

## Global Warming: What it IS...

Earth has warmed by about  $1^{\circ}\text{F}$  over the past 100 years. But why? And how? Well, scientists are not exactly sure. The Earth could be getting warmer on its own, but many of the world's leading climate scientists think that things people do are helping to make the Earth warmer.



### Greenhouse Effect, Climate Change, and Global Warming

**The Greenhouse Effect:** Scientists are sure about the greenhouse effect. They know that greenhouse gases make the Earth warmer by trapping energy in the atmosphere.

**Climate Change:** Climate is the long-term average of a region's weather events lumped together. For example, it's possible that a winter day in Buffalo, New York, could be sunny and mild, but the average weather - the climate - tells us that Buffalo's winters will mainly be cold and include snow and rain. Climate change represents a change in these long-term weather patterns. They can become warmer or colder. Annual amounts of rainfall or snowfall can increase or decrease.

**Global Warming:** Global warming refers to an average increase in the Earth's temperature, which in turn causes changes in climate. A warmer Earth may lead to changes in rainfall patterns, a rise in sea level, and a wide range of impacts on plants, wildlife, and humans. When scientists talk about the issue of climate change, their concern is about global warming caused by human activities.

# Climate and Weather...

Weather is all around us. Weather may be one of the first things you notice after you wake up. Chances are, if it is cold and snowing, you'll wear a jacket when you go outside. If it's hot and sunny, you may wear shorts.

Sounds pretty simple, right?

But what about climate?

How is it different from weather?

And what is weather, exactly?

## Weather

Weather describes whatever is happening outdoors in a given place at a given time. Weather is what happens from minute to minute. The weather can change a lot within a very short time. For example, it may rain for an hour and then become sunny and clear. Weather is what we hear about on the television news every night. Weather includes daily changes in precipitation, barometric pressure, temperature, and wind conditions in a given location. What is your weather like today?



The weather can change very quickly from rain to sunshine.

## Climate

Climate describes the total of all weather occurring over a period of years in a given place. This includes average weather conditions, regular weather sequences (like winter, spring, summer, and fall), and special weather events (like tornadoes and floods). Climate tells us what it's usually like in the place where you live. San Diego is known as having a mild climate, New Orleans a humid climate, Buffalo a snowy climate, and Seattle a rainy climate. How would you describe the climate where you live?



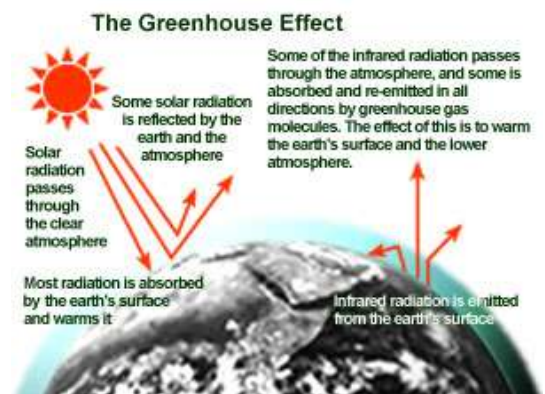
Climate can change too, but in the past it has taken a very long time to do so.

# Greenhouse Effect...

The greenhouse effect is the rise in temperature that the Earth experiences because certain gases in the atmosphere (water vapor, carbon dioxide, nitrous oxide, and methane, for example) trap energy from the sun. Without these gases, heat would escape back into space and Earth's average temperature would be about 60°F colder. Because of how they warm our world, these gases are referred to as greenhouse gases.

Have you ever seen a greenhouse? Most greenhouses look like a small glass house. Greenhouses are used to grow plants, especially in the winter. Greenhouses work by trapping heat from the sun. The glass panels of the greenhouse let in light but keep heat from escaping. This causes the greenhouse to heat up, much like the inside of a car parked in sunlight, and keeps the plants warm enough to live in the winter. The Earth's atmosphere is all around us. It is the air that we breathe. Greenhouse gases in the atmosphere behave much like the glass panes in a greenhouse. Sunlight enters the Earth's atmosphere, passing through the blanket of greenhouse gases. As it reaches the Earth's surface, land, water, and biosphere absorb the sunlight's energy. Once absorbed, this energy is sent back into the atmosphere. Some of the energy passes back into space, but much of it remains trapped in the atmosphere by the greenhouse gases, causing our world to heat up.

The greenhouse effect is important. Without the greenhouse effect, the Earth would not be warm enough for humans to live. But if the greenhouse effect becomes stronger, it could make the Earth warmer than usual. Even a little extra warming may cause problems for humans, plants, and animals.



# What is the climate System?



It may seem hard to believe that people can actually change the Earth's climate. But scientists think that the things people do that send greenhouse gases into the air are making our planet warmer.



## Atmosphere

The atmosphere covers the Earth. It is a thin layer of mixed gases which make up the air we breathe. This thin layer also helps the Earth from becoming too hot or too cold, much like clothing does for us. Weather systems, which develop in the lower atmosphere, are driven by heat from the sun, the rotation of the Earth, and variations in the Earth's surface.

## Oceans

Oceans cover about 70 percent of Earth's surface. Their large mass and thermal properties, enable them to store vast quantities of heat. Oceans buffer and regulate temperature - energy absorbed or lost by the oceans results in a smaller surface temperature change than would occur over land. The atmosphere and ocean constantly exchange energy and matter. For example, water evaporates from the oceans into the atmosphere. This moisture then falls back to the Earth as precipitation - rain, snow, sleet, and even the morning dew on the grass.

## Land

Land covers 27 percent of Earth's surface, and land topography influences weather patterns. For example, the weather in areas covered by mountains can be completely different than the weather in areas where the land is mostly flat.

## Ice

Ice is the world's largest supply of freshwater. It covers the remaining 3 percent of Earth's surface including most of Antarctica and Greenland. Because ice is highly reflective and because of its insulating properties, ice plays an important role in regulating climate.

## Biosphere

The biosphere is that part of Earth's atmosphere, land, oceans that supports any living plant, animal, or organism. It is the place where plants and animals, including humans, live. Large quantities of carbon dioxide are exchanged between the land-based biosphere and the atmosphere as plants take in carbon dioxide and give off oxygen, and animals inhale oxygen and exhale carbon dioxide.

## Climate's come a LONG way!



Earth's climate has been changing constantly over its 5-billion-year history.

Sometimes, the climate has warmed so that the oceans have risen and covered much of the Earth. Each of the changes may seem extreme, but they usually occurred slowly over many thousands of years.

### Ancient Climate History

The first people arrived in America between 15,000 and 30,000 years ago. During that time, much of North America was covered by great ice sheets. Some 14,000 years ago, the last ice sheet began to melt very quickly. By 7,000 years ago, the ice was gone.

This end to the ice ages caused big changes on the Earth. The changes caused many kinds of plants and animals to die. For example, mastodons - elephant-like animals - and other large mammals that preferred cold climates may not have been able to live in the warmer, drier conditions.

### The Little Ice Age

Starting in the 14<sup>th</sup> century, Europeans lived through what is known as the "Little Ice Age." The Little Ice Age lasted for several hundred years. During the Little Ice Age, the advance of glaciers along with hard winters and famines caused some people to starve and others to leave their homes.

### Recent Climate History

The Earth has warmed about 1°F in the last 100 years. The eight warmest years on record (since 1850) have all occurred since 1998, with the warmest year being 2005. Periods of increased heat from the sun may have helped make the Earth warmer. But many of the world's leading climatologists think that the greenhouse gases people produce are making the Earth warmer, too.



*Melting Glaciers:* a glacier is a large sheet of ice that moves very, very slowly. Many glaciers in the world are now melting. For example, glaciers are melting in Montana's Glacier National Park. Some scientists think the glaciers are melting partly because the Earth is getting warmer.



*Rising Sea Level:* have you ever built a sandcastle on the beach, close to the ocean on wet sand? If you have, you probably know that the sandcastle won't last very long. Chances are the waves will wash away the sandcastle as soon as the tide comes in. The water goes higher up the beach

when the tide comes in. At most shores throughout the world, two high tides and two low tides occur every day. But now the level of the sea is rising, so high tides are higher than they were before. Over the last 100 years, the level of the sea has risen about 6-8 inches worldwide. When the sea level rises, the tide goes farther up the beach.

Scientists think the sea has risen partly because of melting glaciers and sea ice. When some glaciers melt, they release water into the sea and make it higher than it was before. Scientists also think that warmer temperatures in the sea make it rise even more. Heat makes water expand. When the ocean expands, it takes up more space.

### What Might Happen?

Scientists are not fortune-tellers. They don't know exactly what will happen in the future. But they can use special computer programs to find out how the climate may change in the years ahead. And the computer programs tell us that the Earth may continue to get warmer.



Together, the melting glaciers, rising seas, and computer models provide some good clues. They tell us that the Earth's temperature will probably continue to rise as long as we continue increasing the amount of greenhouse gases in the atmosphere.

# The Climate Detectives

Scientists have to think like detectives. They look for clues to help them understand how the world works. Then they investigate the clues to find evidence - real facts that can give them a better idea of what is going on. Here are some of the ways that scientists gather evidence about climate, both past and present:



## Weather Stations

Weather stations help us find out the temperature on the surface of the Earth. Weather stations use special thermometers that tell us the temperature. They can be set up almost anywhere on land. Weather stations also can tell us how fast the wind is moving and how much rain falls on the ground during a storm.

## Weather Balloons

Almost everyone likes balloons - including scientists! Weather balloons are released to float high up into the atmosphere. They carry special instruments that send all kinds of information about the weather back to people on the ground.

## Ocean Buoys

A buoy is an object that floats on water, and is often used to warn boats away from dangerous places in the ocean or on a river. But some buoys have special instruments on them. These buoys can tell us the temperature and other things about the conditions of the atmosphere.

## Weather Satellites

Humans send satellites into space to travel around the Earth. The satellites send back information to scientists on the ground. Some of the information they give us is about the weather and the Earth's temperature.

Not just any ice - they are studying the ice from glaciers that have been around for a very long time. They cut pieces of ice and look for air bubbles that were trapped in the ice hundreds or even thousands of years ago. The air bubbles help them discover what the climate used to be like on Earth. The evidence they uncover is creating a historical record of regional temperatures and greenhouse gas concentrations dating back 160,000 years.

### Sediment Analyses

Sediment is the earth and rock that has built up in layers over time. Scientists are learning a great deal about past climate from studying these layers. Sediment layering provides information about where glaciers have been in the past. Ocean sediments provide a map of how ocean currents have flowed in the past. And fossilized pollen found in sediment layers tells us about where different plants have grown in the past.

### Tree Rings

You can tell how old a tree is by counting its rings because it grows a new ring every year. Tree rings also can tell us how much precipitation fell each year in the place where the tree lives. Precipitation is rain or snow or any other moisture that falls to the Earth. Scientists study the sizes of tree rings. The different sizes of the rings tell us about changes in temperature and precipitation.

### What Does All of This Mean?

Weather stations, balloons, ocean buoys, and satellites tell us the Earth's temperature today. Ice cores, sediment layers, and tree rings tell us about what the Earth's climate has been like in the past. With this evidence, scientists are learning how climate changes over time.

### What Are Scientists Still Unsure About?

How do clouds respond to changes in temperature and precipitation? How do oceans transport heat? How do climate and intense weather events like hurricanes affect each other? As scientists try to answer these and other questions, they will discover many more clues about how the Earth's climate system works.

# Can We Change the Climate?



It may seem hard to believe that people can actually change the Earth's climate. But scientists think that the things people do that send greenhouse gases into the air are making our planet warmer.



Once, all climate changes occurred naturally. However, during the Industrial Revolution, we began altering our climate and environment through agricultural and industrial practices. The Industrial Revolution was a time when people began using machines to make life easier. It started more than 200 years ago and changed the way humans live. Before the Industrial Revolution, human activity released very few gases into the atmosphere, but now through population growth, fossil fuel burning, and deforestation, we are affecting the mixture of gases in the atmosphere.



We need energy to do things like drive a car, fly a plane, or make things in factories. But we need to use energy wisely if we want to help slow global warming.

Since the Industrial Revolution, the need for energy to run machines has steadily increased. Some energy, like the energy you need to do your homework, comes from the food you eat. But other energy, like the energy that makes cars run and much of the energy used to light and heat our homes, comes from fuels like coal and oil - fossil fuels. Burning these fuels releases greenhouse gases.

## When Do You Send Greenhouse Gases into the Air?

*Whenever you ...*

- |  |  |
|--|--|
| <input type="checkbox"/> Watch TV                | <input type="checkbox"/> Play a Video Game   |
| <input type="checkbox"/> Use the Air Conditioner | <input type="checkbox"/> Listen to a Stereo  |
| <input type="checkbox"/> Turn on a Light         | <input type="checkbox"/> Wash or Dry Clothes |
| <input type="checkbox"/> Use a Hair Dryer        | <input type="checkbox"/> Use a Dish Washer   |
| <input type="checkbox"/> Ride in a Car           | <input type="checkbox"/> Microwave a Meal    |

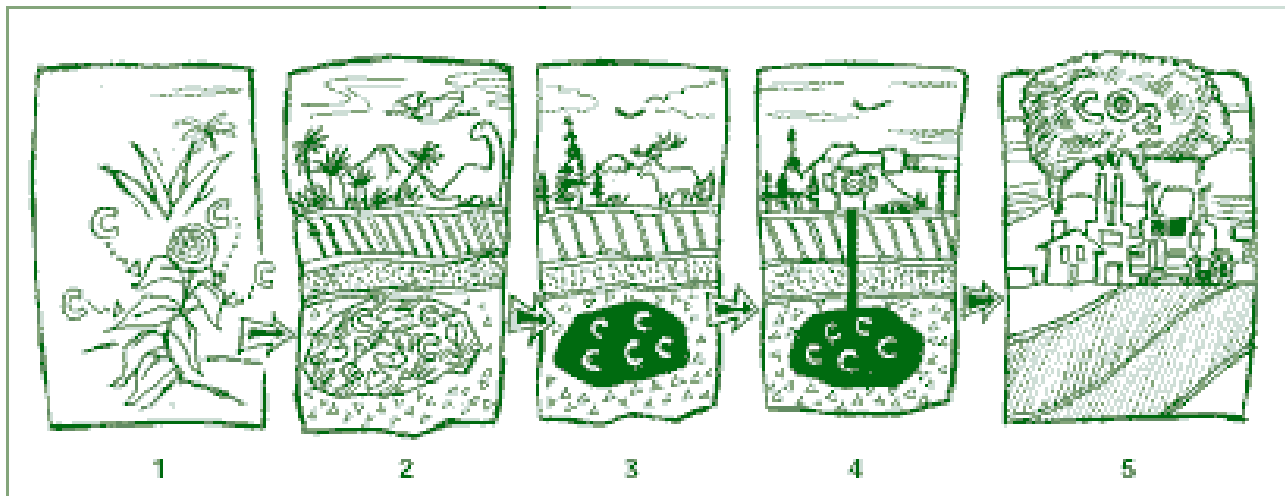
*... you are helping to send greenhouse gas into the air.*

To perform many of these functions, you need to use electricity. Electricity comes from power plants. Most power plants use coal and oil to make electricity. Burning coal and oil produces greenhouse gases.



**Other things we do send greenhouse gases into the air too;**

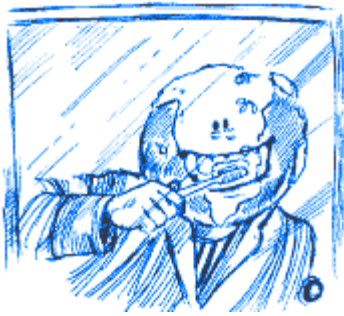
The trash that we send to landfills produces a greenhouse gas called methane. Methane is also produced by the animals we raise for dairy and meat products and when we take coal out of the ground. Whenever we drive or ride in a car, we are adding greenhouse gases to the atmosphere. And, when factories make the things that we buy and use everyday, they too are sending greenhouse gases into the air.



- (1) Plants remove carbon dioxide from the air.
- (2) When the plants died, they were buried in the earth.
- (3) After millions of years, their remains turned into coal and oil.
- (4) People mine the earth for coal and oil, which are called "fossil fuels."
- (5) When people burn fossil fuels, they send carbon dioxide and other greenhouse gases into the air.

## So, what's the BIG DEAL?

Sometimes little things can turn into big things. Think about brushing your teeth. If you don't brush for one day, chances are nothing bad will happen. But if you don't brush your teeth for one month, you may develop a cavity. It's the same thing with global temperatures. If temperatures rise above normal levels for a few days, it's no big deal - the Earth will stay more or less the same. But if temperatures continue to rise over a longer period of time, then the Earth may experience some problems.



Average global temperature has increased by almost  $1^{\circ}\text{F}$  over the past century; scientists expect the average global temperature to increase an additional 2 to  $6^{\circ}\text{F}$  over the next one hundred years. This may not sound like much, but it could change the Earth's climate as never before. At the peak of the last ice age (18,000 years ago), the temperature was only  $7^{\circ}\text{F}$  colder than it

is today, and glaciers covered much of North America!

Even a small increase in temperature over a long time can change the climate. When the climate changes, there may be big changes in the things that people depend on. These things include the level of the oceans and the places where we plant crops. They also include the air we breathe and the water we drink.

*What Might Happen?* It is important to understand that scientists don't know for sure what climate change will bring. Some changes brought about by climate change will be good.

If you live in a very cool climate, warmer temperatures might be welcome. Days and nights could be more comfortable and people in the area may be able to grow different and better crops than they could before. But it is also true that changes in some places will not be very good at all.



## Human Health

Climate change may affect people's health both directly and indirectly. For example, heat stress and other heat related health problems are caused directly by very warm temperatures and high humidity. Untreated, heat stress can be a very serious medical problem. Scientists suspect that, in many places, climate change will increase the number of very hot days that occur during the year. More hot days increases the possibility of heat related health problems. Indirectly, ecological disturbances, air pollution, changes in food and water supplies, and coastal flooding are all examples of possible impacts that might affect human health.

How people and nature adapt to climate change will determine how seriously it impacts human health. Some people and places are likely to be affected more than others. Generally, poor people and poor countries are less likely to have the money and resources they need to cope with preventing and treating health problems. Very young children and the elderly adults will run the highest risks.

## Ecological Systems

Climate change may alter the world's habitats and ecosystems - all living things are included in and rely on these places. Many of these places depend on a delicate balance of rainfall, temperature, and soil type. A rapid change in climate could upset this balance and seriously endanger many living things.

Most past climate changes occurred slowly, allowing plants and animals to adapt to the new environment or move somewhere else. However, if future climate changes occur as rapidly as some scientists predict, plants and animals may not be able to react quickly enough to survive. The ocean's ecosystems also could be affected for the same reasons.

## Sea Level Rise

Global warming may make the sea level become higher. Why? Well, warmer weather makes glaciers melt. A glacier is a large sheet of ice that moves very, very slowly. Some melting glaciers add more water to the ocean. Warmer temperatures also make water expand. When water expands in the ocean, it takes up more space and the level of the sea rises.



Sea level may rise between several inches and as much as 3 feet during the next century. This will effect both natural systems and manmade structures along coastlines. Coastal flooding could cause saltwater to flow into areas where salt is harmful, threatening plants and animals in those areas. For example, an increase in the salt content of the Delaware and Chesapeake bays is thought to have decreased the number of oysters able to live in those waters.

Oceanfront property would be affected by flooding, and beach erosion could leave structures even more vulnerable to storm waves. Whether we move back from the water or build barricades in the face of a rising sea, it could cost billions of dollars to adapt to such change. Coastal flooding also may reduce the quality of drinking water in coastal areas.

## Crops and Food Supply

Global warming may make the Earth warmer in cold places. People living in these places may have a chance to grow crops in new areas. But climate change also might bring droughts to other places where we grow crops. In some parts of the world, people may not have enough to eat because they cannot grow the food that they need.

# We CAN Make a Difference!



Climate change may be a big problem, but there are many little things we can do to make a difference. If we try, most of us can do our part to reduce the amount of greenhouse gases that we put into the atmosphere. Many greenhouse gases come from things we do every day. As we have learned, these greenhouse gases trap energy in the atmosphere and make the Earth warmer.



Driving a car or using electricity is not wrong. We just have to be smart about it. Some people use less energy by carpooling. For example, four people can ride together in one car instead of driving four cars to work. Here are some additional ways you can help make the planet a better place!

## Read

Learning about the environment is very important. There are many good books that will help you learn. To get started, ask a teacher or a librarian for some suggestions. You also can look at the Links page to find other good web sites with information about the environment and climate change.

## Save Electricity

Whenever we use electricity, we help put greenhouse gases into the air. By turning off lights, the television, and the computer when you are through with them, you can help a lot.

## Bike, Bus, and Walk

You can save energy by sometimes taking the bus, riding a bike, or walking.

## Talk to Your Family and Friends

Talk with your family and friends about climate change. Let them know what you've learned.

## Plant Trees

Planting trees is fun and a great way to reduce greenhouse gases. Trees absorb carbon dioxide, a greenhouse gas, from the air.

## Recycle

Recycle cans, bottles, plastic bags, and newspapers. When you recycle, you send less trash to the landfill and you help save natural resources, like trees, oil, and elements such as aluminum.

## When You Buy, Buy Cool Stuff

There are lots of ways we can improve the environment. One of the ways to reduce the amount of greenhouse gases that we put into the air is to buy products that don't use as much energy. By conserving energy, we help reduce climate change and make the Earth a better place. Some products - like certain cars and stereos - are made specially to save energy.

## Some Things to Think About

Did you know that you can help the environment if you buy recyclable products instead of non-recyclable ones? Look for the recycle mark - three arrows that make a circle - on the package. Recyclable products are usually made out of things that already have been used. It usually takes less energy to make recycled products than to make new ones. The less energy we use, the better.

## Solar Energy

Imagine that it's a hot summer day. You put a scoop of ice cream on the sidewalk, and it melts. Why? Well, you probably know that the sun causes the ice cream to melt. But you may not know that the sun produces solar energy. Solar energy is a fancy way of saying "energy that comes from the sun." Solar energy can be used to heat homes, buildings, water, and to make electricity. Today, more than 200,000 houses in the United States take advantage of the sun's energy.

## Cars

Cars are an important part of life for most people. But cars also cause pollution and release a lot of greenhouse gases into the air. Fortunately, there are

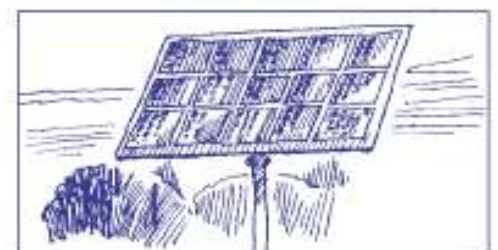


Cars, stereos, and VCRs can be "energy smart"



The "recycle" symbol.

The "ENERGY STAR" symbol



Solar Panels such as these can provide electricity to buildings

some cars that are better for the environment. These cars can travel longer on a smaller amount of gasoline. They don't pollute as much, either. Using these kinds of cars can help reduce the amount of greenhouse gases in the air.

### **ENERGY STAR®**

Many things, like computers, TVs, stereos, and VCRs, have special labels on them. The label says "Energy" and has a picture of a star. Products with the ENERGY STAR® label are made to save energy. Buying products with ENERGY STAR® labels will help protect the environment.

# Global Warming

