



# Antarctica: Researching Global Warming at the Coldest Place on Earth

## 35.1 Introduction

Antarctica is the coldest continent on Earth. The average temperature at the South Pole is  $-74^{\circ}\text{F}$ . At this temperature, spilled coffee can turn to ice before it hits the ground. No one lives on this cold continent. Each summer, though, Antarctica warms up a bit. During these few warmer months, researchers from around the world travel to Antarctica to work.

Researchers come to Antarctica to study many things. One of the most important, however, is **global warming**. This is a slow increase in the temperature of Earth's surface. **Climate** records for the past 25 years show a worldwide surface temperature rise of about  $0.4^{\circ}\text{F}$ . However, this warming is not uniform. Some places are warmer. Some are cooler.

Many scientists believe that this warming relates to a process called the **greenhouse effect**. This occurs when gases in the **atmosphere** prevent heat from Earth's surface from escaping into space. The trapped heat, the scientists believe, makes the Earth warmer. Studies of ice bubbles trapped in polar ice show that amounts of **greenhouse gases** in the atmosphere are increasing. Still, not all scientists think this increase explains Earth's warming. In fact, some aren't sure whether Earth is warming at all.

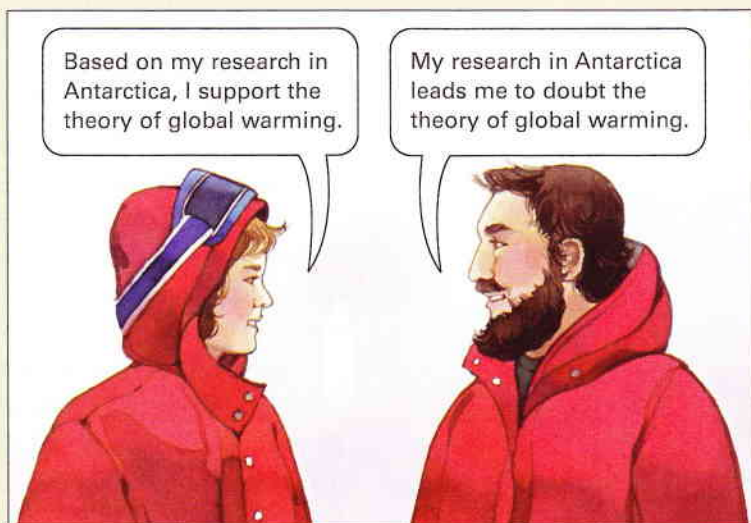
In this chapter, you will look at ideas about global warming and how it may be affecting Antarctica. You will also look at possible effects of global warming on the rest of the world.

### Essential Question

**How might global warming affect the environment in the world's coldest places?**

These two researchers are debating the theory of global warming. One believes that her research in Antarctica supports the theory. The other has doubts based on his research. Think about this debate as you try to answer the Essential Question.

### Graphic Organizer







### A Polar Desert

People think that an ice-capped land must get a lot of rainfall. But Antarctica is a desert. It gets less than three inches of precipitation per year. This polar desert has fewer plants and animals than most desert biomes because it is so cold as well as dry.

## 35.2 The Geographic Setting

The South Pole is the southernmost point on Earth. Antarctica surrounds this point. This icy continent is larger than Australia or Europe. Almost all of its land is buried under **glaciers**. A majority of Earth's fresh water is frozen here as ice.

**The Coldest Place on Earth** Antarctica can be unimaginably cold. On July 21, 1983, instruments in Antarctica registered a temperature of  $-128^{\circ}\text{F}$ . This temperature is the coldest ever recorded on Earth.

Why does Antarctica get so cold? It is the most distant continent from the equator. As a result, it receives less sunshine than other parts of the world. On some winter days, the sun never rises above the horizon. The small amount of **solar energy** that Antarctica does receive is mostly reflected by ice back into space.

Antarctica is also the driest continent. It receives less than two inches of **precipitation** per year. Few living things can survive in such a cold, dry **biome**, or large **ecosystem**. Only two flowering plants grow here. But a variety of animals thrive in the surrounding waters. They include seals, whales, penguins, and many other kinds of birds.

Glaciers cover about 98 percent of Antarctica. Much of this ice is well over a mile thick. Moving flows of ice called **ice streams** slide across the surface of this **ice cap**. These streams carry ice from the center of the continent to the sea. Upon reaching the coast, an ice stream flows outward into the ocean. There it forms an **ice shelf**, or floating sheet of ice, that remains attached to the continent. The Ross Ice Shelf, the largest of these ice shelves, is about the size of France. In some places, it is up to 3,000 feet thick.

**A Continent Reserved for International Research** In 1978, a pregnant woman boarded a plane in Argentina and flew to a research station in Antarctica. While there, she gave birth to a baby boy. He was the first human to be born on the continent. Yet he could not be a citizen of Antarctica. That's because Antarctica has no country or government.

In the past, seven countries claimed parts of Antarctica. In 1959, those countries joined with others to sign the Antarctic Treaty. As part of this treaty, the seven countries agreed to set aside their claims. The treaty stated that Antarctica should be reserved for peaceful activities such as scientific investigation.

More than 4,000 people travel to Antarctica every year to take part in scientific studies. Scientists find Antarctica a good place to do research for many reasons. One reason is that it is the least populated continent on Earth. This helps researchers see how Earth has changed over time without the influence of human activity.

Also, Antarctica's glaciers serve as records of climate change. Researchers drill deep into the thick ice and pull up samples called **ice cores**. They study the cores to learn what the climate was like as far back as 420,000 years ago. Researchers use this information to help understand the warming and cooling of Earth over time.

## ► Geotermis

**biome** a very large ecosystem such as a desert, forest, wetland, or grassland. Each biome is home to its own community of plants and animals.

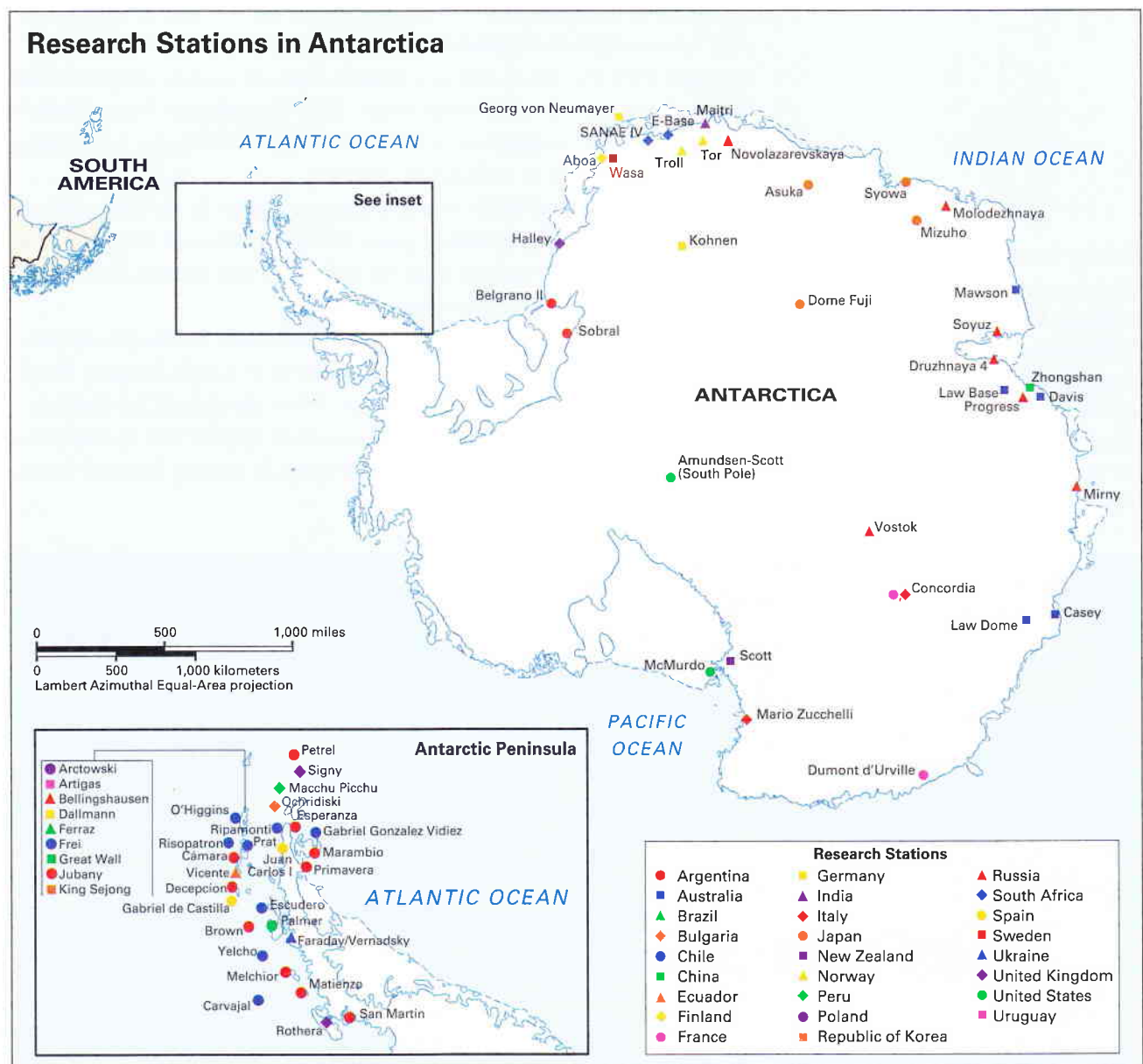
**global warming** the gradual increase in the temperature of Earth's surface over time. This warming may be the result of natural causes. It may also be caused by human activity.

**greenhouse effect** the process by which gases in the atmosphere trap heat from the sun and keep it close to Earth's surface. This trapped heat may contribute to global warming.

**ice shelf** a large, floating sheet of ice that is attached to the coast. Ice shelves can extend out to sea for hundreds of miles.

### A Cool Place for Research

No one owns Antarctica. The Antarctic Treaty makes it a natural reserve. It can be used only for such peaceful purposes as scientific research. Several countries have research stations in Antarctica.



### 35.3 The Theory of Global Warming

In the past, Earth's climate has had both warm and cool periods. Changes from one period to another were caused by natural events. The last cool period ended about 12,500 years ago. Since then, Earth has been in a warm period. During the past 200 years, however, temperatures seem to have risen faster than usual. The theory of global warming tries to explain why the climate is heating up.

**Three Key Ideas About Global Warming** The theory of global warming is based on three key ideas. The first is that Earth's climate is getting warmer. The second is that this trend, or change over time, is mainly caused by human activity, not natural causes. The third key idea is that global warming is harmful to people and many biomes. Because of this, many people believe it should be slowed or even stopped.

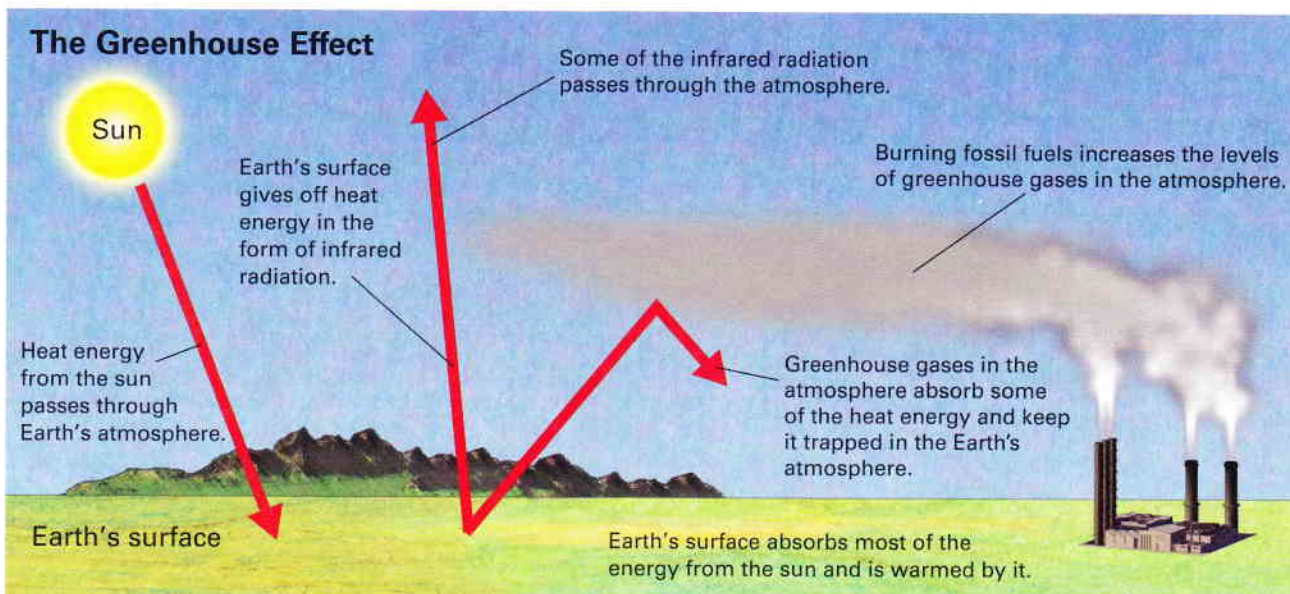
**The Greenhouse Effect Keeps Earth Warm** Earth is kept warm by a natural process called the *greenhouse effect*. This process traps energy from the sun in our atmosphere. The atmosphere then acts like a giant greenhouse surrounding Earth. This "greenhouse" keeps Earth's average surface temperature at a warm 59°F. Without it, the temperature could drop to 0°F, or well below freezing.

The greenhouse effect works because of gases in the atmosphere. The most common greenhouse gases are carbon dioxide, methane, and water vapor. They trap heat from the sun in the atmosphere. Otherwise, this heat would escape into space.

Since around 1800, levels of greenhouse gases in the atmosphere have been rising. This increase is due mainly to people burning **fossil fuels** such as coal, oil, and natural gas. When these fuels are burned, they give off carbon dioxide. Many scientists believe that the increase in carbon dioxide and other greenhouse gases is causing Earth to warm. Others are not so sure.

#### Energy from the Sun

This diagram shows what happens to energy from the sun once it enters Earth's atmosphere. Some energy is absorbed by Earth's surface. Some is reflected back into space. Some is trapped in a layer of gases that surround Earth. This trapped heat may be causing global warming.





## 35.4 Support for the Global Warming Theory

Scientists who support the theory of global warming point to three kinds of evidence. The first is climate records. These records show rising surface temperatures in many places. The second is glacier records. They show that glaciers around the world are melting as temperatures rise. The third type of evidence is rising levels of greenhouse gases in the atmosphere. Studies of air bubbles trapped in polar ice show that greenhouse gas levels are the highest they've been in 420,000 years.

Supporters of the global warming theory trace these changes back to the start of the **Industrial Revolution**. During this time, many new machines were invented. Many were powered by the burning of fossil fuels. Today we use coal, oil, and natural gas to heat our homes, run our cars, and power our factories. As a result of this activity, we add more than 4 billion tons of carbon dioxide to the air every year. This gas will stay in our atmosphere for at least the next 100 years.

The results of global warming, these scientists warn, could have terrible consequences. Some biomes may lose plants and animals that are unable to adapt to warmer conditions. Crop failures may become common, leading to widespread hunger. Ocean levels may rise as polar ice melts. Higher seas may flood low-lying islands and coastal cities. The best way to prevent these disasters, these scientists say, is to reduce activities that create greenhouse gases. This could mean difficult changes in the way many people today live.

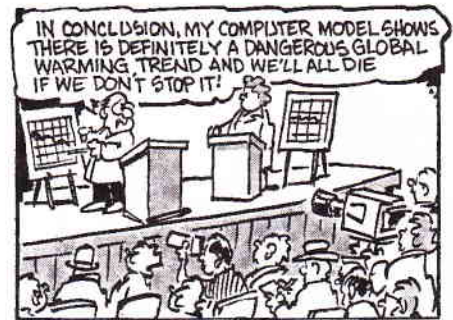
## 35.5 Doubts About the Global Warming Theory

Not all scientists agree with the global warming theory. Some doubt that Earth's temperature is, in fact, rising at all.

Like supporters, the doubters support their views with evidence. They point out that temperature records of the upper atmosphere show little sign of warming. Most surface temperature records, they argue, come from urban areas. City buildings and pavement absorb more heat from the sun than green spaces. As a result, urban areas get warmer as they grow. What looks like global warming may just be city warming. The doubters also note that not all glaciers are shrinking. Some are growing.

Some doubters accept evidence that Earth is warming. But they believe this is due to natural causes. Changes in the sun's energy or in ocean currents are far more likely to cause climate change, they believe, than human activity.

Finally, some doubters question whether rising temperatures will be so disastrous. People living in cold climates, they point out, might welcome warmer winters. Areas that are now too cold for crops might become productive farmland. Also, more carbon dioxide in the air may boost plant growth. The result could be faster growing crops and forests. This might be good, not bad, for many biomes.



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### The Global Warming Debate

Some people believe that global warming will have disastrous effects. They argue for reduced use of fossil fuels to slow climate change. Others don't believe that global warming is a major problem. Some even suggest that warmer weather could benefit people living in cold climate zones.



### Recording Temperatures

The coldest place on Earth is the best place to look for signs of climate change. The slightest rise in Antarctica's air temperature could begin to melt the ice. Annual temperatures are recorded to see whether they are rising.

## 35.6 Studying Temperatures in Antarctica

The impact of global warming on Antarctica could be dramatic. Warmer temperatures could cause glaciers and ice shelves to melt. If the area covered by ice shrinks, less energy from the sun would be reflected back into space. Temperatures would then rise even more.

To find out if such changes are likely, scientists gather data on air temperatures in many parts of Antarctica. They compare that data to records from recent years, noting any trends.

Researchers also collect information about Antarctica's climate from thousands of years ago. The snow that falls here each year doesn't melt. Instead, it piles up in layers. The layers are thicker in wet years and thinner in dry ones.

Researchers drill deep into glaciers to take out cores of ice. An ice core looks like a very long pole with thin cross stripes. Each stripe, or layer, represents a year's snowfall. By examining the cores, researchers can learn what the climate was like when each layer of snow fell. They can determine how much precipitation fell and what temperatures were like for that year. The deeper they drill, the farther back in time they can look.

## 35.7 Studying Ice Shelves in Antarctica

As you have read, ice shelves are floating sheets of ice that are still attached to the continent. Ice shelves form half of Antarctica's coastline and more than a tenth of its surface area. Every summer, the edges of Antarctic ice shelves break off to form **icebergs**. An iceberg is a large mass of ice floating around in the ocean.

Researchers in Antarctica study ice shelves to see if they are growing or melting. They also watch for large chunks of ice that break off and float away. One way they do this is by placing cameras on satellites that orbit, or circle, Earth. The cameras take pictures of ice shelves as they form and break apart.

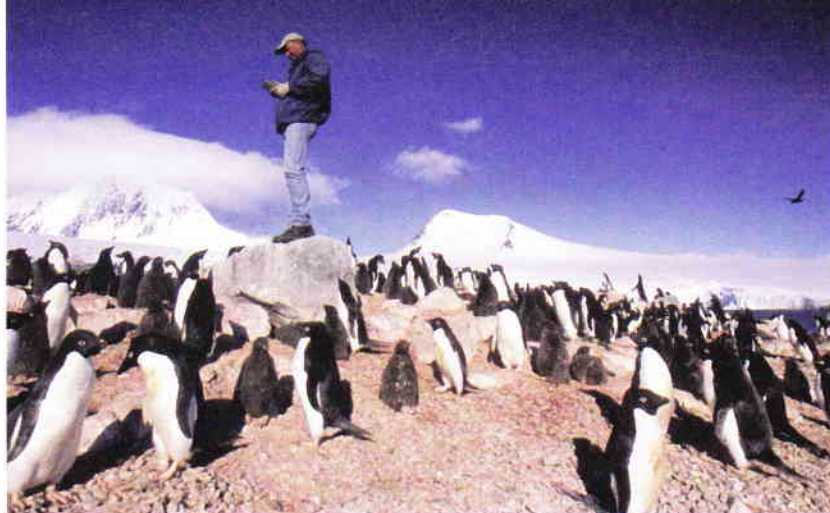
Researchers also spend time at observation posts on or near ice shelves. From these posts they can study how seasonal temperature changes affect the ice shelves.

### The Larsen Ice Shelf

The edges of ice shelves often break off to form icebergs. If temperatures rise too much, whole ice shelves might break apart or melt. The Larsen Ice Shelf pictured here is about the size of Rhode Island. In 2002, about 1,500 square miles of this shelf broke off and floated out to sea.







### Observing Penguins

Warmer temperatures could hurt Adelie penguins. These penguins eat a tiny, shrimplike animal called *krill*. Krill breed under the Antarctic ice sheets. If rising temperatures melt the ice, the krill could disappear.

## 35.8 Studying Penguins in Antarctica

The Adelie is the most common penguin in this polar biome. Nearly 5 million Adelies call Antarctica home. Each summer they raise their young on the few areas of coastline that are not covered with ice.

Global warming could be bad for Adelies. Warmer air can hold more moisture. This could lead to increased snowfall in Antarctica. If snow covers the few bare spots that the penguins need for nesting, they might stop breeding.

Researchers are studying how many Adelie penguins return to their nesting grounds each year. They do this by taking a simple **census**. This means counting the number of penguins at each nesting site. Researchers also try to track the birds' movements over the year. They glue transmitters on the penguins' feathers and use satellites to track the signals given off.



## 35.9 Beginning to Think Globally

In this chapter, you learned that Antarctica is a very cold, remote place. Researchers visit Antarctica to study global warming. They do this by gathering information on air temperatures, ice shelves, and penguins.

Researchers don't always agree on what their studies show. For example, air temperatures are rising in some areas of Antarctica. This may be due to the greenhouse effect. But temperatures are falling in other areas. What this means is unclear.

In recent years, researchers have seen huge chunks of ice shelves break off to form icebergs. But scientists aren't sure what is causing the breakups or what effects they will have on the polar biome.

Researchers have also observed changes in penguin populations. There are far fewer Adelie penguins in some areas than in the past. But other penguin species are increasing their numbers. Neither change may be the result of global warming.

Most scientists connect global warming to rising levels of greenhouse gases in the atmosphere. They argue that this rise comes from human activity, especially the burning of fossil fuels. But countries are very unequal in their use of fossil fuels. Think about this as you look at the maps in the next section.

### What If Antarctica Melts?

This cartoon looks at what could happen if global warming were to melt the ice over Antarctica. The water trapped there would flow into the ocean, and sea levels would rise. If both polar ice caps were to melt, sea levels could rise by 20 feet or more.



## 35.10 Global Connections

The cartogram on the facing page shows greenhouse gases produced by countries around the world. Note the size of the United States. The maps along the bottom show how global warming could affect three parts of the world. The maps show coastlines in each place as they are today. They also show how those coastlines would change were the polar ice caps to melt.

### How might rising sea levels be connected to greenhouse gases?

Greenhouse gases may cause surface temperatures to rise. As Earth warms, glaciers and ice shelves will melt. The result could be a dramatic rise in sea levels around the world.

**Are the countries that produce the most greenhouse gases the ones that will be most affected by rising sea levels?** The biggest producers of greenhouse gases are **developed countries** like the United States and Canada. Such countries run their factories and cars on fossil fuels. Poor countries like Bangladesh and Tuvalu have little industry. But because they are low and flat, they could be severely affected by rising sea levels.

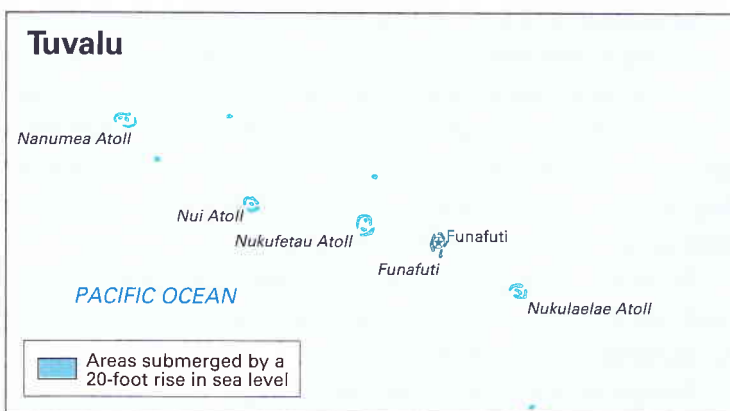
**What can people do to reduce the greenhouse gases they add to the environment?** People can reduce their production of greenhouse gases by using less energy from fossil fuels. One way to do this is to drive cars that get more miles per gallon of gas. Another is to use energy-saving fluorescent lights. Still another is to turn lights and televisions off when they are not being used. Each step may seem small. But together they can add up to big greenhouse gas savings.



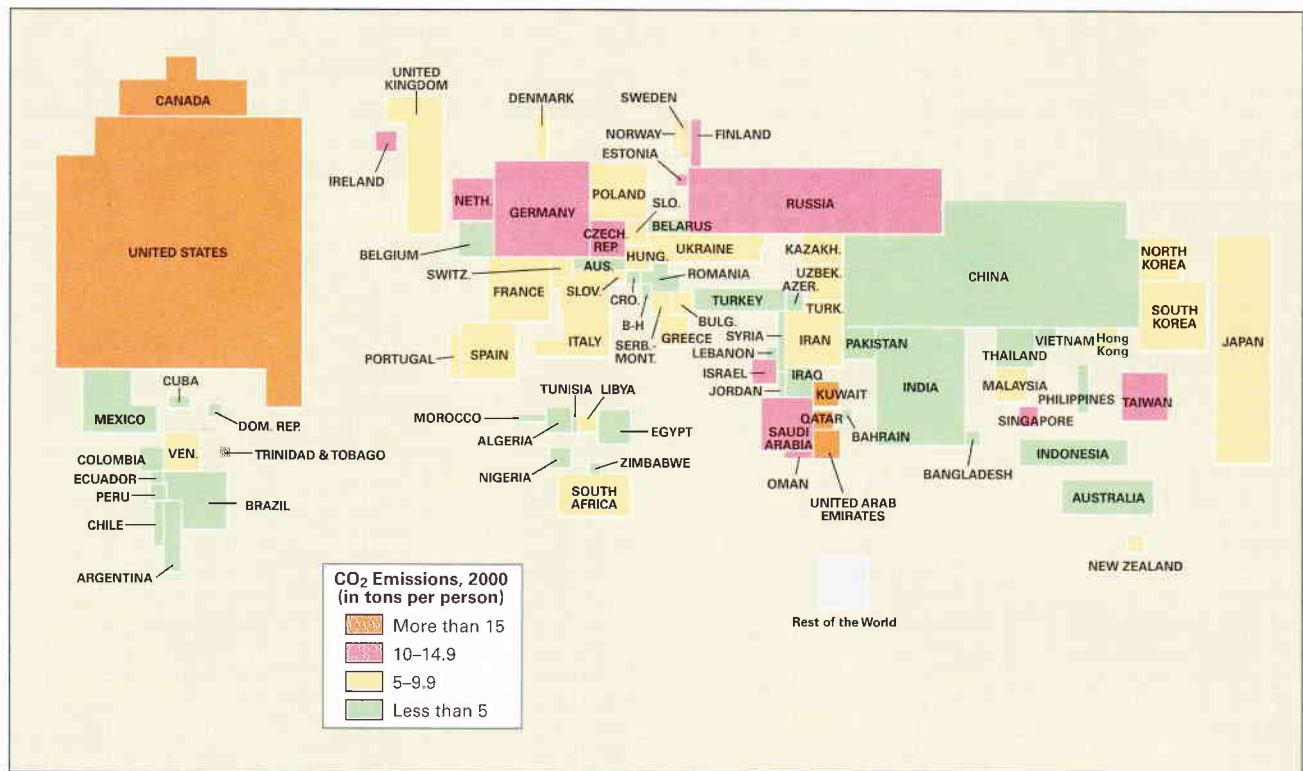
### Flooding in Tuvalu

Tuvalu is a small island country in the South Pacific. Scientists warn that in the next 50 years, rising sea levels could swamp Tuvalu's low-lying atolls. Were that to happen, its people would have to leave their flooded homes forever.

### How Three World Areas May Be Affected by Global Warming and Rising Seas



## Greenhouse Gas Emissions Around the World



Source: *Penguin State of the World Atlas*, 7th edition, by Dan Smith, New York: Penguin, 2003.



### The Impact of Rising Seas

These maps show how the melting of the polar ice caps would affect three coastal areas. Many large U.S. cities would be under water. So would much of Bangladesh and all of Tuvalu.