Air Pollution

Essential Standard 2.5

Understand the structure of and processes within our atmosphere.

Learning Objective 2.5.5

Explain how human activities affect air quality.

I Can Statements

At the end of this lesson, you should be able to say, with confidence:

- I can explain the difference between primary and secondary air pollutants
- I can distinguish between traditional smog and photochemical smog; explain how ozone in the troposphere is formed; explain its effects; and list preventative strategies.
- I can explain how the hole in the ozone is created, its effects on human health, and list strategies for prevention

Types of Air Pollution

Air pollution can be placed into two categories: primary air pollutants and secondary air pollutants.

Primary air pollutants are emitted directly into the air from the source.

Secondary air pollutants are a result of chemical reactions that occur when primary pollutants mix in the air.

Smog

The term smog was first created in the early 1900's, in London, to describe the combination of smoke and fog that reduced visibility and caused respiratory problems.

Smog

Smog first began to become a problem in the early 1800's, as people began to heat their homes and cook with coal, instead of wood.

Coal Burning Stove

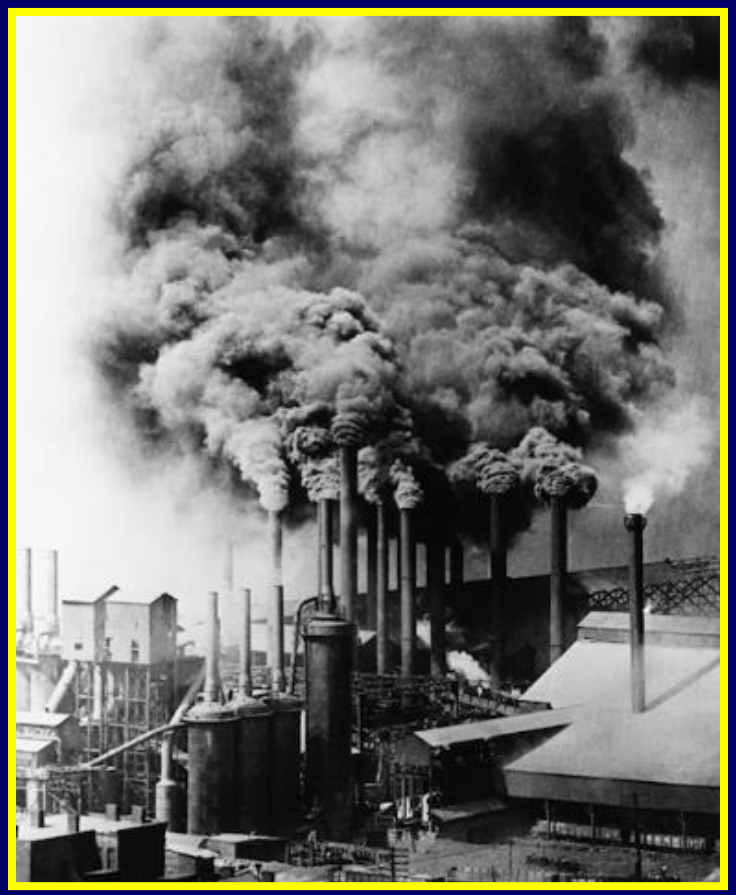
Coal Furnace

Coal Delivery & Chute

Coal was the main source of heat for homes into the 1940's, when it began to be replaced by oil and gas.

Smog

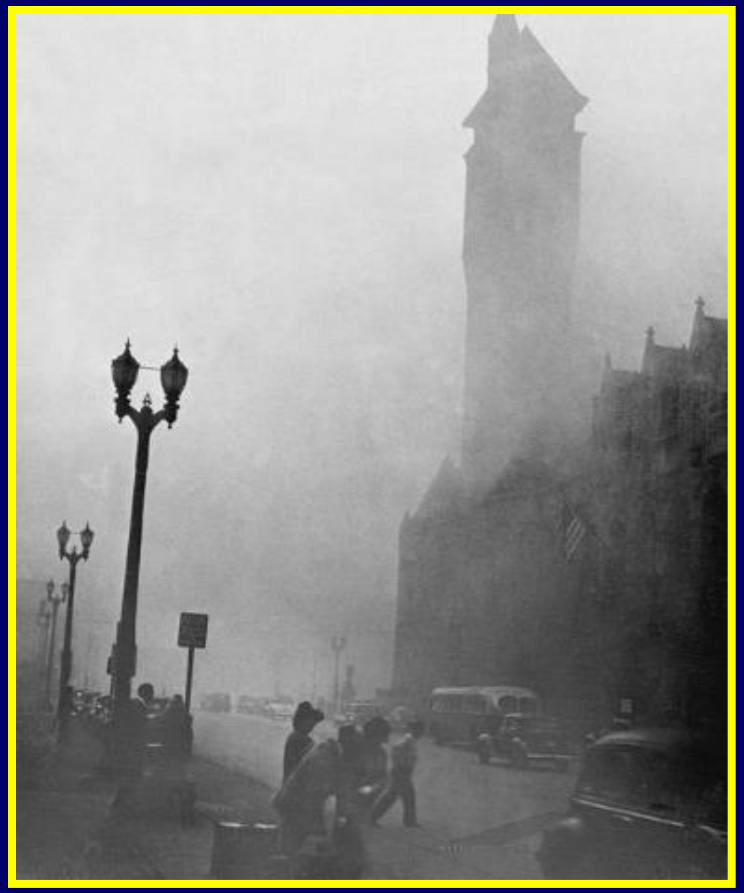
Coal was also used to fuel steam engine trains; as a heat source to melt iron in order to make steel; and by the late 1800's, to generate electricity.



This time period came to be known as the industrial revolution.

Smog

The smog not only made the air in cities dark and breathing difficult, it also covered everything with dark, black soot.



Even inside homes, the windows and walls would be covered with soot.

The tradition of spring cleaning began during this time, when it would become warm enough to stop burning coal and clean away the soot.

Smog

The soot from smog even affected wildlife and played a role in a famous example of how natural selection determines traits in species.

The peppered moth in London, England got its name due to it's sprinkling of black specks on a light grey background.

The coloring pattern helped camouflage the moths from predators as they slept on tree trunks during the day.

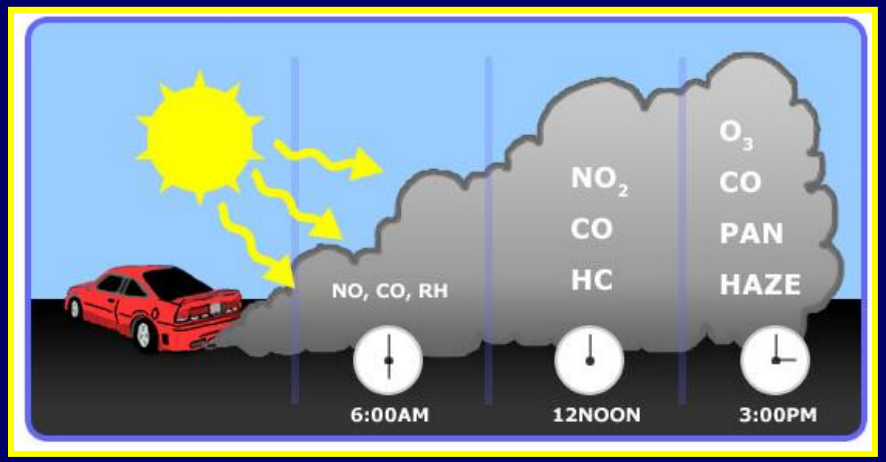
However, during the industrial revolution when soot from coal covered all the tree trunks and turned the tree trunks black, the lighter trait became a disadvantage. The peppered moths that happened to be born all black were better able to remain camouflaged and soon dominated the population.

Smog

While, traditionally, most of the smoke that formed smog usually came from coal burning plants.

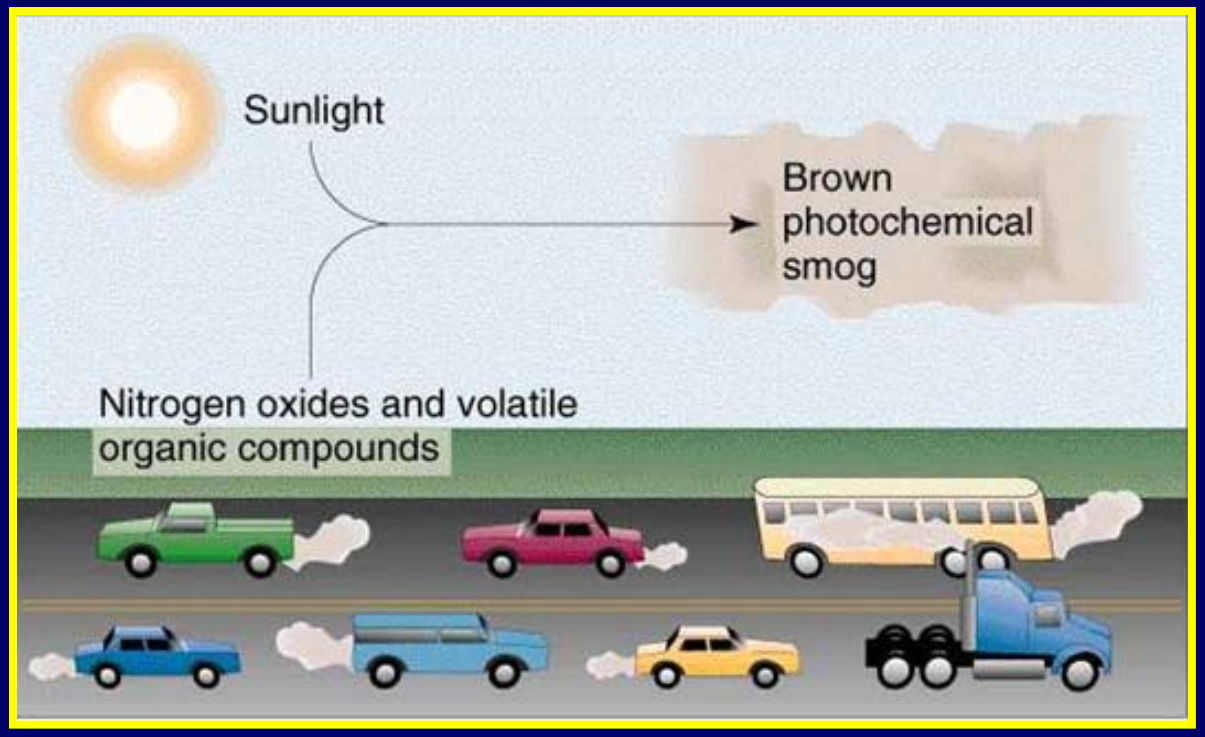
After the Clean Air Act of 1970, coal plants began using methods that reduced smog producing chemicals.

Today, most smog we see, in the United States, is photochemical smog produced from cars and other modes of transportation.



Photochemical Smog

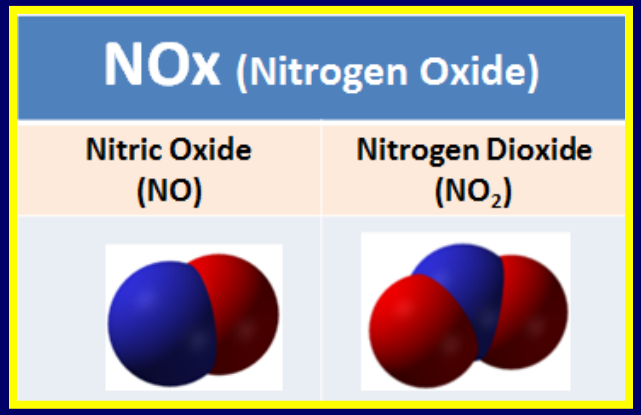
Photochemical smog is formed when sunlight reacts with nitrogen oxides (NOx) and volatile organic compounds (VOCs) which are basically hydrocarbons.



Secondary air pollutant

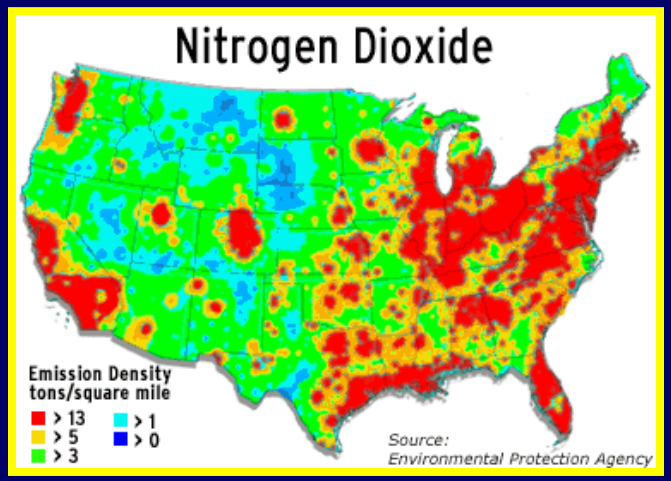
Photochemical Smog

Nitrogen oxides form when fuel is burned at high temperatures.



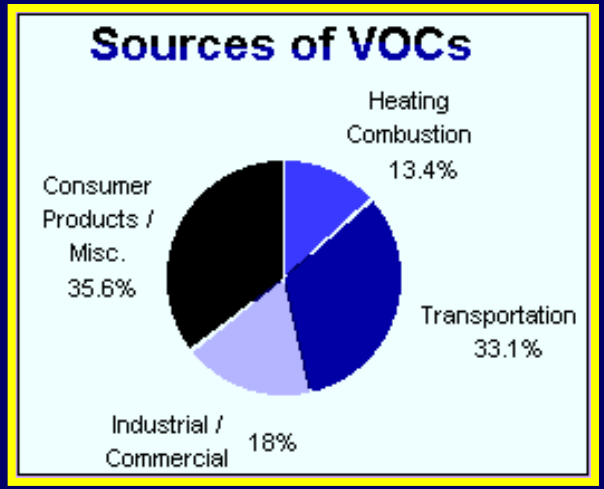
Nitrogen oxides are released by car exhaust, coal burning, and other industrial emissions.

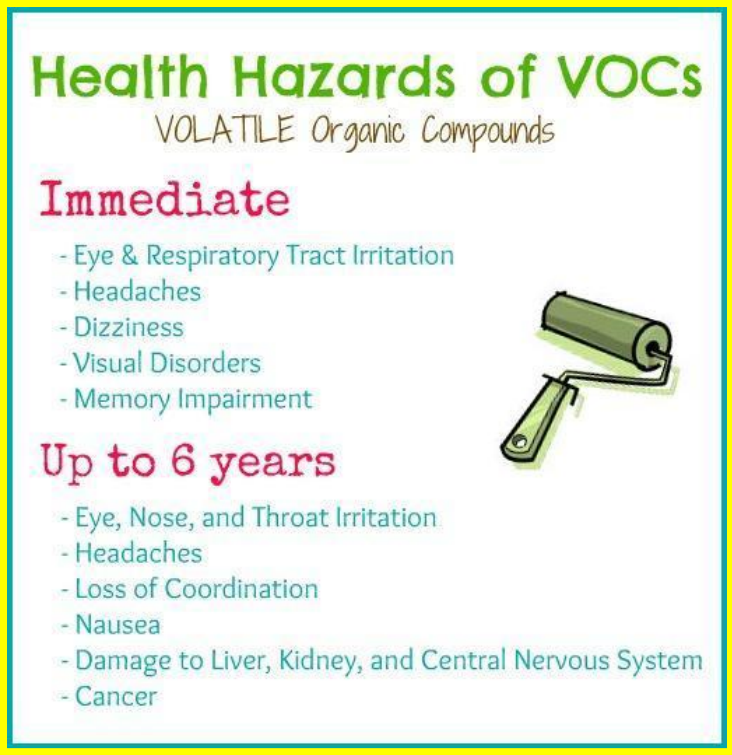
Release of nitrogen oxide into the atmosphere is mostly associated with heavily populated cities.



Photochemical Smog

Volatile organic compounds, VOCs, are released from gasoline, paints, and Dry Cleaning products.

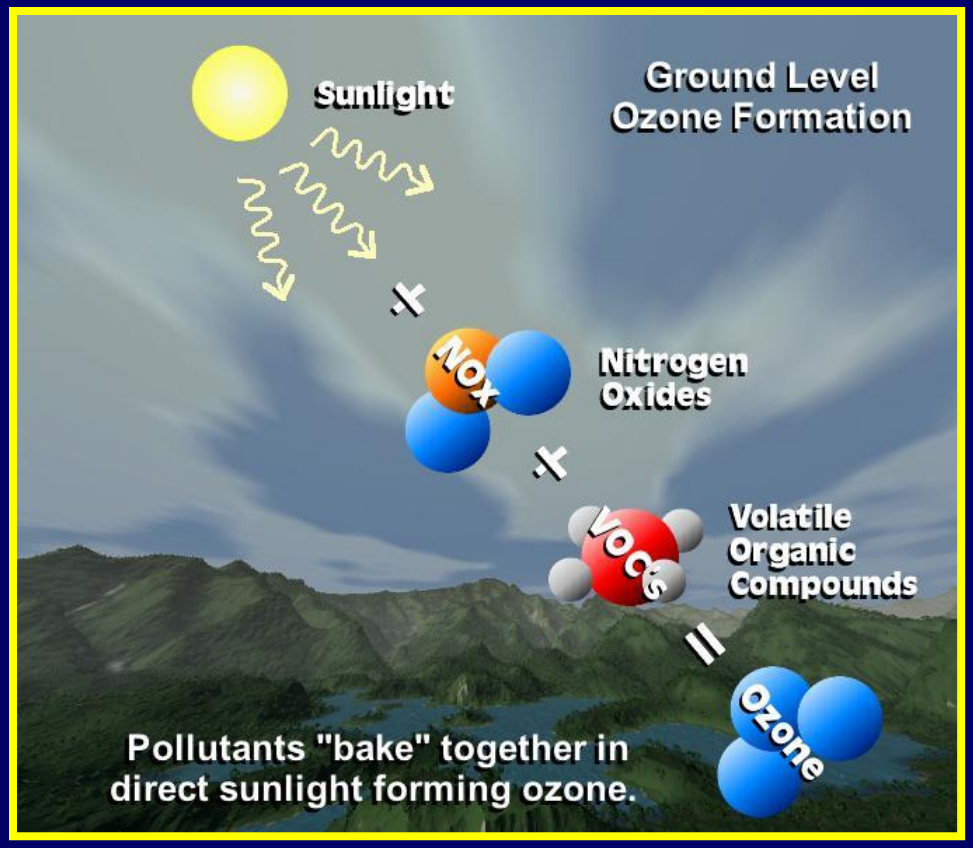


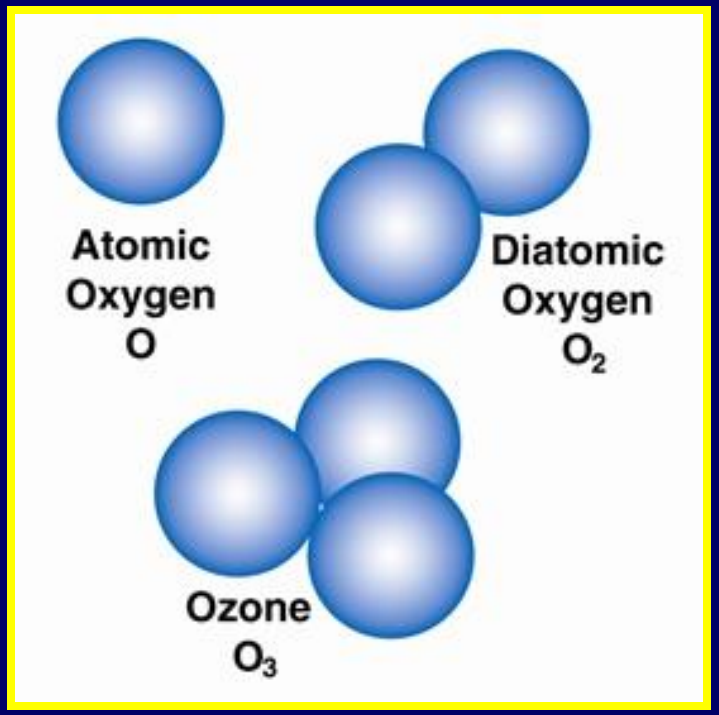


Volatile organic compounds, VOCs, can cause eye and respiratory irritation and damage, cancer, as well as liver, kidney, and central nervous system damage.

Photochemical Smog → Ozone

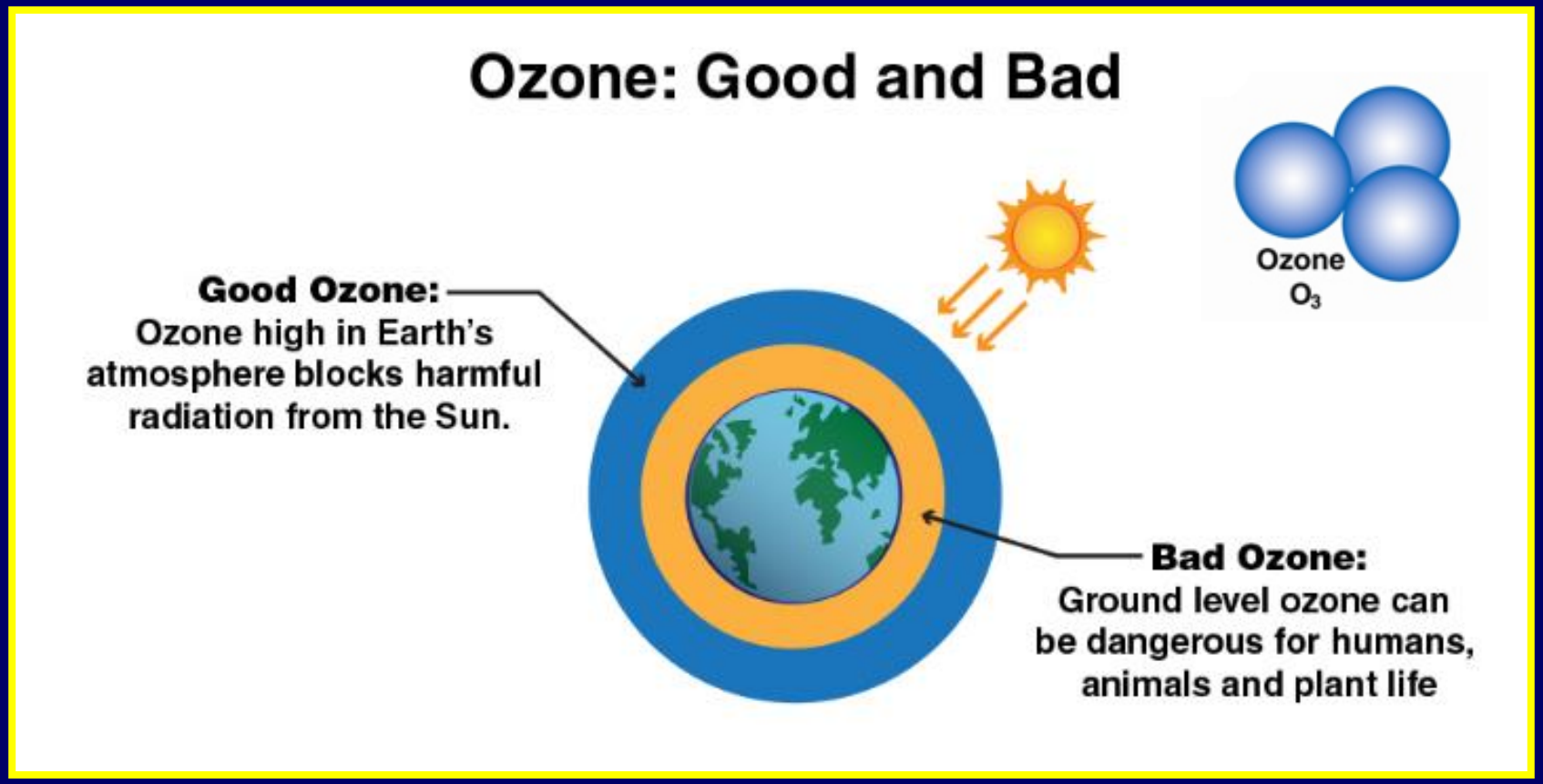
When nitrogen oxides and volatile organic compounds are exposed to sunlight, they react to form ground level ozone, O_3.





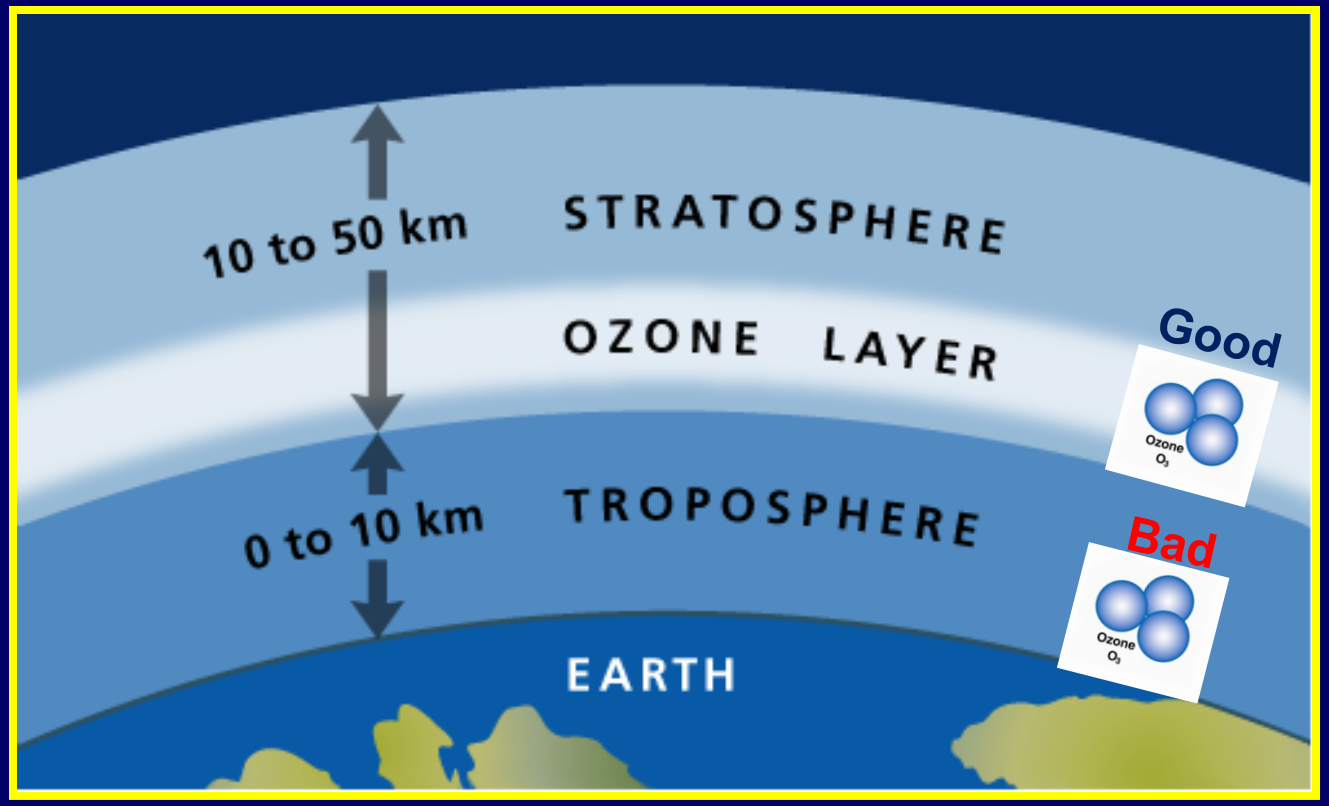
Ozone

Ozone is often referred to as good ozone or bad ozone, but both are still the same molecule - O_3.



Ozone

While ozone is beneficial to life in the stratosphere, where it blocks harmful ultraviolet radiation, ozone in the troposphere is harmful to life when it is breathed in.



Ozone in the Troposphere

With increasing populations, more automobiles, and more industry, there's more ozone in the lower atmosphere.

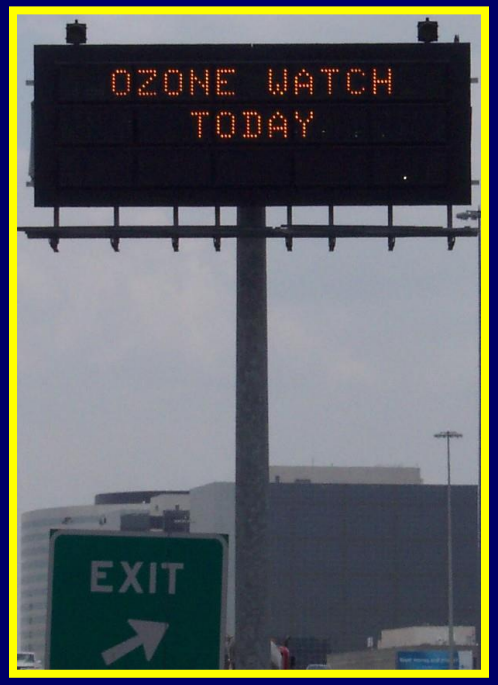
Since 1900 the amount of ozone near the earth's surface has more than doubled.

June 8, 2007

In urban areas, high ozone levels usually occur during the afternoons on warm, sunny, summer days.

Ozone in the Troposphere

People who are sensitive to air pollution should avoid moderate exertion outdoors in the afternoon.



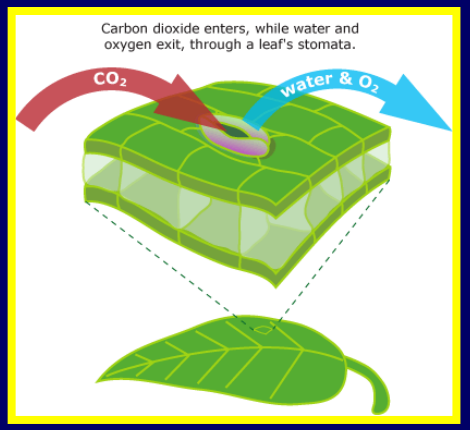
Sensitive groups include children who are active outside, people who work or exercise outdoors and those with respiratory ailments such as asthma, bronchitis, and emphysema.

During ozone alerts, officials ask residents to carpool or drive less and to avoid using gas-powered lawn equipment until later in the evening.

Ozone in the Troposphere

Ground level ozone can also cause more damage to plants than any other air pollutants combined.

Ozone enters plants through small openings in the leaves, called stomata.



Once in the plant, ozone slows down photosynthesis resulting in reduced plant growth, a decrease in the number of flowers and fruits produced, as well as making the plants more susceptible to pests, disease, and drought.

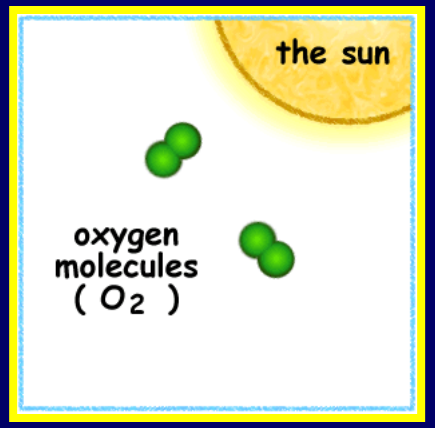
Reducing Ozone

For several decades now, many cities have taken measures to try to reduce ozone by building and promoting mass transit systems.

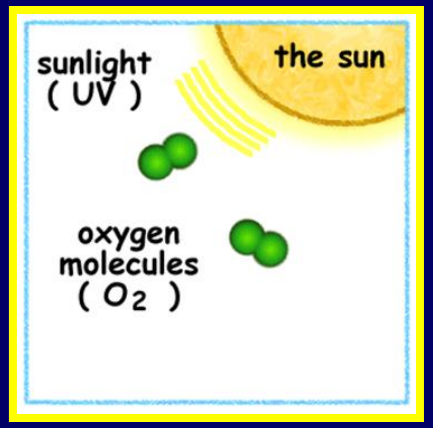
Charlotte's light rail system, HOV lanes, and extensive bus system were all created to reduce traffic and ozone pollution.

Ozone in the Stratosphere

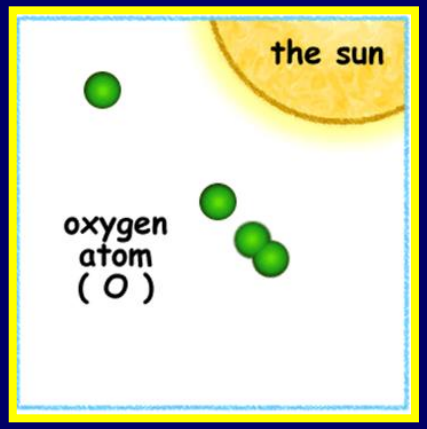
In the stratosphere, sunlight breaks down oxygen molecule, O_2, into two oxygen atoms, O.



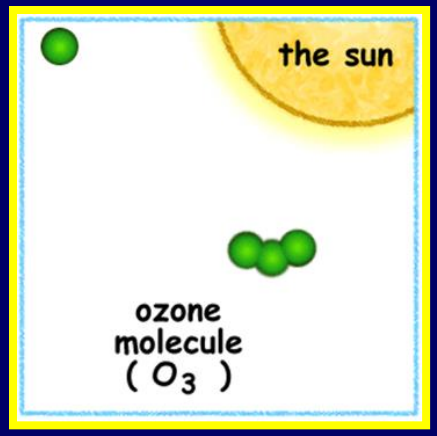
Step 1



Step 2



Step 3

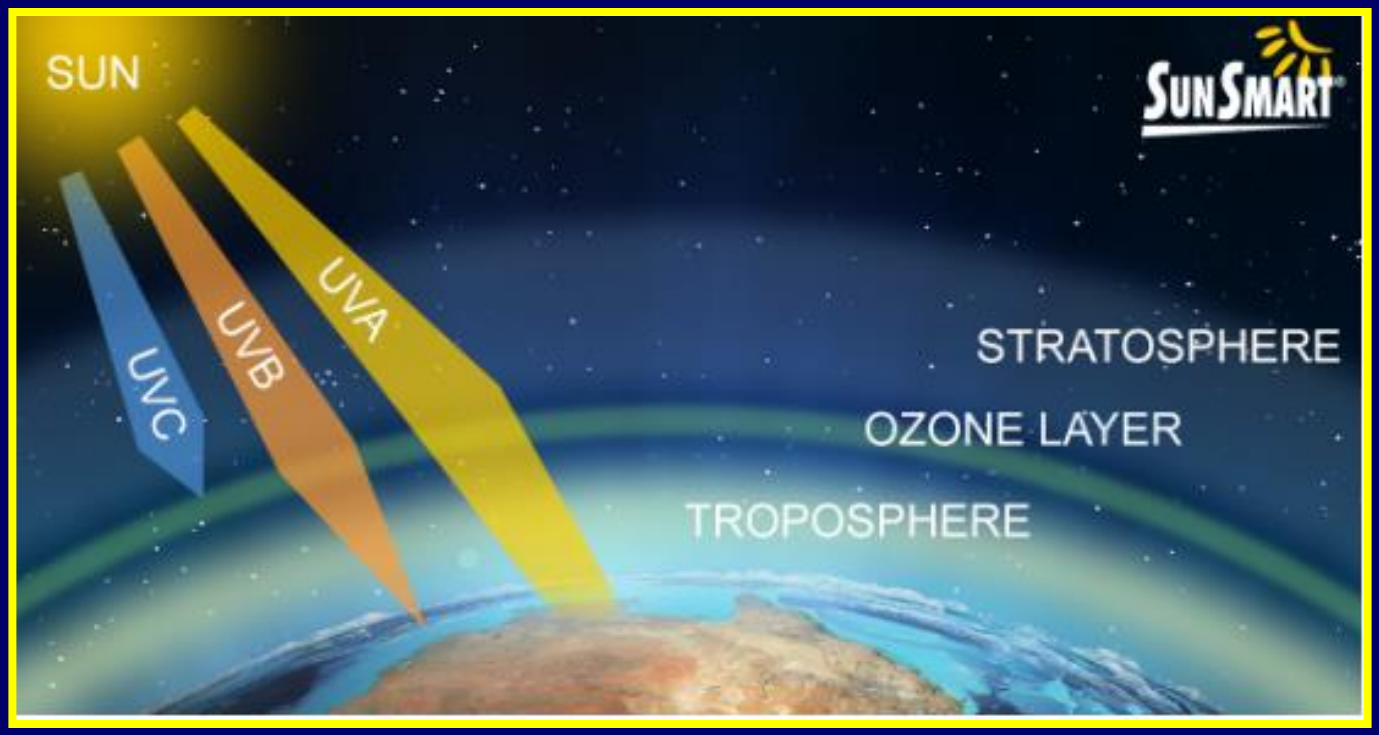


Step 4

The free Oxygen atoms, O, then react with oxygen molecules, O_2, to form ozone molecules, O_3.

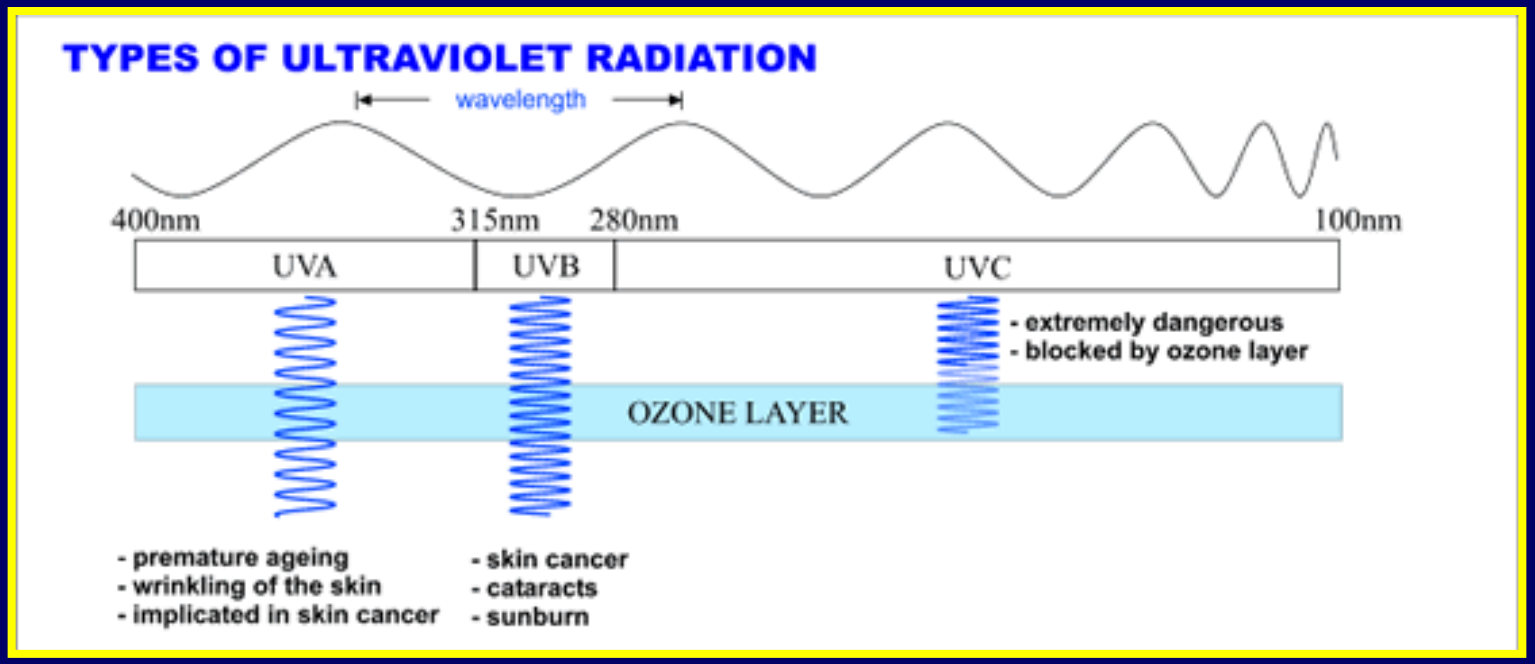
Ozone in the Stratosphere

Ozone molecules, O_3, spread out in the stratosphere to form an ozone layer that surrounds Earth and blocks most of the more harmful forms of ultraviolet, UV, radiation.



Ozone in the Stratosphere

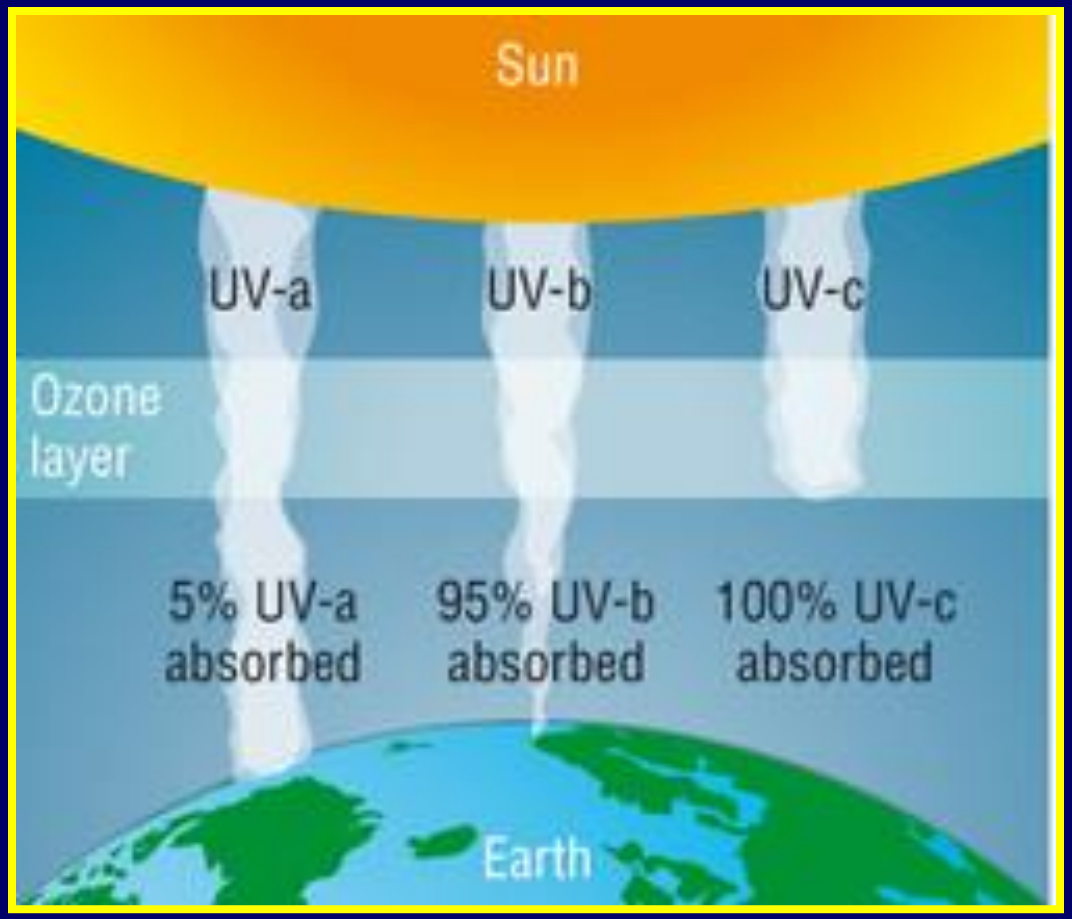
Ultraviolet radiation can be broken into 3 different types, based on wavelengths: UVA, UVB, and UVC.



UVC is the most damaging, but UVB and UVA can cause sunburns, premature aging, and skin cancer.

Ozone in the Stratosphere

The ozone layer blocks 100% of the UVC waves from reaching Earth.



The ozone layer also blocks 95% of the UVB waves.

But the ozone layer only blocks 5% of the UVA waves.

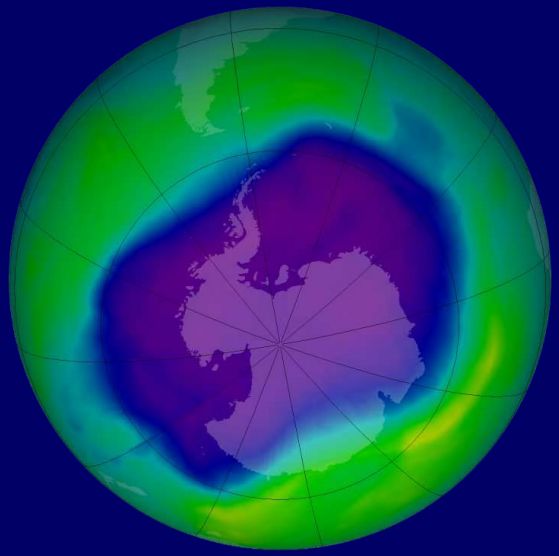
Chlorofluorocarbons

In the early 1930's, a "miracle" compound called Freon, containing chemicals called chlorofluorocarbons, CFCs, were invented to use as propellants in aerosols and refrigeration units.

Chlorofluorocarbons, CFCs, contain one carbon atom, one fluorine atom, and three chlorine atoms.

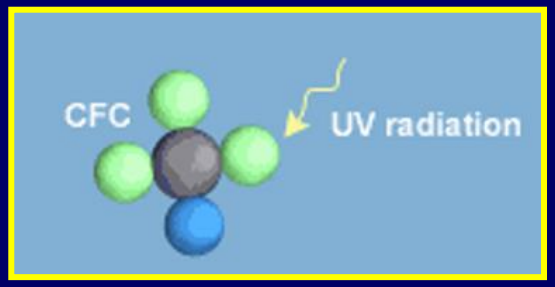
Hole in the Ozone Layer

In the late 1970's, scientists began noticing that the layer of ozone in the stratosphere was thinning, most noticeably above Antarctica.

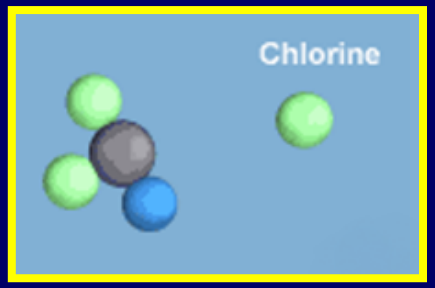


As it turned out, chlorofluorcarbons, CFC's, were breaking down the ozone molecules in the stratosphere.

Chlorofluorocarbons



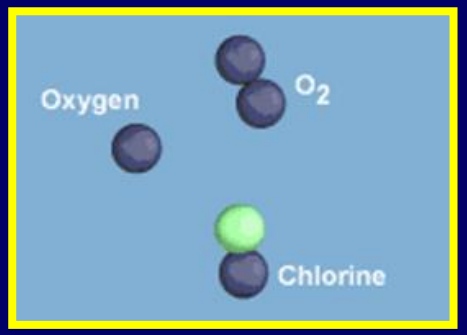
UV radiation strikes a CFC



Chlorine atom breaks free

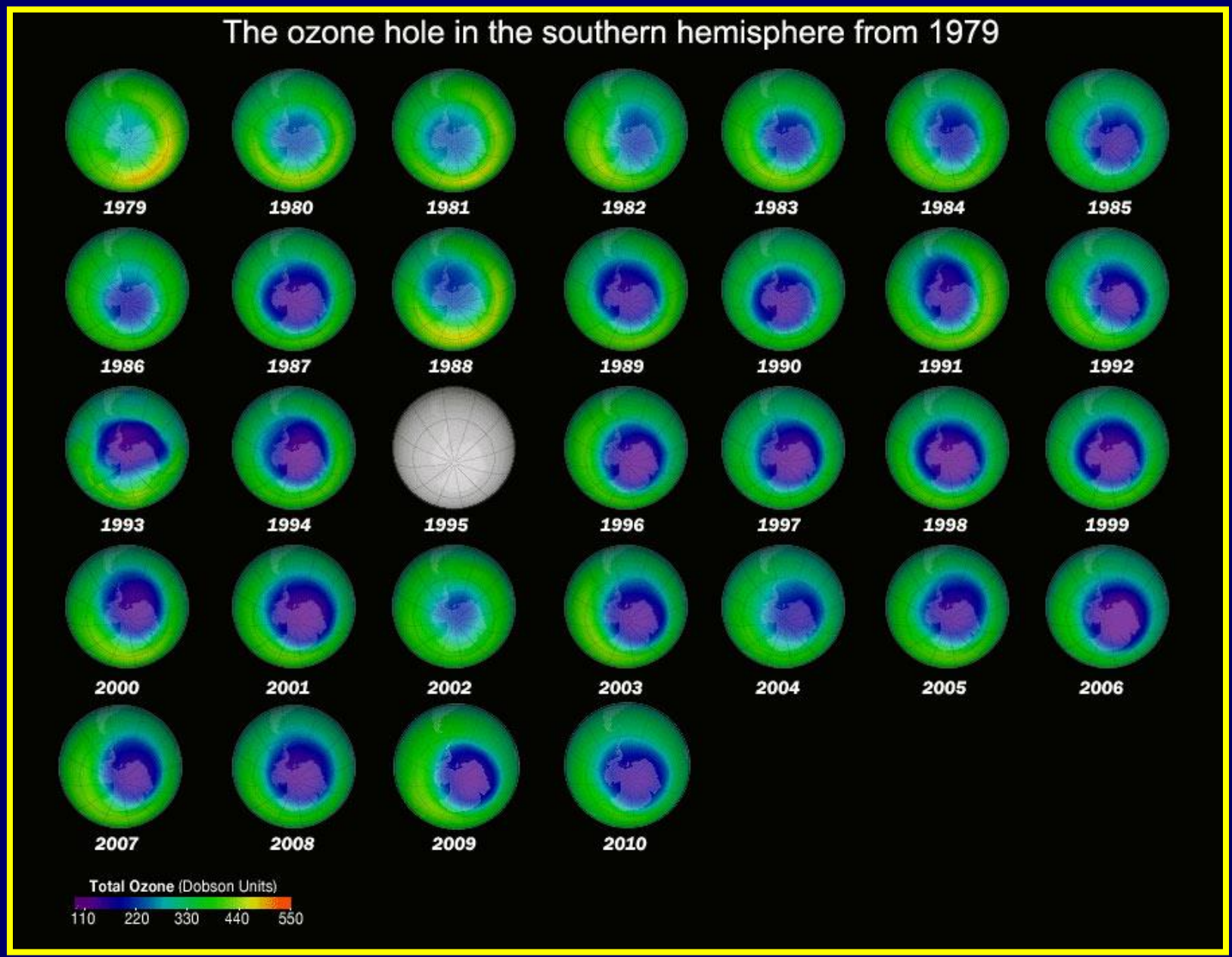
Chlorine atom bonds to ozone

One oxygen atom is removed from the ozone and bonds to the chlorine atom



The Chlorine-oxygen atoms then bond to a free oxygen atom.

The Chlorine atom then breaks free and goes on to destroy other ozone molecules.


The ozone hole in the southern hemisphere from 1979
1979
1980
1981
1982
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1986
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1992
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1994
1995
1996
1997
1998
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2000
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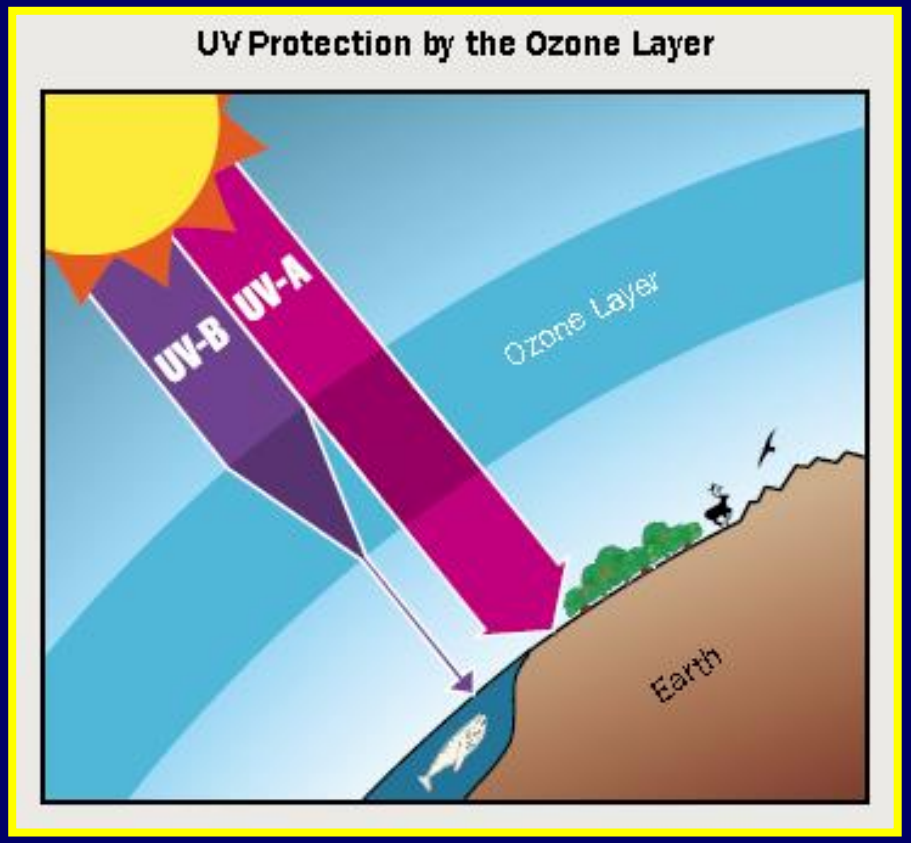
2002
2003
2004
2005
2006
2007
2008
2009
2010
Total Ozone (Dobson Units)
110
220
330
440
550

Hole in the Ozone Layer

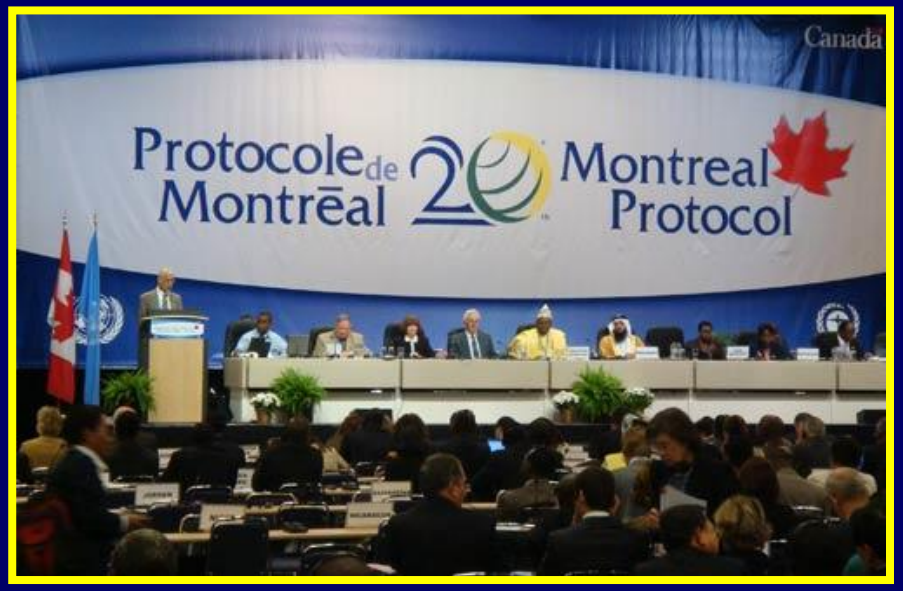
A thinning ozone layer, in the stratosphere, allowed more of the UVB radiation to reach Earth, increasing the chances of skin cancer.



Thinning the ozone layer by 1% increases the chances of skin cancer by 5%.

Montreal Protocol

In 1989, an agreement, called the Montreal Protocol, was made among national leaders to reduce and phase out the use of chemicals that break down ozone in the stratosphere.



However, since CFCs have a lifetime, in the atmosphere, from 20 to 100 years, it may take until the late part of the 21st century for the ozone layer to be fully repaired.

The End