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GLOBAL WARMING AND THE GREENHOUSE EFFECT

Unit Overview

The Earth's climate has changed dramatically in the past as great ice ages came and went. Those changes, however, occurred over hundreds or thousands of years. Scientists are not sure how quickly the Earth will continue to warm or how severe the effects will be. In this unit, you will learn what causes global warming, the effects of enhanced global warming, and some ways we can contribute to the slowing of global warming.

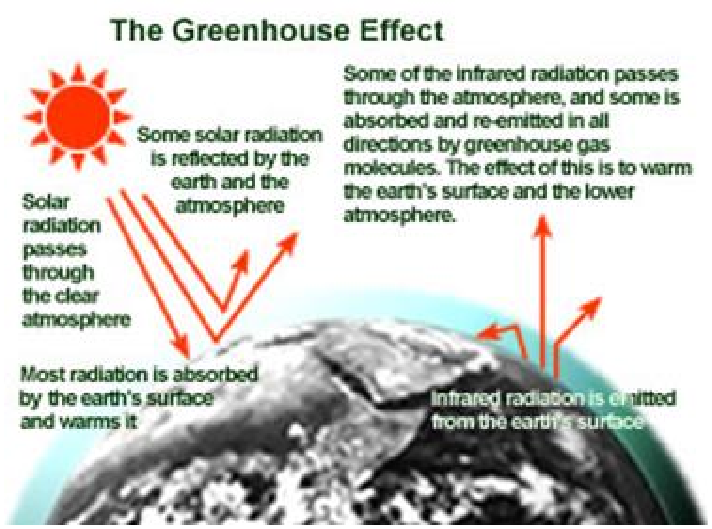
The Greenhouse Effect

The greenhouse effect is a natural process by which some of the radiant heat from the Sun is captured in the lower atmosphere of the Earth, thus maintaining the temperature of the Earth's surface. Gases that help capture the heat, called "greenhouse gases," include water vapor, carbon dioxide, methane, nitrous oxide, and a variety of manufactured chemicals. Some are emitted from natural sources while others result from human activities.

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 (heat) from the sun. Without these gases, heat would escape back into space and Earth's average temperature would be about 60ºF 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, and 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 and the air that plants utilize to grow. 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 our atmosphere. Some of the energy passes back into space, but much of it remains trapped in our atmosphere by the greenhouse gases, causing our world to heat up.



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

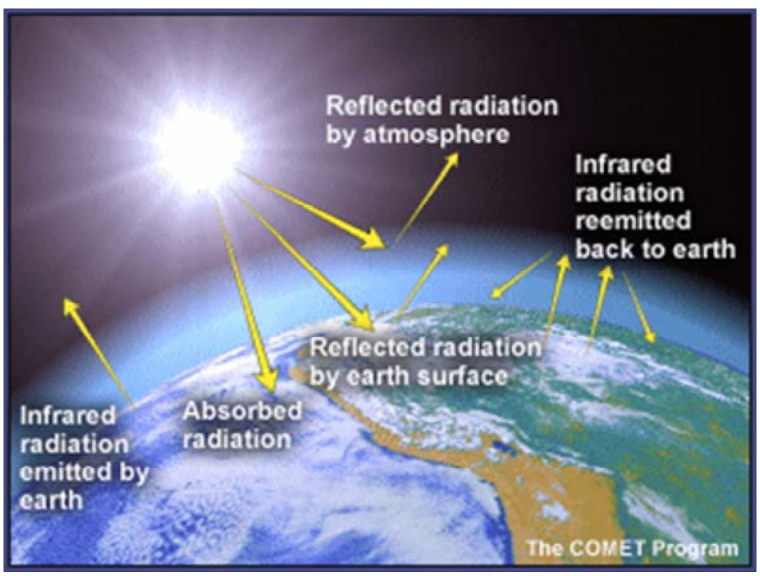
QuickTime Global Warming: The Greenhouse Effect (01:49)

Introduction

In the last unit, we learned the Goldilocks Principle can be summed up neatly as "Venus is too hot, Mars is too cold, and Earth is just right." The fact that Earth has an average surface temperature, comfortably between the boiling point and freezing point of water and thus, suitable to sustain our sort of life, cannot be explained by simply suggesting that our planet orbits at just the right distance from the sun to absorb just the right amount of solar radiation. Our moderate temperatures are also the result of having just the right kind of atmosphere. A Venus-type atmosphere would produce unbearably hot conditions on our planet; a Mars atmosphere would leave us shivering in a Martian-type deep freeze.

	Venus	Earth	Mars
Surface temperature	450°C	13°C	-53°C

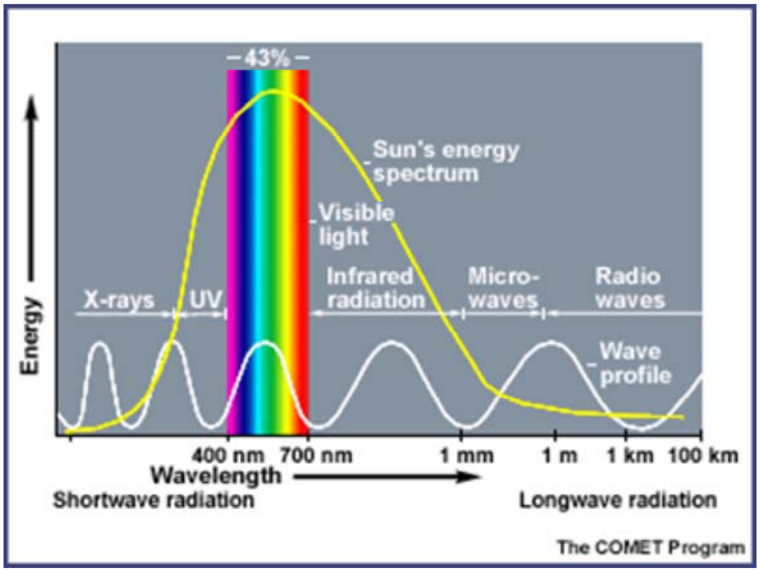
Instead, parts of our atmosphere act as an insulating blanket of just the right thickness, trapping sufficient solar energy to keep the global average temperature in a pleasant range. The Martian atmospheric blanket is too thin, and the Venusian atmospheric blanket is way too thick! The 'blanket' here is a collection of atmospheric gases called 'greenhouse gases' based on the idea that the gases also 'trap' heat like the glass walls of a greenhouse do. The ability of certain trace gases to be relatively transparent to incoming visible light from the sun, yet opaque to the energy radiated from the earth is one of the best understood processes in the atmospheric sciences. This phenomenon, the greenhouse effect, is what makes the earth habitable for life.



These gases, mainly water vapor (H_2O), carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), all act as effective global insulators. To understand why, it's important to understand a few basic facts about solar radiation and the structure of atmospheric gases.

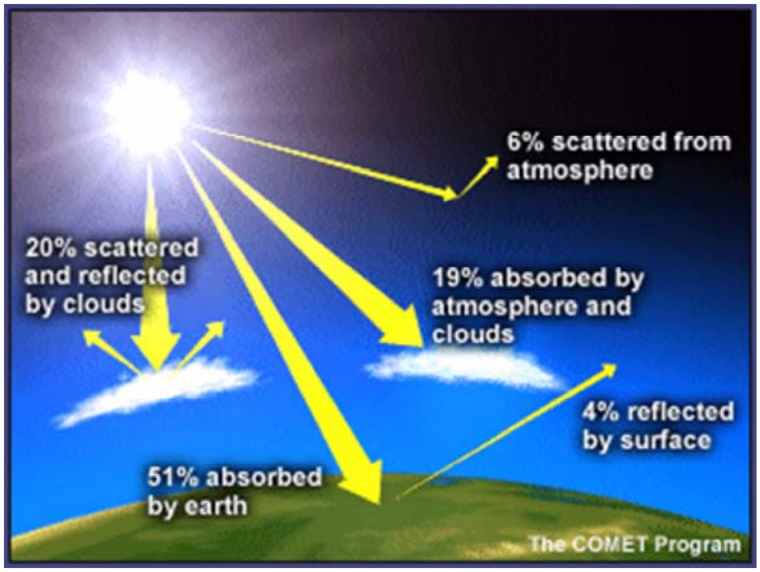
Solar Radiation

The sun radiates vast quantities of energy into space, across a wide spectrum of wavelengths.



Most of the radiant energy from the sun is concentrated in the visible and near-visible parts of the spectrum. The narrow band of visible light, between 400 and 700 nm, represents 43% of the total radiant energy emitted. Wavelengths shorter than the visible account for 7 to 8% of the total, but are extremely important because of their high energy per photon. The shorter the wavelength of light, the more energy it contains. Thus, ultraviolet light is very energetic (capable of breaking apart stable biological molecules and causing sunburn and skin cancers). The remaining 49 - 50% of the radiant energy is spread over the wavelengths longer than those of visible light. These lie in the near infrared range from 700 to 1000 nm; the thermal infrared, between 5 and 20 microns; and the far infrared regions. Various components of earth's atmosphere absorb ultraviolet and infrared solar radiation before it penetrates to the surface, but the atmosphere is quite transparent to visible light.

QuickTime Ultra-Violet Rays: A Hidden Danger (01:45)



Absorbed by land, oceans, and vegetation at the surface, the visible light is transformed into heat and re-radiates in the form of invisible infrared radiation. If that was all there was to the story, then during the day earth would heat up, but at night, all the accumulated energy would radiate back into space and the planet's surface temperature would fall far below zero very rapidly. The reason this doesn't happen is that earth's atmosphere contains molecules that absorb the heat and re-radiate the heat in all directions. This reduces the heat radiated out to space. Called 'greenhouse gases' because they serve to hold heat in like the glass walls of a greenhouse, these molecules are responsible for the fact that the earth enjoys temperatures suitable for our active and complex biosphere.

These greenhouse gases are held in the atmosphere. The atmosphere contains four major layers; these are the troposphere, the stratosphere, the mesosphere, and the thermosphere. These layers are created because of the different molecules, temperatures and air pressures found in the atmosphere. You also need to remember that the closer you get to space, the less gravity affects you.

Let's start with the lowest and densest layer of the atmosphere, the troposphere. This layer starts at Earth's surface and extends about 6 miles upward. Due to the stored radiant energy, the troposphere is warmest near the surface of the Earth. As we travel up through this layer, temperature begins to drop to about -51 Celsius. As the altitude increases, the air pressure decreases. All Earth's weather happens in the troposphere. This layer of the atmosphere is about 78% nitrogen, 21% oxygen, and 1% other trace gases.

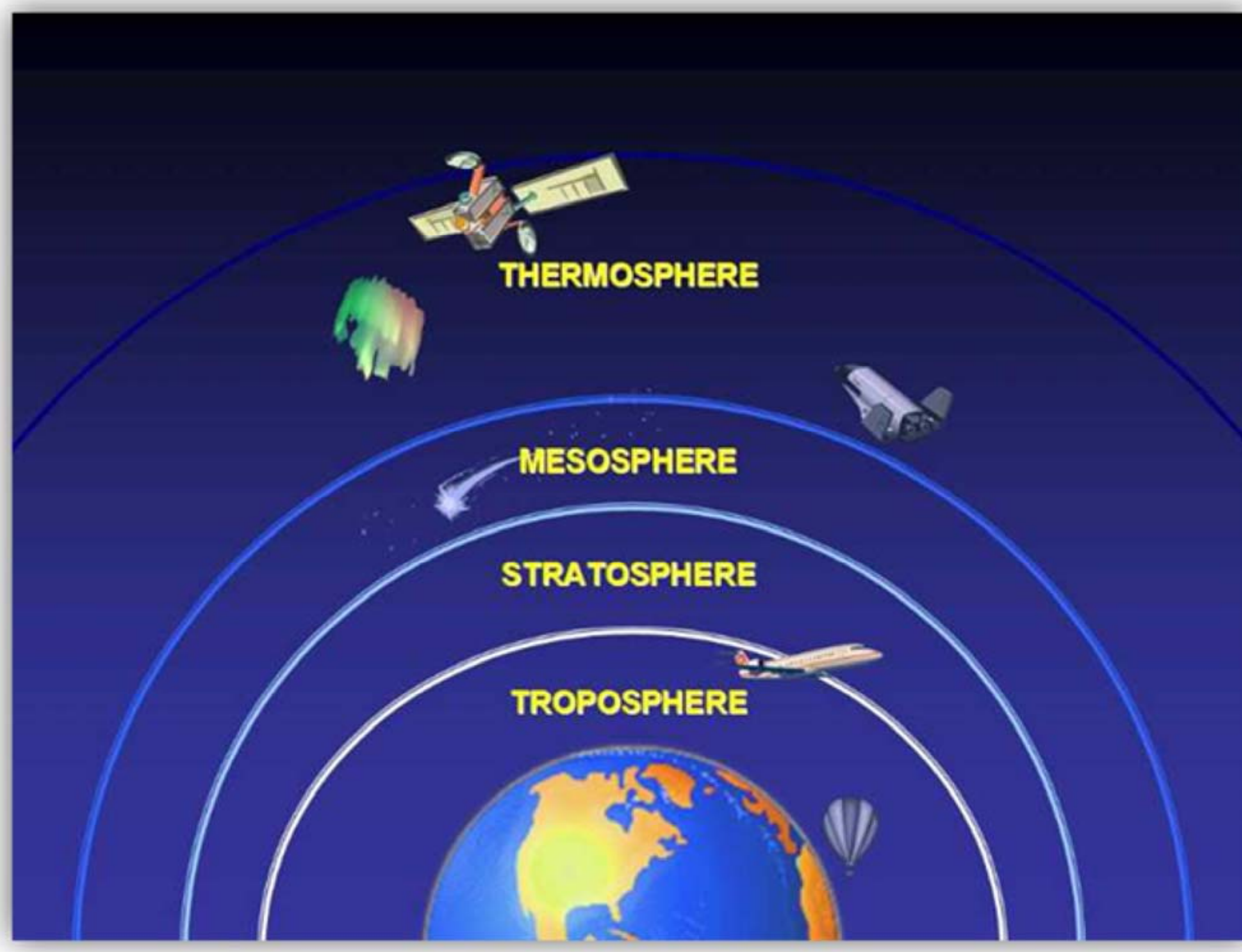
The stratosphere comes next and it is the next densest layer. This layer starts at 7 miles from the Earth and extends to 31 miles above Earth's surface. The stratosphere increases in temperature from a low -51 degrees Celsius to -3 degrees Celsius. A major component of this layer is the Ozone Layer. This is a belt of O3 molecules, three oxygens connected together. The Ozone layer is responsible for absorbing extreme amounts of ultraviolet radiation. The space below the Ozone Layer is cooler than that above because the Ozone keeps the heat from the sun's energy is the higher levels of the stratosphere. You will learn more about the Ozone later in this unit.

The third level is the mesosphere; it ranges from 31 to 53 miles above Earth's surface. This layer starts off -3 degrees Celsius and continues to get colder to -90 degrees Celsius. Little is known about the mesosphere, because it is too high for air craft and too low for space craft. But we do know that in this layer meteorites heading towards Earth burn up, creating shooting stars.

The last layer is the thermosphere. The highest part of this layer reaches 621 miles high. The temperature increases from -90 degrees Celsius to 1000 degrees. There are few molecules this layer, but the molecules that are there absorb great amounts of energy. Temperate measures the energy of the molecules, not the amount of heat. So even though the temperature reads that it is extremely hot, it's not as hot as you might think. This is also where the Aurora Borealis or Northern Lights and the Aurora Australis or Southern Lights occur. These lights in the sky happen when electrons collide in this layer. The thermosphere is the home to the International Space Station. This is a space craft that is housing humans and used as a science lab.

To explore more about the International Space Station click the link below.

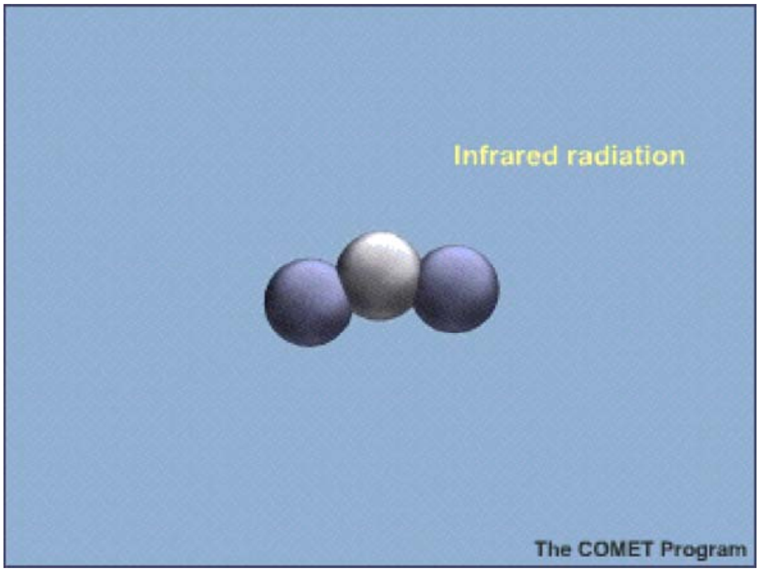
http://www.nasa.gov/audience/forstudents/k-4/stories/nasa-knows/what-is-the-iss-k4.html



Atmosphere (05:08)

Greenhouse Gases

Carbon dioxide (CO_2) is one of the greenhouse gases. It consists of one carbon atom with an oxygen atom bonded to each side. When its atoms are bonded tightly together, the carbon dioxide molecule can absorb infrared radiation and the molecule starts to vibrate. Eventually, the vibrating molecule will emit the radiation again, and it will likely be absorbed by yet another greenhouse gas molecule. This absorption-emission-absorption cycle serves to keep the heat near the surface, effectively insulating the surface from the cold of space.



Carbon dioxide, water vapor (H_2O), methane (CH_4), nitrous oxide (N_2O), and a few other gases are greenhouse gases. They all are molecules composed of more than two component atoms, bound loosely enough together to be able to vibrate with the absorption of heat. The major components of the atmosphere (N_2 and O_2) are two-atom molecules too tightly bound together to vibrate and thus they do not absorb heat and contribute to the greenhouse effect.

How the Energy of Large Cities Affects Weather and Climate (03:19)

Greenhouse Effect

Atmospheric scientists first used the term 'greenhouse effect' in the early 1800s. At that time, it was used to describe the naturally occurring functions of trace gases in the atmosphere and did not have any negative connotations. It was not until the mid-1950s that the term greenhouse effect was coupled with concern over climate change. In recent decades, we often hear about the greenhouse effect in somewhat negative terms. The negative concerns are related to the possible impacts of an **enhanced** greenhouse effect. It is important to remember that without the greenhouse effect, life on earth as we know it would not be possible.

The greenhouse effect is a natural process by which some of the radiant heat from the Sun is captured in the lower atmosphere of the Earth, thus maintaining the temperature of the Earth's surface. The gases that help capture the heat, called "greenhouse gases," include water vapor, carbon dioxide, methane, nitrous oxide, and a variety of manufactured chemicals. Some are emitted from natural sources; others are anthropogenic, resulting from human activities.

Over the past several decades, rising concentrations of greenhouse gases have been detected in the Earth's atmosphere. Although there is not universal agreement within the scientific community on the impacts of increasing concentrations of greenhouse gases, it has been theorized that they may lead to an increase in the average temperature of the Earth's surface. To date, it has been difficult to note such an increase conclusively because of the differences in temperature around the Earth and throughout the year, and because of the difficulty of distinguishing permanent temperature changes from the normal fluctuations of the Earth's climate. In addition, there is not universal agreement among scientists and climatologists on the potential impacts of an increase in the average temperature of the Earth, although it has been hypothesized that it could lead to a variety of changes in the global climate, sea level, agricultural patterns, and ecosystems that could be, on average, detrimental.

While the earth's temperature is dependent upon the greenhouse-like action of the atmosphere, the amount of heating and cooling are strongly influenced by several factors just as greenhouses are affected by various factors.

In the atmospheric greenhouse effect, the type of surface that sunlight first encounters is the most important factor. Forests, grasslands, ocean surfaces, ice caps, deserts, and cities all absorb, reflect, and radiate radiation differently. Sunlight falling on a white glacier surface strongly reflects back into space, resulting in minimal heating of the surface and lower atmosphere. Sunlight falling on a dark desert soil is strongly absorbed, on the other hand, and contributes to significant heating of the surface and lower atmosphere. Cloud cover also affects greenhouse warming by both reducing the amount of solar radiation reaching the earth's surface and by reducing the amount of radiation energy emitted into space.

Scientists use the term **albedo** to define the percentage of solar energy reflected back by a surface. Understanding local, regional, and global albedo effects is critical to predicting global climate change. Some factors that influence the earth's albedo are summarized below.

- **Clouds:** On a hot, sunny day, we usually welcome a big fluffy cumulus cloud passing overhead because we feel cooler immediately. That's because the top of the cloud reflects sunlight back into space before it ever reaches earth. Depending on their altitude and optical properties, clouds either cool or warm the earth. Large, thick, relatively low-altitude clouds, such as cumulus and cumulonimbus, reflect incoming solar radiation and thereby reduce warming of the surface. The whitewash on plant greenhouses has the same effect on a smaller scale. High-altitude, thinner clouds, such as cirrus clouds, absorb long wave radiation reflected from the earth's surface, causing increased warming.

		
Cirrus	*Cumulus*	*Nimbus*

- **Surface albedo:** Just as some clouds reflect solar energy into space, so do light-colored land surfaces. This surface albedo effect strongly influences the absorption of sunlight. Snow and ice cover are highly reflective, as are light-colored deserts. Large expanses of reflective surfaces can significantly reduce solar warming. Dark-colored land surfaces, in contrast, are strongly absorptive and contribute to warming. If global temperatures increase, snow and ice cover may shrink. The exposed darker surfaces underneath may absorb more solar radiation, causing further warming. The magnitude of the effect is currently a matter of serious scientific study and debate.

- **Oceans:** From space, oceans look much different than adjacent land areas - they often appear darker, suggesting that they should be absorbing far more sunlight. But unlike dry land, water absorbs energy in a dynamic fashion. Some of the solar energy contacting the surface may be carried away by currents, some may go into producing water vapor, and some may penetrate the surface and be mixed meters deep into the water column. These factors combine to make the influence of the ocean surface an extremely complex and difficult phenomenon to predict.

  Water also has the capacity to store heat and transport large amounts of heat energy. In addition, oceans are an important sink (storage site) for atmospheric carbon dioxide, and their ability to absorb CO_2 is strongly related to ocean temperature. Because of their enormous size and depth, oceans are extremely important in determining global climate and the future rate of global temperature change.

- **Forested areas:** Like the oceans, the interaction of forests and sunlight is complex. The amount of solar radiation absorbed by forest vegetation depends upon the type and color of vegetation, the time of year, and how well watered and healthy the plants are. In general, plants provide a dark surface, so you might expect high solar absorption. A significant fraction of the solar radiation is captured by the plants and used to make food through photosynthesis (and thus it doesn't re-radiate as heat); some of the energy is dissipated as water evaporates from plant leaves; and some is absorbed and distributed deep within the forest canopy. These complexities make a simple definition of forest influences impossible. To a lesser extent, the same complexities apply to any relatively continuous-cover ecosystem (for example, grasslands and farmlands).

Global Warming

Global warming is the gradual increase of the temperature of the Earth's lower atmosphere as a result of the increase in greenhouse gases since the Industrial Revolution.

The temperature of the atmosphere near the earth's surface is warmed through a natural process called the greenhouse effect. Visible, shortwave light comes from the sun to the earth, passing unimpeded through a blanket of thermal, or greenhouse, gases composed largely of water vapor, carbon dioxide, methane, nitrous oxide, and ozone. Infrared radiation reflects off the planet's surface toward space but does not easily pass through the thermal blanket. Some of it is trapped and reflected downward, keeping the planet at an average temperature suitable to life, about 60°F (16°C).

Growth in industry, agriculture, and transportation since the Industrial Revolution has produced additional quantities of natural greenhouse gases plus **chlorofluorocarbons** and other gases, augmenting the thermal blanket. It is generally accepted that this increase in the quantity of greenhouse gases is trapping more heat and increasing global temperatures, making a process that has been beneficial to life potentially disruptive and harmful. During the past century, the atmospheric temperature has risen 1.1°F (0.6°C), and sea level has risen several inches. Some projected, longer-term results of global warming include melting of polar ice, with a resulting rise in sea level and coastal flooding; disruption of drinking water supplies dependent on snow melts; profound changes in agriculture due to climate change; extinction of species as ecological niches disappear; more frequent tropical storms; and an increased incidence of tropical diseases.

Among factors that may be contributing to global warming are the burning of coal and petroleum products (sources of carbon dioxide, methane, nitrous oxide, ozone); deforestation, which increases the amount of carbon dioxide in the atmosphere; methane gas released in animal waste; and increased cattle production, which contributes to deforestation, methane production, and use of fossil fuels.

Much of the debate surrounding global warming has centered on the accuracy of scientific predictions concerning future warming. To predict global climatic trends, climatologists accumulate large historical databases and use them to create computerized models that simulate the earth's climate. The validity of these models has been a subject of controversy. Skeptics say that the climate is too complicated to be accurately modeled, and that there are too many unknowns. Some also question whether the observed climate changes might simply represent normal fluctuations in global temperature. Nonetheless, for some time there has been general agreement that at least part of the observed warming is the result of human activity, and that the problem needs to be addressed. In 1992, at the United **Nations Conference on Environment and Development**, over 150 nations signed a binding declaration on the need to reduce global warming.

In 1994, however, a UN scientific advisory panel, the Intergovernmental Panel on Climate Change, concluded that reductions beyond those envisioned by the treaty would be needed to avoid global warming. The following year, the advisory panel forecast a rise in global temperature of from 1.44 to 6.3°F (0.8–3.5°C) by 2100 if no action is taken to cut down on the production of greenhouse gases, and a rise of from 1 to 3.6°F (0.5–2°C) even if action is taken (because of already released gases that will persist in the atmosphere).

A UN Conference on Climate Change, held in Kyoto, Japan, in 1997 resulted in an international agreement to fight global warming, which called for reductions in emissions of greenhouse gases by industrialized nations. Not all industrial countries, however, immediately signed or ratified the accord. In 2001 the G. W. Bush administration announced it would abandon the Kyoto Protocol; because the United States produces about one quarter of the world's greenhouse gases, this was regarded as a severe blow to the effort to slow global warming. Despite the American move, most other nations agreed later in the year (in Bonn, Germany, and in Marrakech, Morocco) on the details necessary to convert the agreement into a binding international treaty.

Improved automobile mileage, reforestation projects, energy efficiency in construction, and national support for mass transit are among relatively simpler adjustments that could significantly lower U.S. production of greenhouse gases. More aggressive adjustments include a gradual worldwide shift away from the use of fossil fuels, the elimination of chlorofluorocarbons, and the slowing of deforestation by restructuring the economies of developing nations. In 2002 the Bush administration proposed several voluntary measures for slowing the increase in, instead of reducing, emissions of greenhouses gases.

The Ozone Layer

The Earth's atmosphere is divided into several layers. The lowest region, the troposphere, extends from the Earth's surface up to about 10 kilometers (km) in altitude. The next layer, the stratosphere, continues from 10 km to about 50 km. Most atmospheric ozone is concentrated in a layer in the stratosphere, about 15–30 kilometers above the Earth's surface.

Ozone is a molecule containing three oxygen atoms. It is blue in color and has a strong odor. Normal oxygen, which we breathe, has two oxygen atoms and is colorless and odorless. Ozone is much less common than normal oxygen. Out of each 10 million air molecules, about 2 million are normal oxygen, but only 3 are ozone.

However, even the small amount of ozone plays a key role in the atmosphere. The ozone layer absorbs a portion of the radiation from the sun, preventing it from reaching the planet's surface. Most importantly, it absorbs the portion of ultraviolet light called UVB. UVB has been linked to many harmful effects, including various types of skin cancer, cataracts, and harm to some crops, certain materials, and some forms of marine life.

At any given time, ozone molecules are constantly formed and destroyed in the stratosphere. The total amount, however, remains relatively stable. While ozone concentrations vary naturally with sunspots, the seasons, and latitude, these processes are well understood and predictable. Each natural reduction in ozone levels has been followed by a recovery.

Recently, however, convincing scientific evidence has shown that the ozone shield is being depleted well beyond changes due to natural processes.

QuickTime Ozone: Harmful and Helpful (03:56)

Ozone Depletion

For over 50 years, chlorofluorocarbons, or CFCs, were thought of as miracle substances. They are stable, nonflammable, low in toxicity, and inexpensive to produce. Over time, CFCs found uses as refrigerants, solvents, foam blowing agents, and in other smaller applications. Other chlorine-containing compounds include methyl chloroform, a solvent, and carbon tetrachloride, an industrial chemical. Halons, extremely effective fire extinguishing agents, and methyl bromide, an effective produce and soil fumigant, contain bromine. All of these compounds have atmospheric lifetimes long enough to allow them to be transported by winds into the stratosphere. Because they release chlorine or bromine when they break down, they damage the protective ozone layer.

In the early 1970s, researchers began to investigate the effects of various chemicals on the ozone layer, particularly CFCs, which contain chlorine. They also examined the potential impacts of other chlorine sources. Chlorine from swimming pools, industrial plants, sea salt, and volcanoes does not reach the stratosphere. Chlorine compounds from these sources readily combine with water and repeated measurements show that they rain out of the troposphere very quickly. In contrast, CFCs are very stable and do not dissolve in rain. Thus, there are no natural processes that remove the CFCs from the lower atmosphere. Over time, winds drive the CFCs into the stratosphere.

The CFCs are so stable that only exposure to strong UV radiation breaks them down. When that happens, the CFC molecule releases atomic chlorine. One chlorine atom can destroy over 100,000 ozone molecules. The net effect is to destroy ozone faster than it is naturally created.

Why is the ozone layer important?

The ozone layer is a concentration of ozone molecules in the stratosphere. About 90% of the planet's ozone is in the ozone layer. The layer of the Earth's atmosphere that surrounds us is called the troposphere. The stratosphere, the next higher layer, extends about 10–50 kilometers above the Earth's surface. Stratospheric ozone is a naturally occurring gas that filters the sun's ultraviolet (UV) radiation. A diminished ozone layer allows more radiation to reach the Earth's surface. For people, overexposure to UV rays can lead to skin cancer, cataracts, and weakened immune systems. Increased UV can also lead to reduced crop disruptions in the marine food chain, and other harmful effects.

How does ozone depletion occur?

It is caused by the release of chlorofluorocarbons (CFCs) and other ozone-depleting substances (ODS), which were used widely as refrigerants, insulating foams, and solvents. The discussion below focuses on CFCs, but is relevant to all ODS. Although CFCs are heavier than air, they are eventually carried into the stratosphere in a process that can take as long as 2 to 5 years.

When CFCs reach the stratosphere, the ultraviolet radiation from the sun causes them to break apart and release chlorine atoms, which react with ozone, starting chemical cycles of ozone destruction that deplete the ozone layer. One chlorine atom can break apart more than 100,000 ozone molecules.

Other chemicals that damage the ozone layer include methyl bromide (used as a pesticide) and halons (used in fire extinguishers). As methyl bromide and halons are broken apart, they release bromine atoms, which are 40 times destructive to ozone molecules than chlorine atoms.

How do we know that natural sources are not responsible for ozone depletion?

While it is true that volcanoes and oceans release large amounts of chlorine, the chlorine from these sources is easily dissolved in water and washes out of the atmosphere in rain. In contrast, CFCs are not broken down in the lower atmosphere and do not dissolve in water. The chlorine in these human-made molecules does reach the stratosphere. Measurements show that the increase in stratospheric chlorine since 1985 matches the amount released from CFCs and other ozone-depleting substances produced and released by human activities.

What is being done about ozone depletion?

In 1978, the use of CFC propellants in spray cans was banned in the U.S. In the 1980s, the Antarctic "ozone hole" appeared and an international science assessment more strongly linked the release of CFCs and ozone depletion. It became evident that a stronger worldwide response was needed. In 1987, the Montreal Protocol was signed and the signatory nations committed themselves to a reduction in the use of CFCs and other ozone-depleting substances.

Since that time, the treaty has been amended to ban CFC production after 1995 in the developed countries, and later in developing. Today, over 160 countries have signed the treaty. Beginning January 1, 1996, only recycled and stockpiled CFCs will be available for use in developed countries like the US. This production phase-out is possible because of efforts to ensure that there will be substitute chemicals and technologies for all CFC uses.

Will the ozone layer recover? Can we make more ozone to fill in the hole?

The answers, in order, are: yes and no. We can't make enough ozone to replace what's been destroyed, but provided that we stop producing ozone-depleting substances, natural ozone production reactions should return the ozone layer to normal levels by about 2050. It is very important that the world comply with the Montreal Protocol; delays in ending production could result in additional damage and prolong the ozone layer's recovery.

How do we impact the ozone layer and global warming?

Earth has warmed by about 1ºF 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 make the Earth warmer.

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.

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.

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.

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.**

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 ….

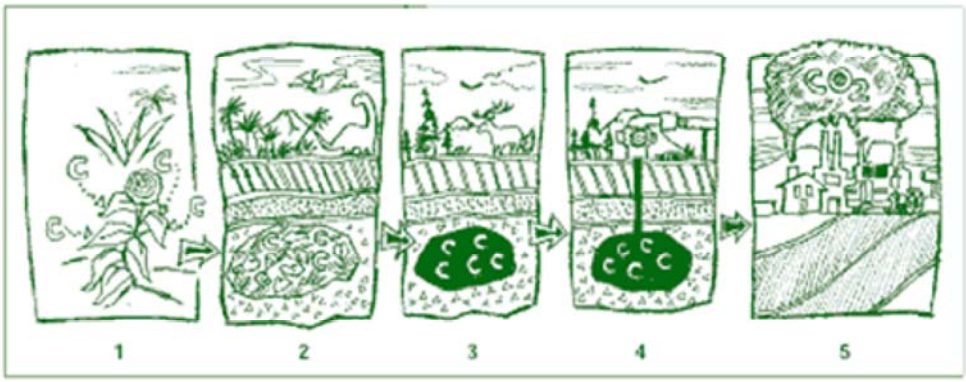
- Watch TV
- Play a Video Game
- Listen to a Stereo
- Use the Air Conditioner
- Turn on a Light
- Wash or Dry Clothes
- Use a Hair Dryer
- Use a Dish Washer
- Ride in a Car
- Microwave a Meal

…. ***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.

We Can Make a Difference!

Global warming 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
Using electricity, puts 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
Taking the bus, riding a bike, or walking saves energy.

Talk to Your Family and Friends
Talk with your family and friends about global warming. 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 global warming 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 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.

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 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.

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

The "recycle" symbol.

The "ENERGY STAR" symbol

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.

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


Solar Panels such as these can provide electricity to buildings

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.

Now answer questions 1 through 30.

Below are additional educational resources and activities for this unit.

Unit 26 Climate Change Activity