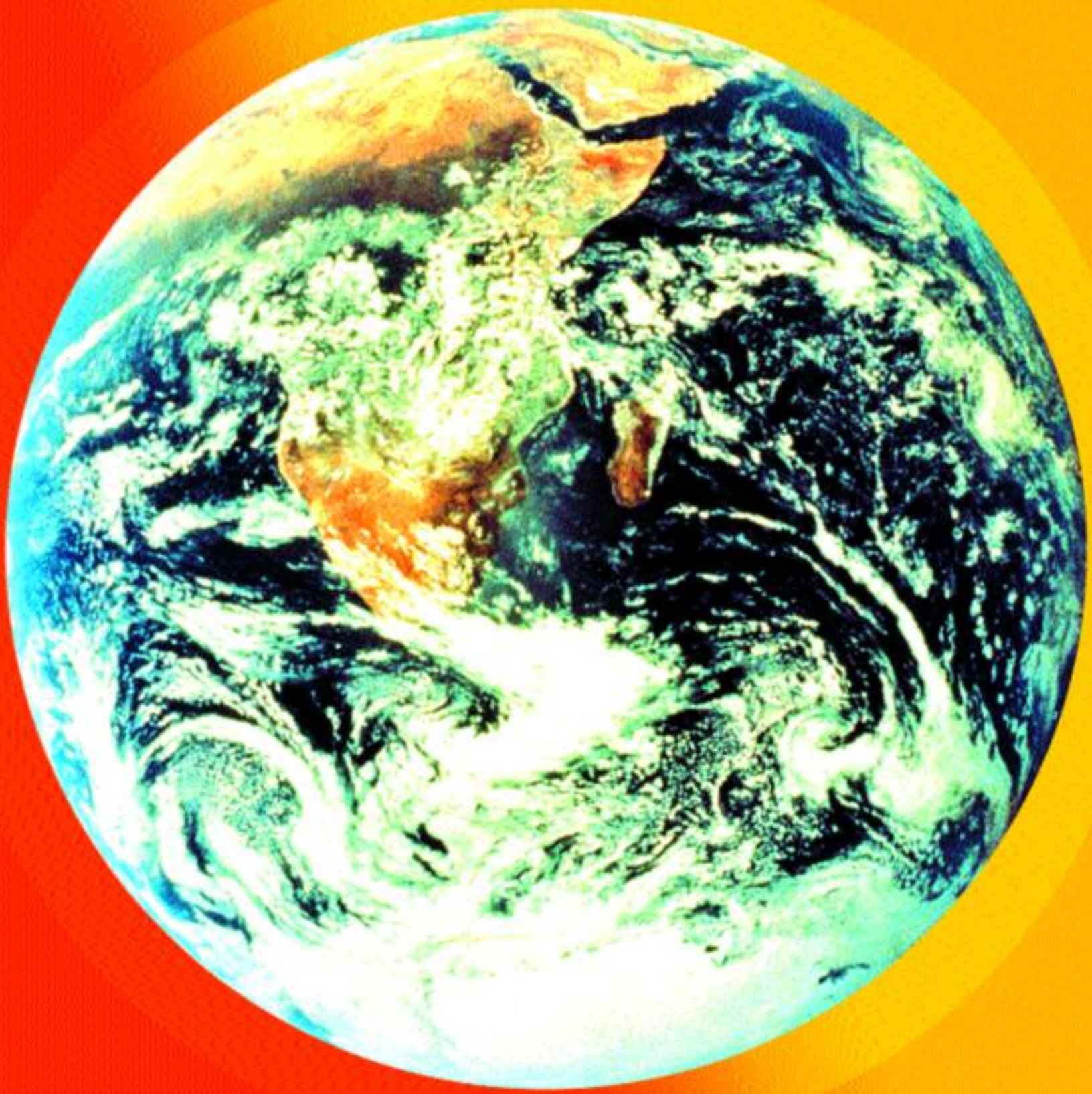


Climate Change

A HOT TOPICS NEWSPAPER SUPPLEMENT FROM:

THE FACTS ABOUT CLIMATE CHANGE

It's in your hands

Almost every science organization studying the Earth agrees. The planet is heating up. Its atmosphere is warming. The scientists don't all agree about exactly how much it is warming or about how much time there is to stop the damage. But, there is time. People can still turn things around and make a difference.

This newspaper section will look at climate change. What will happen to plants and animals, to cities, to beaches like the one above? What will happen to you?

How can governments and businesses help? How can you help? You will learn that the kind of world you live in depends very much on the actions you take.

"Every action has an equal and opposite reaction," says a law of physics. "Everything is connected to everything else," says a law of ecology. Both are true. A simple act such as driving a car, or turning on a light switch, has global repercussions that touch dolphins in the ocean, farmers in the Ukraine, penguins in Antarctica, redwood trees in California, tourists on the Florida coast, and you.

Your actions have reactions. Your actions are connected to events that may affect an entire planet. To get the most from this supplement, work in small groups to share ideas, and do the activities in sequence, starting here and working your way through to the last page.

Check out the newspaper

Learning standards: understanding the factors that affect weather, interpreting the relationship between weather and environment, identifying the effects of climate change.

- Weather is important to newspapers because it affects everybody—and everybody has an interest in it. Scan the newspaper for several days and keep a log of stories or photographs whose subject is weather. Are the stories newsworthy because of short-term conditions or long-term conditions?
- Analyze the weather stories for trends. How many are connected to climate change in some way? Be alert to connections that may not be obvious.
- How do the weather conditions reported in the stories affect ecology or the environment in the short-term? How about long-term?

The Climate Change Quiz

HOT FACT: The theory of global warming from increased carbon dioxide emissions was first proposed by Swedish chemist Svante Arrhenius—in 1896!

What do you know?

Let's test what you already know about climate change and the Earth's atmosphere. Work alone if you like, or share what you think in groups.

1. The Earth's atmosphere is composed of several gases, including oxygen, nitrogen, and carbon dioxide. What percentage of the air you breathe is carbon dioxide?

a 30% **b** 3% **c** 0.3% **d** 0.03%

2. What is the average temperature of the Earth's surface, from north to south pole, throughout the year?

a 0°F **b** 35°F **c** 60°F **d** 72°F

3. Without the greenhouse effect, what would be the annual average temperature of the Earth's surface?

a -30°F **b** 0°F **c** 10°F **d** 35°F

4. Since 1890, what has happened to the Earth's average temperature?

a Dropped one degree **b** Increased one degree
c Remained constant **d** Increased four degrees

5. The hole in the ozone layer is the chief cause of climate change.

a True **b** False

6. In the space provided, write a definition of the following terms:

Climate change: .....

.....

Greenhouse effect: .....

.....

Are they the same? *(circle one)* **Yes** **No** **Unsure**
Can you find these definitions in any dictionaries? *(circle one)* **Yes** **No**
The answers to questions 1-5 can be found on Page 15. See how well you did.
Do any of the right answers surprise you? *(circle one)* **Yes** **No**

Which ones? .....
Why? .....
.....

The definitions will be revealed in the next few pages.

What are the causes of climate change? And what are the possible effects? Working alone or in groups, fill in as many of the blanks as you can. Feel free to add others.

Causes	Effects
.....	.....
.....	.....
.....	.....
.....	.....
.....	.....
.....	.....
.....	.....
.....	.....

Save this list of causes and effects. We will come back to it.

Check out the newspaper

Learning standards: writing for creativity, understanding the effect of human interaction on the environment

- Movie stars like Leonardo DiCaprio and rock musicians like Sting have made concerns about the environment part of their work. DiCaprio even hosted a massive Earth Day event in Washington DC. Look through the newspaper for examples of either the causes or effects of global warming you listed above.
- Write a rap or music lyric that addresses the problem. Use specifics from the paper. Perform your lyric, if you dare!

Climate Change and the greenhouse effect

One is natural, the other is not

No question about it. The Earth's climate is changing. Then again, it is forever changing. For millions of years, the Earth's climate has alternated between cycles of warm and cold. When dinosaurs lived, the planet was about 25 degrees warmer than it is today. At one time, the planet was virtually ice-free; at another time, ice covered 30 percent of the Earth's surface.

These climate changes have occurred naturally, and so slowly that they could not be detected in a lifetime.

Now there is a growing concern that the climate may change rapidly because of what human beings have done to the atmosphere.

In late 1995, a team of 2,500 scientists working for the United Nations dramatically declared that the warm-up in the Earth's atmosphere is "unlikely to be entirely due to natural causes" but a "climatic response to human activities."

The year 2010 tied with 2005 as the warmest in history. And while 2007 wasn't the warmest year, the winter 2006-2007 was the warmest winter recorded since 1880 when weather record keeping began. As a result, many scientists now believe that the warming we have seen in recent years may be permanent. Then again, not everyone agrees this will happen.

To understand the debate over climate change, you need to understand the "greenhouse effect."

Let's begin with a simple fact: the greenhouse effect is not a problem. In fact, we could not live on Earth without it.

So just what is it?

Remember the last time you tried to enter a sealed-up car on a hot summer day? You opened the car door, heat poured out and the upholstery burned your skin. The temperature inside was easily 20 degrees hotter than the air outside.

What happened inside that car was the result of the greenhouse effect. Sunlight passes through glass, but heat does not. Sunlight heats the objects it strikes inside the car, those objects give off heat and warm the air inside the car, and the warmth can't get out.

The Earth's atmosphere works similarly. It admits light but blocks some of the heat.

Figure 1 shows how the greenhouse effect works. Light from the sun travels in a variety of wavelengths. Visible light—what you see shining from the sun—is only one of several types of sun rays. Others, such as infrared and ultraviolet, you can't see.

Heat travels as infrared rays, which are long-wave energy. Ultraviolet rays, which burn and tan your skin, are of short wavelength.

Short wavelength rays pass through the atmosphere and warm the Earth's surface. Objects like rocks and buildings radiate, or give off, that heat at night.

However, certain greenhouse gases trap some of the heat by absorbing it.

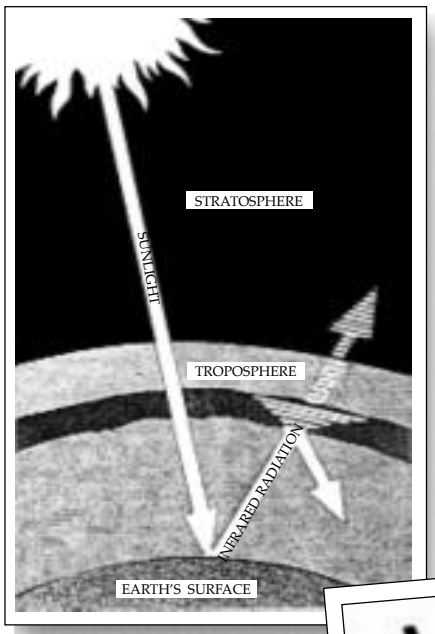


FIG. 1. The greenhouse effect. The earth's surface radiates long wavelength infrared heat; this radiation is absorbed by greenhouse gases in the air.

Figure 2 illustrates the Earth's solar energy budget. Like a budget for a business or a household, it's a balance sheet, showing what comes in, what goes out and what's left over.

On the left, notice that when 100 units of sunlight shine through the atmosphere, less than half the units—45—actually reach the Earth's surface. The rest are absorbed or reflected by the atmosphere.

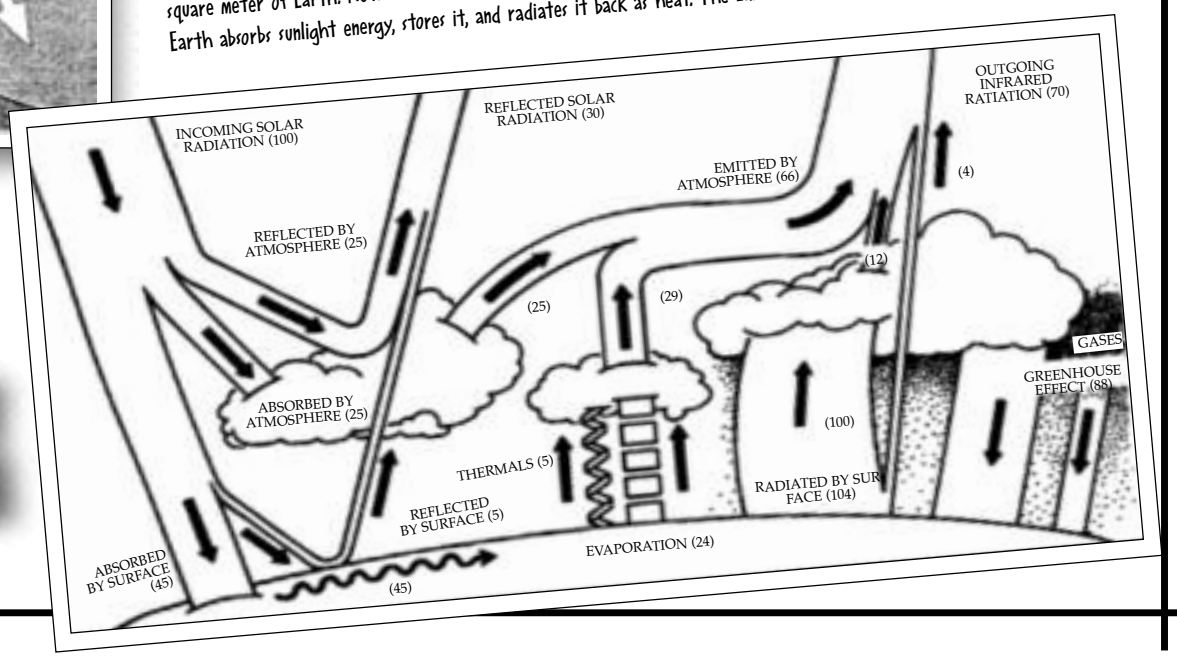
Now look at the right side of the diagram. The Earth's surface radiates 104 units back into the atmosphere. This is possible because the Earth stores solar energy as heat, as well as generating heat of its own.

Of the 104 units radiated back into the atmosphere, the greenhouse effect traps 88 of them, allowing only 16 units to pass through. These 88 units are directed back to the surface to continue warming us.

Go back to Questions 2 and 3 on the previous page. The Earth's average temperature is almost 60 degrees Fahrenheit. Without the greenhouse effect, the temperature would be close to 0.

So remember! The greenhouse effect occurs naturally and is a necessary condition for life. It is not to be confused with the term "climate change." The greenhouse effect is not an issue. Climate change is.

FIG. 2. The Earth's solar energy budget. The numbers in parentheses represent the amount of energy as a percentage of the average solar constant at the top of the atmosphere. The solar constant—the energy striking the Earth—is 340 watts per square meter of Earth. Notice that the surface radiates 104% back to the atmosphere. How is this possible? Because the Earth absorbs sunlight energy, stores it, and radiates it back as heat. The Earth can store tremendous amounts of heat.



HOT FACT: In 130 years of record keeping, all 10 of the warmest years on record have occurred since 1980.

CO2: key greenhouse gas

The air you breathe is a complex collection of molecules—nitrogen, oxygen, water vapor, carbon dioxide and ozone, not to mention neon, helium, hydrogen, methane, argon, krypton, xenon and more.

But all these molecules are not mixed in equal parts. Far from it.

More than three quarters of the molecules you inhale are nitrogen. Oxygen comprises almost 21 percent of your air. Carbon dioxide (CO_2) accounts for only 0.03 percent of the atmosphere. Yet it is critical, because it is the single most important agent for global warming. And it is slowly but surely increasing its presence in the atmosphere.

Scientists think there's about 30% more carbon dioxide in the air today than when the Industrial Revolution began in 1760. Worse, it may hit 600 ppm—double the former level—by the year 2025. How old will you be then?

Carbon dioxide is the chief greenhouse gas. CO_2 is released into the atmosphere by many natural processes, such as the respiration of animals and plants, which give off CO_2 at night when sunlight is not present. You exhale carbon dioxide. Volcanoes and forest fires release it, too.

But since 1760, unnatural, man-made processes have added dramatically to the natural level of carbon dioxide in the air. The Industrial Revolution marked the beginning of burning fossil fuels—coal, oil, natural gas—to produce heat and power. Burning fossil fuels produces large amounts of carbon dioxide.

Any motor or engine produces it as the major waste product.

The two major causes of carbon dioxide in the atmosphere are transportation—cars, planes, trains, trucks—and electric utilities.

On the previous page, you learned how the greenhouse effect works. When long-wavelength infrared heat travels up through the atmosphere, greenhouse gases such as carbon dioxide absorb the heat and warm the air.

As the Earth warms in the decades ahead, one of the biggest reasons will be increased concentrations of greenhouse gases, including carbon dioxide.

The hottest years on record: fluke or trend?

Climate change became a hot issue in the brutally warm summer of 1988, when drought parched a huge portion of the United States, especially in the Southeast.

Farmers lost their crops, and livestock perished in large numbers. Oppressive heat covered much of the country.

That summer, Dr. James Hansen of NASA's Goddard Institute for Space Studies told Congress that he was 99 % sure the planet was warming due to increases in greenhouse gases. His was the first declaration of this by a scientist of his stature.

By the time that summer ended, it would become one of the hottest on record. In more than 130 years of record keeping, the five hottest years ever all happened since 1998.

The scientists working for the United Nations group, along with the U.S. Environmental Protection Agency, examined those years closely in efforts to assess the impact of warming trends.

They found that warmth is happening just about everywhere and is largest at high latitudes in the Northern Hemisphere. Over the last 50 years, the largest annual and seasonal warming has occurred in Alaska, Siberia and the Antarctic Peninsula. Most ocean areas have warmed. Because these areas are remote and far away from major cities, it is clear to climatologists that the warming is not due to the influence of pollution from urban areas.

Check out the newspaper

Learning standards: understanding energy sources and their use, evaluate the consequences of continued reliance on fossil fuels, understanding supply and demand

- The burning of fossil fuels is a major source of carbon dioxide in the air. Carbon dioxide is the single most important reason for climate change. Look through the newspaper and make a catalogue of items in stories, photos or ads that run off fossil fuels. Be careful to include items that indirectly depend on them—electricity, for example, is often generated by burning fossil fuels.
- The price of a product often affects how many people buy or use it. Find an ad for a product that uses fossil fuel. Should the government set higher prices on it to discourage use? If so, how much of a price increase would be fair? Would such a plan work in the marketplace of the U.S.?

Climate Change Suspects

Can you find the guilty party?

On Page 3, you were asked to define the terms "climate change" and "greenhouse effect". Check back to Page 3 to see what you wrote. How close does it come to these suggested definitions?

GREENHOUSE EFFECT: The natural warming of the Earth's atmosphere due to a blanket of heat-trapping gases like carbon dioxide.

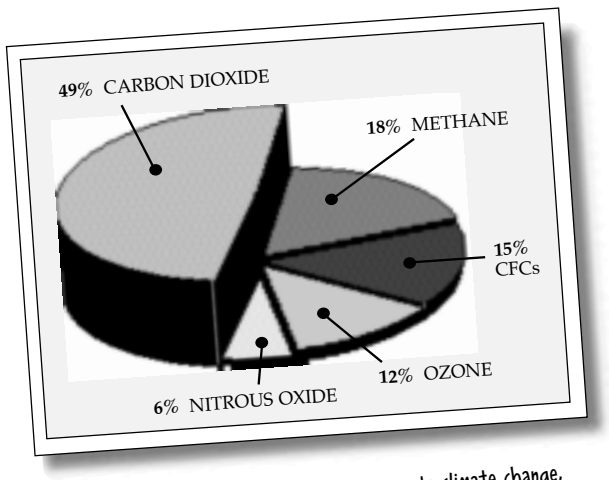
CLIMATE CHANGE: The unnatural warming of the Earth's atmosphere due to rising concentrations of greenhouse gases.

Now that you understand some simple concepts, let's complicate matters.

Carbon dioxide (CO_2) is the chief greenhouse gas, and therefore the chief suspect in climate change. But the atmosphere is loaded with other compounds that are also called "greenhouse gases." So carbon dioxide is just one of a host of suspects.

The listing below shows five other important greenhouse gases. Each one absorbs heat the Earth radiates back into the atmosphere, so each one warms the air.

The graphic below illustrates the contribution of each greenhouse gas to climate change. You can see that carbon dioxide is the worst offender in climate change, causing almost one-half of the increase. But you can also see that other greenhouse gases are also guilty of contributing to the increase.



The contributions of greenhouse gases to climate change.

Methane (CH_4)

Natural gas, an important source of energy, is mostly composed of methane. This colorless gas is produced when organic material decomposes without oxygen. It is formed underground, alongside oil and coal. In the last 150 years, the concentration of atmospheric methane has doubled, due mostly to leaks from coal mines, oil drilling, and pipelines. Some people are even worried about methane released by cattle—cows' stomachs produce methane, which is expelled into the atmosphere when the animal burps or, well, you know... And one molecule of methane is 27 times more efficient at trapping heat than CO_2.

Ozone (O_3)

Ozone is necessary high in the atmosphere, as we'll see on Page 11. But at lower elevations, ozone is a greenhouse gas, and is one of the main components of smog—the blanket of air pollution that smothers city skylines in August.

Freon (CFCs)

Chlorofluorocarbons (CFCs) are stable molecules that last 75 to 100 years in the atmosphere. They have been indicted as the culprits eating a hole in the ozone layer. CFCs are used inside refrigerators and air conditioners, but may escape these appliances through leaks. CFCs have been used in the production of Polystyrene (styrofoam) plastic, but that is changing. One molecule of CFC is an amazing 10,000 times more effective at trapping heat than CO_2.

Water (H_2O)

Water vapor in the atmosphere traps heat and is a greenhouse gas. The hotter the Earth is, the more water evaporates from the surfaces of lakes and oceans, warming the air further, which evaporates more water—a vicious cycle that is difficult to break.

Nitrous oxide (N_2O)

This is the "laughing gas" dentists use to put you under. It's also naturally produced by soil bacteria and released into the atmosphere in very small concentrations. Farmers applying large amounts of nitrogen fertilizers to the soil have accelerated this natural process. In this century, atmospheric nitrous oxide has increased by 10%. Molecule for molecule, N_2O can trap 200 times more heat than CO_2.

Working alone or in groups, see if you can match each "suspect" gas with one of its sources in the atmosphere. *(Answer key is on Page 15.)*

1. _____ Methane (CH_4)
2. _____ Ozone (O_3)
3. _____ Freon (CFCs)
4. _____ Water (H_2O)
5. _____ Nitrous oxide(N_2O)

a. evaporation from sunlight and transpiration through plants
b. released from refrigerators and air conditioners
c. decomposition of swamps
d. use of fertilizers in soil
e. car exhaust and coal burning

HOT FACT: The atmosphere of Venus is 97% CO_2. Its greenhouse effect pushes temperatures to about 800° F.

Talk about it

- Nitrous oxide, methane, and CFCs are all more efficient at trapping heat than CO_2. Why does CO_2 contribute to 49% of the world's warming?

Models for Climate Change

We've now established that greenhouse gases are being added to the air and that some of the hottest years on record have occurred during the last ten years.

Does that mean the Earth is warming permanently? And if so, by how much?

How can scientists predict?

As you read these words, supercomputers in different parts of the world are calculating and re-calculating predictions for global weather patterns for years into the future.

These supercomputers are capable of creating complex three-dimensional models of Earth's climate patterns.

Although all models don't agree, the table to the right lists five models of how temperatures and precipitation may increase assuming that the amount of carbon dioxide (CO2) doubles in the atmosphere, from 300 to 600 parts per million (ppm).

Even these models disagree somewhat, but in general scientists believe that with a doubling of current CO2 levels, the planet's temperature would increase from 3°to 9°Fahrenheit.

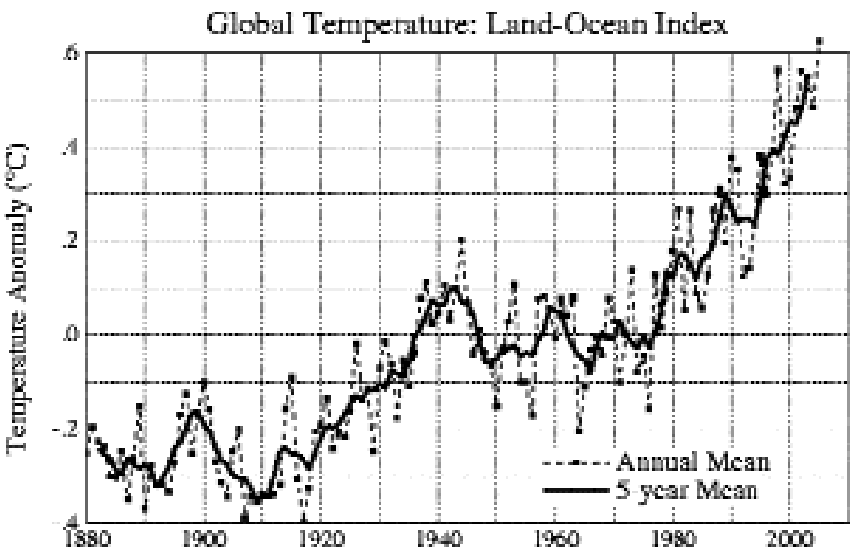
There is a catch to this: It is not certain when, or even if, CO_2 concentrations would reach that level. It would depend on population growth, the availability of fossil fuel, global economic growth and what measures nations take to control emissions.

Still, it is expected that CO_2 levels will grow between 75 and 200 percent by the end of the 21st century.

The graph below shows the global mean land-ocean temperature index. The dotted line is the annual mean and the solid line is the five-year mean. Changes from year to year are normal. But can you find a trend overall? Notice that temperatures fluctuate over a very small range, but small changes can have big effects.

Predictions for global climate changes if CO_2 doubles

MODEL	TEMPERATURE INCREASE	PRECIPITATION INCREASE
National Atmospheric & Oceanic Administration	7.2° F	8.7%
Goddard Institute for Space Studies	7.6° F	11.0%
Oregon State University	5.0° F	7.8%
United Kingdom Meteorological Office	9.4° F	15.8%
National Center for Atmospheric Research	6.3° F	7.1%



Check out the newspaper

Learning standards: understanding the factors that affect the weather, making predictions based on data

- Your copy of today's newspaper contains a lot of weather information. Turn to Page One, and find the weather prediction for today. Is it correct?
- Now turn to the weather report inside the paper. Is today hotter or colder than normal? Wetter or drier?
- Where was it warm in the U.S. yesterday? Is that what you expected? Where was it cold? Where do you think it will be hot or cold tomorrow?
- Predicting the weather is difficult—even when looking just days in advance. Study the weather map in today's paper. Check out the high and low pressure systems. Highs bring good weather, lows bad. Make a five-day forecast for your area, based on today's map.

Results of a warming world

Let's assume the worst. Let's assume average temperatures rise 3° to 8° F. What would be the consequences? What would happen to natural ecosystems? What would happen to human societies? Go back to your list of the effects of climate change on Page 3. Compare it to the set of effects presented on these pages.

Possible effects of climate change on natural systems

Average temperatures rise

Temperatures, as we've discussed, may rise between 3° and 8° F. But temperatures won't rise uniformly. Warming will be more pronounced in the polar regions, which may warm by an average of 18° F. Equatorial regions may only warm 2° to 4° F.

Climate patterns change

The difference in temperatures between polar and equatorial regions is one of the driving forces of atmospheric circulation. Reread the above paragraph. The difference between polar and equatorial temperatures will decrease, and this will change atmospheric circulation patterns worldwide. Some regions will get more rain, others much less. And hurricanes, monsoons and tornadoes may become more common in places.

Sea levels rise

The ocean will rise for two reasons: polar ice may melt and water volume expands when it is heated. Sea levels will increase even if the ice caps don't melt. How much the ocean will rise is a huge area of disagreement—one model says 5 to 15 inches by the year 2025; another model says 5 or more feet.

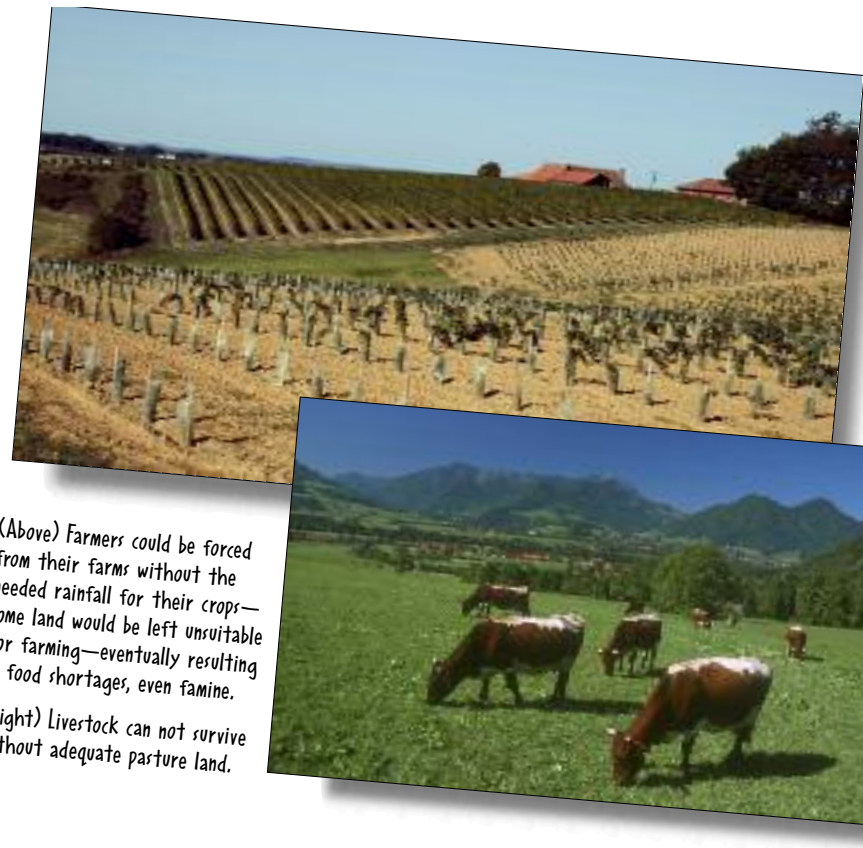
Habitats change

As weather changes, so will the climate that supports certain plants and animals. Evergreen forests will not be able to migrate north to follow climate suitable for their existence. Rainforests may become less wet. Deserts may become less dry. Whole ecosystems will change.

Extinctions

As ecosystems change with weather patterns, some species of plants and animals may disappear. Perhaps birds and insects can migrate to proper climate, but reptiles, amphibians, fish in ponds and lakes, trees and flowers will have a harder time adjusting to quick changes in climate. Most ecologists expect large numbers of species to disappear, although how many is unknown.

Changes in the climate, like droughts, can destroy trees which help reduce CO_2 levels.



(Above) Farmers could be forced from their farms without the needed rainfall for their crops—some land would be left unsuitable for farming—eventually resulting in food shortages, even famine.

(Right) Livestock can not survive without adequate pasture land.

Possible effects on people and cities

Flooding

Fully one-third of the Netherlands lies below sea level on the coast of Europe. If oceans rise, that country would be in deep trouble. Island nations would be in danger, not to mention U.S. coastal areas and the cities in them: New York, Miami, New Orleans, Los Angeles.

Greenhouse refugees

The Maldives are islands in the Pacific Ocean, home to 200,000 people. A small increase in sea level would cover these coral islands—forcing these people to find homes elsewhere. Rising sea levels could displace millions of people. The displaced already have a name: "greenhouse refugees."

Droughts and famines

The Midwest is the breadbasket of this country—and much of the world. This area would likely experience drier climates—and would be unable to produce as much food. Droughts in these regions and elsewhere could mean food shortages, even famine, for many parts of the world.

Water shortages

Residents of Long Island, New York, among others, drink water that's pumped from underneath their soils in geological formations called "aquifers." As sea levels rise, salt water intrudes into aquifers, poisoning the drinking water of millions of people. The Midwest and other areas would suffer water shortages from lack of rainfall.

The new world order

This map shows the results of computer model predictions of changes in climate patterns by the year 2025. It represents soil moisture patterns—whether the soil then is wetter or drier than at present. Soil moisture depends directly on amount of rainfall. Examine the map and answer the questions listed here.

1. What happens to the climate of your area?

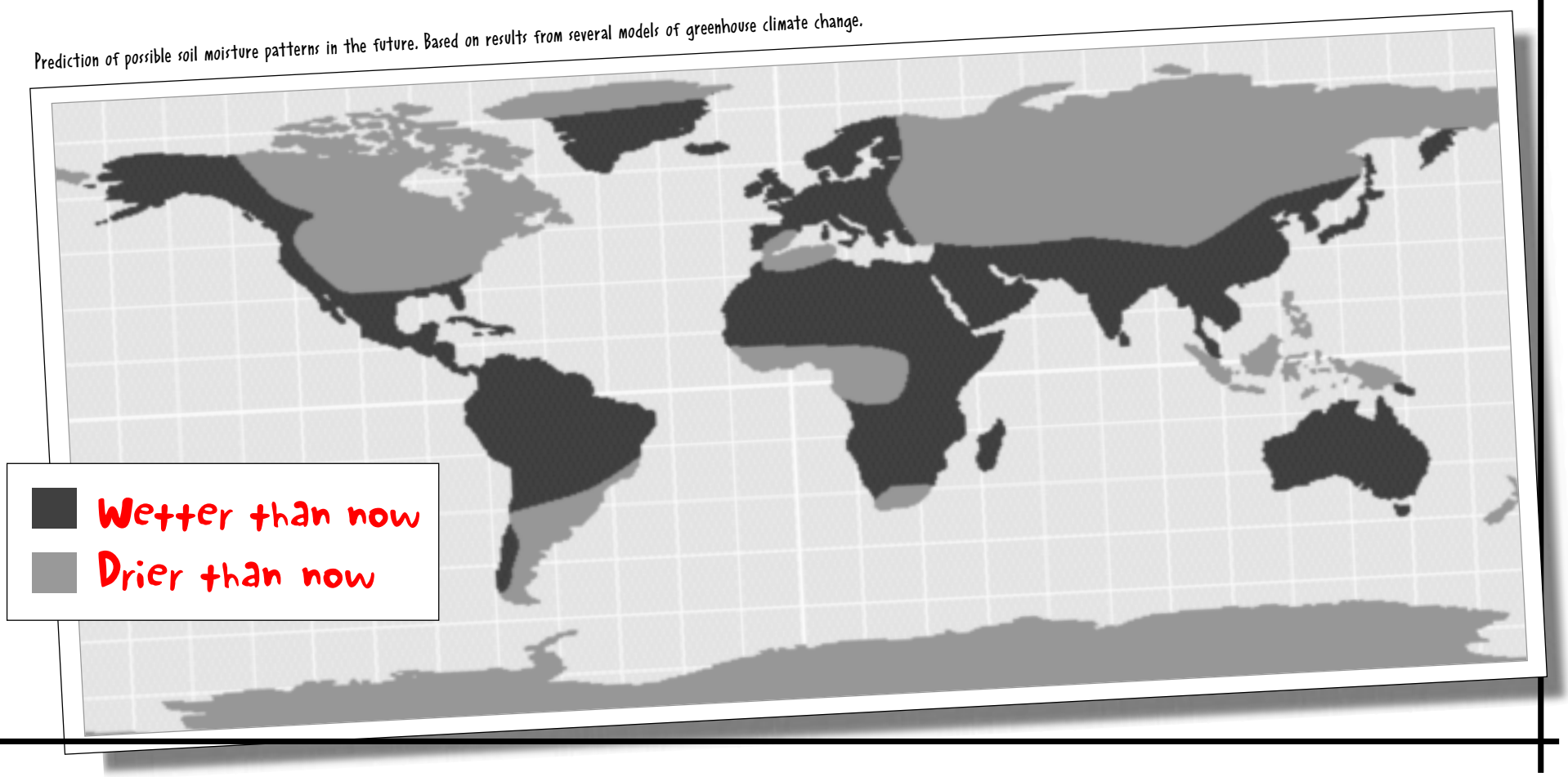
2. Look for the Sahara Desert in northern Africa, and the Arabian desert in Saudi Arabia. What happens to the climate in those places? What might the effects be?

3. The Amazon rain forest is located in northern South America. The Congo is a huge rainforest ecosystem on the west coast of central Africa. What happens to the climate in those places? What then happens to the millions of plants and animals that live in the rain forests?

4. Might some parts of the world change for the better in some ways? Are there greenhouse "winners" and "losers"? Who might they be?

5. Do any of the geographic side effects of climate change worry you? Which worry or concern you the most?

Prediction of possible soil moisture patterns in the future. Based on results from several models of greenhouse climate change.



Climate Change wild cards

Unpredictable events make predicting the future difficult

You've now read about and thought about some of the things that could happen as the world warms. At this point it's important to remind you that no one knows for sure what's really going to happen to the world's climate in the years ahead.

The world might warm. Then again, it might not. Humankind is, in effect, experimenting with changes in the atmosphere. We've altered the very air we breathe, and continue to alter it with each passing day. The results of the experiment, in the worst case, will be the list you read on the previous two pages.

But whether that worst case, or something different, will come about is a very big mystery. Scientists don't yet fully understand exactly how the planet's atmosphere works, nor exactly how the atmosphere interacts with oceans and forests. At right are some global "wild cards" that may (or may not) change the outcomes predicted earlier.

Cloud Cover

A hotter Earth means increased evaporation from the surface, resulting in more clouds. Clouds act like atmospheric mirrors, reflecting sunlight back into space before it hits the Earth. But clouds are composed of water vapor, a greenhouse gas. It's unclear which role clouds will play in greenhouse Earth—agent of temperature increase, or decrease.

Plant growth in the ocean

Plant growth in the ocean may store large amounts of carbon, too. As ocean plants die, they sink to the ocean bottom, taking that carbon with them. The ocean is another carbon sink, another way nature will slow the climate change.

Plant growth on land

Plants need carbon dioxide to grow, and evidence indicates that some plants may grow very well in an atmosphere rich in CO_2. Profligate plant growth would store carbon in its tissues, removing it from the atmosphere. Plants then may become a "carbon sink," a place to store excess carbon and halt the warming of the atmosphere. Plant growth would also cool the soil, and help retain soil moisture.

Volcanoes & Fires

Erupting volcanoes spew ash and dust into the atmosphere. These particles act as mirrors, reflecting incoming solar sunlight into space. The eruption of the Mt. Pinatubo volcano in the Philippines in June 1991 injected colossal amounts of particle matter into the upper atmosphere. This created a worldwide veil that actually reduced sunlight. A global cooling trend followed. Once the particles dispersed, the world's climate appeared to warm again.

Check out the newspaper

Learning standards: skimming, gathering supporting details for debate, analyzing current events, understanding the impact of technology

- In 1997 delegates from more than 150 countries met in Japan and agreed to set legal limits on man-made gases that are causing the air of the Earth to get warmer. At the same time the U.S. announced that the country's emissions of such heat-trapping gases grew in '97 at the highest rate since the nation pledged to cut them back. Using the newspaper as a resource, debate what role advanced countries like the U.S. should play reducing such gases in the world.
- The heat-trapping gases that impact on climate change are produced by such human activities as driving cars, running power plants, using air conditioning. If you were a world leader trying to reduce these gases, what steps would you recommend people and nations take?
- It has been about 25 years since computers have allowed scientists to measure and predict changes in the climate and temperature of the world. Such computer "models" of climate change are extremely important. Look through the newspaper for other ways computers are used to help make predictions. Make a class list and number them in order of importance.
- Many American factory owners say that setting tight limits on heat-trapping gases will affect companies that produce the gases while making products. Look through the business section of the paper for news about a manufacturing business. Write how tighter controls on gas emissions would, or would not, affect this business.

Connected issues

HOT FACT: Every minute, some 80 acres of tropical rain forest disappear.

Solving one problem could solve several, or make matters worse

Climate change is just one of many environmental issues that now command the attention of the world.

Also out there: worldwide loss of rain forests, depletion of the ozone layer in the stratosphere, loss of species diversity, the solid waste crunch, acid rain, and more.

We mentioned a law of ecology earlier: "Everything is connected to everything else."

That's especially true of these issues. They share cause and effect. Solving one may make others worse. Or taking action on one issue may solve several. Let's sort out the connecting threads.

Ozone depletion

As we discussed on Page 6, ozone is a major component of smog, and can harm your respiratory system when inhaled. You also know that, low in the atmosphere, ozone is a greenhouse gas. Ozone, however, is a necessary ingredient high in the atmosphere, in the layer called the stratosphere, 15 miles overhead.

Stratospheric ozone is necessary because it filters out ultraviolet rays of light that burn your skin.

Scientists agree that chlorofluorocarbons (CFCs) released by leaks in air conditioners and refrigerators, among other sources, are carried by winds into the stratosphere. There, CFCs have destroyed ozone molecules.

A huge hole in the ozone layer reappears each year between August and November over the continent of Antarctica. A smaller hole has been reported over the Arctic Circle. Ozone from over the equator tries to fill in the holes at the North and South Poles, decreasing ozone concentration worldwide.

As ultraviolet light passes unfiltered through the holes to the surface below, one effect is an increase in skin cancers and eye cataracts among many animals, including people.

Ozone holes do not cause global warming. But CFCs warm the atmosphere in addition to devouring ozone molecules. For this reason, CFCs are being banned by governments and phased out by manufacturers.

The rain forest

Rain forests cover much of the Earth's surface in a belt around the equator. The diversity of plant and animal life within these habitats is astonishingly high—beetles, orchids, wasps, poisonous tree frogs, monkeys, lizards, etc.

Yet rain forests are disappearing at an alarming rate due to human activity.

Thousands of acres are being cleared as farmland or grazing land; cities and highways are expanding; the wood of tropical trees—prized all over the world—is being harvested and sold.

When rain forests disappear, climate change is impacted in several ways.

First, there are fewer trees left to absorb carbon dioxide into their tissues. Second, burning trees to clear forests releases large amounts of CO_2. Third, rice paddies and cattle pasture increase the amount of atmospheric methane (see Page 6).

Population

Each person needs resources to stay alive—food, water, energy, etc. Each time another person is born, whether poor or affluent, the balance among these issues is affected.

Each additional American child, for example, increases the amount of electricity this country needs to burn, increases the amount of food we must grow, increases the amount of garbage we have to dispose of, and adds to the greenhouse burden.

Garbage and solid waste

Garbage must be disposed of somehow, and the somehows are limited: We can burn it, bury it, or recycle and reuse it. Burning garbage adds carbon dioxide to the air. Burying garbage in landfills leads to increased atmospheric methane as the garbage decays. Recycling requires energy (to melt an aluminum can, for example). Even turning trash to steam to make electricity adds to the greenhouse burden. Only re-using a waste product makes little contribution to climate change.

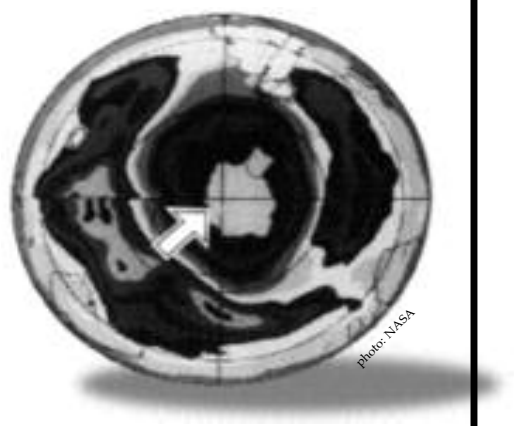


photo: NASA

The gray area indicated by the arrow in this photograph shows the hole in the ozone layer over Antarctica.

Biodiversity

"Biodiversity" is a measurement of the number of plants and animals that live on Earth. So far, fewer than 10 million species—everything from bacteria to blue whales—have been named. Some indications suggest 50 million species share this planet. As the climate changes, biodiversity decreases—species of plants and animals become extinct. As the environmental slogan reminds us: "Extinction is forever."

The world's population increases at the rate of three people every second. Calculate the following: *(Answer key on Page 15.)*

1. How many people are added every hour? _____ **2.** Every day? _____ **3.** Every year?_____

4. If the Earth's population is about 7 billion, how many years will it be until we reach 8 billion? _____ 10 billion? _____

5. What will the Earth's population be in the year 2050? _____

Talk about it

- Can you rank the five issues discussed on this page in order of priority? Why did you choose this order?
- If disposing of our garbage can raise our planet's temperature, what does that mean for you in your lifetime?

Hot Headlines

Your newspaper offers information and thought-provoking opinions

HOT FACT: Recycling one newspaper saves about 50 pounds of carbon dioxide from the atmosphere.

Climate change has made lots of headlines in the last few years. When a new study is released, or when the official average temperature for the Earth is finalized each year, that is presented as a news story. If a major movie or rock star decides to promote an environmental cause, that's reported in the features section.

Take a few minutes to page through today's newspaper, checking the headlines as you go.

- **Are there any stories about weather, or temperature, or climate change?**
- **Are there any stories that discuss other environmental issues? What are the issues? What is at stake? What action is being reported on?**

Now turn to the editorial pages of your newspaper. Once upon a time in early America, people gathered in town squares to discuss issues of the day. Today many people call talk radio, or chat on the Internet about matters that concern them.

The editorial pages of a newspaper are the same kind of idea forum. They are the place in the paper where opinions from a variety of sources are gathered and discussed, so that people can consider them and think out their own positions on the issues.

But unlike talk radio or the village square, you can clip these opinions and save them for future reference.

The editorial board of the paper writes its opinion in the column directly under the paper's masthead, usually on the left. This is the official position of the newspaper.

- **What are today's editorials about?**
- **What position is your newspaper taking on the issues?**
- **What are your personal positions on these issues?**

Now look for an editorial cartoon. An editorial cartoon uses art to make a point or state an opinion.

- **What is your cartoon about?**
- **What is the editorial cartoonist's position on the issue?**
- **What is your position?**

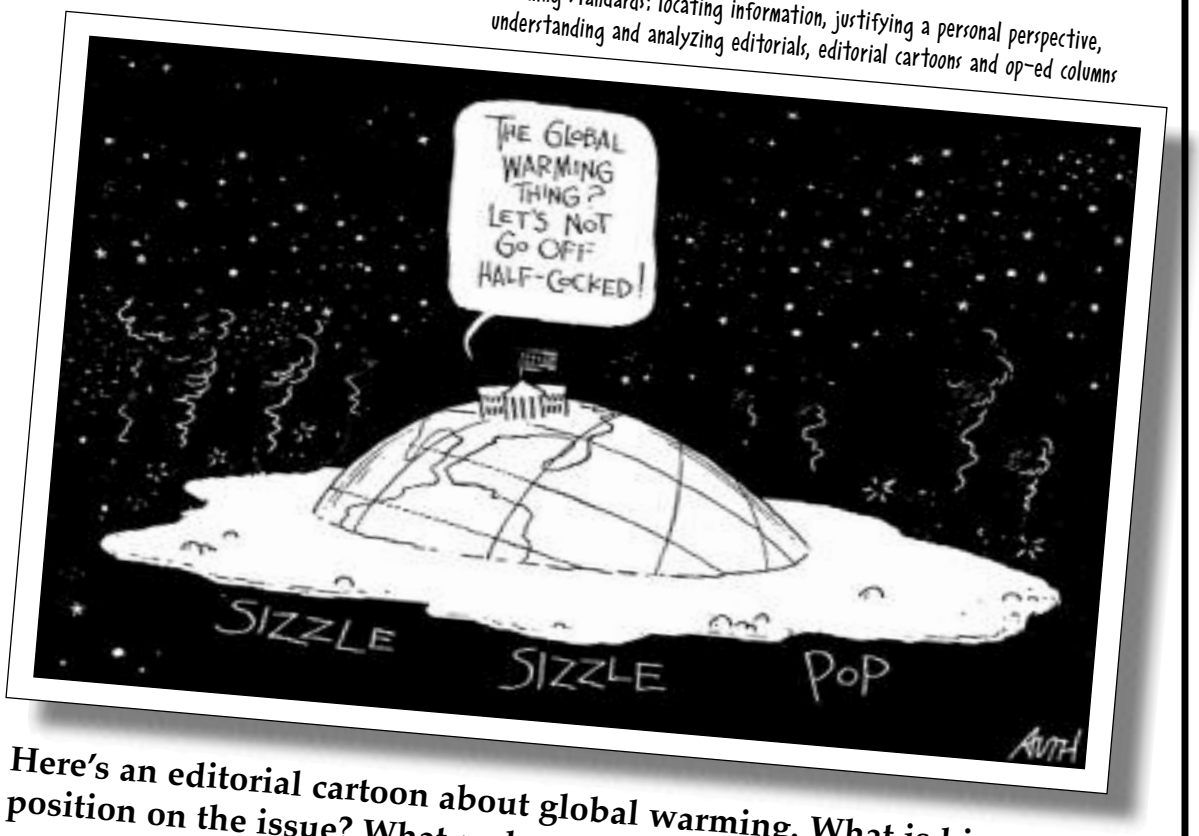
Now look at the letters to the newspaper written by readers. Newspapers run letters to give readers a place to speak out about the reporting or editorials of the newspaper—or to address other issues.

- **Pick a letter on an environmental topic. (If there isn't one today, pick one on a topic that interests you.) What position did the letter writer take?**
- **What is your position?**

Finally, there are op-ed columns. These are essays—by the newspaper's staff, syndicated writers and others—written to advocate certain positions. Often their positions are in disagreement with the newspaper's official position.

- **Scan the columns to see what topics inspired the writers.**
- **Pick a column on an environmental topic if there is one. (If there isn't today, pick one on a topic that interests you.) What position did the writer take?**
- **What is your position?**

Learning standards: locating information, justifying a personal perspective, understanding and analyzing editorials, editorial cartoons and op-ed columns



Here's an editorial cartoon about global warming. What is his position on the issue? What makes the cartoon effective? Funny?

The Future of the Planet

What To Do

There is a lot of debate and disagreement about what should be done about climate change. Some people favor immediate action to stave off the side effects this warming might have. They want individuals, corporations and governments to do what is necessary right now. Others think that more research is needed to see if climate change is a reality and in need of attention right now.

While the debate goes on, you can try these actions to curb pollution and slow climate change:

- Replace your regular (incandescent) light bulbs with fluorescent bulbs that use 60% less energy. Turn off lights, TV, computers and other electronics when not in use.
- Use less energy by turning the temperature up 2 degrees in the summer when your air conditioning is on and down 2 degrees in winter when the heat's on.
- Use less water (and less energy to heat the water) by showering more quickly.
- Unplug your electronics like your cell phone charger when you're not using them. They use electricity even when they're off.
- Recycle cans, newspaper, plastic and glass.
- Eat fresh food. Frozen food takes 10 times more energy to produce.
- Eat less meat. Methane is a significant greenhouse gas. Know who produces a tremendous amount of methane? Cows. They exhale it with every breath. When people eat less meat, we need fewer cows.
- Walk, bike, ride a bus. Almost 1/3 of the carbon dioxide in the U.S. comes from transportation vehicles. Use fewer of those and reduce carbon dioxide.

HOT FACT: Concentrations of atmospheric methane have doubled since 1800.

Global Means Worldwide

While the United States may currently be the world's biggest contributor to pollution, climate change is a problem worldwide. China, the second largest contributor to pollution, may pass the U.S. as the largest emitter of greenhouse gases in about ten years.

As China's economy and population grow, its people consume more energy, creating more pollution. According to the World Bank, 16 of the world's most polluted cities are in China. Air pollution there kills about 400,000 people each year.

China's pollution has shown up in the U.S. skies. Pollution is traveling halfway around the world! India is also contributing to pollution levels in increasing numbers as the population there grows and becomes more industrialized.

Life is Sweet in Brazil

Countries worldwide are working to cut down on emissions as they seek ways to use alternative fuels so that they won't have to depend on foreign countries to supply them with oil. Brazil cut its dependence on imported oil from 85% of its energy consumption in 1978 to nearly zero by 2005. How'd they do it? It started with sugar.

More than 30 years ago the government of Brazil began a program to research mixing gasoline with sugar-based ethanol (a type of alcohol) to power their cars. Then they developed cars that ran on just ethanol. Now they have "flex fuel" cars that can run on ethanol or gas or a mixture. They also started fueling trucks and buses with biodiesel made from vegetable oils like corn, sunflower, soybean and African palm -- all renewable resources.

A Global Plan

In December 1997, the Kyoto Protocol was signed at a meeting in Kyoto, Japan. It was, essentially, a promise made by 38 industrialized countries to cut down on the emissions of greenhouse gases between 2008 and 2012. When he was elected, President Obama said that he believed climate change legislation may be necessary. It remains a political issue. How do you think countries might work together to reduce pollution?

Talk about it

Plan a class debate about climate change and the environment. Here are some of the questions you might consider debating:

- Should action be taken immediately to reduce the amount of greenhouse gases in the atmosphere. If so, what action(s)?
- What is the role of population increase in climate change?
- Which is more important, a change in individual action (such as creating incentives for people to take mass transit) or corporate action (such as mandating that automakers build more fuel-efficient cars)?
- What should the United States' climate change policy be?

Your contributions to Climate Change

Are they avoidable?

The box below contains nine spaces. In each space, write an example of how you use energy in the course of a typical day. Can you fill all nine spaces? Feel free to work in groups and share examples. As you complete the grid, consider any appliance that needs electricity, any activity that burns fuel, gas or coal.

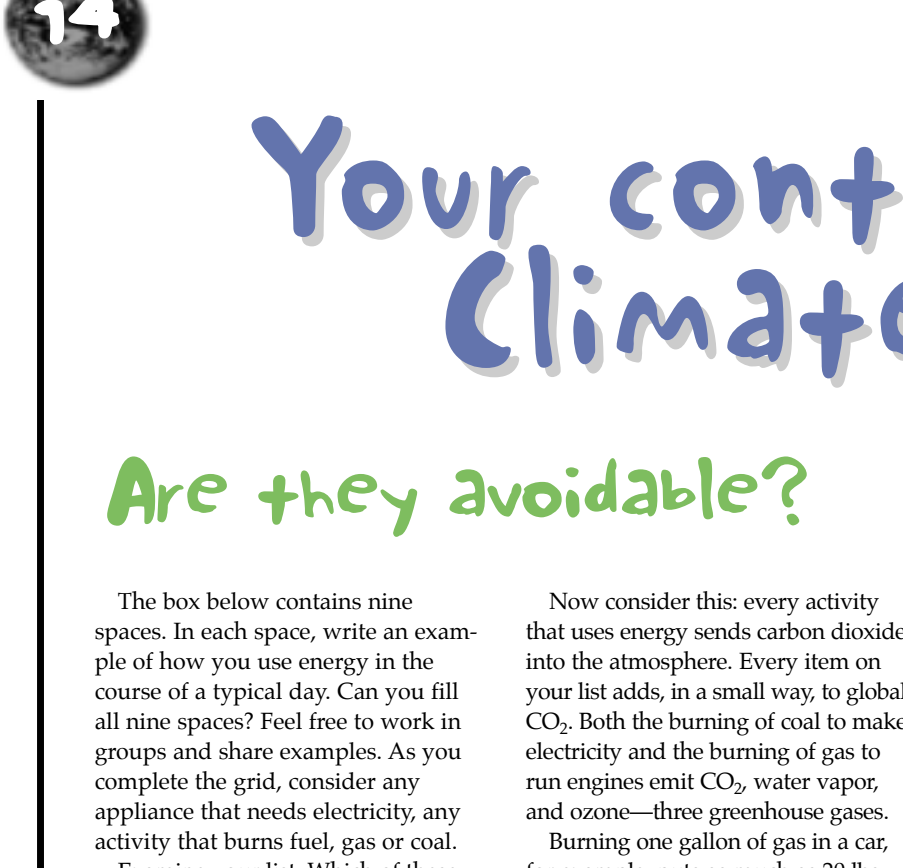
Examine your list. Which of these are necessities, needed to maintain life itself? Which of these are luxuries, things that enhance life? Is there a difference between needs and wants?

Which items would you be willing or able to give up if it would improve air quality and reduce the rate of global warming? Which items are necessities in the life of your family?

Now consider this: every activity that uses energy sends carbon dioxide into the atmosphere. Every item on your list adds, in a small way, to global CO_2. Both the burning of coal to make electricity and the burning of gas to run engines emit CO_2, water vapor, and ozone—three greenhouse gases.

Burning one gallon of gas in a car, for example, puts as much as 20 lbs. of CO_2 into the air; the average car contributes about five tons of CO_2 to the atmosphere annually.

Americans contribute disproportionately to the world's CO_2 output. Although we are only 5% of the world's population, we contribute 20% of its CO_2.



HOT FACT: Treating a car to an annual tune-up saves about 1,000 pounds of CO_2 from entering the atmosphere.

Consider the following energy-related activities. In the space next to each, place a plus sign (+) if you believe that activity increases CO_2 emissions, a minus (-) sign if you believe it decreases them.

(Answer key is on Page 15.)

1. ____ Recycling aluminum cans
2. ____ Planting shade trees around houses
3. ____ Using a car's air conditioner
4. ____ Leaving house's front door open in winter
5. ____ Closing window shades and curtains at night
6. ____ Leaving TV running when no one is watching
7. ____ Burning leaves in your backyard
8. ____ Keeping car tires inflated
9. ____ Taking a bus to school
10. ____ Washing clothing in cold water

Think Green

In the last few years, the word *green* has taken a new meaning. It's now synonymous with *environmental* or *ecological*.

Products in the supermarket, for example, use the word on their label to indicate low impact on the environment. A European political party, the Greens, advocates environmental concerns as its foremost priority.

Some "green" thinkers are touting the use of alternative fuels. Those aren't made from petroleum (oil). They may be made from natural gas or alcohol or hydrogen or corn or even plant or animal fat (biodiesel fuel).

We may someday be able to heat and cool our homes with alternative fuels. And, cars are huge polluters so when cars burn alternative fuels, they pollute less. That's why some people have turned to hybrid vehicles. The word hybrid means two or more things mixed together. Hybrid vehicles may use two forms of energy – gas and electricity. They use less gas and pollute less. Hybrid vehicles are becoming increasingly popular with new models coming out each year. They are more expensive than gas-only cars but some people are willing to pay more to drive "green."

The ultimate in "green" thinking may be an activity involving something green. It's one of the easiest environmentally friendly activities. It's planting a tree. Trees "inhale" carbon dioxide. A fast-growing tree can recycle almost 50 pounds of carbon dioxide each year. One scientist estimated that planting 100 million trees in U.S. cities would shade streets and homes cutting air conditioning costs by $4 billion every year.

Polls and Policies

Looking for answers for our planet

Policy makers need good information to decide the best course of action to take. Scientists are working around the clock to answer all the questions we've been raising on these pages. When more information is available, world leaders will be better able to formulate sound policy.

But world leaders also need to understand what people think. Public opinion polls can help take the pulse of the people, to determine what you, your parents, and other members of the community think about critical issues.

Polls are used extensively during political campaigns like the race for president. Examine your newspaper's first few pages to see if any poll results made the news today. What were the polls about? Who administered them? What were the results?

Talk about it

- What percentage of those polled thought the Earth is warming? Is that higher/ lower/same as you expected?
- Compile a list of different actions people said they would commit to taking to combat climate change. Which action was the most popular? What was the most creative/interesting answer? Do you agree with each one as a possible action step?

Climate Change poll

Divide your class into pairs. Each pair should poll 12 other students. Read each question aloud to the person you are polling, asking the person to decide which category his or her response falls into.

1A. Is the Earth's temperature increasing? ..... **Yes** **No** **Unsure**

If answered "Yes" to Question 1A, then ask 1B. If answered "No" or "Unsure", skip B and go to Question 2.

B. Is it increasing because of human activity? ..... **Yes** **No** **Unsure**

2. Should climate change be a major concern for the U.S. government? ..... **Yes** **No** **Unsure**

3. Should each individual change his/her lifestyle to combat climate change? ..... **Yes** **No** **Unsure**

4. Should auto manufacturers be forced to produce more fuel-efficient cars? ..... **Yes** **No** **Unsure**

5. Should your school conserve energy to combat climate change? ..... **Yes** **No** **Unsure**

6. Rank the following issues in order from 1 (most important) to 5 (least important).

Jobs/Economy #____ Environment #____ AIDS #____ Homelessness #____ Racism #____

7. If you could take one action to combat climate change, what would it be?

_____

_____

Credits:

- The writer was Mike Weilbacher, an award-winning environmental educator and free-lance science writer.
- Consulting writer was Anthony R. Wood, a weather expert who reports for the Philadelphia Inquirer.
- The Franklin Institute Science Museum, Philadelphia, provided information and assistance.

Answers:

Climate Change Quiz (Page 3)

1 d 2 c 3 b 4 b 5 b

Greenhouse Gases (Page 6)

1 c 2 e 3 b 4 a 5 d

Population Math (Page 11)

1) 10,800 2) 259,200 3) 94,608,000
4) 12 years to reach 8 billion
90 years to reach 10 billion
5) about 9 billion

Energy-Related Activities (Page 14)

Anything that increases energy efficiency decreases greenhouse gas emissions.
1) decreases 2) decreases
3) increases (car ACs use extra gas to operate)
4) increases 5) decreases
6) increases 7) increases
8) decreases (properly inflated tires increase efficiency)
9) increases CO_2 if you normally walk; decreases CO_2 if the alternative is your parents driving you
10) decreases

What now?

We've tracked the story of climate change through 15 pages and many activities. Do you understand the issues more clearly? Are there questions you have that are as yet unresolved? Below are some suggestions on what to do as a follow-up to this supplement.

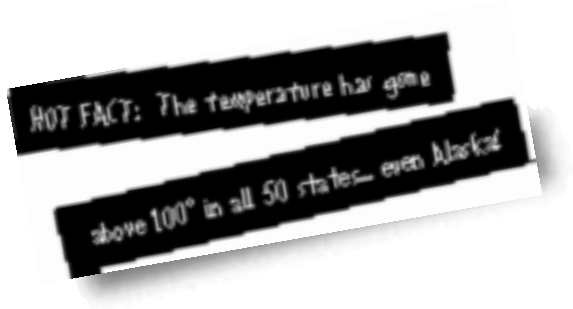
Things to do...

- Join the Earth Day celebrations on April 22. Plant a Greenhouse Garden on your school property. Invite the press and the community to its dedication.
- Write to your U.S. Senators and Congressman, our ambassador to the United Nations, and even the President to express your concerns about U.S. actions on global warming. Ask what steps each is taking.
- Track the environmental votes of the U.S. Senators and Congressmen from your state, and the state legislators from your area. Pick an issue of importance to you and write or meet with your legislators.
- Continue learning about climate change and other environmental issues. Use the bibliography provided on this page as a resource list for additional reading.
- Write to the organizations listed on this page for more information about global warming and environmental concerns. See if there is a local chapter you could get involved with. Ask if you could start one, if there is not.
- Write a letter to the editor of your paper—or post it on the Internet—stating your concerns on global warming, air quality, or ecology. Suggest some course of action.
- Remember that while you can read the news, you can also make the news. Look at the environmental or development issues facing your community and find ways to persuade people to your point of view.
- Attend local planning, conservation or zoning board meetings when issues of development, environment or highways are at stake.
- Find ways to encourage use of public transportation. Use it yourself.

Get plugged in... groups to contact

- Environmental Defense
  http://www.environmentaldefense.org
  Innovative and practical ways to solve the most urgent environmental problems
- Greenpeace
  http://www.greenpeace.org/international/
- Sierra Club
  http://www.sierraclub.org/
  America's oldest, largest and most influential grassroots environmental organization
- The Intergovernmental Panel on Climate Change (IPCC)
  http://www.ipcc.ch/
  Established to assess scientific, technical and socio-economic information relevant for the understanding of climate change
- University Corporation for Atmospheric Research
  http://www.ucar.edu/
  UCAR strives to advance the understanding of weather and climate in order to benefit society.
- Climate Action Network
  http://www.climatenetwork.org/
  A non-profit organization working on climate change issues
- Natural Resources Defense Council (NRDC)
  http://www.nrdc.org/
- An Inconvenient Truth
  http://www.climatecrisis.net/
  Former Vice President Al Gore's book and movie, "An Inconvenient Truth" looks at climate change. Read about it and watch clips from the movie.

Please note that websites change frequently.



Hot books to read

- ***A Hot Planet Needs Cool Kids: Understanding Climate Change and What You Can Do About It.*** Julie Hall and Sarah Lane, 2007
- ***Under the Weather: Stories About Climate Change.*** Tony Bradman, 2010
- ***Weather and Climate Change.*** Laura Howell, 2009
- ***National Geographic Investigates: Extreme Weather: Science Tackles Global Warming and Climate Change.*** Kathleen Simpson, 2008
- ***Weird Weather: Everything You Didn't Want to Know About Climate Change But Probably Should Find Out.*** Kate Evans and George Monbiot, 2007
- ***Climate Change.*** Peter Benoit, 2011
- ***The Greenhouse Effect***. Darlene R. Stile, Compass Point Books, 2006