environment. To conclude, ask your students what steps they might personally take to become more energy efficient.

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How to Save Energy and Money

Transportation
(50% of average personal energy use)

- Walk or ride a bike for short trips (100%savings).
- Use a car pool or mass transit as much as possible (50% or more).
- Use a bus or train for long trips (50% or 75%)
- Buy an energy-efficient car (30% to 70%)
- Consolidate trips to accomplish several purposes (up to 50%)
- Keep engine tuned and replace air filter regularly (20% to 50%)
- Obey speed limits (20% or more).
- Accelerate and brake gently and don't warm up the engine for more than a minute (15% to 20%).
- Use steel-belted radial tires and keep tire pressure at recommended level (2% to 5%).

Home Space Heating (25%)

- Build a super insulated or highly energy-efficient house or retrofit an existing house (50% to 100% savings).
- Dress more warmly, humidify air, and use fans to distribute heat so that thermostat setting can be lowered without loss of comfort (saves 3% for each ºF decrease).
- Install the most energy-efficient heating system available (15% to 50%).
- Install an electronic ignition system in furnace, have furnace cleaned and tuned once a year, and clean or replace intake filters every two weeks (15% to 35%).
- Install stack dampers in the furnace or boiler flue (variable).
- Insulate heating ducts that pass through unheated spaces (2% to 5%).
- Do not heat closets and unused rooms (variable savings).
- Insulate attic ceiling or floor, all outside walls, and floors over unheated spaces (20% to 50%).
- Caulk and weatherstrip cracks (10% to 30%).
- Use insulated steel or wood doors with magnetic weather stripping or install storm doors, storm windows, or insulated shutters, or, best, install modern superwindows(R-5 to R-12 +) (5% to 25%)
- Extinguish furnace pilot lights during summer or, best of all, install an electronic ignition system (variable).
- Do not use electricity for space heating (30% to 50%).

Hot Water Heating (9%)

- Install the most energy-efficient system available, such as active solar, instant tankless, or high-efficiency-gas water heaters (15% to 60%).
- Turn down thermostat on water heater to 110º-120ºF(5% to 25%)
- Use less hot water by taking two-to five-minute showers instead of baths, washing dishes and clothes only with full loads, washing clothes with warm or cold water, repairing leaky faucets, installing aerators on faucets, using low-flow showerheads, and not letting water run while bathing, shaving, brushing teeth, or washing dishes (10% to 25%).
- Do not use an electric water heater.

Cooking, Refrigerating and Other Appliances (9%)

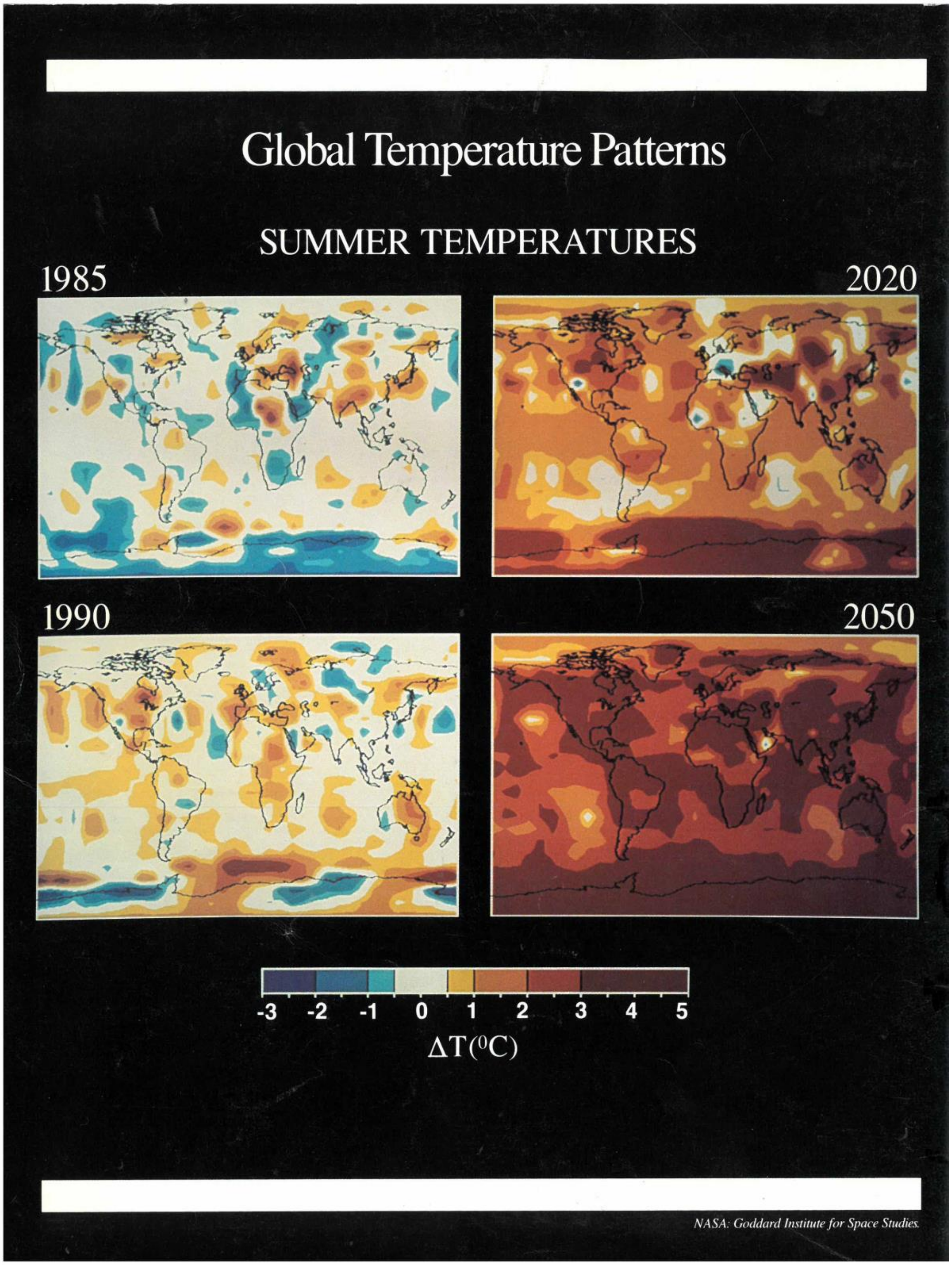
- Buy only the most energy-efficient stove, refrigerator, and other appliances available – ideally powered by natural or LP gas, not electricity (25% to 60%).
- Use a gas stove instead of an electric stove.

- Install electronic ignition systems on all gas stoves and other appliances (10% to 30%).
- Use a chest freezer rather than an upright model to prevent unnecessary loss of cool air when door is opened, and keep it almost full (variable).
- Do not locate refrigerator or freezer near a stove or other source of heat and keep condenser coils on back clean (variable).
- Don’t use oven for space heating (very expensive).

Cooling, Air Conditioning, and Lighting (7%)

- Buy the most energy-efficient air conditioning system available (30% to 50%+).
- Increase thermostat setting (3% to 5% for each ºF).
- Close off and do not air condition closets and unused rooms (variable).
- Use small floor fans, ceiling fans, and whole-house, window, or attic fans to eliminate or reduce air conditioning needs (variable).
- Close windows and drapes on sunny days and open them on cool days and at night (variable).
- Close bathroom and laundry room doors and use an exhaust fan or open window to prevent transfer of heat and humid air to rest of house (variable).
- Try to schedule heat-and moisture- producing activities such as bathing, ironing, and washing during the coolest part of the day (variable).
- Cover pots while cooking (variable).
- Use compact fluorescent and other energy-saving bulbs wherever possible (50% to 75%).
- Turn off lights and appliances when not in use and reduce lighting levels by using dimmers and lower wattage (variable).
- Disconnect air conditioners at the circuit breaker during winter – otherwise a small heater in the compressor runs year-round.

NFSA


Global Temperature Patterns
SUMMER TEMPERATURES
1985
2020
1990
2050
-3 -2 -1 0 1 2 3 4 5
ΔT(°C)
NASA: Goddard Institute for Space Studies.