



CURRICULUM FOR THE COAST

Global Warming

Global warming is a controversial topic, not because scientists are uncertain of what is happening but because powerful interests are resisting efforts to reverse it. This module answers the following questions about global warming:

- *What is global warming?*
- *Who or What are the main causes?*
- *What impact will it have on Earth?*
- *What is being done to stop it?*
- *What can we do?*

I. What is Global Warming?

Our Earth Is Becoming an Overheated Greenhouse

The Dutch chemist and Nobel Prize winner Paul Crutzen has said that we should stop thinking of ourselves as living in the *Holocene Epoch*, which began about 12 million years ago as the last ice age ended. A new age has begun, Crutzen argues, marked by the impact man has had on the Earth.¹ He suggests we regard the invention of the coal-powered steam engine by Scottish engineer James Watt in the 1780s as the beginning of what he calls the *Anthropocene Age*. Everyone agrees the steam engine triggered the Industrial Revolution and changed man's relationship with Nature. Others might point to the mid-1600s, when the human population, then at the half-billion mark, started to sharply increase.² Or we could regard the discovery and use of oil in the late 1800s as our demarcation point.

Whatever date we might choose for the beginning of Crutzen's *Anthropocene Age*, his point is valid. Mankind has altered the balance of natural forces on Earth. We've conquered nature many times over, but although we've won all the battles so far, we may someday lose

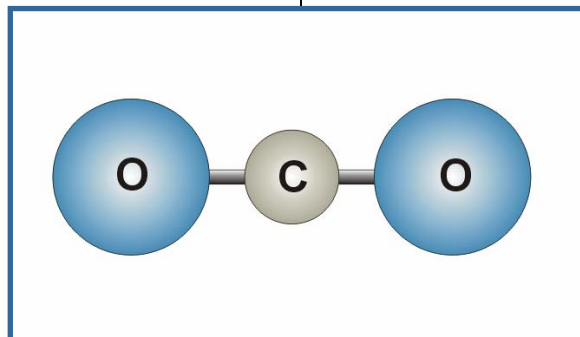
the war. We have polluted our fresh water supplies and oceans, polluted and despoiled our lands, and polluted our atmosphere. Not only do our assaults appear not to be ending anytime soon, our mismanagement is warming up our atmosphere, with consequences that we are just beginning to understand.³

Warming things up with CO₂

Scientists and environmentalists are concerned about the gradual warming of Earth's atmosphere over the last 100 years. Having

linked hydrocarbons and other gasses to temperature increases in the atmosphere, some fear the levels of gasses we are spewing into the air are reaching a critical point. Ice-core samples show that as Mr. Watt perfected his steam engines, carbon dioxide

(CO₂) levels in the 1780s were about 280 parts per million (ppm), a level that had been constant since the first cities were formed 6,000 years ago. CO₂ is a normal component of our atmosphere, produced by decaying vegetation, respiration of oxygen-breathing creatures (like us), and chemical weathering. However, CO₂ levels rose to 300 ppm by the mid-1930s, to 330 ppm by the mid-1970s, to 360 ppm by the mid-1990s, and to 380 ppm by the mid-2000s. If the trend continues, CO₂ levels could reach 500 ppm by the middle of the 21st century.⁴



Why care? Ice cores have revealed that the last time CO₂ levels reached 500 ppm – almost double Mr. Watts' pre-industrial level -- was during the Eocene Age, about 50 million years ago. During that age, "...crocodiles roamed Colorado and sea levels were nearly 300 feet higher than they are today."⁵ In other words, ice will melt, sea levels will rise, and local climates will change.

Hot enough for you?

The 1990s was the warmest decade since the mid-1800s, when temperature record keeping started. The hottest years recorded were 1997, 1998, 2002, 2003, 2005, and 2007. If the trend continues, the United Nations' Intergovernmental Panel on Climate Change (IPCC) projects that global temperatures will rise a scary 3 to 10° Fahrenheit (1.6 to 5.5° Celsius) by 2100. Why scary? Read on.

With just a three degree rise, rainforests will begin to die, releasing vast new amounts of carbon dioxide; algae will fail in the warmer oceans and stop generating cooling clouds and stop absorbing carbon; and the Greenland glacier, which sits atop land and, thus, above the ocean level, will go into meltdown, releasing enough water to flood many of the world's cities.

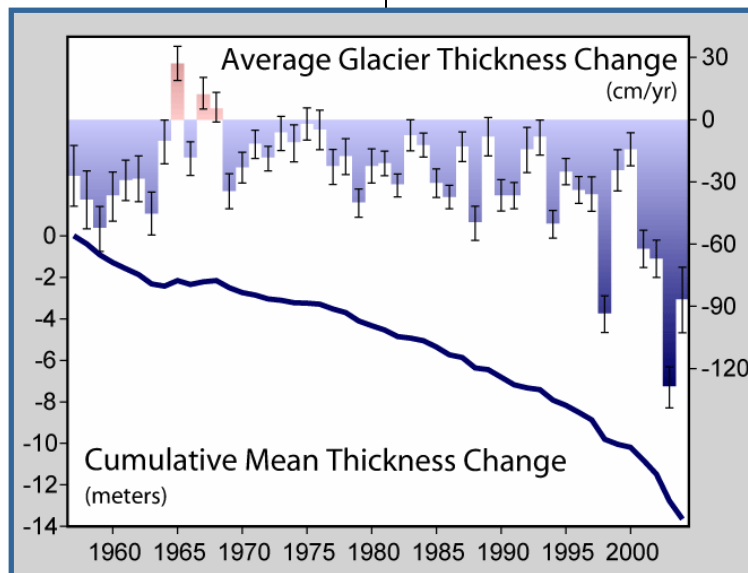
Temperature fluctuations have occurred in the past. During the last ice age, approximately 70,000 to 12,000 years ago, ice covered much of North America and Europe—yet sudden, sometimes drastic, climate changes occurred during the period. Greenland ice cores indicate one spike in which the area's surface temperature increased by 15° F (9° C) in just 10 years.⁶ We know spikes occur, so the question

is, "Are we seeing another spike or a long-term increase?"

We're in for the long haul

Scientists believe the "balance of evidence" indicates we are seeing long-term increases. This is bad because for every incremental increase in CO₂, the atmosphere's average temperature will rise. Every degree increase means more ice will melt and create, among other things, sea level rise. The average temperature rose 1° F in the last century from 59° F to 60° F. Since CO₂ has a shelf life of about 100 years, even if we cut our emissions significantly, we're still in trouble. Rising temperatures are already melting ice caps,

glaciers, and permanent mountain snow. This frozen water accounts for 68.7 percent of Earth's fresh water and 1.74 percent of Earth's total water. Now, 1.74 percent doesn't sound like very much, but it amounts to 5,773,000 cubic miles of water (24,064,000 cubic kilometers).⁷ (As the atmosphere,



part of the troposphere, grows warmer, the stratosphere, high above the earth's surface, has cooled, an expected result of heat trapped in the troposphere.)

Today more than 40 percent of the world's population gets its fresh water from rivers, lakes, and streams that flow from glaciers due to annual seasonal melting, which is then replenished by snowfall each year. Should a glacier eventually disappear, populations depending on its melting water could face severe water shortages. In addition, ice and snow on glaciers reflect 90 percent of the sun's rays. As warmer air temperatures accelerate their melting, the newly exposed land and ocean waters will absorb 90 percent of the sun's rays, accelerating the cycle.

If CO₂ levels continue to rise, the atmosphere's average temperature could rise 1 to 4.5° F (0.6 to 2.5° C) by 2050, and 2.2 to 10° F (1.4 to 5.8° C) by about 2100 (different temperature estimates reflect different best-case, worst-case variables used in computer models).^{8, 9} If this happens, sea levels, which now are rising at up to a foot every 100 years, are expected to rise about two feet along U.S. coastlines and throughout the world.

The problem, however, is even more serious. Scientists are discovering that the ice in Greenland, the Arctic, and Antarctica is melting faster than falling snow can replace it, something scientists didn't initially expect.¹⁰ Greenland is covered by 630,000 cubic miles of ice, most of it above the ocean's surface. If it melts, it will release enough water to raise global sea levels by 23 feet. Carl Egede Boggild, a professor of snow-and-ice physics at the University Center of Svalbard, said Greenland could be losing more than 80 cubic miles of ice per year.¹¹ If this worldwide melting continues, one NASA research director thinks ocean levels could -- in an admittedly extreme worst-case scenario -- rise not just by two feet but by up to 80 feet within 40 years.¹²

since the coastal population is expected to increase by 12 to 13 million between 2000 and 2010,¹⁵ what's going to happen if CO₂ hits 500 ppm?

Get a topographical atlas at your library and identify how many of the world's coastal cities could be threatened by a rise in mean sea levels. Globally, more than 100,000,000 people now hug the shorelines, living between mean sea level and just three feet above that mark.¹⁶ For the past 100 years, the global mean sea level has risen by 3.9 to 7.8 inches (1 to 2 mm)¹⁷ or more (variations are due to differing land upheavals and subsidence). Scientists estimate that a sea rise of about 20 inches (50 centimeters) would put 92 million people at risk, and a sea level rise of 3.28 feet (1 meter) would put 118 million people at risk.¹⁸ Can you imagine the devastation if sea levels rise 80 feet, as some now fear?

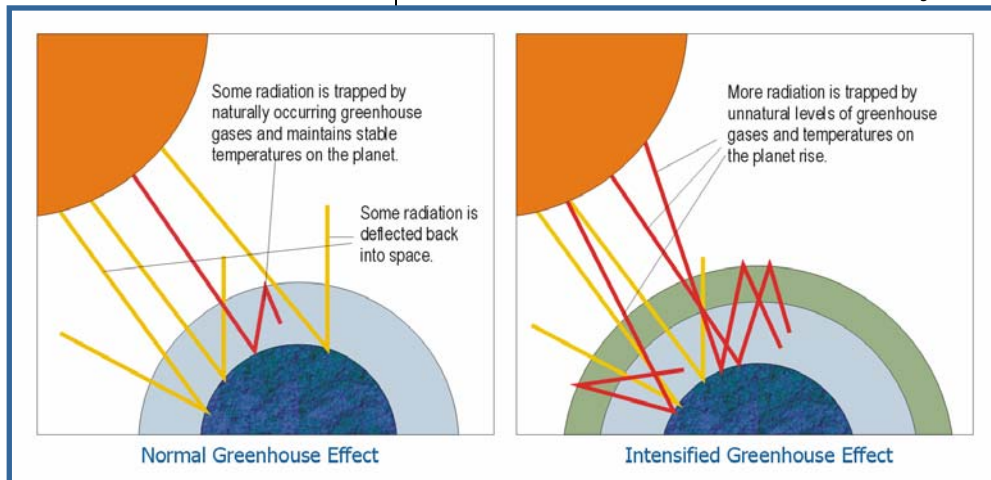
Earth's normal 'greenhouse effect'

What is the "greenhouse effect" and how does it work? When the sun's heat or energy (the visible and *short wavelength* infrared rays, called radiation) hits the Earth, about 49 percent of that energy is reflected back into space by the Earth's atmosphere. The remaining 51 percent strikes the Earth and most is absorbed by land,

Everyone may get oceanfront property

Consider this: Approximately half of the 300 million Americans live within 50 miles (80 kilometers) of the sea, including the megalopolises of Boston-New

York-Washington, the entire state of Florida, New Orleans-Houston-Galveston, and Los Angeles-San Francisco. Although these coastal areas are only 5 to 10 percent of the country's land area (depending on how you define "coastal"), they have at least five times the population density as inland areas¹³ and account for 34 percent of all U.S. employment.¹⁴ And



water, and vegetation.¹⁹ These warmed surfaces then radiate their own energy as *long wavelength* radiation back into the atmosphere, where it is naturally reflected back to Earth by water vapor (clouds), which, incidentally is the predominant greenhouse gas, or absorbed by CO₂ and other atmospheric gases.

Short wavelength radiation from the sun can penetrate the atmosphere, while reflected long wavelength radiation can't. This normal phenomenon of Earth's gasses holding and reflecting heat back to Earth is called the "greenhouse effect."

Why call it a "greenhouse effect"? Consider the glass roof and walls of a greenhouse. They behave as the atmosphere does, allowing the sun's short wavelength radiation to enter the greenhouse, while trapping inside the structure the long wavelength rays being emitted by the warmed plants, floor, and walls. The greenhouse glass and the Earth's atmosphere perform the same function -- trapping heat. We're lucky this natural greenhouse effect exists. Since long wavelength radiation is trapped by water vapor in the atmosphere, this natural greenhouse effect keeps the Earth's *average* global surface temperature at about 60 °F (15.5° C). Without this entrapment of gasses and energy, the Earth's temperature would be much, much colder -- about 6 °F (14.5° C). It was only when humans began adding to the natural occurrence of CO₂ and other greenhouse gases that the trouble began.

Concerns heat up

Concerns about global warming began in the 1950s when American scientist David Keeling developed a method to accurately measure CO₂ levels. Then scientists at the Mauna Loa Observatory in Hawaii discovered that CO₂ levels were rising. After a debate on whether the Earth was warming up or actually cooling down, numerous studies involving the theoretical work of climate modelers and the field work of scientists on every continent have confirmed both rising CO₂ levels and their links to warmer temperatures. Rather than detail their research in this tutorial, we've created a high-level chronology of the work, while the American Physics Institute has a much more detailed list.

In 2001, an IPCC report, enticingly entitled *Carbon Dioxide Capture and Storage*, said the current rate of warming was "very likely" greater than any seen within the last 10,000 years, that is, there was a 90 to 99 percent chance -- or certitude -- that the results were true. This warning was based primarily on computer-based modeling techniques. It also said that claims

that this warming was caused by human activity had a 66 to 90 percent likelihood of being true. However, in 2007, the panel's new reports from three working groups -- based primarily on field research -- were more emphatic. The IPCC judged it "very likely" -- a more than 90 percent chance of being true -- that the warming was largely due to the rise of greenhouse gases. The International Climate Change Task Force, an alliance of three think-tanks in the U.S., Australia, and Britain, argued in a February, 2005 report that even a two-degree rise could take the planet past a point of "no return." Scientists are debating whether we've reached that "tipping point," as no one is absolutely sure. However, climate records show that just a few degrees increase in temperature will make the Earth hotter than anytime since our species -- *Homo sapiens* -- evolved 4 million years ago.

What's going wrong with our atmosphere?

The *natural* composition of the atmosphere before mankind started to muck about was 78.084 percent nitrogen (by volume), 20.947 percent oxygen, 0.934 percent argon, and 0.035 percent carbon dioxide, with trace amounts of other gases.²⁰ However, certain key gasses are increasing:

- **Carbon dioxide** has increased nearly 30 percent, caused by burning solid waste, fossil fuels (oil, natural gas, and coal), and wood and wood products;
- **Methane** has increased 100 percent, caused during the production and transport of coal, natural gas, and oil, as well as by the decomposition of organic wastes in municipal solid waste landfills and the manure of livestock;
- **Nitrous oxide** has risen by about 15 percent, caused by agriculture and industry, as well as by burning solid waste and fossil fuels; and
- Other powerful **man-made gases** -- not naturally occurring in the atmosphere -- are increasing, including hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluorides (SF₆) because of a variety of industrial processes.²¹
- Water vapor, the dominant greenhouse gas, has remained constant.

Kicking it up a notch

Each greenhouse gas differs in its ability to trap heat in our atmosphere. HFCs and PFCs are the most heat-absorbent, methane traps over 21 times more heat per molecule than CO₂, and nitrous oxide absorbs 270 times more heat per molecule than CO₂.²² Then why is CO₂ the bad boy of the atmospheric gasses? Because that is the dominant gas produced by burning fossil fuels.

The reason the average global surface temperature rose 1° F within the last 100 years was the dawn of Crutzen's *Anthropocene Age*, when we increased our use of coal and later natural gas and oil. The additional heat-trapping gasses, in turn, increased the heat-trapping capability of the Earth's atmosphere. If the increases in CO₂ and other "greenhouse" emissions continue, the projected changes of 1 to 4.5°F (0.6 to 2.5°C) by 2050 and 2.2 to 10°F (1.4 to 5.8°C) by 2100^{23, 24} would be unprecedented in comparison with the best available records from the last several thousand years. (Different assumptions result in different rates of increase.) Remember, however, these are global averages. Variations will occur region by region, and some areas could even get colder.

II. Who is to Blame for Global Warming?

Guess who is the biggest polluter?

Human activities, such as burning fossil fuels, globally release 7 billion tons of carbon emissions a year.²⁵ While Americans make up about 4.5 percent of the world's population, we produce about 25 percent of the CO₂ generated by burning fossil fuels -- by far the largest share of any country,²⁶ a 20 percent increase in the past 20 years. Total U.S. greenhouse gas emissions amount to about 6.6 tons per person,^{27, 28} although some estimates go as high as 20 tons.²⁹

In the U.S., fossil fuels burned to heat and power homes and businesses, and to run cars and trucks, are responsible for about:

- 98% of CO₂ emissions,
- 24% of methane emissions, and
- 18% of nitrous oxide (NO_x) emissions.

Increased agriculture, deforestation (especially slash and burn clearing), landfills with decomposing vegetation, industrial production, and mining also contribute to emissions. And by 2100, in the absence of emissions control policies, U.S. CO₂ concentrations are projected to be 30-150 percent higher than today's levels (variations reflect best-case/worst-case scenarios).³⁰

An environmental study released in January, 2006 by Yale and Columbia Universities flunked U.S. efforts to reduce emissions, ranking it 28th in effectiveness over all, behind most of Western Europe, Japan, Taiwan, Malaysia, Costa Rica and Chile. U.S. efforts are ahead of Russia and South Korea.³¹ The study looked at a set of critical environmental goals ranging from clean drinking water and low ozone levels to sustainable fisheries and low greenhouse gas emissions. The study also showed that annual CO₂ emissions, measured as metric tons per \$1 million of gross domestic product, average about 363 tons worldwide. CO₂ emissions from nations with rapid economic expansion, like China and India, are more than double the world average at 731 tons and 621 tons, respectively. The United States, at 171 tons per \$1 million of gross domestic product, ranks below some other nations in the Group of 8, the major industrial powers – France, 56 tons; Japan, 57 tons; Germany, 80 tons; and Britain, 118 tons - but close to Canada, 168 tons; ahead of Australia, 209 tons; and far ahead of Russia, 914 tons.



Power plants power global warming

U.S. power plants produce more than 2.5 billion tons of CO₂ every year, more than 35 percent of

our total CO₂ emissions.³² About 70 percent of that tonnage is from obsolete coal-fired plants. As many as 600 existing power plants are between 30 to 50 years old and are up to 10 times dirtier than new power plants built today.³³ Of the total gas emissions of the U.S. power industry, coal-fired power plants contribute:

- 96% of sulfur dioxide (SO₂) emissions,
- 93% of nitrogen oxide (NO_x) emissions,
- 88% of CO₂ emissions, and
- 99% of mercury emissions.³⁴

That's pretty dirty. Unfortunately, while these older plants don't burn as cleanly as a new plant, most of the 114 planned to be built in the U.S. will be using the traditional pulverized coal, and not the state-of-the-art technology to minimize pollutant emissions called I.G.C.C. (for integrated gasification combined cycle). I.G.C.C. minimizes pollutant emissions by converting coal into a gas before it is burned, but the process can add about 20 percent to the cost of a plant.

When Congress wrote the Clean Air Act of 1970 (amended in 1977), it exempted existing coal plants, assuming that modern, cleaner and more efficient facilities would replace these plants. That didn't happen. The industry has been slow to invest, and has continued to coddle the old plants to keep them running. President Clinton signed an executive order requiring the more stringent standards to be applied to any plant upgrades, but President Bush rescinded that order. Today, neither these old plants nor most factories are regulated by federal clean air requirements. As oil prices rise, some energy experts fear that the U.S., with far more coal reserves than those of natural gas or oil, will begin shifting from them to the dirtier coal. Our coal reserves could last at least two centuries at current rates of use.³⁵ Environmentalists also cringe at this prospect because mining coal is not only far more destructive to the environment than extracting gas oil or gas, the air pollution emitted by burning coal causes more premature deaths than drunk driving and homicides combined.³⁶

Our love affair with gas-guzzlers

Our love of cars has made driving the second largest source of CO₂, nearly 1.5 billion tons or

21 percent annually.³⁷ The U.S. automobile gas efficiency average in 2005 was about 20 miles per gallon, down about 5 percent from the mid-1980s average. At that mileage rate, a vehicle driven 100,000 miles will produce 43 metric tons of carbon during its lifetime.³⁸ One reason for the per-mile drop is the popularity of sport utility vehicles (SUVs), especially the four-wheel-drive variety that average as low as 10 to 12 miles per gallon.

In 1975, Congress established corporate average fuel economy (CAFE) fleet standards for vehicle manufacturers of 27.5 miles per gallon for cars and 20.7 miles per gallon for light trucks. Trucks over 8,500 pounds, such as four-wheel drives and heavy trucks, were exempted. American car manufacturers make more money selling large beasts loaded with expensive options than they do selling smaller, fuel-efficient cars, so they quickly took advantage of the loophole and redesigned their trucks into jumbo SUVs. The government's new standards published in March, 2006, for "light trucks" -- pickup trucks, SUVs, and minivans up to 10,000 pounds -- require an 8.1 percent increase in miles per gallon over the four model years from 2008 through 2011.

In 2006, the U.S. Department of Transportation ruled that by 2011 the largest light trucks and sport-utility vehicles must average 24 miles per gallon and the others in this class 28.4 miles per gallon. However, the United States Public Interest Research Group says that a 40-miles-per-gallon standard was feasible for all passenger vehicles. In 2004, SUVs accounted for 40 percent of all U.S. car sales. Vehicles now average about 4,100 pounds in weight, up from about 3,200 in the early 1980's, as buyers switched to larger cars, SUVs, and minivans, and as automakers added safety equipment.

U.S. car manufacturers oppose higher mileage rates, claiming they will unfairly benefit overseas competitors, whose total sales include a lower percentage of the gas-guzzling dinosaurs. However, when hurricanes threatened gas and oil production in the Gulf of Mexico in 2005, price jumps in gasoline to more than \$3.00 per gallon had a sobering effect on consumers. Sales of SUVs slumped, while sales of mid-sized cars -- especially foreign imports -- increased.

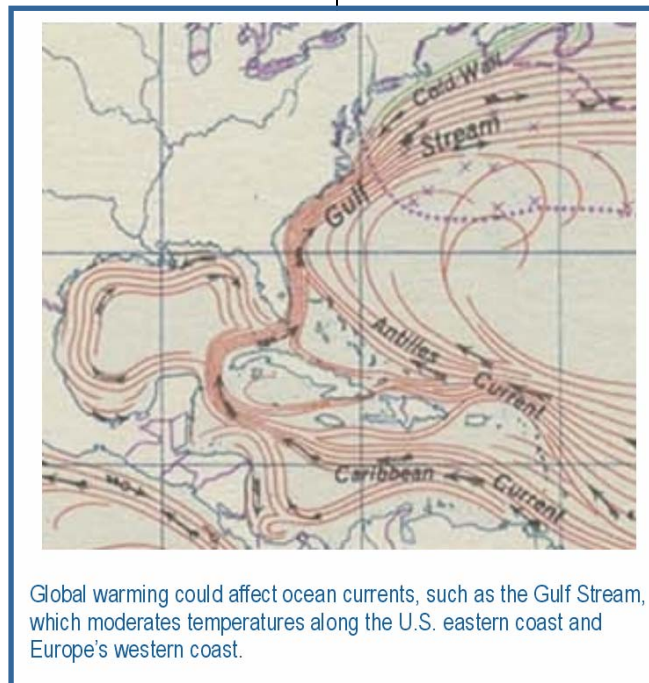
Higher oil prices may force us back to smaller cars, which could help reduce CO₂ emissions. But don't underestimate the Americans' love of big cars.

III. What Impact Will Global Warming Have?

Impact on the land

On land, if the Earth's atmosphere continues to become warmer due to increased CO₂ and other gas emissions:

- Coastlines throughout the world will be flooded as glaciers, pack ice, and permanent mountain snow melt;
- With less snow and ice covering the ground, the exposed land will absorb more radiation, thus increasing further the rate of atmospheric warming;
- Rain patterns and distribution, as well as other local and regional climate conditions, could be altered, although scientists say predicting exact local climate changes are difficult;
- Agriculture would be affected, as rain and temperature changes reduce crop yields in some areas and alter water supplies;
- Famines could break out with the decline of local food supplies;
- Increased diseases among both humans and animals could be triggered by changes in pest and plant populations, from increased poison ivy to mosquito-borne malaria;
- Efforts to develop energy fields in the melting North Arctic waters could result in polluting the land, remaining ice, and seas;
- Animal habitats and fragile ecosystems could be damaged or destroyed, from the



Global warming could affect ocean currents, such as the Gulf Stream, which moderates temperatures along the U.S. eastern coast and Europe's western coast.

cold-weather ice flows of the polar bear to coral reefs to the tropical forests of frogs, salamanders and their kin³⁹;

- Many plant and animal species could be threatened or become extinct;⁴⁰ and
- Desertification could overtake existing farmlands, rangelands, and forests.⁴¹

Impact on the oceans

In the oceans, changes will be no less dramatic:

- Oceans, vast reservoirs of energy, will become warmer -- but not as quickly as the atmosphere and land;
- Warmer oceans could increase the release of CO₂ and methane, which are stored naturally in the ocean waters, increasing

further the rate of global warming;

- Rising sea levels would threaten low-lying coastal areas, endangering lives, property, and commerce;
- Warmer ocean temperatures could alter current flows, dramatically changing marine habitats, endangering certain marine species, and causing others to become extinct;
- Coral reefs and coastal wetlands

could be damaged or destroyed, depriving already stressed fish and other marine species of habitat and nurseries they need to survive

- Storms, especially hurricanes and cyclones, could increase in both number and severity.

Impact on native populations

Ice in the Arctic Circle is melting rapidly. In 2005, the 25-square-mile, 100-foot-thick, 3,000-year-old Ayles Ice Shelf broke clear from the coast of Ellesmere Island, about 500 miles south of the North Pole in the Canadian Arctic. Ninety

percent of the 3,900 square miles of ice shelves that existed in 1906 when the Arctic explorer Robert Peary first surveyed the region are already gone.⁴²

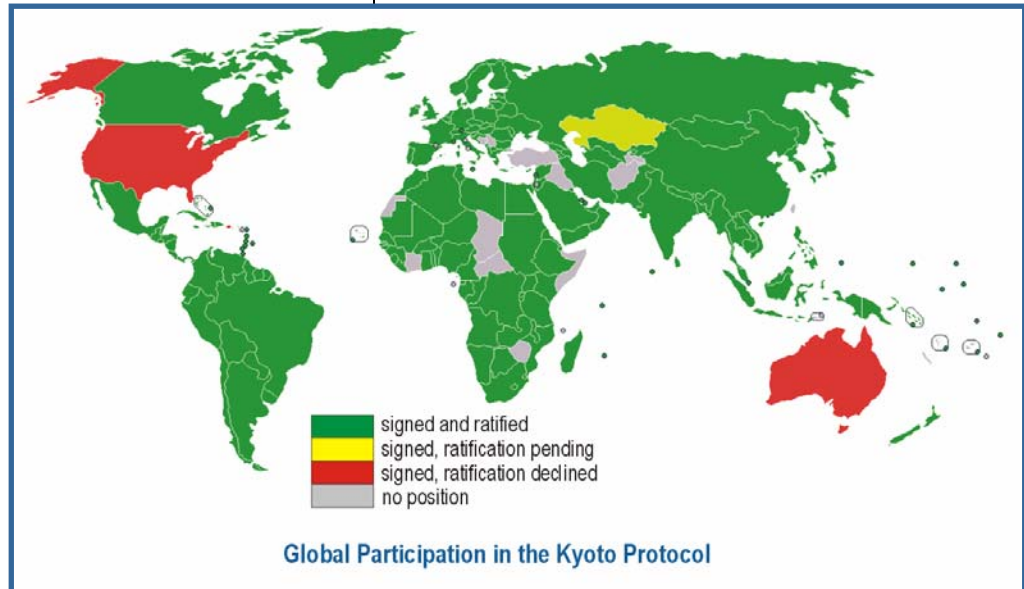
A push to develop the Arctic is being quickened by this rapid melting, carrying its own rewards and dangers for people in the region. The discovery of vast petroleum fields in the Barents and Kara Seas has raised fears of catastrophic accidents as ships loaded with oil and, soon, liquefied gas churn through the fisheries off Scandinavia to markets in Europe and North America. Once untouched land could become polluted by the growing energy, fishing, and shipping industries.

For the four million people who live north of the Arctic Circle, in remote outposts and even in some industrial centers in Russia, a warming climate presents new opportunities but also threatens their environment, their homes and, for those whose traditions rely on the ice-bound wilderness, the preservation of their culture. The warming climate also has distressed polar bears, seals, reindeer, and fish, which in turn affect natives who live off the bounty of both land and the sea. With a declining population of 20,000 to 25,000 polar bears worldwide, the U.S. is planning to put the bears on its endangered species list.

More modern communities, such as Vorkuta, a coal-mining city of 130,000 people in Russia, are crumbling. Many of the Vorkuta's homes and factories were built not on hard rock, but on permafrost, a layer of perpetually frozen earth that covers 65 percent of Russia's territory. As the permafrost underneath melts, the ground turns to mush, undermining roads and buildings.⁴³

Game of the century?

The melting ice and snows over the Arctic Ocean have set off a land rush among six nations with Arctic territories -- the United States, Canada, Greenland, Finland, Norway, and Russia -- to be first on the spot. Everyone wants to cash in: oil and natural gas companies, fishing companies, maritime shippers, and the myriad support companies such industries spawn. Even cruise ships and the tourism industry are getting into the act.⁴⁴



International law recognizes a nation's sovereignty over the submerged land of its continental slope. These six countries are maneuvering to determine how the boundaries between adjacent nations will be drawn over the bottom of the sea, in order for each to claim as much of the newly accessible ocean bottom as it can. To reinforce its claims, the Russians have been the first to send a ship to the North Pole, until recently inaccessible by water. If the ice continues to melt, the fabled Northwest Passage may yet become a reality for summertime maritime shipping as early as 2040.⁴⁵

Potentially, billions of dollars are at stake. In 2004, scientists found hints of oil in seabed samples about 200 miles from the North Pole, and the United States Geological Survey estimates that one quarter of the world's undiscovered oil and gas deposits may be in the Arctic. Control of these suspected oil and gas deposits becomes critical as developing nations,

such as China and India, bid against traditional industrial nations, such the United States and the European countries, for the limited and increasingly expensive energy supplies throughout the world.⁴⁶ None of this bodes well for the Arctic environment or its inhabitants.

IV. What is Being Done to Stop Global Warming?

Kyoto Treaty grapples with global warming

International political leaders, pushed by scientific findings and increased public concern, responded with the first international agreement on global warming, the UN Framework Convention on Climate Change ([UNFCCC](#)), which was adopted in 1992. Unfortunately, its voluntary goals were soon missed. An addendum to the treaty was adopted in Kyoto, Japan, in 1997 and took effect in February 2005. That pact, the Kyoto Protocol, requires most industrialized countries to reduce their greenhouse gas emissions below 1990 levels by 2012. The United States and Australia, which accepted the 1992 treaty but not the Kyoto accord, will continue to promote voluntary programs to slow growth in emissions.

The Kyoto Treaty requires industrialized countries to reduce by 5.2 percent below their 1990 levels their combined emissions of six major greenhouse gases, principally CO₂, during the five-year period from 2008 to 2012. Regrettably, Australia declined to sign on and Congress refused to ratify it, despite support from President Bill Clinton. Then, in March 2001, U.S. President George W. Bush announced that the United States would never sign it, claiming "the Kyoto treaty would severely damage the United States economy."⁴⁷ The White House has set up its own study group which, in lieu of setting emission limits, has expressed industry's "concern" over the problem and has called for voluntary efforts.

Meanwhile, the United Nations issued a report in October, 2006, claiming emissions grew from 2000 to 2004 even in the European Union, which has led the diplomatic campaign for reductions.

The nay sayers say 'nay'

Notwithstanding the concern of other countries and a steady flow of scientific reports, many critics of the "greenhouse" theory argue that scientists haven't "proven" their case, so we shouldn't worry yet about global warming. They understand how science works, but hope most people don't. So they try to cast doubt among the general public by distorting how the scientific method -- the basis of science today - actually works. The rising CO₂ levels and global warming are being challenged by conservative politicians, the oil industry, the thermoelectric power industry, the automotive industry, and every other polluting industry. One U.S. senator called global warming a "hoax," quoting a science fiction writer as his expert. Another misrepresented requests for higher gas mileage for SUVs and other vehicles as imposing "gas quotas on soccer moms."

Governmental inaction

Meanwhile, the U.S. officially ignores global warming:

- President Bush dismissed as just a "report put out by the bureaucracy" a 268-page U.S. Environmental Protection Agency (EPA) report to the UN, which predicted in 2002 that man-made greenhouse gases created by the U.S. will increase 43 percent between 2000 and 2020;
- Bush persistently resists efforts by other world leaders, including those of the G-8 Summit and the United Nations, to even discuss the problem;
- News reports have revealed that the EPA was pressured to tone down its references to global warming;⁴⁸
- A White House aide heavily edited a 2002 report by the U.S. Climate Change Science Program, which coordinates research among 13 governmental agencies, to eliminate references to global warming. The aide then went to work for ExxonMobil;
- The federal National Climate Assessment report detailing the effects of global warming has been suppressed;⁴⁹
- A climate scientist, James E. Hansen, director of National Aeronautics and Space Administration's (NASA) Goddard Institute for Space Studies in Manhattan, and several other employees, charged Bush

Administration appointees at NASA had pressured them to downplay the effects of global warming;⁵⁰

- The NASA's political appointees in 2006 removed from its mission statement any reference to protecting the U.S. environment, presumably to undercut global warming studies.

The 'fuzzies' obscure the issues

The energy, power, and automotive industries have organized and funded a number of organizations with pseudo-scientific, "warm and fuzzy" environmental, and civic-sounding names that try to cast doubt on the scientific evidence that has been building up for decades. One environmental-sounding organization, the Greening Earth Society, is funded by the U.S. Western Fuels Association (guess what they sell). The group claims that CO₂ levels of even 750 ppm are nothing to worry about because plants like lots of CO₂. Other critics of the global warming theory hope to discredit studies by focusing on discrepancies of the various predictive computer models – which actually result from different "best case-worst case" assumptions.

For example, in September, 2006, the Royal Society, a 1,400-member scientific association, strongly criticized ExxonMobil for spreading "inaccurate and misleading" information about climate change and for financing groups that misinform the public on the issue. There is a "false sense somehow that there is a two-sided debate going on in the scientific community" about the origins of climate change, said Bob Ward, a spokesman for the Royal Society. The reality is that "thousands and thousands" of scientists around the world agree that climate change is linked to greenhouse gases, he said, with "one or two professional contrarians" who disagree.⁵¹

What's in the name "climate change?"

While the terms "global warming" and the "greenhouse effect" have been used interchangeably, many polluters prefer the more euphemistic "climate change," which suggests somewhat more benign, localized, and temporary weather variations, rather than major and perhaps irreversible global warming. Unfortunately, the U.S. EPA, buckling to political

pressure, uses the term. Euphemisms are nothing new. Efforts to permit lumber companies to cut trees on federal lands and, incidentally, subsidized by U.S. taxpayers, were called the "Healthy Forests Initiative," while a so-called air pollution bill that really loosens emissions controls was called the "Clear Skies Act." And businesses often warn of dire consequences to "the economy" or "business efficiency" whenever they want to avoid environmental regulations.

Semantics aside, "global warming" will *cause* both global and localized atmospheric warming. The *results* could be extensive coastal flooding; increased and more violent storms; major changes in local weather patterns, such as heavy rains (that will be good for some and bad for others) or droughts; disease and famine; and major dislocations in agricultural "bread baskets," such as the U.S. Midwest. The results of these dramatic and long-lasting changes could be starvation, disease, poverty, loss of human life, the destruction of property, disruptions in food supplies, desertification, and shifts in available water supplies.

Ocean critters to the rescue?

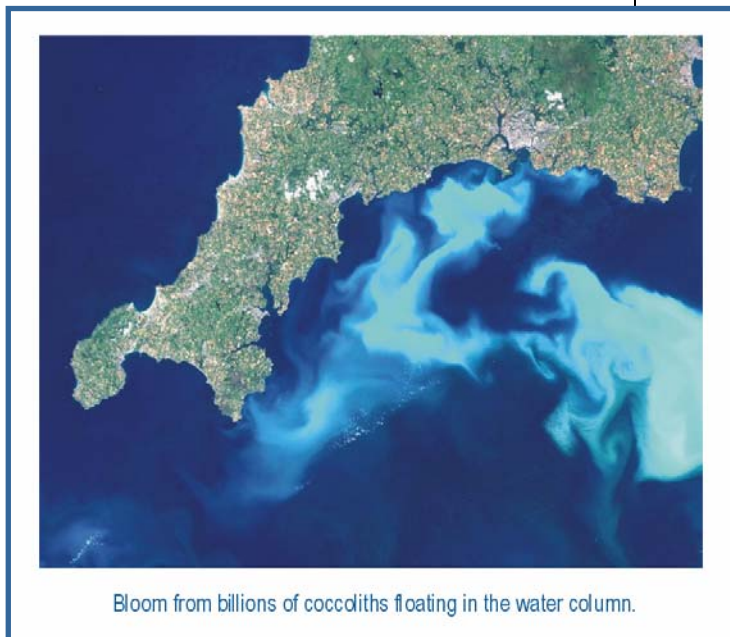
As we noted above, human-generated CO₂ from burning fossil fuels amounts to more than 7 billion tons a year. As the years pass, however, only about half that amount has been found in the Earth's atmosphere. Where does it go? Some suspect algae are absorbing it. No, we're not kidding. Scientists have shown that a microorganism, coccolithopores, one-celled marine plants that live in large numbers throughout the upper layers of the ocean, surround themselves with a microscopic plating made of limestone (calcite). These platelets, known as coccoliths, require CO₂ as coccolithopores build and shed their chalky discs. Scientists estimate that the organisms dump more than 1.5 million tons (1.4 billion kilograms) of calcite a year, making them the leading calcite producers in the ocean.

The tiny creatures also have another beneficial effect; they produce dimethyl sulfide (DMS), a natural product of recycling sulfur. DMS has been found to cause water vapor to condense and create clouds. Scientists believe the coccolithopores absorb sulfur from the ocean

waters and release DMS into the atmosphere. As the DMS helps create clouds, the sun is blocked from the area the coccolithopores occupy, preventing them from undergoing photosynthesis. As the coccolithopores die off for lack of sunshine, their numbers decrease and they release less DMS, which in turn creates fewer clouds. Then the cycle begins again. Thus, some believe, the coccolithopores act as a natural thermostat to help regulate the Earth's temperature.⁵²

energy absorbed by the ocean and stored as heat.⁵³ Thus, the creatures' possible regulatory mechanisms are being closely studied by scientists.

Nature may have a variety of such regulators, but we doubt Nature will continue to solve our environmental crises. We can't wantonly belch out into our atmosphere all the CO₂ and other gasses we want in the mistaken belief that the phytoplankton will save us.



Bloom from billions of coccoliths floating in the water column.

V. What Can You Do to Help Stop Global Warming?

Concerned citizens often have a great impact in reducing or eliminating local pollution, but global warming is the result of the sum of all pollution. Only the concerted actions of nations working together can control global warming, such as through the Kyoto Treaty. When politicians cease worrying about corporate profits and their own political futures – and such individuals are rare birds, indeed – will we be able to control global warming.

Meanwhile, keep up the pressure on the President and Congress to:

- Ratify the Kyoto Treaty and join the rest of the world;
- Enforce the Clean Air Act to require lower emissions from fossil-fuel power plants;
- Require upgrades of older power plants to meet the requirements of the Clean Air Act;
- Encourage cleaner and renewable energy sources;
- Require higher vehicle average gas mileage, including trucks and SUVs; and
- Emphasize conservation instead of oil and gas exploitation.

They also could have an impact on global warming. Coccolithophores make their coccoliths out of one part carbon, one part calcium, and three parts oxygen (Ca CO₃). So each time a molecule of coccolith is made, one less carbon atom is allowed to roam freely in the world to form greenhouse gases and contribute to global warming. Three hundred twenty pounds of carbon go into every ton of coccoliths produced. All of this material sinks harmlessly to the bottom of the ocean to form sediment. Alas, the chemical reaction that makes the coccolith also generates a carbon dioxide molecule, a potent greenhouse gas, from the oxygen and carbon already in the ocean. One other thing: Coccolithophore blooms reflect nearly all the visible light that hits them, which means that sunlight that could be absorbed by the water actually is reflected back into the atmosphere. The more light is being reflected, the less

Also write to your state governor, elected state officials, and the head of your state's department of environmental protection (the actual name varies from state to state) about tightening your state's emissions standards and promoting conservation. While many state and local officials (especially those in coastal states) have begun to address global warming, few place the needed emphasis on conservation at

the state, local, and individual level. Also check out how your neighborhood is affected by local power plants.

You can affect the emissions of about 4,800 pounds of carbon equivalent (nearly 32 percent of the total emissions per person) by conserving

Electricity by:

- Turning off lights when not in use
- Using fluorescent rather than incandescent light bulbs (if every American replaced one incandescent bulb we'd eliminate 90 billion pounds of CO₂ -- the equivalent of eliminating 7.5 million cars)
- Using energy efficient appliances
- Insulating your home, and
- Not wasting hot water

Garbage wastes by:

- Composting organic waste
- Recycling aluminum, glass, plastic, and paper
- Purchasing products or food without excessive packaging

Gasoline by:

- Buying high-mileage cars
- Not driving unnecessarily—combine trips, carpool, take public transportation
- Driving no faster than 55 mph (The speed limit was reduced in the 70s because 55 mph was the most fuel-efficient speed)
- Keeping your car tuned
- Keeping tires at the recommended air pressure (5 pounds under pressure costs a 2 percent drop in fuel efficiency).

A synopsis of this tutorial

In this tutorial, we talked about how CO₂, methane, and nitrous oxide are contributing to a warmer global climate because they are absorbing more of the sun's long-wavelength radiation. We also discussed the corporate and political opposition to cutting greenhouse gasses. As to the so-called "debate" about global warming, scientists will tell you uncertainties are intrinsic to almost any science, and are part of any decision-making process. But uncertainties should not be used as an excuse for inaction. Self-serving industry critics who use uncertainties to justify delays in reducing emissions should remember that uncertainty cuts both ways -- things could be far worse than forecast.

Are You Ready to be a Crusader for the Coast?

Take Our Quiz and find out!

This quiz is designed to review and reinforce what you've read. Answers are found on the following page. Circle the letter of the correct answer.

1. What causes global warming?
 - A. Melting glaciers and ice caps
 - B. Increased amounts of heat absorbing gases in the atmosphere
 - C. Changes in ocean currents
 - D. All of the above
2. What has been the average increase in atmospheric temperature in the past 100 years?
 - A. 0.5° F
 - B. 1.0° F
 - C. 1.75° F
 - D. All of the above
3. If global warming continues, what will the temperature increase be at the end of the 21st Century?
 - A. 1.0° F
 - B. 2.2° F
 - C. 4.5° F
 - D. 10° F
 - E. All of the above
4. How high are the ocean levels rising today?
 - A. 0.5 foot per 100 years
 - B. 1 foot per 100 years
 - C. 1.3 feet per 100 years
 - D. All of the above
5. If global warming continues, how high will ocean levels rise by the end of the 21st century?
 - A. 1 foot or more
 - B. 2 feet or more
 - C. 24 feet or more
 - D. 60 feet or more
 - E. 80 feet or more
 - F. All of the above
6. How many people will be affected by rising sea levels?
 - A. 50 million people
 - B. 71 million people
 - C. 92 million people
 - D. 118 million people
 - E. All of the above

7. Which of these land conditions will result from global warming?

- A. Coastlines will be flooded as glaciers, ice, and snow melt
- B. Newly exposed land will absorb more radiation, increasing atmospheric warming
- C. Local climates would be altered
- D. Rain patterns would be altered
- E. Agriculture would be affected by changing rain patterns
- F. Famines could break out with the decline of local food supplies
- G. Diseases among both humans and animals could be triggered by changes in pest populations
- H. Developing oil and gas fields in the melting North Arctic waters could increase ocean pollution
- I. Animal habitats and fragile ecosystems could be damaged or destroyed
- J. Many species could be threatened or become extinct
- K. Desertification could overtake existing farmlands, rangelands, and forests
- L. All of the above

8. Which of these ocean conditions will result from global warming?

- A. Oceans will become warmer -- but not as quickly as the atmosphere and land
- B. Rising sea levels would threaten low-lying coastal areas, endangering lives, property, and commerce
- C. Warmer oceans could increase the release of CO₂ and methane, which are stored naturally in the ocean waters, increasing further the rate of global warming
- D. Ocean currents could be altered, changing marine habitats, endangering some marine species, and causing others to become extinct
- E. Coral reefs could be damaged or destroyed
- F. Storms, especially hurricanes and cyclones, could increase in both number and severity
- G. All of the above

9. What can individual citizens do to help stop global warming?

- A. Press the President and Congress to enforce the Clean Air Act to require lower emissions from fossil-fuel power plants
- B. Write to your state governor about tightening your state's emissions standards
- C. Demand that energy plans emphasize conservation over new exploration for oil and gas
- D. Wash your clothes in cold water
- E. Recycle
- F. Don't occupy a bigger house than you need
- G. All of the above

10. Name the international treaty designed to reduce greenhouse gasses.

- A. North Atlantic Treaty Organization (NATO)
- B. European Union (EU)
- C. Kyoto Treaty
- D. Clean Air Act
- E. All of the above

Global Warming Quiz - Answers

1 - B. *Increased amounts of heat absorbing gases* -- CO₂, methane, and nitrous oxide – prevent heat from radiating out into space, which increases atmospheric temperature. Melting glaciers and ice caps and perhaps changing ocean currents are the *results* of global warming, not the *causes*.

2 - B. *The average temperature rose 1° F in the last 100 years* from 59° F to 60° F.

3 - E. *All of the above*. Depending upon the different best-case, worst-case variables included in computer models, temperatures could rise 1 to 4.5° F (0.6 to 2.5° C) by 2050, and 2.2 to 10° F (1.4 to 5.8° C) by about 2100.

4 - B. *Ocean levels are rising about 1 foot every 100 years*. Land upheavals and subsidence affect local averages.

5 – B. *At present, the conservative outside estimate is 2 feet or more*. However, the unexpectedly rapid melting of ice in Greenland and Antarctica could produce much higher levels in shorter time spans, some fear up to 80 feet in 40 years!

6- E. *All of the above*. A sea rise of about 20 inches (50 centimeters) would put 92 million people at risk, and a sea rise of 3.28 feet (1 meter) would put 118 million people at risk. We don't even want to think about the effects of an 80-foot sea rise.

7 – L. *All of the above*

8 - G. *All of the above*

9- G. *All of the above*

10 – C. *The Kyoto Treaty*, which went into effect in February, 2005, commits industrialized nations to reducing emissions of greenhouse gases, principally CO₂, by around 5.2 percent below their 1990 levels. The U.S. won't sign the agreement.

TO LEARN MORE . . .

Publications

- *Time Magazine*, "Special Report: Global Warming," April 3, 2006.
- "Next Victim of Warming: The Beaches," *New York Times*, 6/20,2006, <http://www.nytimes.com/2006/06/20/science/earth/20sea.html?8dpc> .
- *New Yorker*, "The Climate of Man I-III," a three-part series by Elizabeth Kolbert, April 25, May 2, May 9, 2005

Reports

- Everyone should read the [Pew Ocean Commission's](#) nine-page [Executive Summary](#) and its complete 166-page report, [America's Living Oceans](#), on the deplorable state of our less-than-healthy oceans.
- The "[Stern Review on the Economics of Climate Change](#)," prepared for the British government, examines the economic impact global warming will have the world's economy.
- The UN has a [report](#) claiming worldwide emissions grew from 2000 to 2004 even in
- The complete reports of the [Intergovernmental Panel on Climate Change \(IPCC\)](#) are available at the IPCC website.
- American Littoral Society's, "New Jersey's Vulnerability to Sea Level Rise", with Rutgers University, download from www.littoralsociety.org.

Websites

- The [U.S. Environmental Protection Agency \(EPA\)](#) has [special web pages](#) on global warming.
- The [Union of Concerned Scientists](#) has [special web pages](#) on global warming.
- The [World Wildlife Fund](#) has [special web pages](#) on global warming.
- [Clear the Air](#) is a clearinghouse website on air quality issues, including global warming.
- [U.S. Global Change Research Program](#) coordinates U.S. research on the interactions of natural and human-induced changes in the global environment and their implications for society.
- The [National Resources Defense Council](#) has a [website](#) dedicated to global warming.
- The [Realclimate website](#), run by scientists, has interesting technical information, although some might find it a bit esoteric.

Documentaries

"An Inconvenient Truth," Paramount Classics and Participant Productions, 2006. Running time: 96 minutes. Directed by Davis Guggenheim; produced by Laurie David, Lawrence Bender, and Scott Z. Burns. Narrated by Al Gore. Available on DVD.

Also, rate your environmental *bona fides* at these sites:

- The [Union of Concerned Scientists](#) has a [website](#) that rates your carbon footprint.
- The [U.S. Environmental Protection Agency](#) has a [website](#) that also rates how environmentally savvy you are.
- The [Sierra Club](#) has a [website](#) that lets you rate how a more fuel-efficient car could save you money and help the environment.

IMAGE CREDITS

Page 1, Carbon Dioxide Model, American Littoral Society, 2007.

Page 2, Glacier Mass Balance. *This figure was prepared by [Robert A. Rohde](#) from published data and is part of the [Global Warming Art](#) project. Permission is granted to copy, distribute and/or modify this document under the terms of the [GNU Free Documentation License](#), Version 1.2 or any later version published by the Free Software Foundation; with no Invariant Sections, no Front-Cover Texts, and no Back-Cover Texts. See [www.wikimedia.com](#).*

Page 3, Greenhouse Effect Simplified, American Littoral Society.

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Page 11, Coccolith Bloom. *This file is in the [public domain](#) because it was created by [NASA](#). NASA copyright policy states that "NASA material is not protected by copyright **unless noted**". See [www.wikimedia.com](#).*

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