SAVING “MOMMY CAT”

- Mommy cat became severely ill from worsening Asthma. Her Veterinarian and I found that her life span was at risk and our choices for therapy were limited. She was already on PO steroids so the only other choice was Flovent an inhalation aerosol This would take weeks to make her comfortable using the Cat-Aerosol (aerocat-For Cats is not easy to use! I felt a home Air Filter could help and with the luck of Amazon I had the Hapaspace-002 delivered the next day. It was a miracle !!

- Mommy cat over the next 24 hrs improved substantially. Over 24hrs the PM2.5 changed from the high numbers inside our house to 9-10. My education started because I didn’t have a clue on what the numbers meant so I started my education on Air Quality Control and PM2.5 and PM 10.

- Here is what I learned-it was amazing !!

HAZARDOUS AIR POLLUTION

PM 2.50-PM 10- Our Ozone layer and us at risk

DR CHRISTINE MILLER

Every day now I look up the PM and AQI

24-Hour $PM_{2.5}$ Levels (µg/m^3)

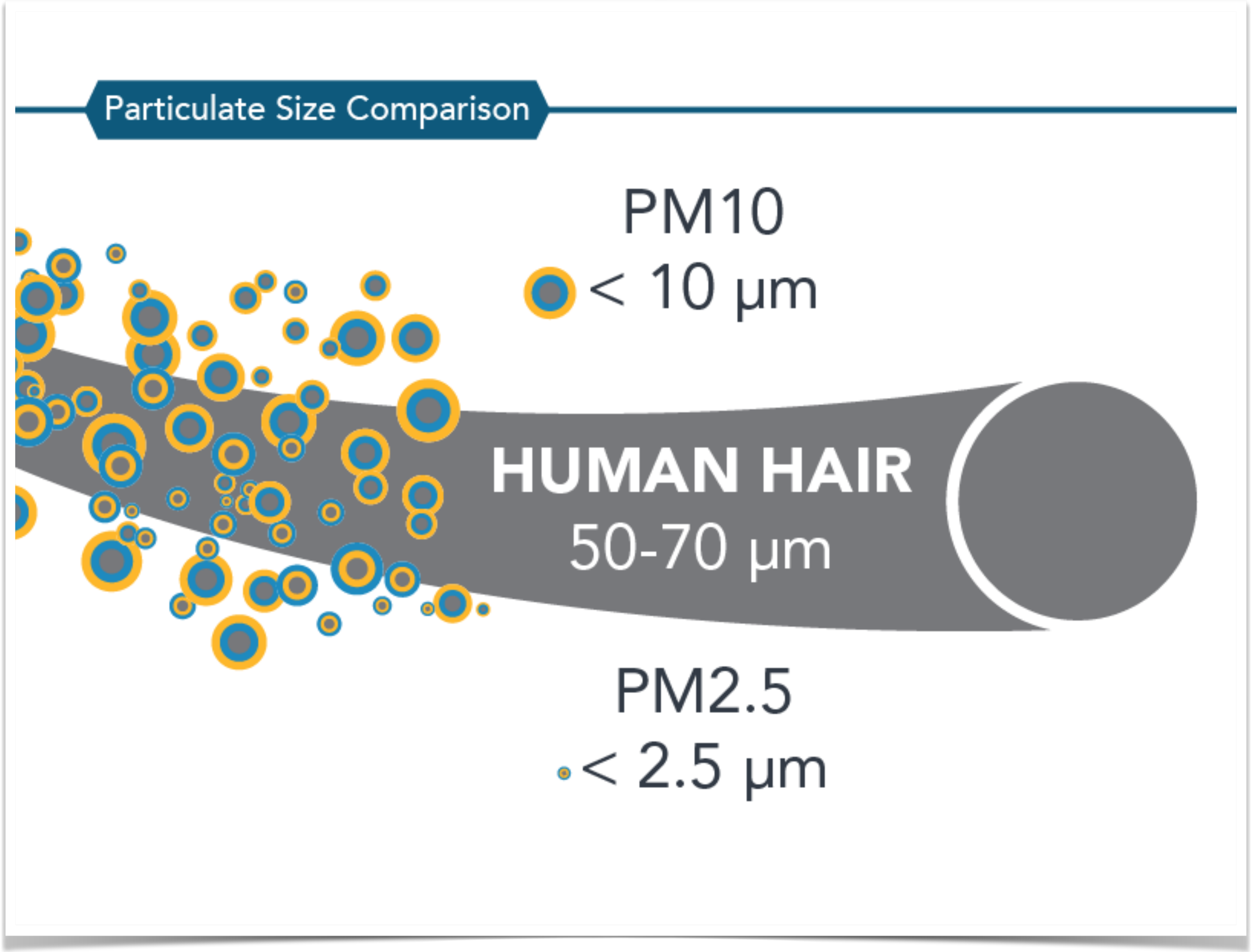
$PM_{2.5}$	Air Quality Index	$PM_{2.5}$ Health Effects	Precautionary Actions
0 to 12.0	Good 0 to 50	Little to no risk.	None.
12.1 to 35.4	Moderate 51 to 100	Unusually sensitive individuals may experience respiratory symptoms.	Unusually sensitive people should consider reducing prolonged or heavy exertion.
35.5 to 55.4	Unhealthy for Sensitive Groups 101 to 150	Increasing likelihood of respiratory symptoms in sensitive individuals, aggravation of heart or lung disease and premature mortality in persons with cardiopulmonary disease and the elderly.	People with respiratory or heart disease, the elderly and children should limit prolonged exertion.
55.5 to 150.4	Unhealthy 151 to 200	Increased aggravation of heart or lung disease and premature mortality in persons with cardiopulmonary disease and the elderly; increased respiratory effects in general population.	People with respiratory or heart disease, the elderly and children should avoid prolonged exertion; everyone else should limit prolonged exertion.
150.5 to 250.4	Very Unhealthy 201 to 300	Significant aggravation of heart or lung disease and premature mortality in persons with cardiopulmonary disease and the elderly; significant increase in respiratory effects in general population.	People with respiratory or heart disease, the elderly and children should avoid any outdoor activity; everyone else should avoid prolonged exertion.
250.5 to 500.4	Hazardous 301 to 500	Serious aggravation of heart or lung disease and premature mortality in persons with cardiopulmonary disease and the elderly; serious risk of respiratory effects in general population.	Everyone should avoid any outdoor exertion; people with respiratory or heart disease, the elderly and children should remain indoors.


AIR POLLUTION – THE SILENT KILLER
Every year, around
7 MILLION DEATHS
are due to exposure from both outdoor and household air pollution.
Air pollution is a major environmental risk to health. By reducing air pollution levels, countries can reduce:
Stroke
Heart disease
Lung cancer, and both chronic and acute respiratory diseases, including asthma
REGIONAL ESTIMATES ACCORDING TO WHO REGIONAL GROUPINGS:
Over 2 million
in South-East Asia Region
Over 2 million
in Western Pacific Region
Nearly 1 million
in Africa Region
About 500 000
deaths in Eastern Mediterranean Region
About 500 000
deaths in European Region
More than 300 000
in the Region of the Americas

WHAT IS PM 2 OR 10 -WHERE DOES IT COME FROM ?

What is Particulate Matter?

Airborne particulate matter (PM) is not a single pollutant, but rather is a mixture of many chemical species. It is a complex mixture of solids and aerosols composed of small droplets of liquid, dry solid fragments, and solid cores with liquid coatings. Particles vary widely in size, shape and chemical composition, and may contain inorganic ions, metallic compounds, elemental carbon, organic compounds, and compounds from the earth's crust. Particles are defined by their diameter for air quality regulatory purposes. Those with a diameter of 10 microns or less (PM10) are inhalable into the lungs and can induce adverse health effects. Fine particulate matter is defined as particles that are 2.5 microns or less in diameter (PM2.5). Therefore, PM2.5 comprises a portion of PM10.



regular hair is 70 micrometers PM2.5 is much smaller and not visible

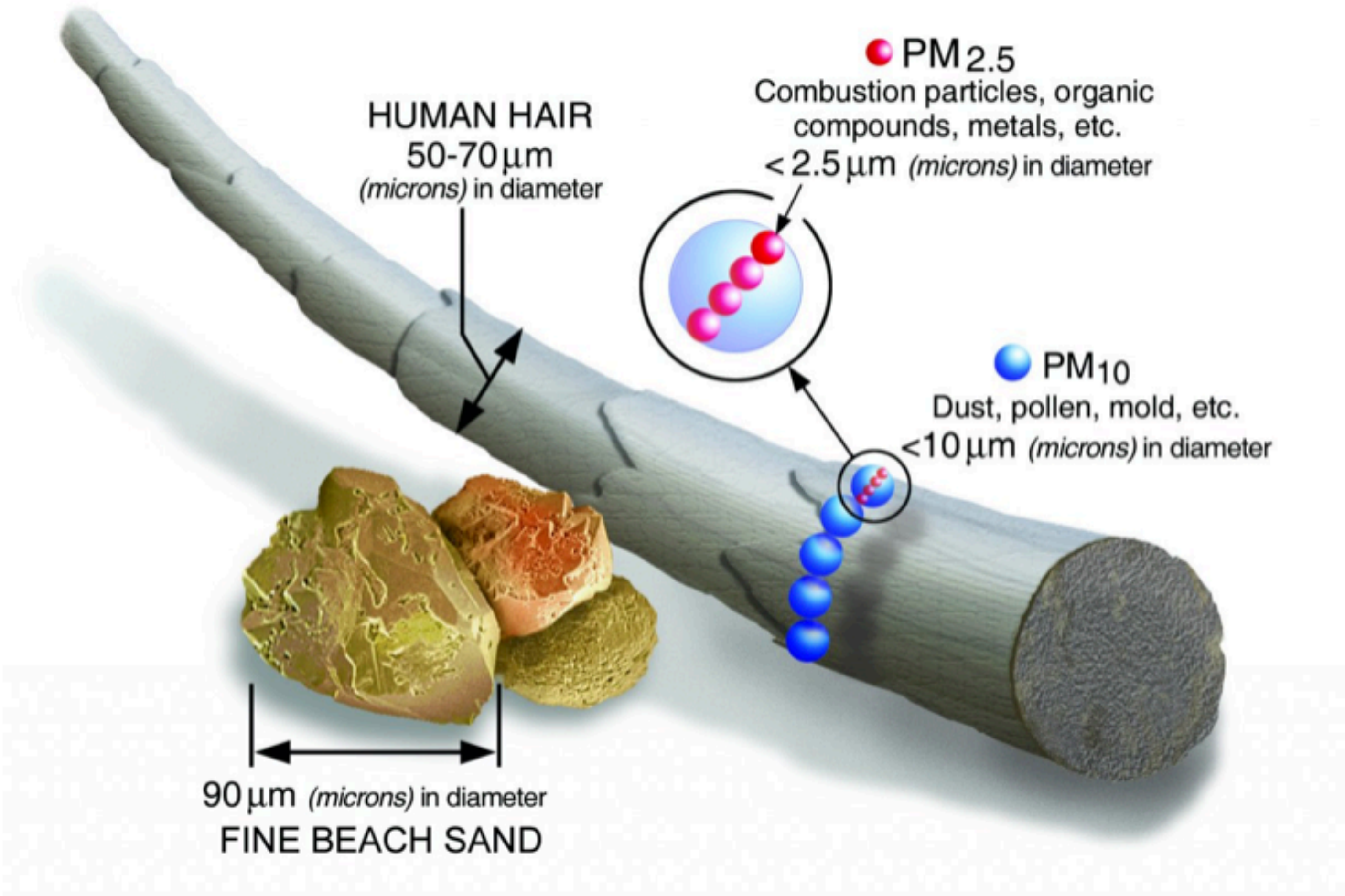
What is the Difference Between PM10 and PM2.5 micrometers.

PM10 and PM2.5 often derive from different emissions sources, and also have different chemical compositions. Emissions from combustion of gasoline, oil, diesel fuel or wood produce much of the PM2.5 pollution found in outdoor air, as well as a significant proportion of PM10. PM10 also includes dust from construction sites, landfills and agriculture, wildfires and brush/waste burning, industrial sources, wind-blown dust from open lands, pollen and fragments of bacteria.

PM may be either directly emitted from sources (primary particles) or formed in the atmosphere through chemical reactions of gases (secondary particles) such as sulfur dioxide (SO2), nitrogen oxides (NOX), and certain organic compounds. These organic compounds can be emitted by both natural sources, such as trees and vegetation, as well as from man-made (anthropogenic) sources, such as industrial processes and motor vehicle exhaust. The relative sizes of PM10 and PM2.5 particles are compared in the figure below.

What is PM, and how does it get into the air?

PM stands for particulate matter (also called particle pollution): the term for a mixture of solid particles and liquid droplets found in the air. Some particles, such as dust, dirt, soot, or smoke, are large or dark enough to be seen with the naked eye. Others are so small they can only be detected using an electron microscope.

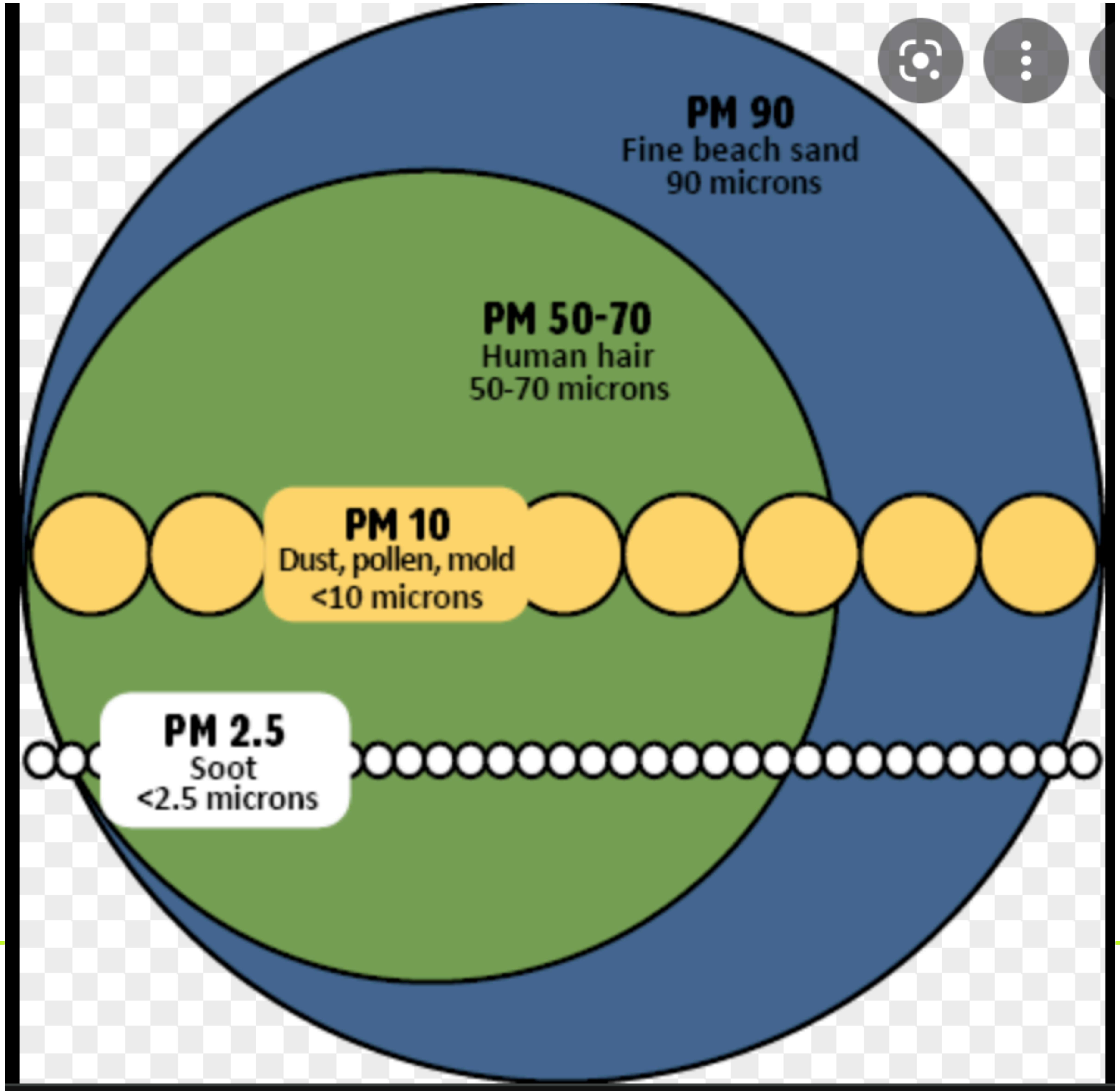


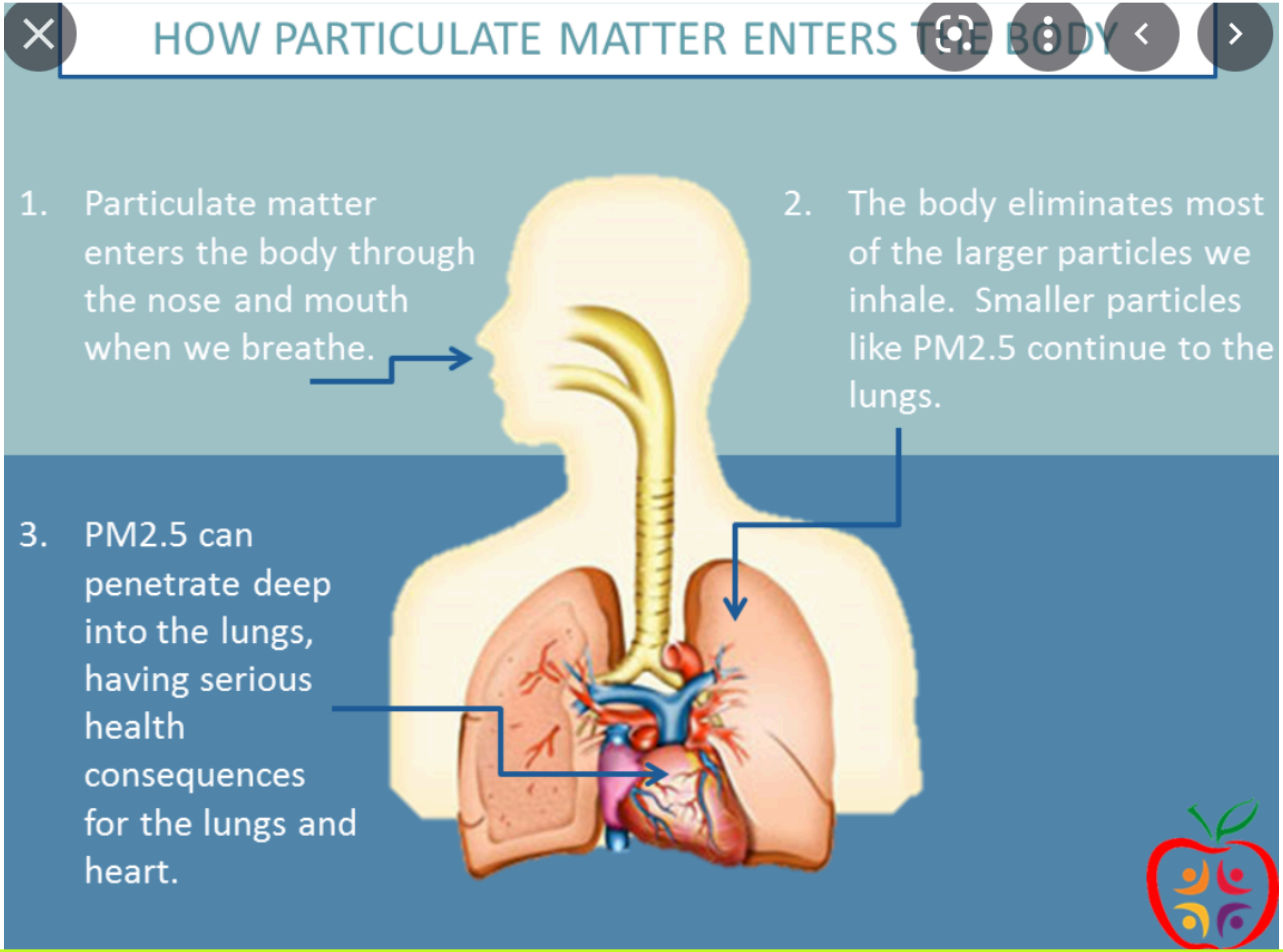
Size comparisons for PM particles

Particle pollution includes:

- **PM_{10}** : inhalable particles, with diameters that are generally 10 micrometers and smaller; and
- **$PM_{2.5}$** : fine inhalable particles, with diameters that are generally 2.5 micrometers and smaller.
  - How small is 2.5 micrometers? Think about a single hair from your head. The average human hair is about 70 micrometers in diameter – making it 30 times larger than the largest fine particle.

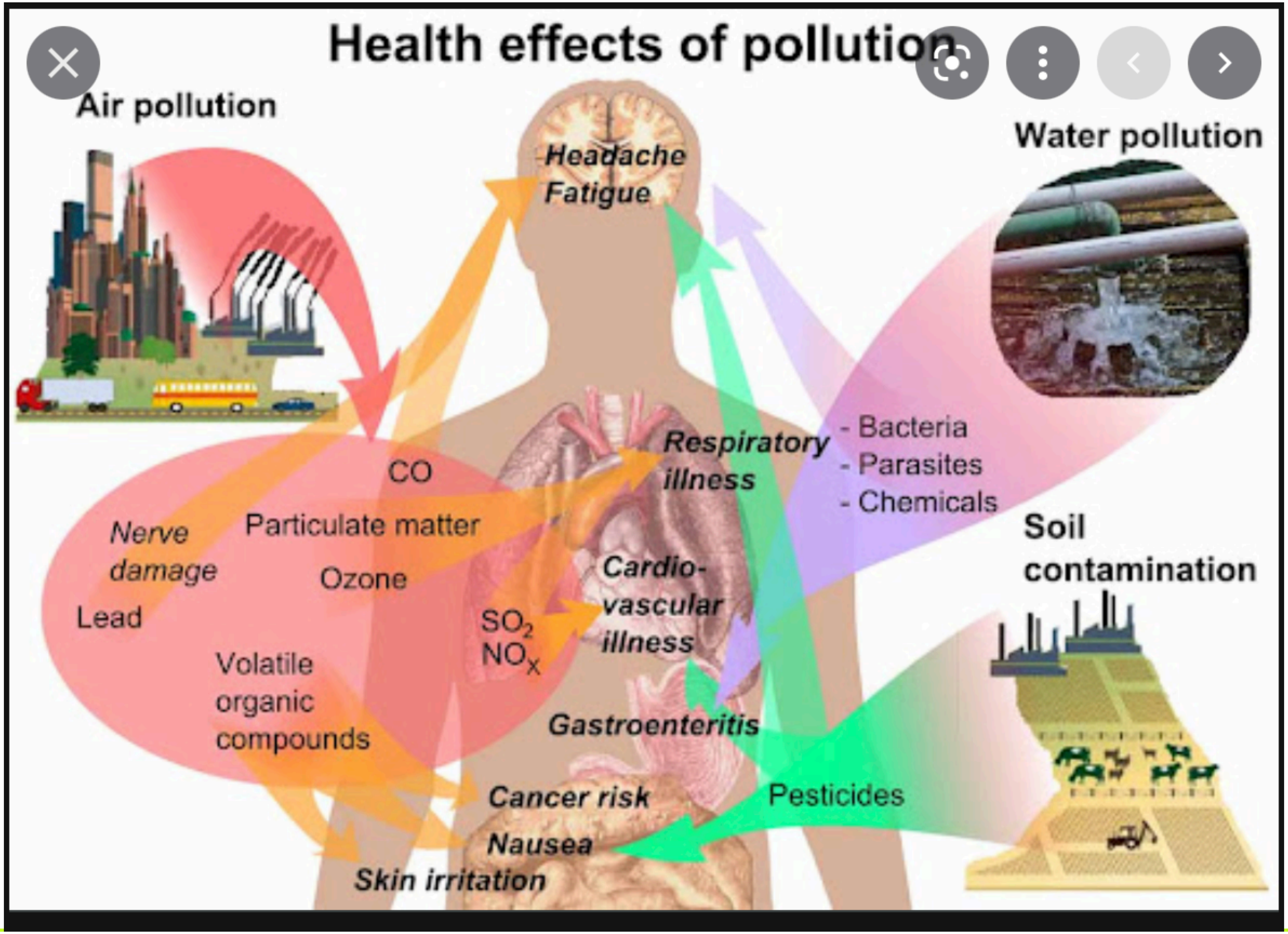
Particulate Matter



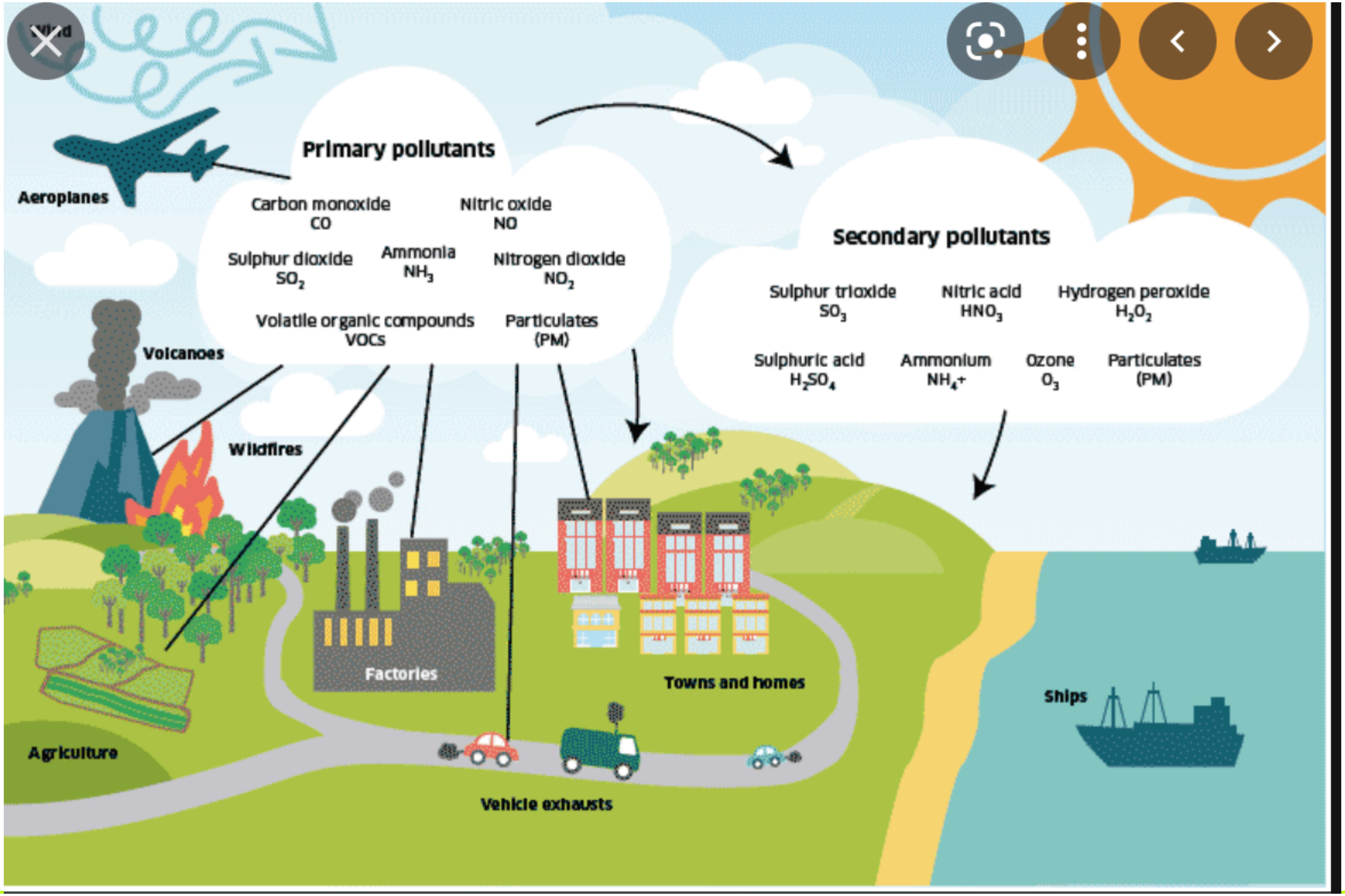


HOW PARTICULATE MATTER ENTERS THE BODY
1. Particulate matter enters the body through the nose and mouth when we breathe.
2. The body eliminates most of the larger particles we inhale. Smaller particles like PM2.5 continue to the lungs.
3. PM2.5 can penetrate deep into the lungs, having serious health consequences for the lungs and heart.

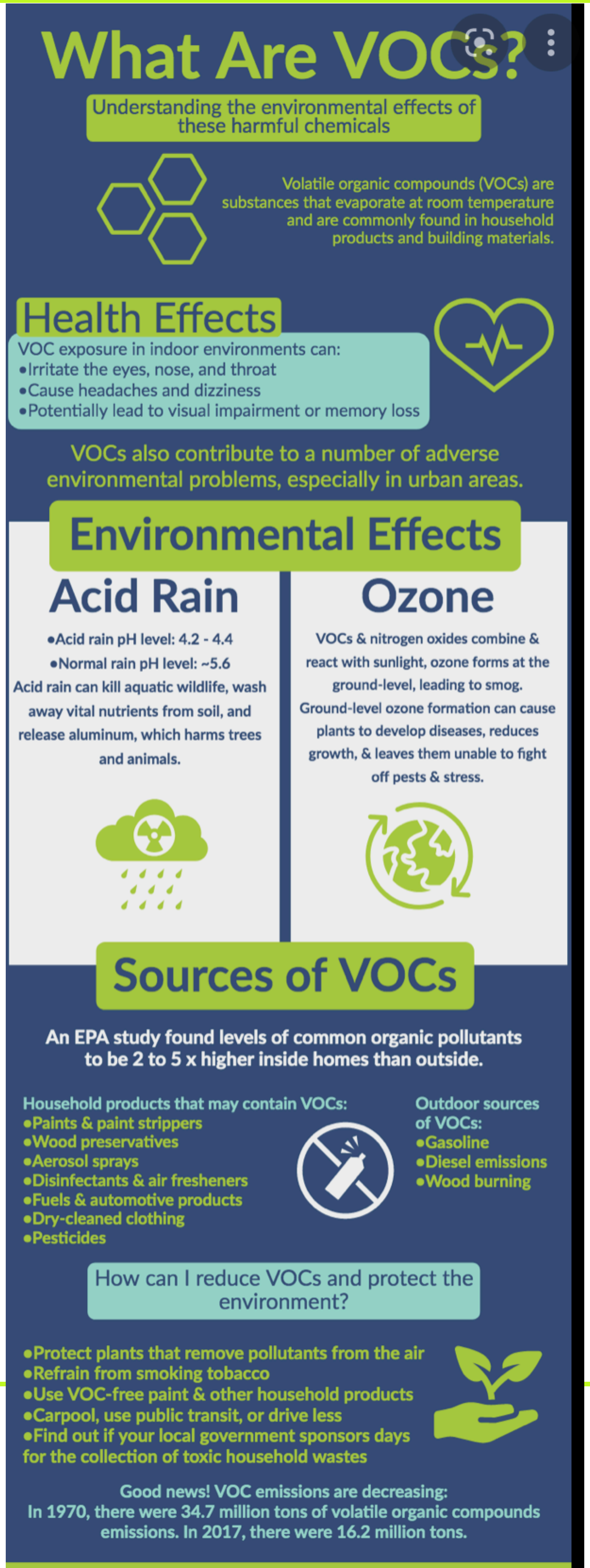
VOCs



Health effects of pollution
Air pollution
Water pollution
Headache
Fatigue
Respiratory illness
- Bacteria
- Parasites
- Chemicals
CO
Nerve damage
Particulate matter
Ozone
Lead
SO_2
NO_x
Cardio-vascular illness
Soil contamination
Volatile organic compounds
Gastroenteritis
Cancer risk
Pesticides
Nausea
Skin irritation

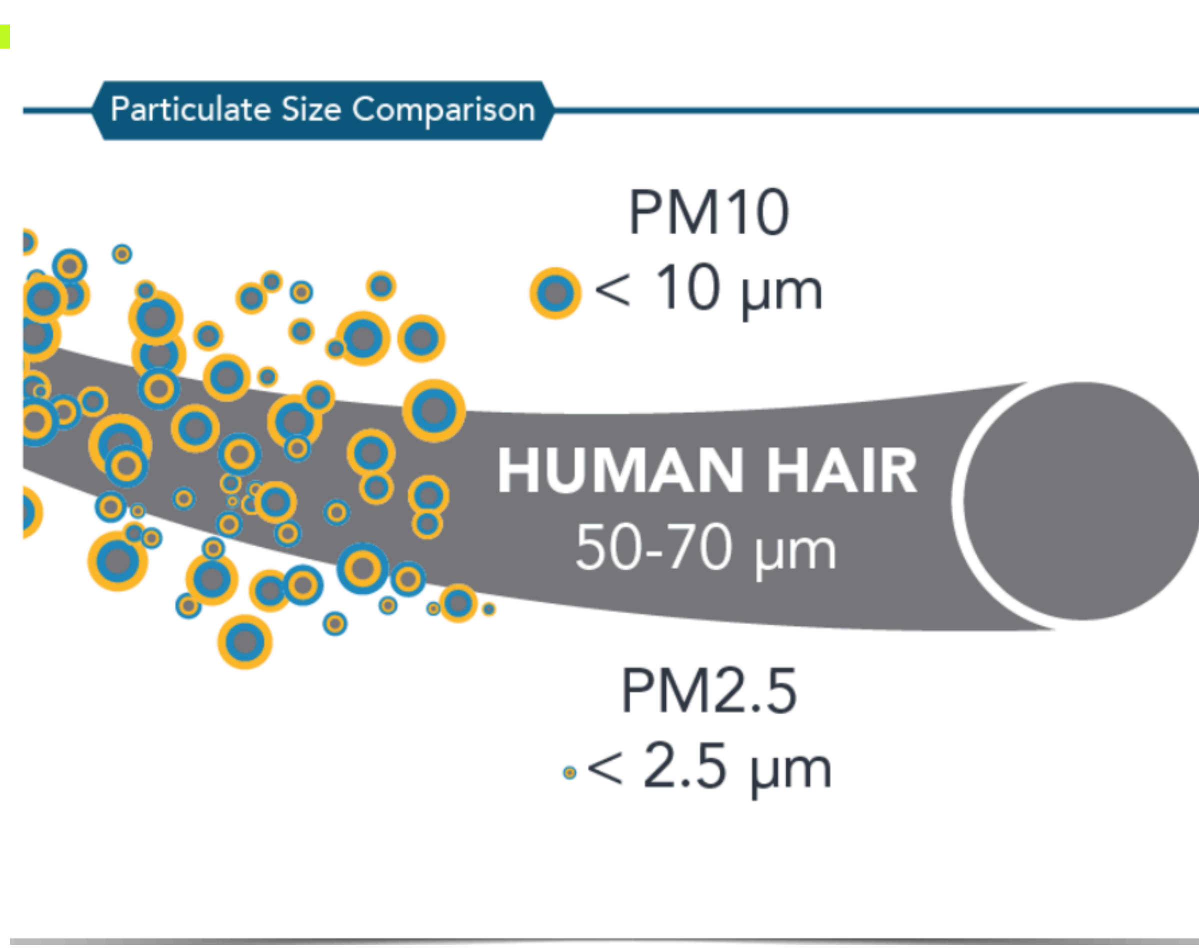

Primary pollutants
Carbon monoxide CO
Nitric oxide NO
Sulphur dioxide SO_2
Ammonia NH_3
Nitrogen dioxide NO_2
Volatile organic compounds VOCs
Particulates (PM)
Secondary pollutants
Sulphur trioxide SO_3
Nitric acid HNO_3
Hydrogen peroxide H_2O_2
Sulphuric acid H_2SO_4
Ammonium NH_4^+
Ozone O_3
Particulates (PM)
Aeroplanes
Volcanoes
Wildfires
Factories
Towns and homes
Agriculture
Vehicle exhausts
Ships

List of VOCs



What Are VOCs?
Understanding the environmental effects of these harmful chemicals
Volatile organic compounds (VOCs) are substances that evaporate at room temperature and are commonly found in household products and building materials.
Health Effects
VOC exposure in indoor environments can:
•Irritate the eyes, nose, and throat
•Cause headaches and dizziness
•Potentially lead to visual impairment or memory loss
VOCs also contribute to a number of adverse environmental problems, especially in urban areas.
Environmental Effects
Acid Rain
•Acid rain pH level: 4.2 - 4.4
•Normal rain pH level: ~5.6
Acid rain can kill aquatic wildlife, wash away vital nutrients from soil, and release aluminum, which harms trees and animals.
Ozone
VOCs & nitrogen oxides combine & react with sunlight, ozone forms at the ground-level, leading to smog.
Ground-level ozone formation can cause plants to develop diseases, reduces growth, & leaves them unable to fight off pests & stress.
Sources of VOCs
An EPA study found levels of common organic pollutants to be 2 to 5 x higher inside homes than outside.
Household products that may contain VOCs:
•Paints & paint strippers
•Wood preservatives
•Aerosol sprays
•Disinfectants & air fresheners
•Fuels & automotive products
•Dry-cleaned clothing
•Pesticides
Outdoor sources of VOCs:
•Gasoline
•Diesel emissions
•Wood burning
How can I reduce VOCs and protect the environment?
•Protect plants that remove pollutants from the air
•Refrain from smoking tobacco
•Use VOC-free paint & other household products
•Carpool, use public transit, or drive less
•Find out if your local government sponsors days for the collection of toxic household wastes
Good news! VOC emissions are decreasing:
In 1970, there were 34.7 million tons of volatile organic compounds emissions. In 2017, there were 16.2 million tons.

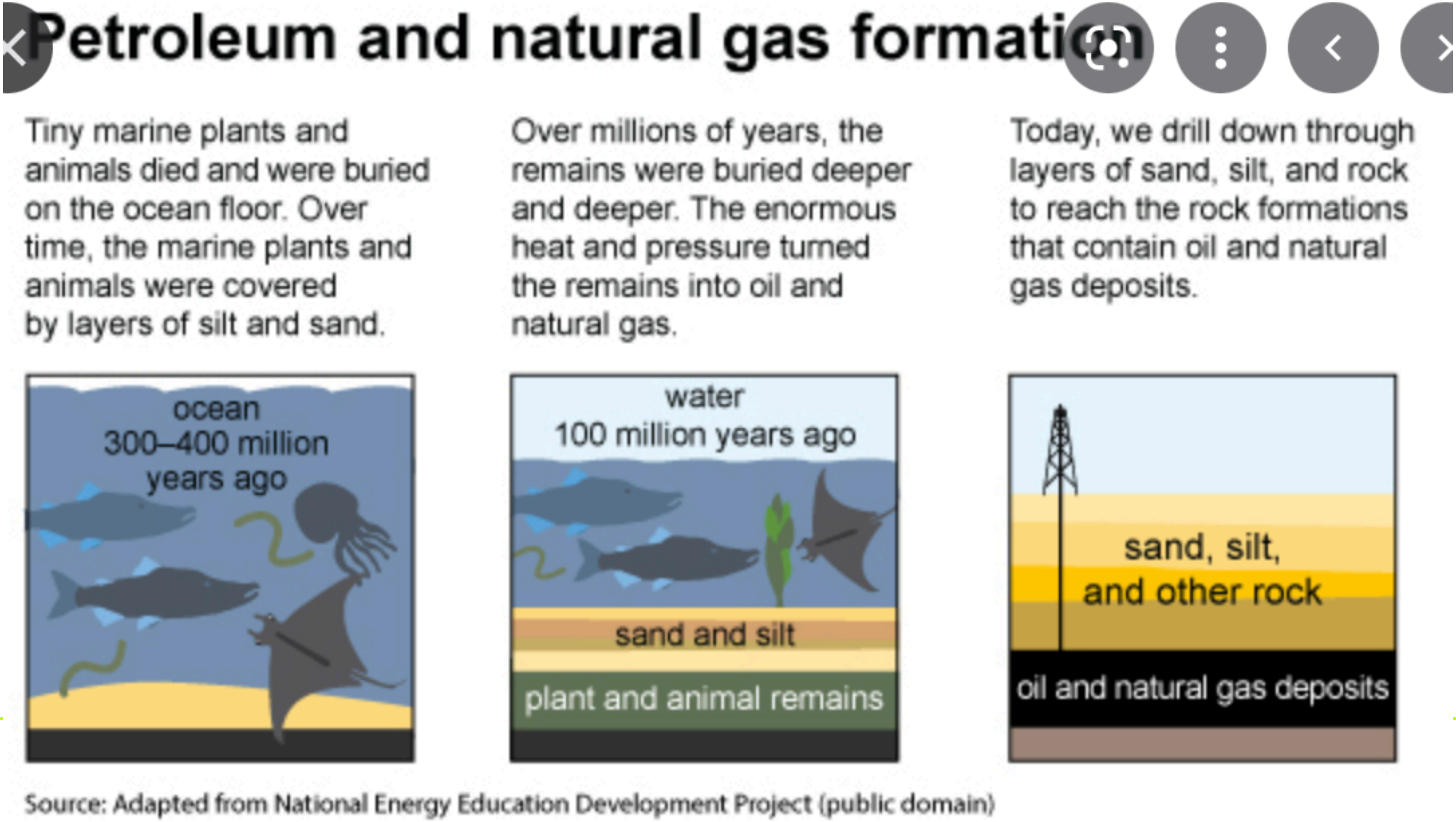
PM2.5 - Why you should care!

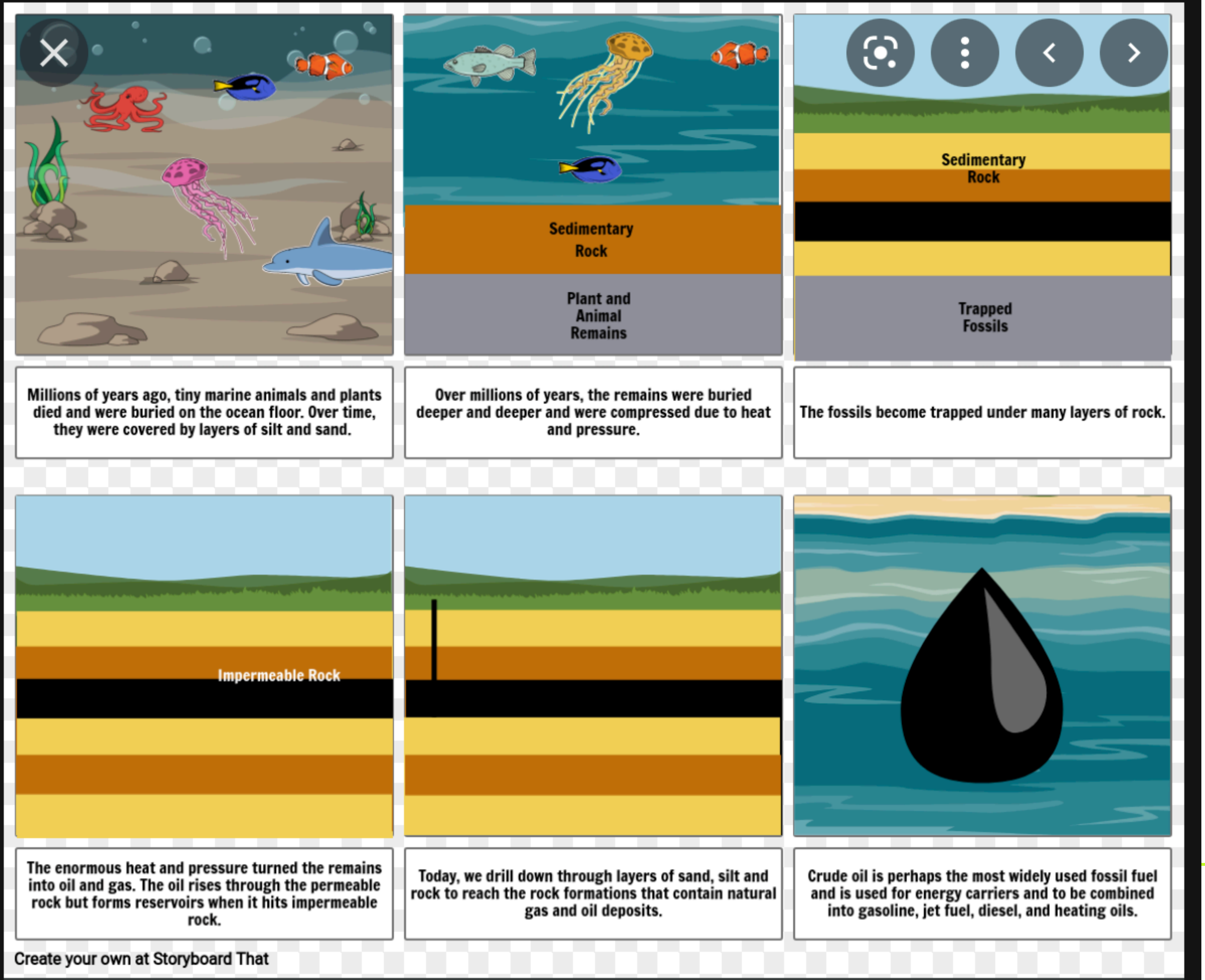


- Coal Power plants release sulfur dioxide that reacts with Oxygen and water droplets in the air to form Sulfuric acid as a 2nd particle. Since they are so small they stay longer in the air than heavier particles increasing the chances of Humans and Animals inhaling them into the body.
- The minute size <2.5 micrometers can then bypass the nose ,throat and penetrate deep into the lungs and circulatory system!
- EXPOSURE= Heart attacks, vascular inflammation plaque deposits, Asthma,Bronchitis and other respiratory problems!!
- A study published from JAMA suggests there is an associated 4%-8% increased risk for Cardiopulmonary and Lung Cancer Mortality r/t the ingestion of PM2.5 and PM10!!

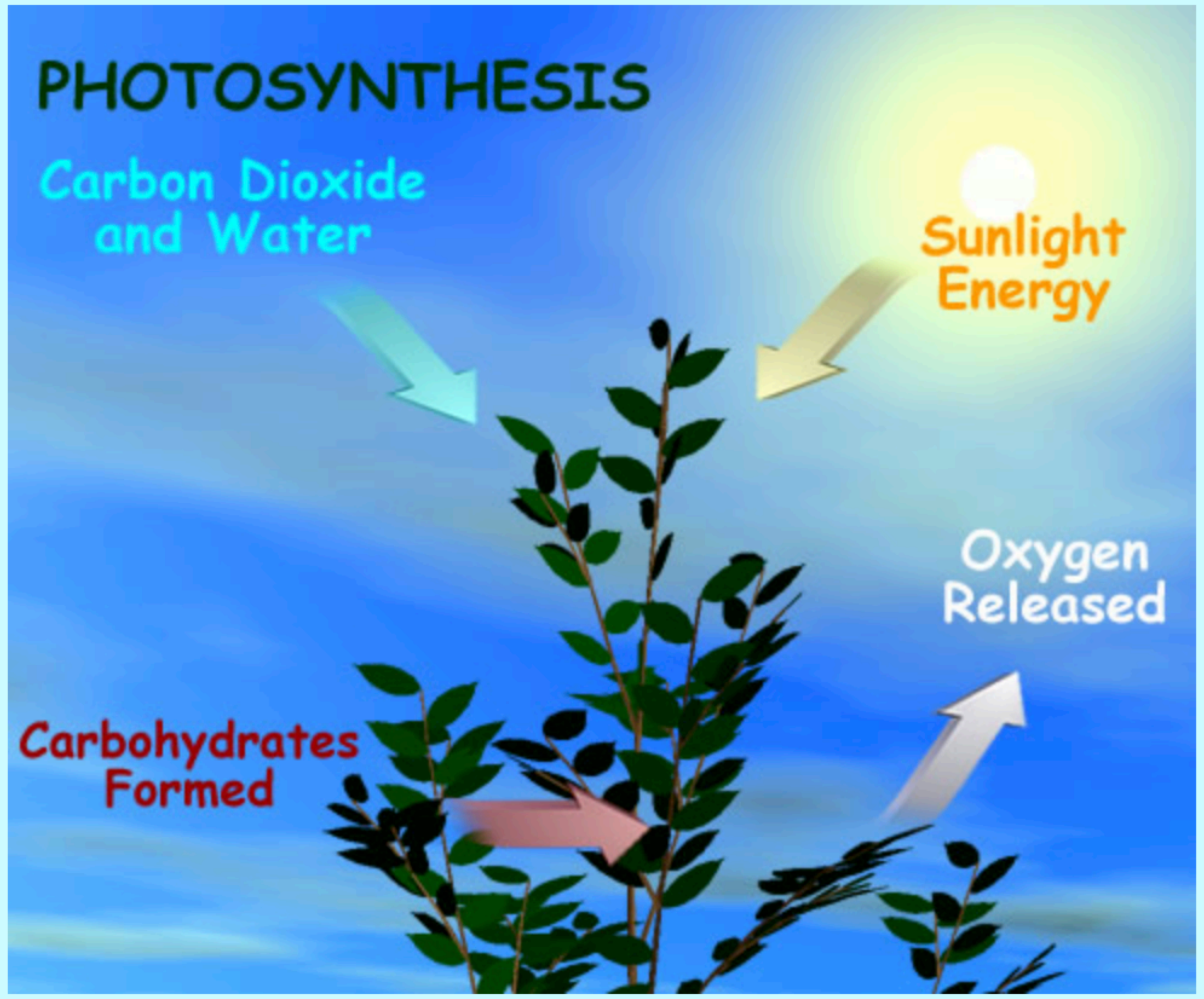

WHERE DO FOSSIL FUELS COME FROM ?
DEEP IN THE EARTH

Where does Oil and natural gas come from




Sedimentary
Rock
Plant and
Animal
Remains
Sedimentary
Rock
Trapped
Fossils
Millions of years ago, tiny marine animals and plants died and were buried on the ocean floor. Over time, they were covered by layers of silt and sand.
Over millions of years, the remains were buried deeper and deeper and were compressed due to heat and pressure.
The fossils become trapped under many layers of rock.
Impermeable Rock
The enormous heat and pressure turned the remains into oil and gas. The oil rises through the permeable rock but forms reservoirs when it hits impermeable rock.
Today, we drill down through layers of sand, silt and rock to reach the rock formations that contain natural gas and oil deposits.
Crude oil is perhaps the most widely used fossil fuel and is used for energy carriers and to be combined into gasoline, jet fuel, diesel, and heating oils.
Create your own at Storyboard That

Where Does the Energy in Fossil Fuels Come From?



A Solar Power Bank

All the energy in oil, gas, and coal originally came from the sun, captured through photosynthesis. In the same way that we burn wood to release energy that trees capture from the sun, we burn fossil fuels to release the energy that ancient plants captured from the sun. We can think of this energy as having been deposited in a natural solar power bank over millions of years.

So, in one sense, gasoline-burning cars, coal-burning power plants, and homes heated by natural gas are all solar powered!

Withdrawals Without any New Deposits

One major problem is that we are withdrawing oil, gas, and coal from our natural bank of solar power without making any significant deposits. Fossil fuels take millions of years to form and are not renewable within a human life span. Therefore, once we consume all the available deposits there will be none left for future generations.

Energy--and Carbon Dioxide--from the Past

Another problem with our heavy use of fossil fuel is associated with the release of carbon dioxide. By burning fossil fuels, we are not only consuming energy that has been stored for a million years but also releasing carbon that has been stored for a million years. This huge release of carbon (in the form of carbon dioxide) is overwhelming the natural cycles that balance the amount of carbon dioxide in the air.

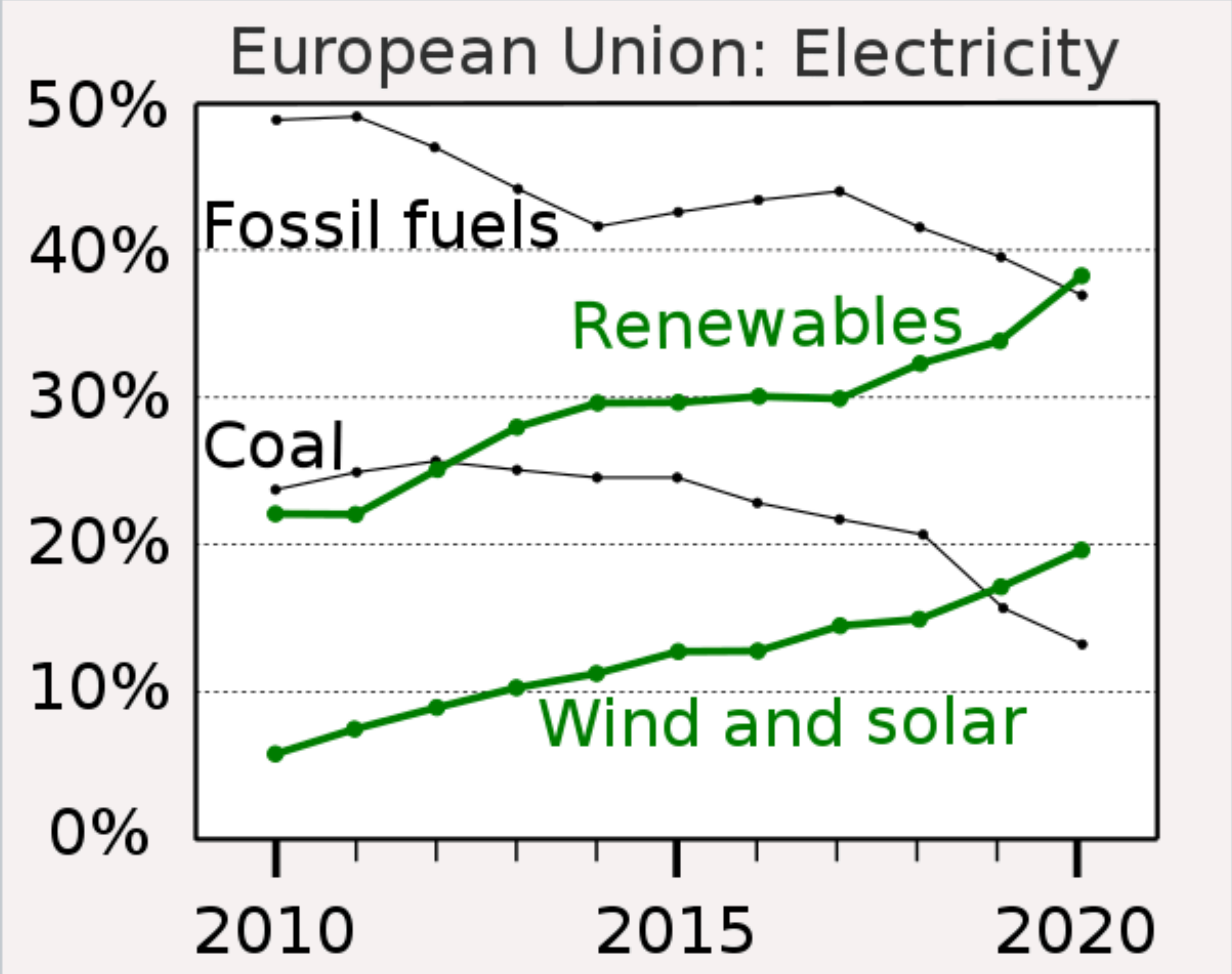
How we are polluting the Earth

A **fossil fuel** is a hydrocarbon-containing material formed underground from the remains of dead plants and animals that humans extract and burn to release energy for use. The main fossil fuels are coal, petroleum and natural gas,[1] which humans extract through mining and drilling. Fossil fuels may be burnt to provide heat for use directly (e.g. for cooking), to power engines (such as internal combustion engines in motor vehicles), or to generate electricity.[2]

Coal, a fossil fuel. Coal forms in a millions-of-years geological process, transforming biomass into a solid rock-like carbon mineral. Because it is a solid, it is easily mined and transported. Coal is an important source of energy and has historically been an important ingredient in steelmaking and other industrial processes.

A petrochemical refinery in Grangemouth, Scotland, UK

An oil well in the Gulf of Mexico



In 2020, renewables overtook fossil fuels as the European Union's main source of electricity for the first time.[32]

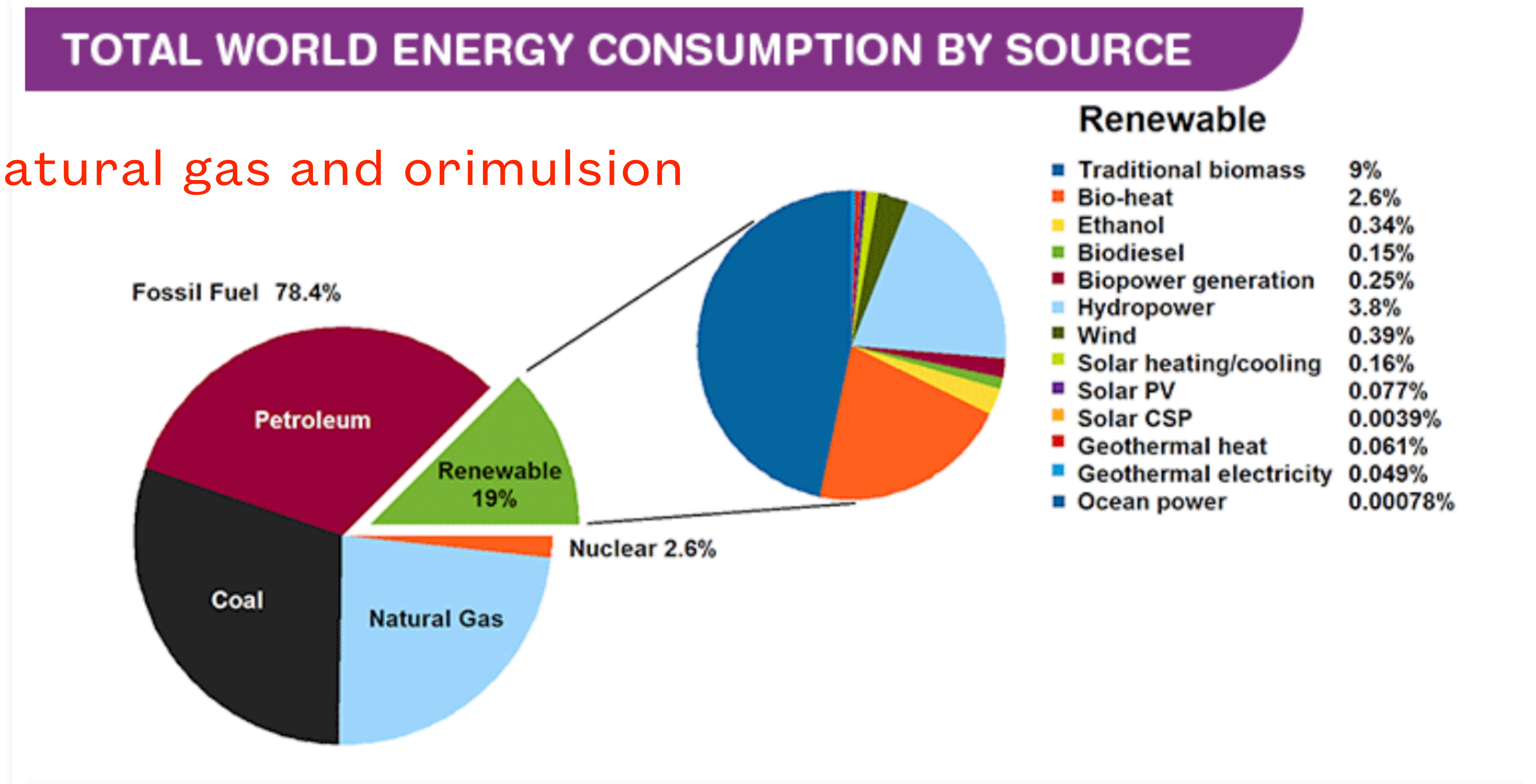
What are the 4 Types of Fossil Fuels

Petroleum, coal, natural gas and orimulsion are the four fossil fuel types. They have a variety of physical, chemical and other essential properties in general, but the most vital thing regarding fossil fuels, perhaps, is that they are not green.

Fossil fuels are made from plants and animals that decompose. In the Earth's surface, these oils contain carbon and hydrogen, which can be burned for oil.

A variety of air emissions that are detrimental to both the atmosphere and public health are released from burning fossil fuels. Emissions of sulphur dioxide (SO_2), mostly the product of coal burning, lead to acid rain and to the formation of toxic particulate matter.

Petroleum, coal ,natural gas and orimulsion



What are the types of coal?

There are four major types (or “ranks”) of coal. Rank refers to steps in a slow, natural process called “coalification,” during which buried plant matter changes into an ever denser, drier, more carbon-rich, and harder material. The four ranks are:

- **Anthracite**: The highest rank of coal. It is a hard, brittle, and black lustrous coal, often referred to as hard coal, containing a high percentage of fixed carbon and a low percentage of volatile matter.
- **Bituminous**: Bituminous coal is a middle rank coal between subbituminous and anthracite. Bituminous coal usually has a high heating (Btu) value and is used in electricity generation and steel making in the United States. Bituminous coal is blocky and appears shiny and smooth when you first see it, but look closer and you might see it has thin, alternating, shiny and dull layers.
- **Subbituminous**: Subbituminous coal is black in color and is mainly dull (not shiny). Subbituminous coal has low-to-moderate heating values and is mainly used in electricity generation.
- **Lignite**: Lignite coal, aka brown coal, is the lowest grade coal with the least concentration of carbon. Lignite has a low heating value and a high moisture content and is mainly used in electricity generation.

The precursor to coal is peat. Peat is a soft, organic material consisting of partly decayed plant and mineral matter. When peat is placed under high pressure and heat, it undergoes physical and chemical changes (coalification) to become coal.

COAL

What is coal used for?

Coal is primarily used as fuel to generate electric power in the United States. In coal-fired power plants, bituminous coal, subbituminous coal, or lignite is burned. The heat produced by the combustion of the coal is used to convert water into high-pressure steam, which drives a turbine, which produces electricity. In 2019, about 23 percent of all electricity in the United States was generated by...

What is coal?

Coal is a sedimentary deposit composed predominantly of carbon that is readily combustible. Coal is black or brownish-black, and has a composition that (including inherent moisture) consists of more than 50 percent by weight and more than 70 percent by volume of carbonaceous material. It is formed from plant remains that have been compacted, hardened, chemically altered, and metamorphosed by heat...

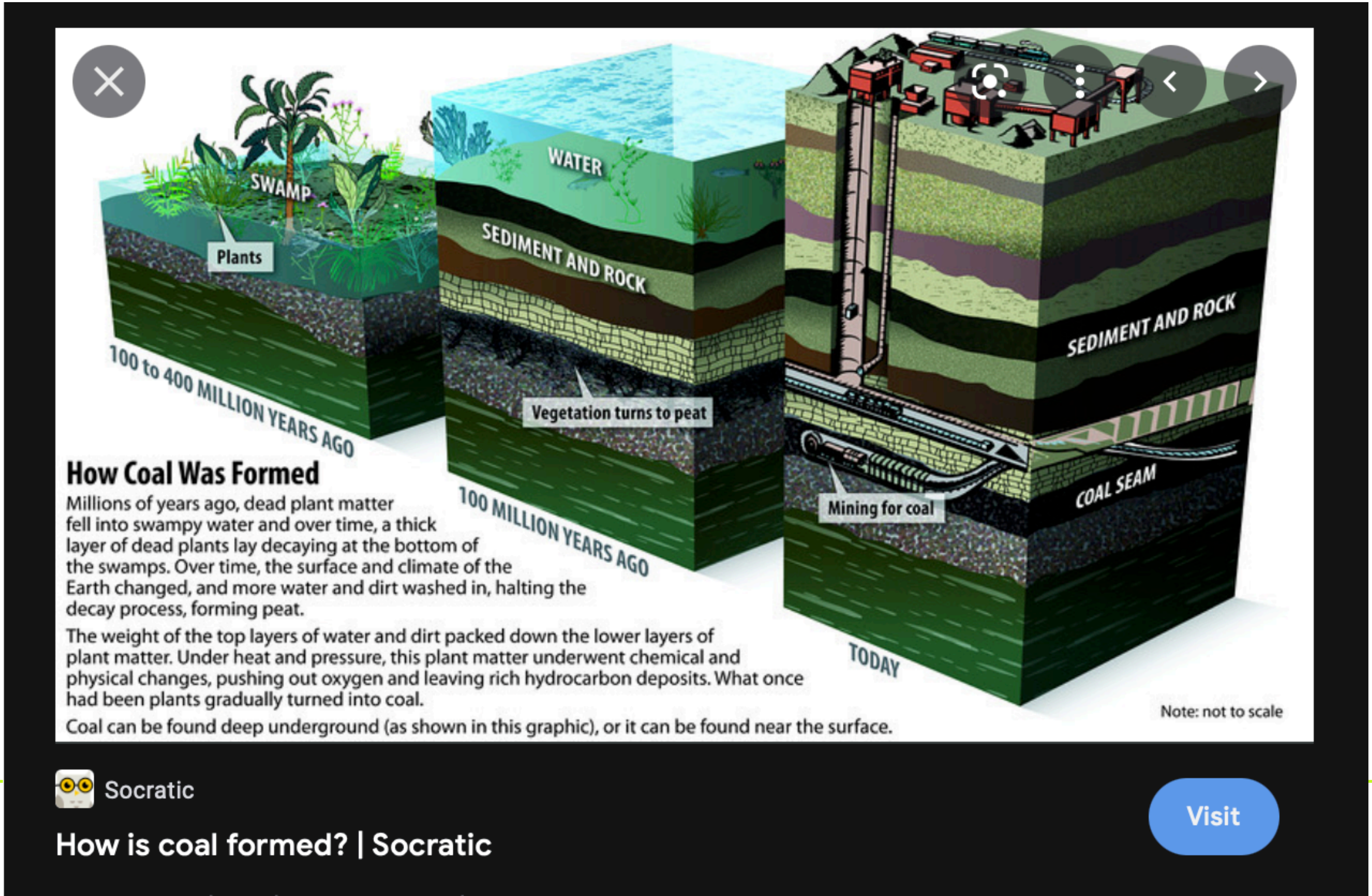
What is the biggest coal deposit in the United States?

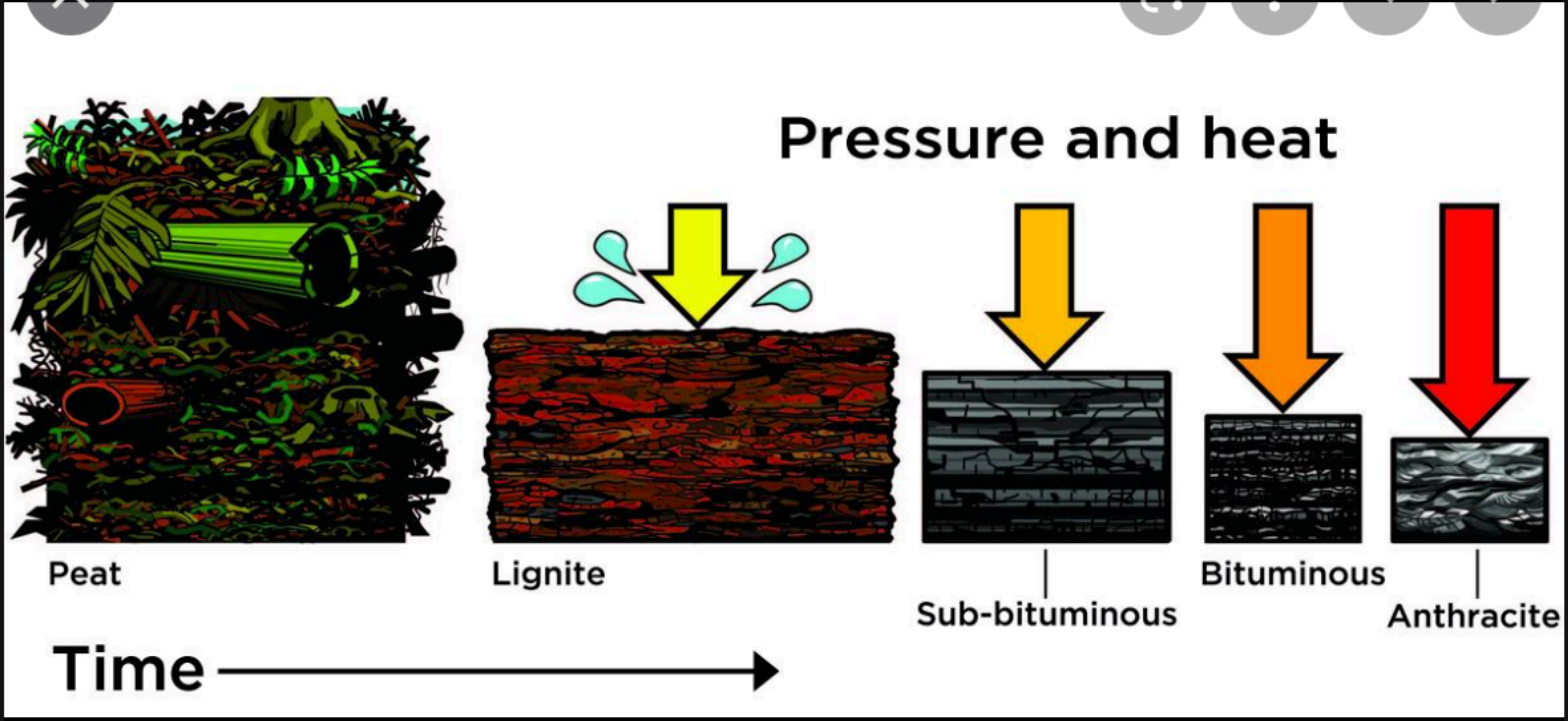
The biggest coal deposit by volume is the Powder River Basin in Wyoming and Montana, which the USGS estimated to have 1.07 trillion short tons of in-place coal resources, 162 billion short tons of recoverable coal resources, and 25 billion short tons of economic coal resources (also called reserves) in 2013. The coal in the Powder River Basin is subbituminous in rank. Large coal deposits can also...

Which country has the most coal?

As of January 2020, the United States has the largest recoverable coal reserves with an estimated 252 billion short tons of coal remaining, according to the U.S. Energy Information Administration.Learn more:U.S. Coal Resources and AssessmentWorld Coal Quality Inventory

Mining for Coal





Union of Concerned Scientists

How Coal Works | Union of Concerned Scientists

Visit

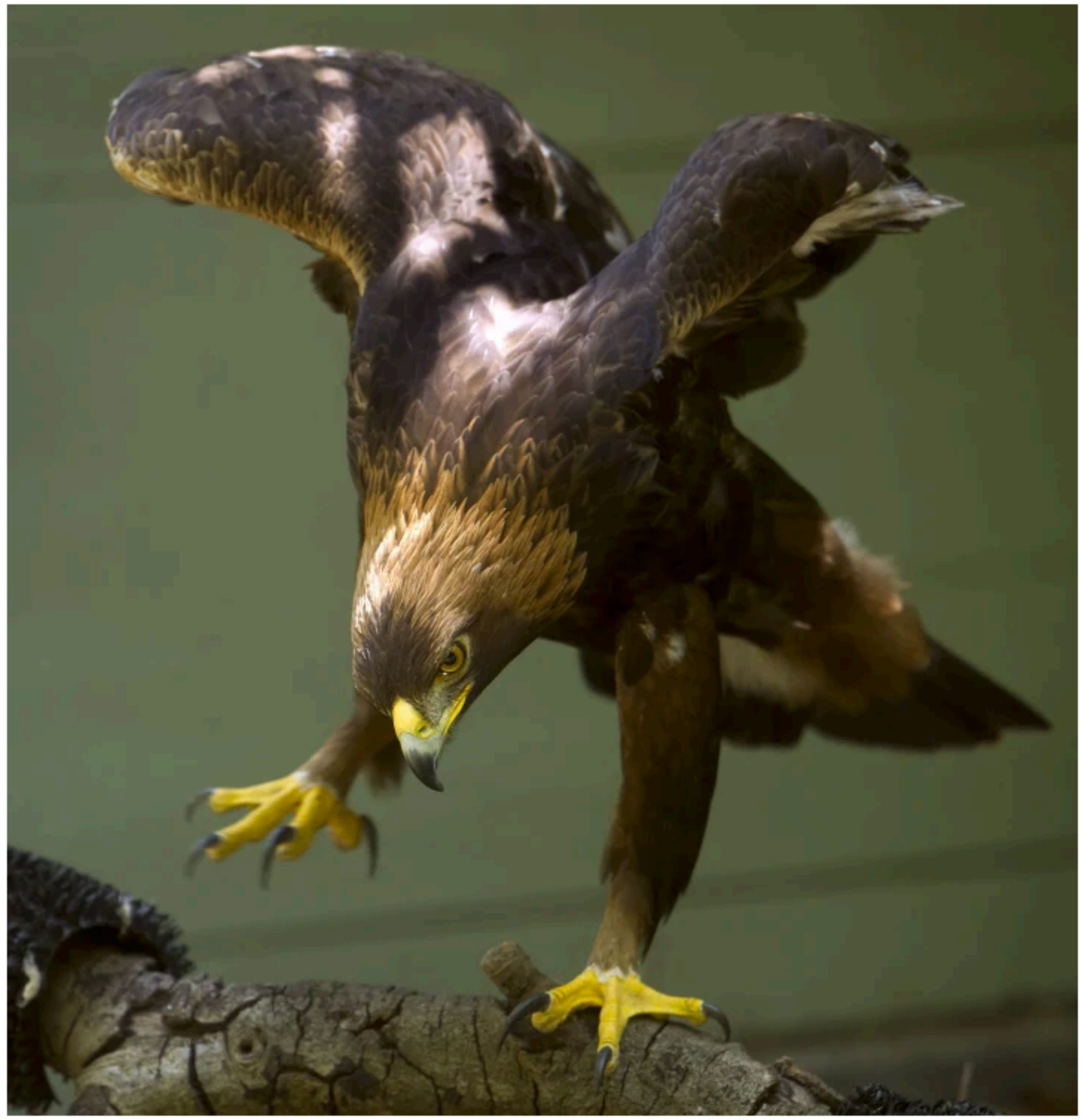
The Burning of Fossil Fuels - Here is what we are dealing with

The burning of fossil fuels is the primary cause of current climate change, altering the Earth's **ecosystems** and causing human and environmental health problems.

Flares burn at sunset in the Bakken oil and gas fields in North Dakota Credit: Jeff Peischl/CIRES and NOAA

Wind Energy is renewable and clean but it is noisy and hurts animals and birds

WE NEED TO DO BETTER



According to keepers, a wind turbine near the Altamont Pass severed a portion of this 14-year-old golden eagle's left wing in 2000, leaving him unable to fly or survive in the wild. Noah Berger / AP file

Radar-based maps and migration forecasts could save birds from spinning turbine b

Ozone and Particulate Matter

- THESE TWO ARE THE MOST DETRIMENTAL TO OUR HEALTH AT GROUND LEVEL!
- OZONE WHEN WE INHALE IT IS LIFE THREATNING AT GROUND LEVEL
- PARTICULATE MATTER INHALED AT 2.5 MICRONS NEVER LEAVES OUR BODY

Particulate Matter

Airborne particles such as ***smoke, dust, dirt, soot, and salt.*** The sources of these particles are numerous- including vehicles, factories, fires, and any other natural or human activity resulting in the addition of particulates into the air.

Ground Level Ozone

Ground level ozone is not directly emitted into the air, but forms when ***nitrogen oxides (NOx)*** emissions react with other ***volatile organic compounds (VOCs***) in the presence of heat and sunlight.

Emissions from industrial facilities and electric utilities, motor vehicle exhaust, and chemical solvents are some of the major sources of NOx and VOCs.

weather.gov/airquality

Six Major Outdoor Air Pollutants

- 1.OZONE (03)
- 2.NITROGEN OXIDES (NOx)
- 3.CARBON MONOXIDE (CO)
- 4.SULFUR DIOXIDE (SO2)
- 5.PARTICULATE MATTER (PM 10 PM 2.5)
- 6. LEAD

What is the Ozone Layer??

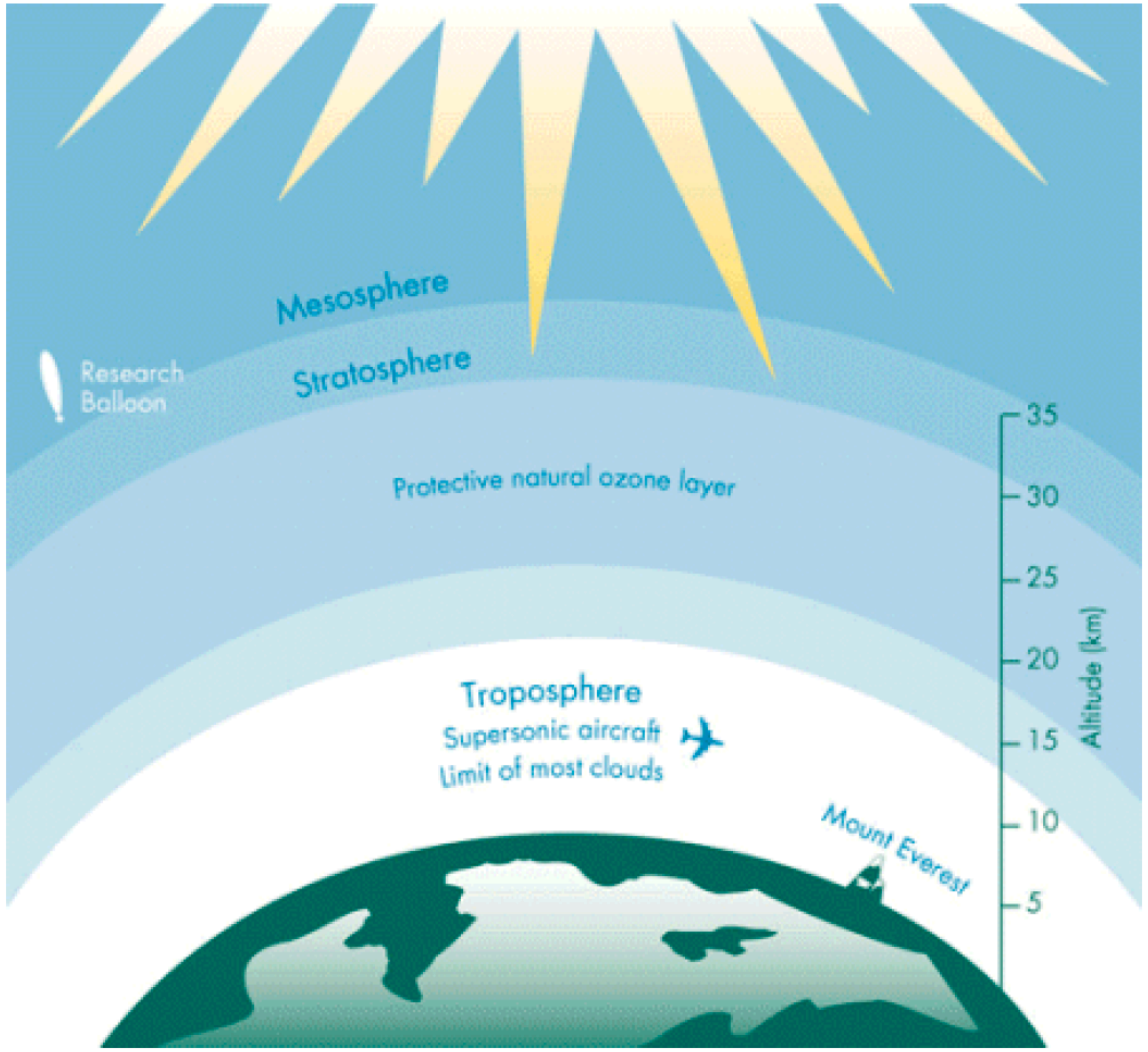
- The ozone layer is a deep layer in the stratosphere (which is the second major layer of earths atmosphere) encircling the earth. That protects humans and other organism from the UV radiation.
- This layer shields the entire earth from much of the harmful ultraviolet radiation that comes from the sun.
- It absorbs 97-99% of the suns high frequency ultraviolet light, which is potentially damaging to the life form on earth.

Damaging the Ozone level

How do we do it?

Where is the ozone layer?

- **The ozone layer is a protective layer of gas molecules located within the stratosphere.**
- **Ozone gas also exists in the troposphere and at ground level, but most is located within the stratospheric layer shown to the right.**



Ultra-Violet Radiation

- UV rays penetrate the Earth's atmosphere at 3 slightly different wavelengths called UV-A, UV-B, and UV-C rays.

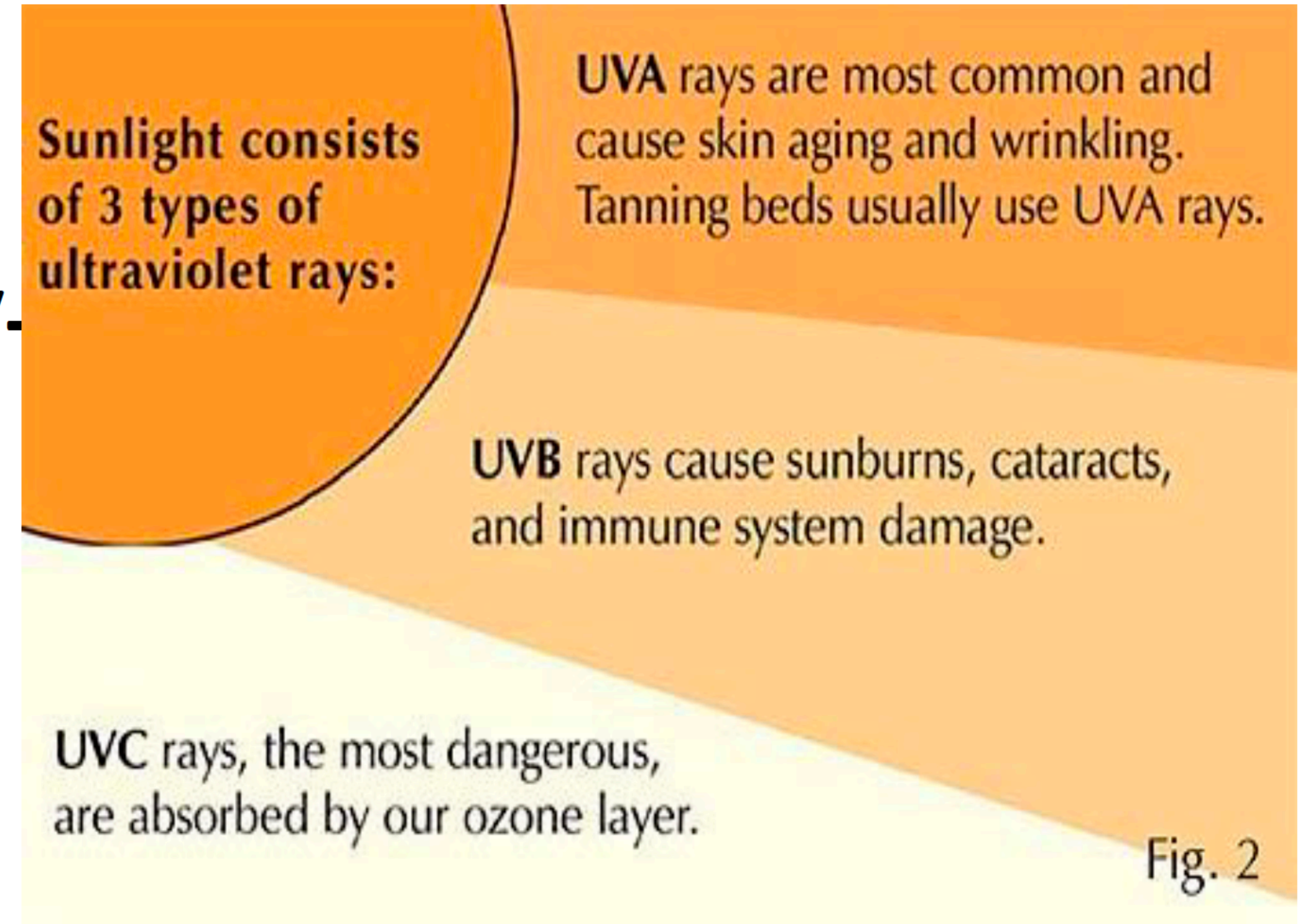


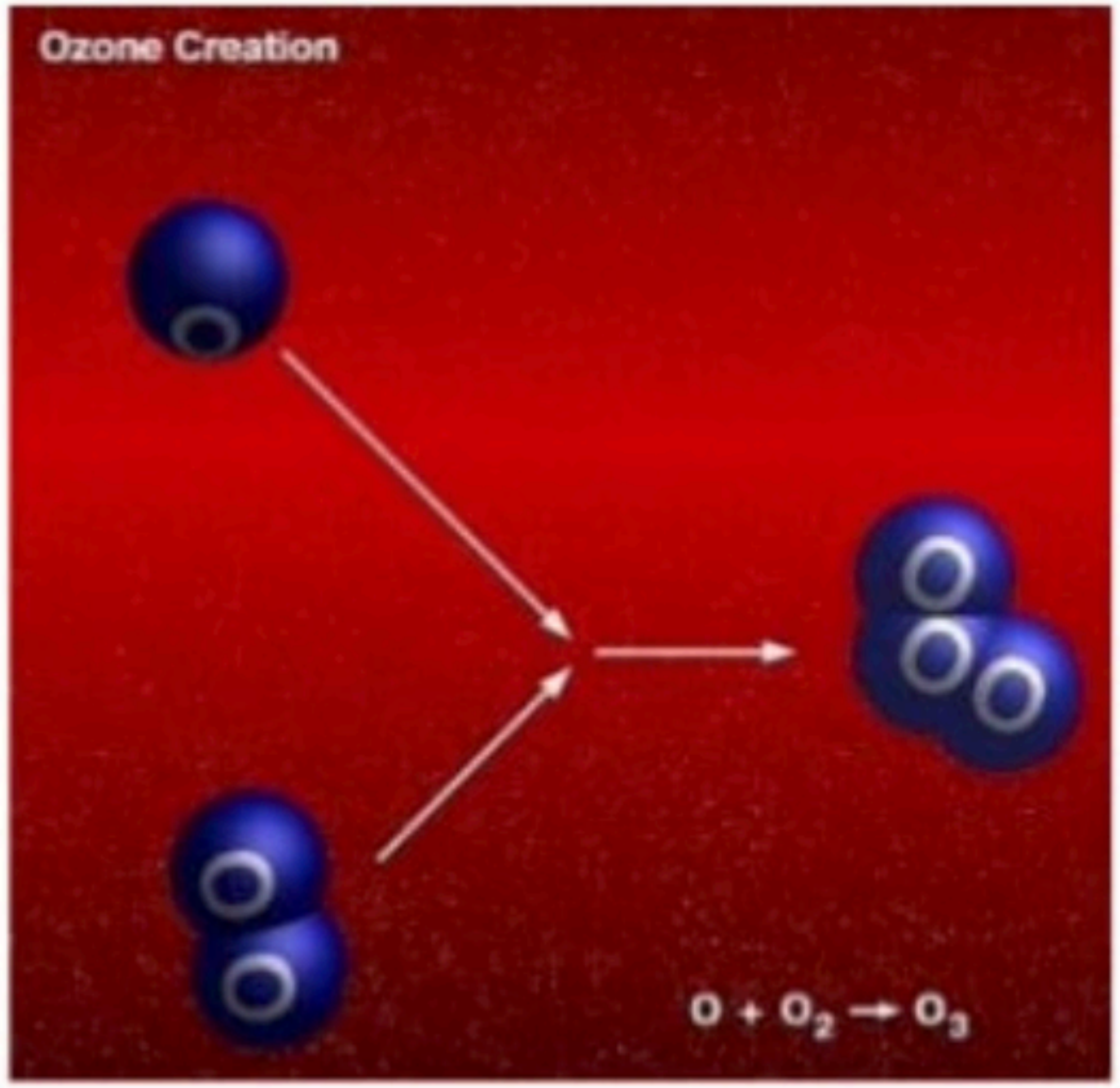
Fig. 2

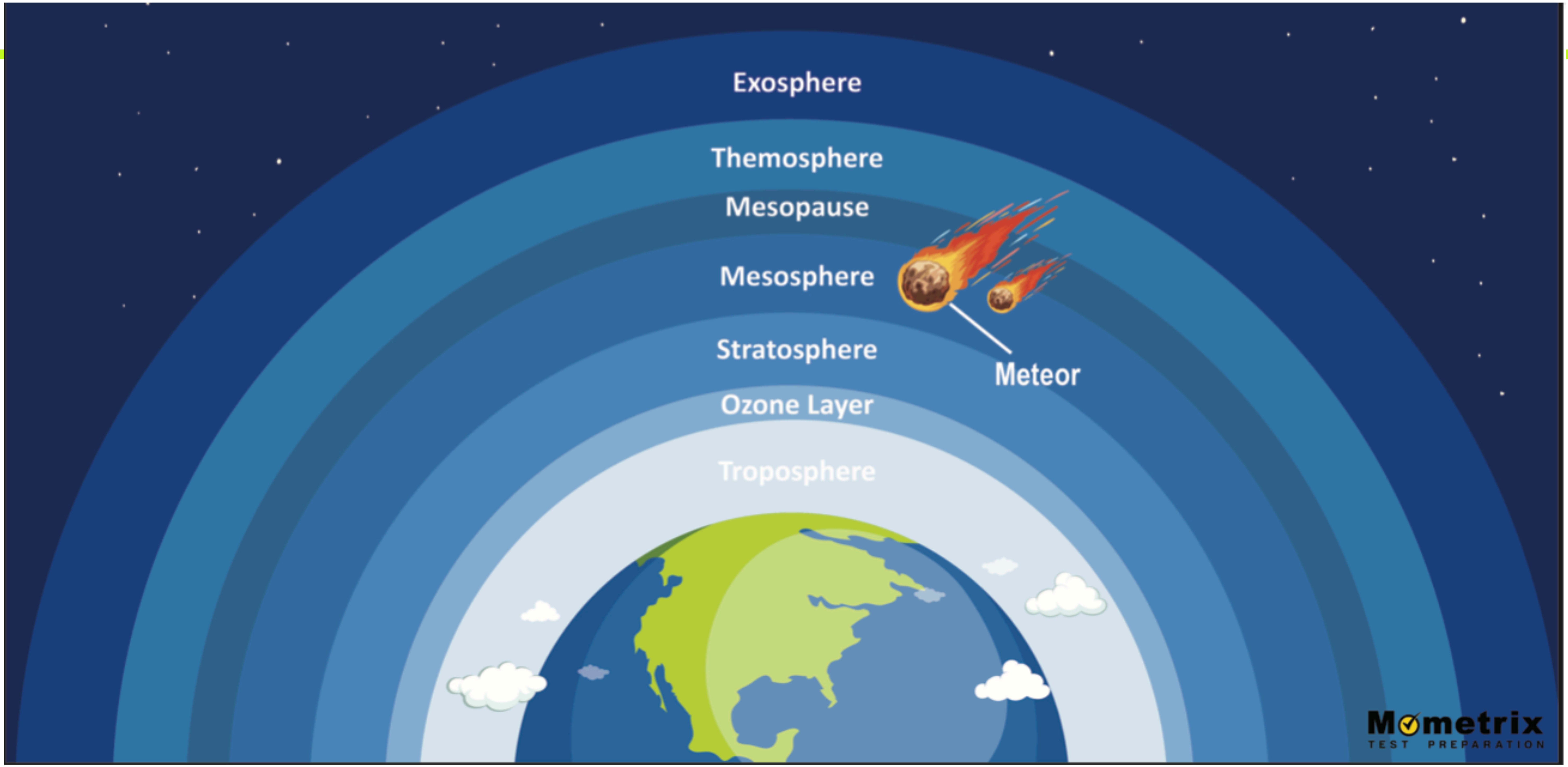
What is Ozone? Ozone Layer?

- Ozone (O_3) is a highly-reactive from of oxygen.
- Unlike oxygen (O_2), ozone has a strong scent and is blue in color.
- Ozone exists within both the tropospheric and stratospheric zones of the Earth's atmosphere
- In the troposphere, ground level ozone is a major air pollutant and primary constituent of photochemical smog
- In the stratosphere, the ozone layer is an essential protector of life on earth as it absorbs harmful UV radiation before it reaches the earth.

What is the ozone layer?

- The ozone layer is a layer of gas consisting of O_3 molecules, called ozone, that forms when free Oxygen molecules bond to O_2 molecules.





The thickness of the ozone layer varies worldwide and is generally thinner near the equator and thicker near the poles.[9] Thickness refers to how much ozone is in a column over a given area and varies from season to season. The reasons for these variations are due to atmospheric circulation patterns and solar intensity.[10]

What is the Ozone Layer??

- The ozone layer is a deep layer in the stratosphere (which is the second major layer of earths atmosphere) encircling the earth. That protects humans and other organism from the UV radiation.
- This layer shields the entire earth from much of the harmful ultraviolet radiation that comes from the sun.
- It absorbs 97-99% of the suns high frequency ultraviolet light, which is potentially damaging to the life form on earth.

So what might life be like without the ozone layer?

-- Skin Cancer (melanoma and nonmelanoma)
-- Premature aging of the skin and other problems
-- Cataracts and other eye damage
-- Immune system suppression

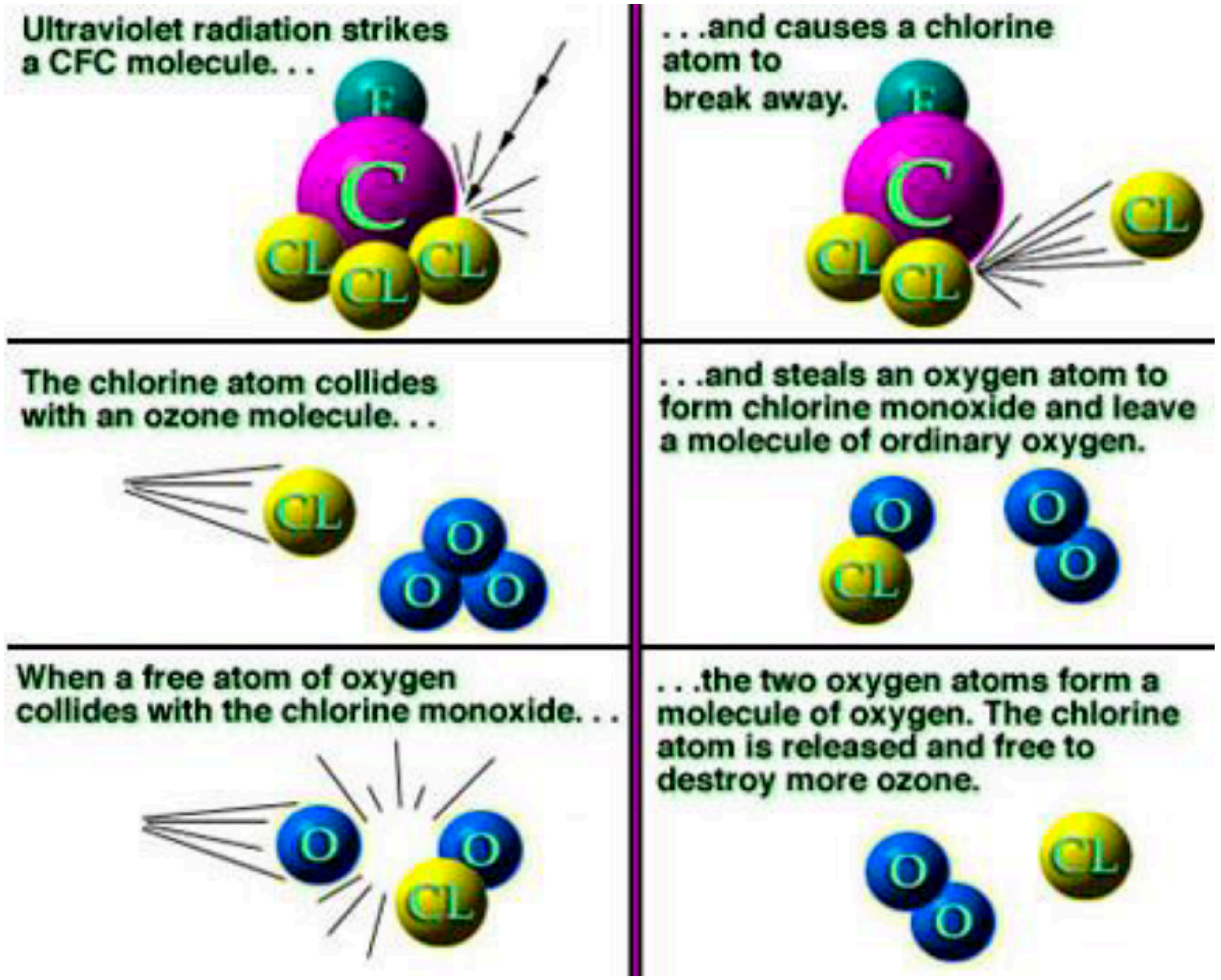
II. Ozone Depletion

When chlorine and bromine atoms come into contact with ozone in the stratosphere, they destroy ozone molecules. One chlorine atom can destroy over 100,000 ozone molecules before it is removed from the stratosphere. Ozone can be destroyed more quickly than it is naturally created.

Some compounds release chlorine or bromine when they are exposed to intense UV light in the stratosphere. These compounds contribute to ozone depletion, and are called ozone-depleting substances (ODS). ODS that release chlorine include chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), carbon tetrachloride, and methyl chloroform. ODS that release bromine include halons and methyl bromide. Although ODS are emitted at the Earth's surface, they are eventually carried into the stratosphere in a process that can take as long as two to five years.

In the 1970s, concerns about the effects of ozone-depleting substances (ODS) on the stratospheric ozone layer prompted several countries, including the United States, to ban the use of chlorofluorocarbons (CFCs) as aerosol propellants. However, global production of CFCs and other ODS continued to grow rapidly as new uses were found for these chemicals in refrigeration, fire suppression, foam insulation, and other applications.

CFCs and Ozone



How does ozone depletion affect global warming and ultimately climate change?

- **As ozone levels in the stratosphere are depleted, more solar radiation penetrates the Earth's atmosphere.**
- **This affect results in an increase in solar radiation reaching the Earth's surface adding to an increase in surface temperature.**
- **In turn, global warming actually results in a warming of the troposphere, but a cooling of the stratosphere, hindering the ozone layer's natural chemistry for repairs.**

How are we as humans affecting the ozone layer?

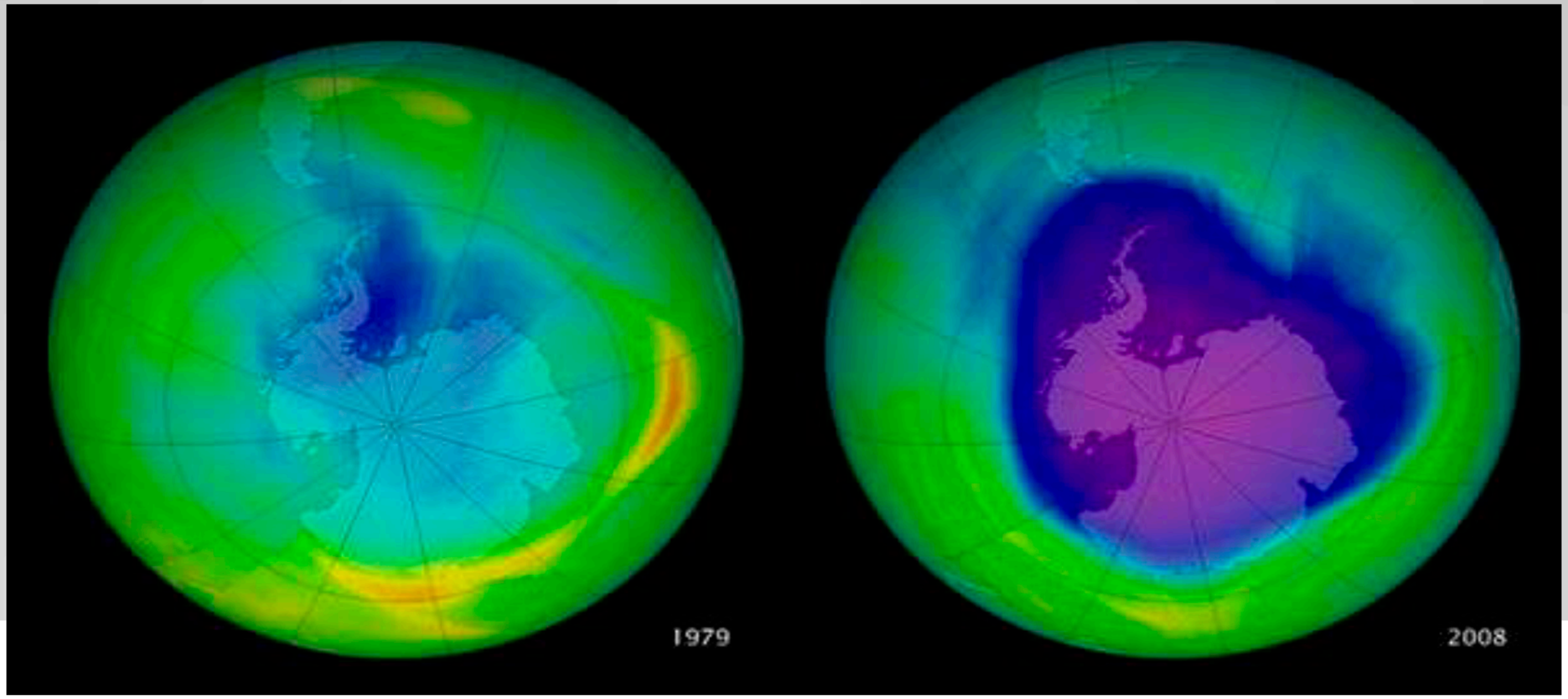
- **Since 1928, Chlorofluorocarbons have been produced, originally as nonflammable refrigerants for use in refrigerators, and eventually for use in fire extinguishers, dry cleaning agents, pesticides, degreasers, adhesives, and as propellants for aerosol products.**
- **As these CFCs have been released into the atmosphere, the level of ozone in the stratosphere has decreased.**
- **CFCs have an estimated lifespan of more than 100 years.**

What is being done about the ozone layer depletion?

- Ending the production, import and use of ozone-depleting substances (ODS), often ahead of the Montreal Protocol schedule
- Ensuring that ODS are recycled properly, and prohibiting unnecessary releases of ODS
- Identifying safe alternatives through the Significant New Alternatives Policy (SNAP) program
- Banning the release of ozone-depleting refrigerants during the service, maintenance, and disposal of air conditioners and other refrigeration equipment
- Requiring that manufacturers label products containing or made with the most harmful ODS

What is being done to protect the ozone Layer??

- The ozone layer is now being constantly monitored.
- It is predicted that by 2070, the ozone layer will have returned to pre-1980 levels.



Ozone at ground level-

Ozone

When you can see the ozone, that's not a good sign. Tanes Ngamsom/Shutterstock

Comprised of three oxygen atoms, ozone is created at ground level by a chemical reaction between oxides of nitrogen (NOx) and volatile organic compounds (VOCs) in the presence of sunlight. Depending on its location in the atmosphere, ozone can be "good" or "bad."

"Good" ozone occurs naturally in the stratosphere, 10 to 30 miles above the surface of the earth and it forms a layer that protects life on earth from the powerful rays of the sun. "Bad" ozone contains motor vehicle exhaust, industrial emissions, chemical solvents and other hazardous substances, forming the bulk of the clouds of smog that form over many urban areas.

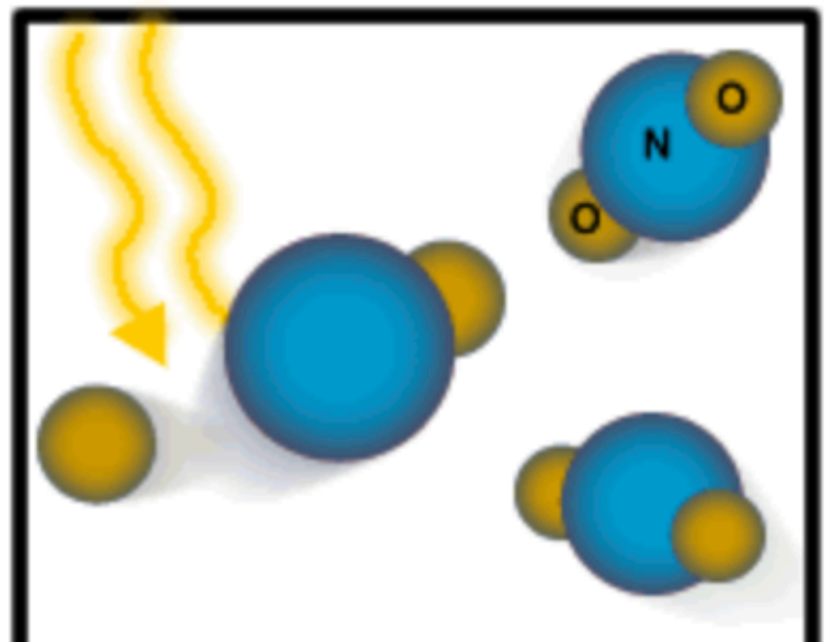
Ozone in the Troposphere

Ozone and other air pollutants are common in urban areas in late afternoon.
Credit: UCAR

In the stratosphere, ozone molecules play an important role - absorbing ultraviolet radiation from the Sun and shielding Earth from dangerous rays. But in the troposphere, near ground-level, ozone molecules are both air pollutants, threatening the health of living things, and greenhouse gases, trapping heat and contributing to climate change.

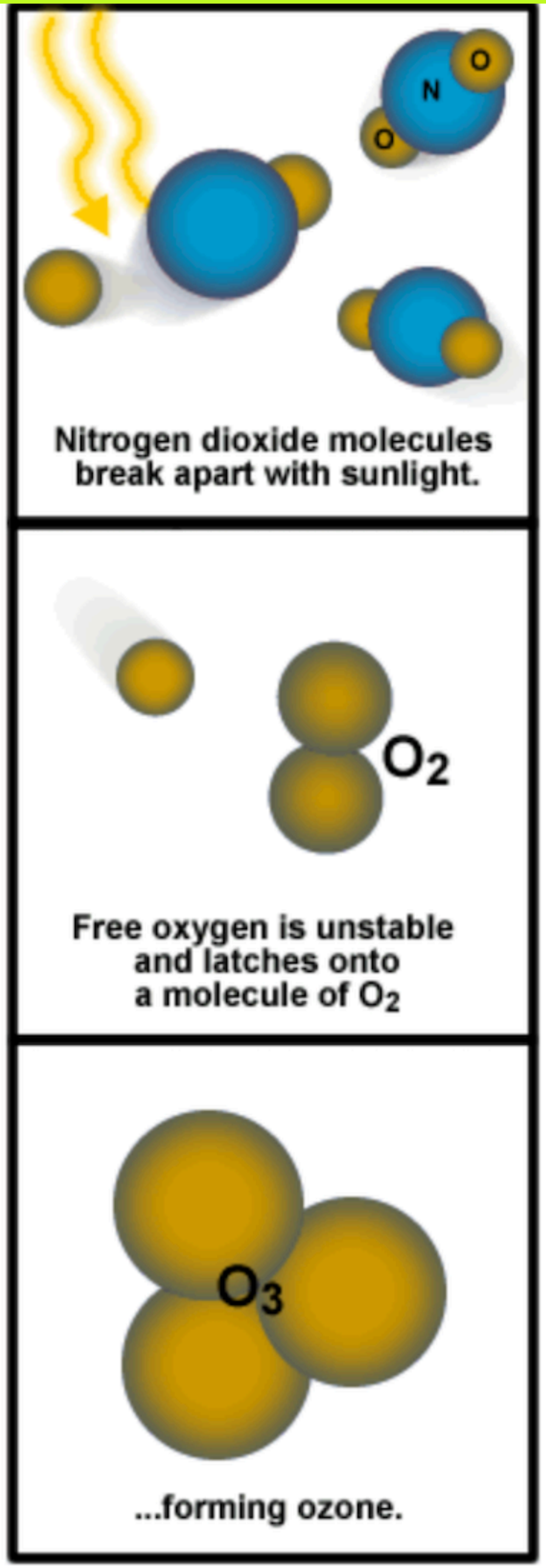
A small amount of ozone does occur naturally at ground level. Plants and soil release some. Some migrates down from the stratosphere. But neither of these sources contributes enough ozone to be considered a threat to the health of humans or the environment. Most of the ozone that is found near the ground comes from vehicle exhaust and emissions from factories, power plants, and refineries. Since 1900, the amount of ozone near the Earth's surface has more than doubled due to more automobiles and industry.

Unlike most other air pollutants, ozone is not directly emitted into the air. Tropospheric ozone is formed by the interaction of sunlight, particularly ultraviolet light, with hydrocarbons and nitrogen oxides, which are emitted by automobile tailpipes and smokestacks. In urban areas, high ozone levels usually occur during warm summer months. Typically, ozone levels reach their peak in mid to late afternoon, after exhaust fumes from morning rush hour have had time to react in sunlight. A hot, sunny, still day is the perfect environment for the production of ozone pollution. At the end of the day, as the Sun starts to set, the production of ozone begins to subside. To form, ozone needs sunshine to fuel the chemical reaction.



Nitrogen dioxide molecules break apart with sunlight.

Forming Ozone in the Troposphere



How ground-level ozone is formed.

Problems with the Ozone layer

- Ozone itself is a type of oxygen but unlike the oxygen we need to breath, it's a poisonous gas.

- It is the main ingredient of todays city smog and irritates conditions like asthma and bronchitis diseases.

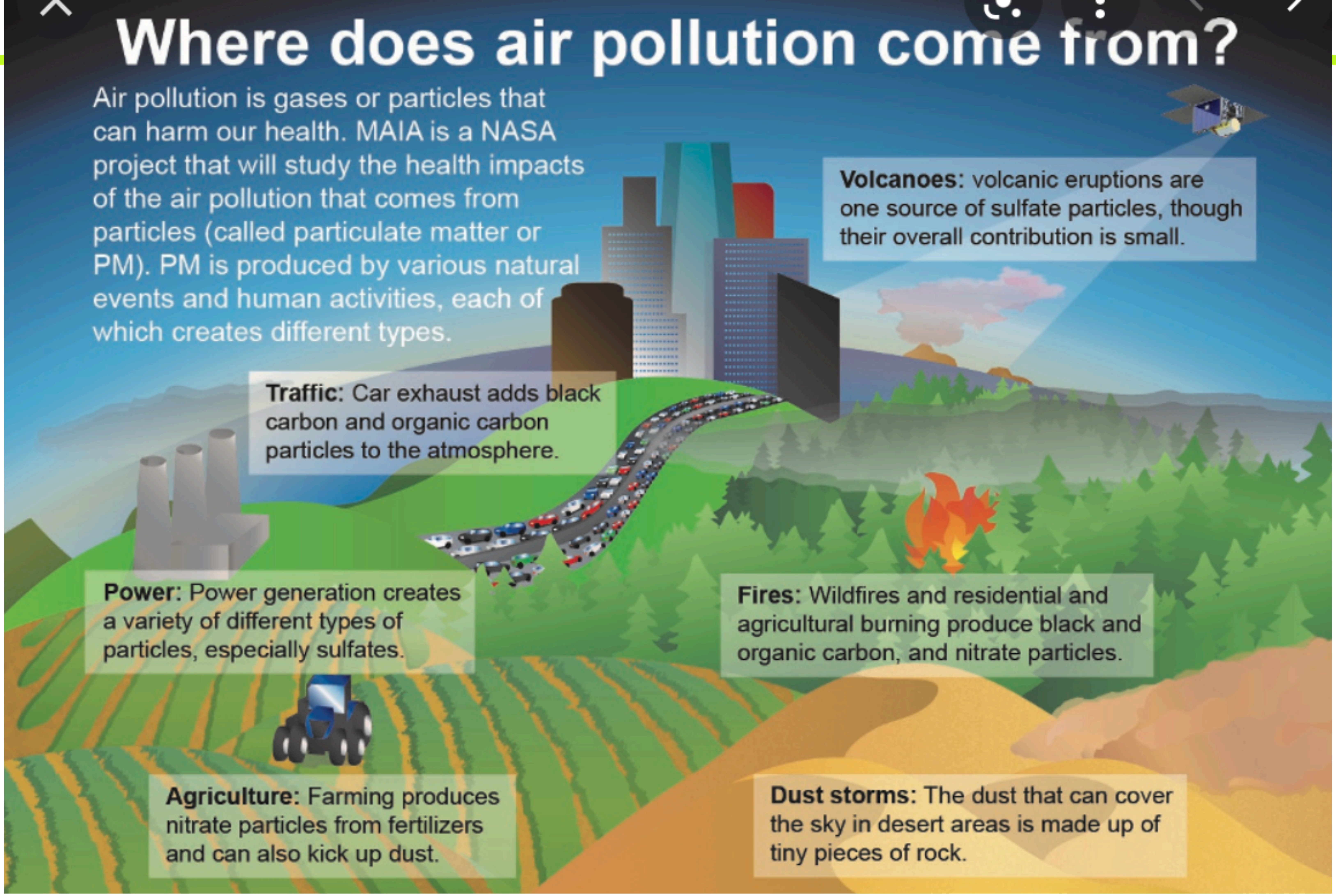
OZONE POLLUTION

When ozone pollution reaches high levels, pollution alerts are issued urging people with respiratory problems to take extra precautions or to remain indoors. When it's inhaled, ozone can damage lung tissues. Ozone is harmful to all types of cells. It can impair an athlete's performance, create more frequent attacks for individuals with asthma, cause eye irritation, chest pain, coughing, nausea, headaches and chest congestion. It can worsen heart disease, bronchitis, and emphysema.

Ozone also damages materials like rubber, textile dyes, fibers, and certain paints. These materials can be weakened or degraded by exposure to ozone. Some elastic materials can become brittle and crack, while paints and fabric dyes may fade more quickly.

What can we do to decrease the production of ozone in the troposphere? Choosing public transportation, walking, or biking instead of traveling in cars is a good step. If you wait until evening to refuel your car or mow your lawn, it's unlikely that the pollutants released will become ozone. And, on a larger scale, you can look for energy sources that don't emit the pollution that leads to ozone. Check with your utility company to find out where your energy comes from.

Check out the EPA's Actions You Can Take to Reduce Air Pollution for more tips to reduce air pollution.



They spew forth from automobiles and factories, waft up into the air from livestock farms and even come from the ground and other natural sources. Common air pollutants are found all around us, and they can cause severe health effects as well as environmental damage.

Man-Made Causes of Air Pollution

The burning of fossil fuels such as coal, gasoline and kerosine produces most of the world's air pollution.

COAL-OUR MAIN PROBLEM

Coal Power

Coal is the most iconic source of power for many people. In actual practice, reliance on coal varies widely throughout the United States. A few areas, like Long Island and parts of Hawaii and Alaska, are completely coal-free. However, parts of the Midwest draw more than half of their electricity — up to 71 percent — from coal plants.

Despite tremendous growth in renewable energy over the past decade, fossil fuels — natural gas and coal — still provide the majority of electricity in the United States. Even with coal production at a 40-year low, it is still our second-largest source of electricity, producing 27 percent of the nation's power overall.

Gases that lead to air pollution

Gases that lead to air pollution include carbon, nitrogen and sulfur oxides. While some of these gases occur naturally, like carbon dioxide in the expulsion of air from the lungs, the serious polluters come from the burning of fossil fuels: coal, oil and natural gas.

Photochemical smog

Photochemical smog is a type of smog produced when ultraviolet light from the sun reacts with nitrogen oxides in the atmosphere. It is visible as a brown haze, and is most prominent during the morning and afternoon, especially in densely populated, warm cities.[2] Cities that experience this smog daily include Los Angeles, Sydney, Mexico City, Beijing, and many more.

Figure 1. Photochemical smog over Shanghai.[1]

Formation

Photochemical smog forms from a complex process, however the source of it is quite apparent. The largest contributor is automobiles, while coal-fired power plants and some other power plants also produce the necessary pollutants to facilitate its production. Due to its abundance in areas of warmer temperatures, photochemical smog is most common in the summer.[3]

Photo Chemical SMOG

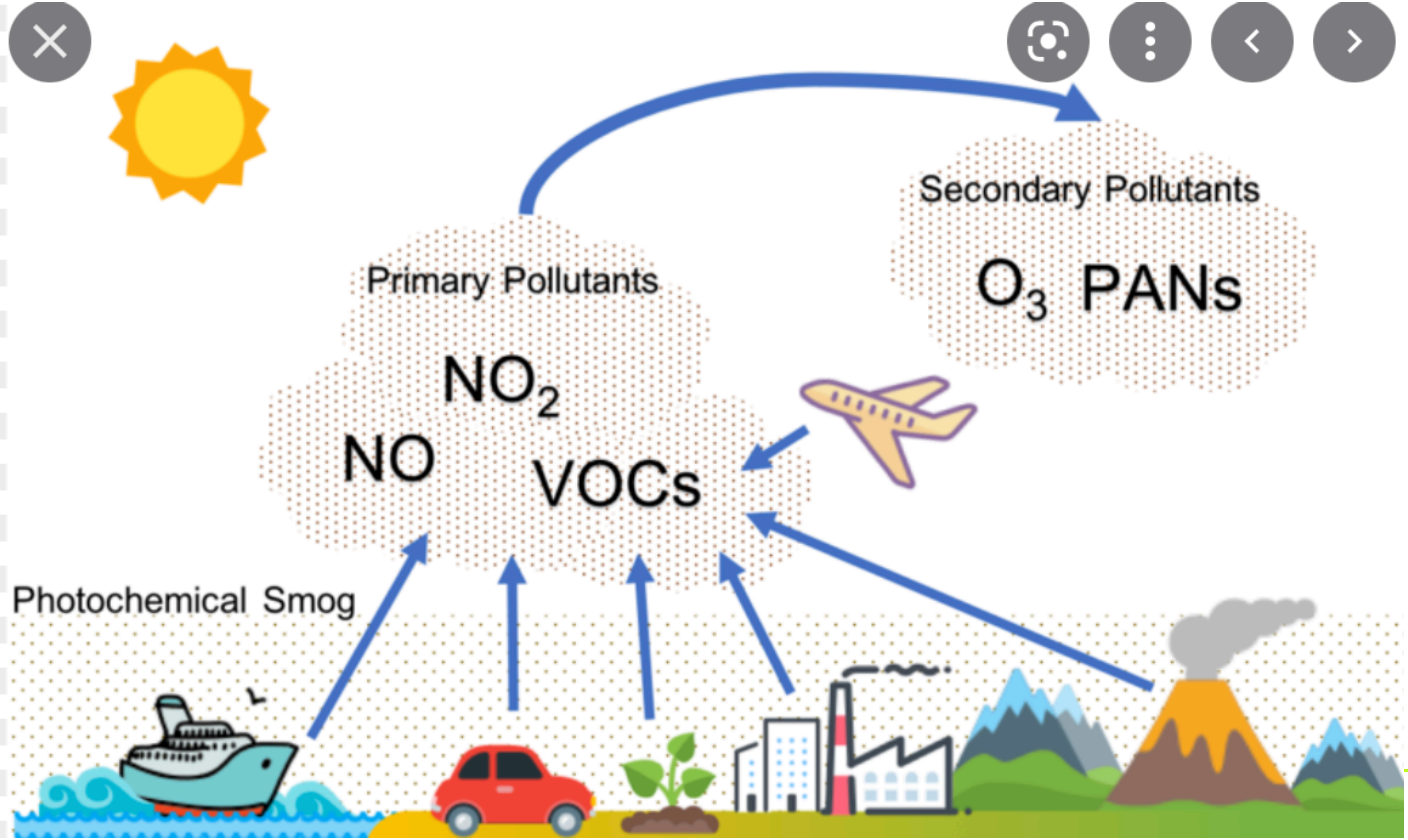


Photo Chemical SMOG

It forms in the morning when a tremendous number people are driving their vehicles to work. Nitrogen oxides produced in the car engine are introduced into the atmosphere, which may combine with water to form nitric acid or react with sunlight to produce singular oxygen atoms, which then combine with molecular oxygen to produce ozone.[2] The nitric acid may precipitate to the Earth resulting in acid rain, or remain in the smog. Due to the direct production of it by vehicles, the smog forms over cities where many people may encounter its adverse health effects.

Hotter days mean more photochemical smog, especially in the densely populated cities such as those mentioned above. As more and more urban populations arise around the globe, this problem is only expected to increase.[4]

Composition

Nitric oxide (NO) and nitrogen dioxide (NO_2) are emitted from the combustion of fossil fuels, along with being naturally emitted from things such as volcanos and forest fires (it is the *immense concentration* of these pollutants within cities that is of the most concern however, as natural emissions tend to spread out over larger areas). When exposed to ultraviolet radiation, NO_2 goes through a complex series of reactions with hydrocarbons to produce the components of photochemical smog—a mixture of **ozone**, **nitric acid**, **aldehydes**, **peroxyacyl nitrates** (**PANs**) and other secondary pollutants.[4]

Photo Chemical SMOG

NO_2, ozone and PANs are called **photochemical oxidants** because they can react and oxidize certain compounds in the atmosphere or within a person's lungs that are not normally oxidized. Even small traces of these chemicals can affect the respiratory tract of humans and animals, and damage crops and trees.[4]

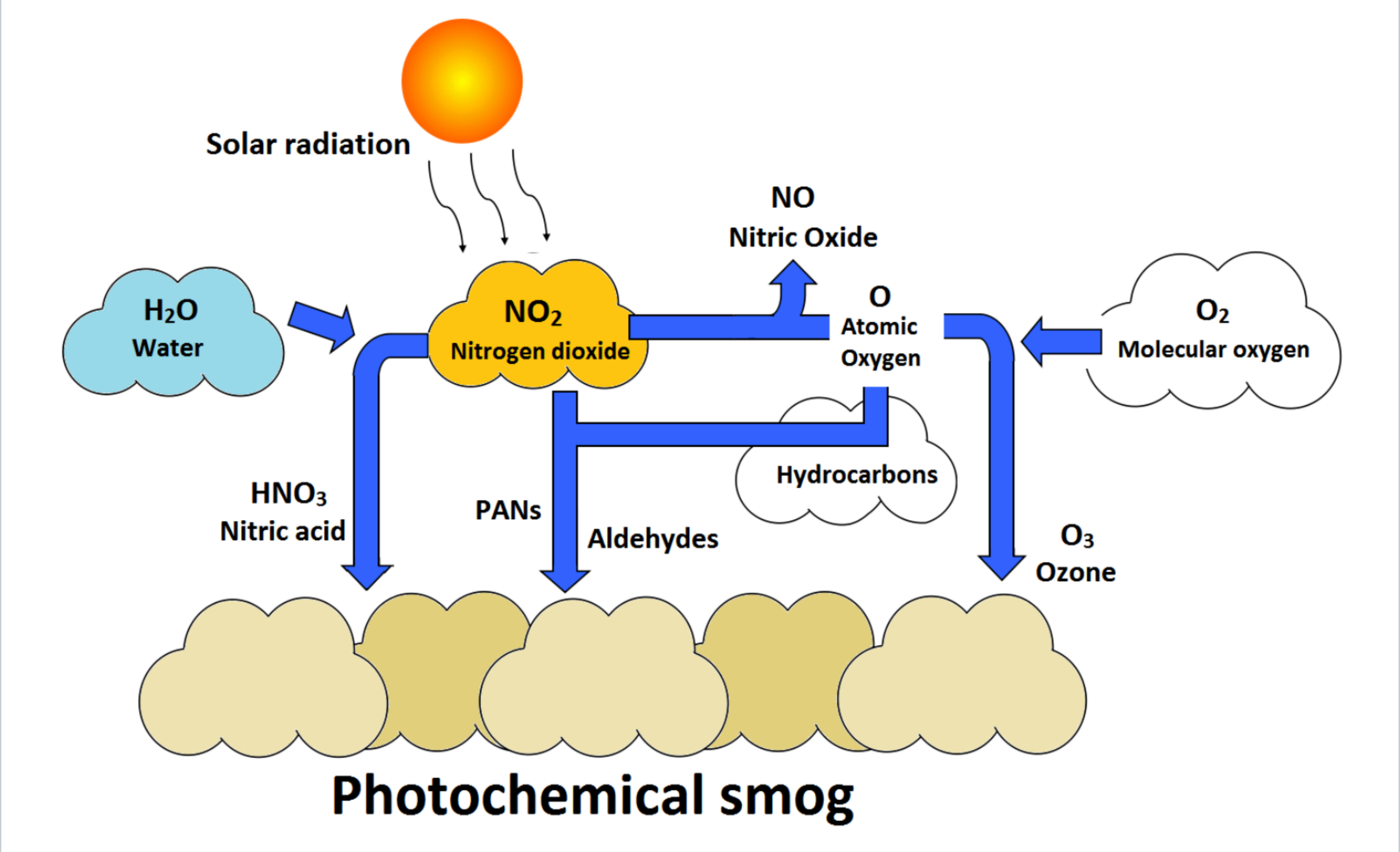


Figure 2. Photochemical smog formation; sunlight reacts with NO_2 which then interacts with other molecules in the air to form smog.[5]

Solutions

- Clean vehicle and fuel technologies provide us with an affordable means of reducing related air pollution and and climate change emissions .
- These include fuel efficient vehicles that use less oil and have cleaner fuels that produce fewer emissions.

The Earth can be saved!!

The science is in: We don't have to accept a fate of gloom and doom for the Earth. This is a hopeful wake-up call, but only if we act with great urgency.

In recent, published research from The Nature Conservancy and 12 peer organizations, **science points us to a better path** for building a more sustainable, more hopeful future for the Earth.

A future in which catastrophic climate change is kept at bay while we still power our developing world. A future in which we can feed 10 billion people worldwide and provide cleaner, more abundant drinking water while also protecting life-giving lands, lakes and rivers. A future in which nature's wild heart still beats strong through healthy wildlife and magnificent landscapes while our cities are strengthened by harmony with nature.

A future in which people and nature thrive together. Science shows us this vision of the future is achievable, and **we must join together** and put all our effort into the big priorities that will make this vision a reality.

The 3 Things We Must Do

The stakes couldn't be higher. If we follow the path that science shows us, we have the power to save nearly all habitat types across the world's lands. That's a huge win for wildlife, birds, plants, insects and the diversity of life that makes our natural world such a treasure.

Urgent action is essential, and we must seize the unprecedented opportunities to change the course of history. The international community is preparing to make path-defining choices for the future, with once-in-a-lifetime agreements that have the power to stop catastrophic climate change and preserve biodiversity on Earth.

This could be the decade we save the planet. But we must follow through on the promises, policies, and collaborative effort needed to protect nature from collapse.

Here are three top ways we need to up-end 'business as usual' and act boldly to advance conservation. Read on or check out our interactive graphic of the big impact these solutions can make.

1. Produce More Food on Less Land

Problem:

Today's version of large-scale agriculture is the biggest source of land conversion, drives deforestation that worsens climate change, uses 70 percent of the world's freshwater supply and relies on fertilizer practices that pollute our waters. As the need to feed a billion more people increases, agricultural expansion could devastate habitats, release even more carbon into the atmosphere, and dry up rivers.

TARGETED AGRICULTURAL EXPANSION Identify areas where crops grow best to avoid destroying nature.

How to fix it:

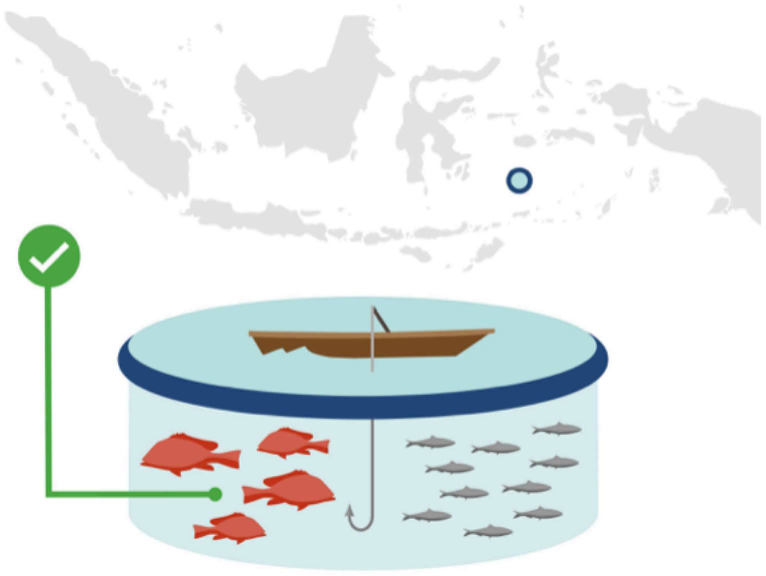
Produce food where it's most likely to thrive, which will use less water and less land.

How we're taking action right now:

We're analyzing satellite images and local yield potential to pinpoint where soy farming and cattle ranching can expand without destroying nature. This approach is especially vital in Brazil's Cerrado region, where half of all natural habitat has already been converted to cropland and pasture. Cooperating with farmers on sustainable practices can help save what's left of the Cerrado's rich savanna.

2. Eliminate Overfishing

Problem:



TARGETED FISHING Use technology to catch only the right species.

Overfishing and poor fisheries management is not only devastating to the fish species being pushed to the brink of collapse. It endangers food webs and ocean ecosystems by disrupting the balance of all sea life. And it threatens billions of people who rely on seafood as an important source of livelihood and animal protein. Without serious changes, 84 percent of the world's fish stocks will be in peril in our lifetime.

How to fix it:

Refine our fishing methods to only take what the fish populations can tolerate now, so our oceans can be more abundant and healtheir in the future.

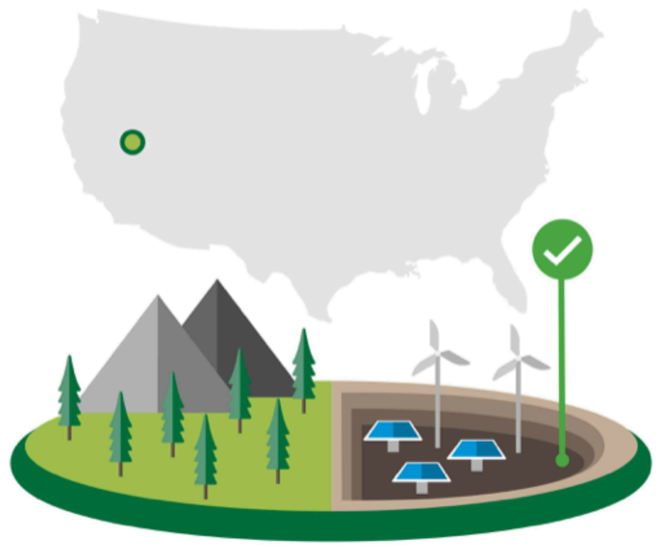
How we're taking action right now:

We're making it fast, easy and affordable for fishers to use data to manage their catches more sustainably. Like image recognition software, FishFace technology we're pioneering in Indonesia uses artificial intelligence and machine learning to identify fish species and track their numbers so fishers can avoid catching too many or the wrong kind.

3. Increase Clean Energy

Problem:

Climate change is the single most serious threat facing our planet today. We must reduce carbon emissions to, or below, levels agreed to in the Paris Climate Agreement to prevent catastrophic harm. And with global energy demand expected to increase 56 percent over the next couple decades, it will be impossible to meet those emissions targets if we stick primarily with traditional fossil fuels.



TARGETED ENERGY SITING Use already degraded land for energy development.

How to fix it:

Shift 85 percent of the world's energy supply to non-fossil fuel sources and invest in strategies like reforestation that capture carbon dioxide.

How we're taking action right now:

We're championing regulations that allow former mining lands to be repurposed for solar and wind energy. Tens of thousands of acres of degraded mine sites in Nevada's Great Basin are now available for renewable energy development. By targeting already-disturbed land, new turbines and solar panels won't need to destroy more natural habitat.

WE CAN DO THIS

WE CAN DO THIS

WE CAN DO THIS

The Interdependence Of Humanity And Earth

November 8, 2017 · 8:27 AM ET

MARCELO GLEISER

Stromatolites (deposits built by colonies of cyanobacteria), are seen underwater at high tide in Shark Bay, Western Australia.
Auscape/UIG via Getty Images

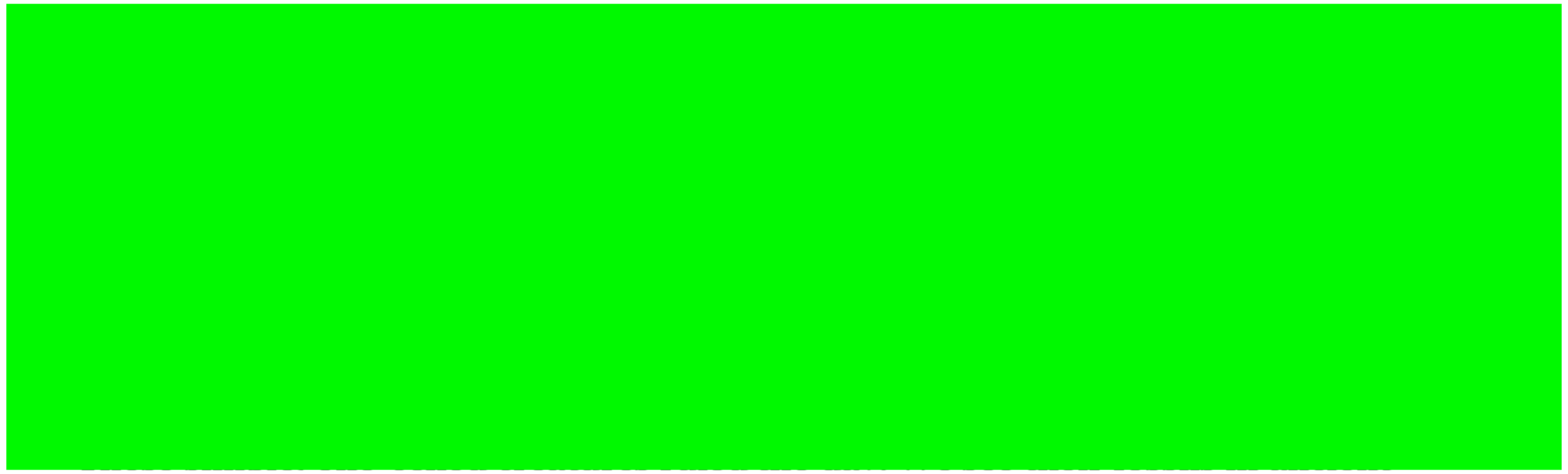
Living in cities or suburbs, amid the race of everyday routine, we have little time to care about what goes on at the planetary level — or about the uniqueness of our planet.

But even if every world out there, among the trillions in our galaxy alone, is unique, there is something very special about Earth: Our existence is completely and inextricably dependent on it. This is something we should pause to consider, even amid the race of everyday routine, as the last week's report from the Trump Administration starkly reminds us.

First, there is the sun. The energy it generates, and has been generating for almost five billion years, is absolutely essential for life on Earth. Our planet lies in the so-called habitability zone, defined as the range of distances from star to planet where water, if present, has a chance of being in its liquid state. Why the fuss about liquid water? The premise here is that without it there is no life, at least as we know it.

Still, we see that Venus and Mars, also in the sun's habitability zone, haven't fared so well. (Note that there are controversial debates about what really comprises a planet's habitability zone, as for example, here. As in a football game, being well-positioned isn't enough for a player to score a touchdown. A player needs talent and speed, what, in a planet, we'd call appropriate properties.

Venus is truly like hell, so hot that rocks glow. Its super-dense atmosphere is filled with sulfur compounds, including hydrogen sulfide, the one that gives rotten eggs their disgusting stink. Mars is a frozen desert, with canyons and other rich geological structures that show that things were different in its past. In its infancy, Mars had plenty of water, enough, many believe, to have had some kind of rudimentary life. But its weak gravity couldn't stop its atmosphere from being blown off by solar winds, the radiation the sun blows across the solar system.



Earth is approximately 4.53 billion years old. During its first 600 million years, constant bombardment from asteroids and comets, debris from the early formation of the planets in the solar system, brought a host of precious compounds and water — but also created impossible conditions for life to thrive. Still, as things quieted down, the stage was set for the primordial stew to brew the first living creatures, at least 3.5 billion years ago, possibly sooner.

These simple, one-celled creatures ruled the day. We see their fossils in ancient bacterial colonies called stromatolites, as the ones found in Australia's Shark Bay. For a billion years, little happened. But Earth cooled and settled, and shallow bits of land poked up from the oceans here and there. Some 2.4 billion years ago, these unicellular beings went through a fundamental mutation that made them capable of photosynthesis, essentially the property of turning sunlight into food by consuming carbon dioxide and eliminating oxygen. Slowly, these creatures promoted a global change in Earth's atmosphere, which became progressively richer in oxygen.

We owe our existence to these little photosynthetic bacteria. But there is much more to this story, as life can only mutate and adapt when the planet offers the right conditions. Despite the many dramatic changes that Earth underwent during its existence, it has remained fairly stable for the last 2 billion years. There were, of course, huge cataclysms: massive volcanic eruptions, global methane release, collisions with large asteroids and comets. Although these events changed the environment and affected the lifeforms then prevalent, they never got life to the point of complete extinction. (The great Permian-Triassic extinction event came close: Starting 299 million years ago and lasting for 15 million years, it eliminated more than 95 percent of marine and 70 percent of terrestrial species.)

Compared to other worlds we know, Earth stands out as an oasis for life. Its atmosphere protects surface dwellers from lethal solar ultraviolet rays. Its magnetic field also acts as a powerful shield against radiation from space, especially particles from the solar wind. The slow drift of tectonic plates recycles carbon dioxide between oceans and atmosphere. Our large moon stabilizes Earth's tilted rotation axis, allowing for the seasons and for water to remain liquid in much of its surface. These properties, taken together, make our planet home for countless life forms, from the cold and dark depths of oceans to frozen mountaintops.

A NOTE TO THINK ABOUT AT THE END OF THIS LECTURE

We are not here by chance. We are the product of this story, of the mutations that transformed bacteria into people, of the cataclysmic accidents that redefined the conditions on our planet, of the climatic and geologic changes that unfolded over billions of years.

Knowing this doesn't make us smaller, as many believe. Quite the contrary, it sends us to the top of this extended chain of life, as we are the only creatures we know capable of reconstructing our past with such detail and, at the same time, of asking questions about our future.

On the other hand, we must realize that being at the top doesn't mean we can despise those below. From power comes responsibility, which, in this case, means to work to protect life and our planet, understanding that we are part of the same chain that connects bacteria to whales. If our knowledge makes us strong, we remain fragile when confronting nature's power. If we plan to remain here for a few more thousands of years, the only option we have is to treat Earth with humility and respect.

Marcelo Gleiser is a theoretical physicist and writer — and a professor of natural

END LECTURE HERE

Photosynthetic Cells

Cells get nutrients from their environment, but where do those nutrients come from? Virtually all organic material on Earth has been produced by cells that convert energy from the Sun into energy-containing macromolecules. This process, called photosynthesis, is essential to the global carbon cycle and organisms that conduct photosynthesis represent the lowest level in most food chains (Figure 1).

Figure 1: Photosynthetic plants synthesize carbon-based energy molecules from the energy in sunlight. Consequently, they provide an abundance of energy for other organisms.
Plants exist in a wide variety of shapes and sizes. (A) *Coleochaete orbicularis* (Charophyceae) gametophyte; magnification x 75 (photograph courtesy of L. E. Graham). (B) Chara (Charophyceae) gametophyte; magnification x 1.5 (photograph courtesy of M. Feist). (C) Riccia (liverwort) gametophyte showing sporangia (black) embedded in the thallus; magnification x 5 (photograph courtesy of A. N. Drinnan). (D) Anthoceros (hornwort) gametophyte showing unbranched sporophytes; magnification x 2.5 (photograph courtesy of A. N. Drinnan). (E) Mnium (moss) gametophyte showing unbranched sporophytes with terminal sporangia (capsule); magnification x 4.5 (photograph courtesy of W. Burger). (F) Huperzia (clubmoss) sporophyte with leaves showing sessile yellow sporangia; magnification x 0.8. (G) Dicranopteris (fern) sporophyte showing leaves with circinate vernation; magnification x 0.08. (H) Psilotum (whisk fern) sporophyte with reduced leaves and spherical synangia (three fused sporangia); magnification x 0.4. (I) Equisetum (horsetail) sporophyte with whorled branches, reduced leaves, and a terminal cone; magnification x 0.4. (J) Cycas (seed plant) sporophyte showing leaves and terminal cone with seeds; magnification x 0.05 (photograph courtesy of W. Burger).

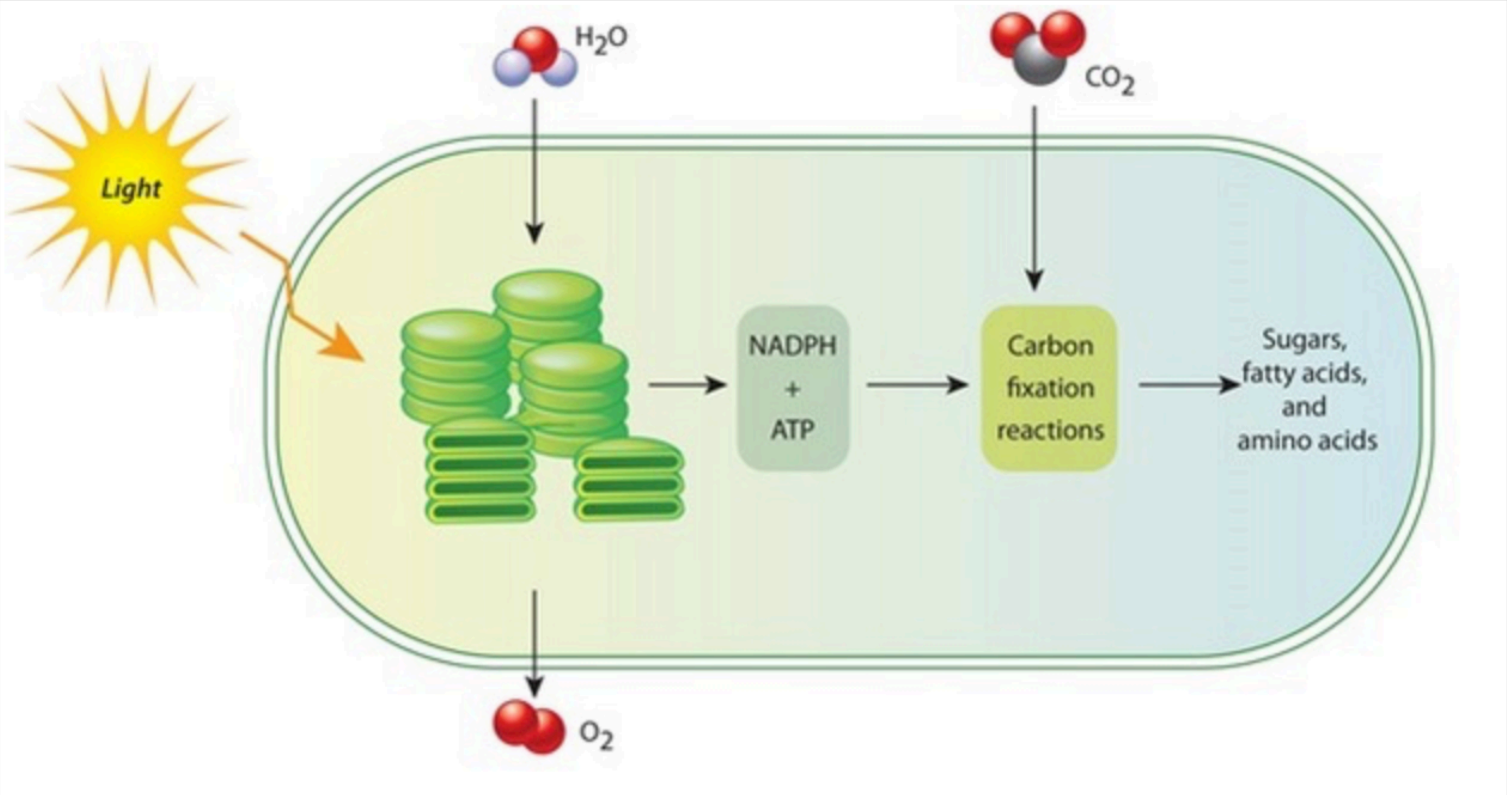


Figure 5: The light and dark reactions in the chloroplast
The chloroplast is involved in both stages of photosynthesis. The light reactions take place in the thylakoid. There, water (H_2O) is oxidized, and oxygen (O_2) is released. The electrons that freed from the water are transferred to ATP and NADPH. The dark reactions then occur outside the thylakoid. In these reactions, the energy from ATP and NADPH is used to fix carbon dioxide (CO_2). The products of this reaction are sugar molecules and various other organic molecules necessary for cell function and metabolism. Note that the dark reaction takes place in the stroma (the aqueous fluid surrounding the stacks of thylakoids) and in the cytoplasm.

Figure Detail

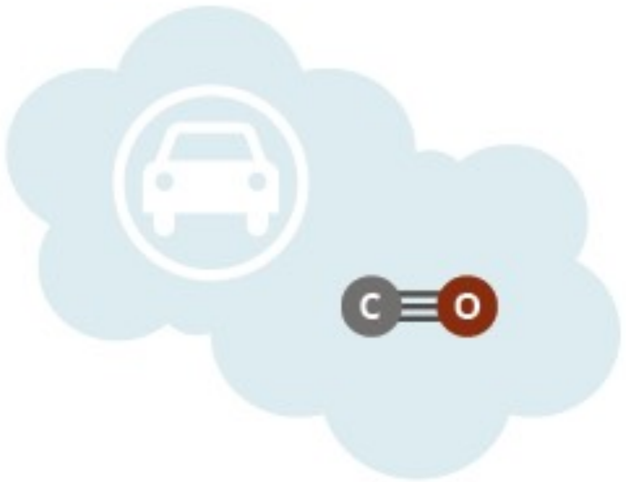
Once the light reactions have occurred, the light-independent or "dark" reactions take place in the chloroplast stroma. During this process, also known as carbon fixation, energy from the ATP and NADPH molecules generated by the light reactions drives a chemical pathway that uses the carbon in carbon dioxide (from the atmosphere) to build a three-carbon sugar called glyceraldehyde-3-phosphate (G3P). Cells then use G3P to build a wide variety of other sugars (such as glucose) and organic molecules. Many of these interconversions occur outside the chloroplast, following the transport of G3P from the stroma. The products of these reactions are then transported to other parts of the cell, including the mitochondria, where they are broken down to make more energy carrier molecules to satisfy the metabolic demands of the cell. In plants, some sugar molecules are stored as sucrose or starch.

Conclusion

Photosynthetic cells contain chlorophyll and other light-sensitive pigments that capture solar energy. In the presence of carbon dioxide, such cells are able to convert this solar energy into energy-rich organic molecules, such as glucose. These cells not only drive the global carbon cycle, but they also produce much of the oxygen present in atmosphere of the Earth. Essentially, nonphotosynthetic cells use the products of photosynthesis to do the *opposite* of photosynthesis: break down glucose and release carbon dioxide.

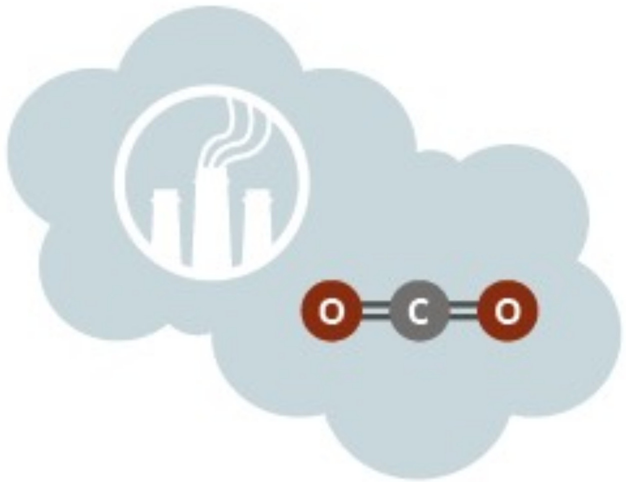
A BRIEF GUIDE TO ATMOSPHERIC POLLUTANTS

A number of different chemical entities, from a range of sources, can contribute towards atmospheric pollution, the consequences of which can include global warming and smog. This graphic looks at a selection of major groups of atmospheric pollutants, their major sources, and their effects.



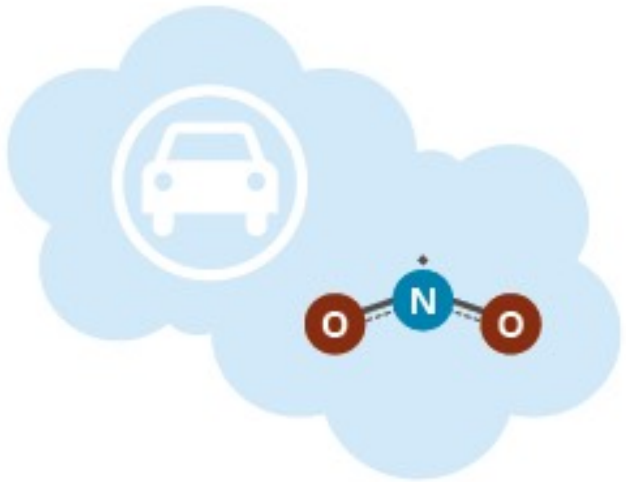
CARBON MONOXIDE

A gas generated by the incomplete combustion of fuels – primarily from road transport. Affects human health, as it reduces oxygen-carrying capacity of the blood. It also reacts with other atmospheric gases to produce ozone.



CARBON DIOXIDE

A gas generated by the burning of fossil fuels in the production of electricity. Also emitted by natural processes. Human emissions are linked with rising atmospheric CO_2 levels and anthropogenic global warming.

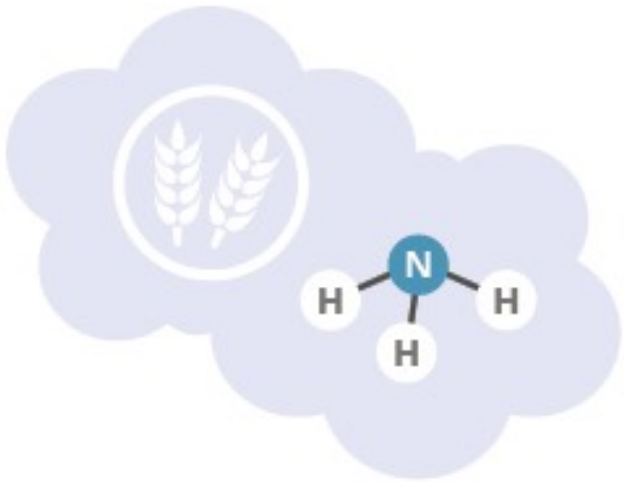


NITROGEN OXIDES

Primarily created by combustion in road transport. Nitrous oxide is an important global warming contributor, whilst nitrogen dioxide is involved in ground-level ozone forming reactions, and is also a component of smog.

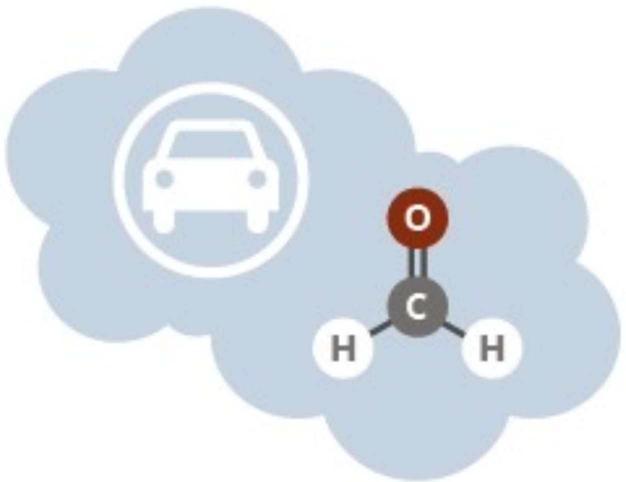
SULFUR DIOXIDE

The primary source of sulfur dioxide is the burning of fossil fuels to generate electricity. It can contribute to smog, reacts with water to produce acid rain, and can also cause wheezing and breathing problems for asthmatics.



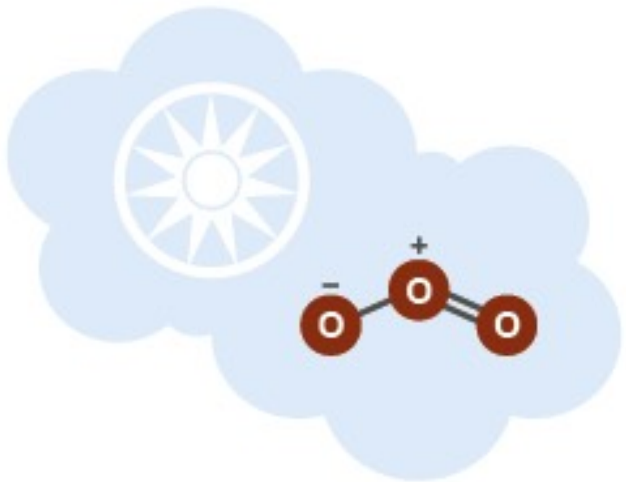
AMMONIA

Ammonia's primary atmospheric source is from its use in agriculture, such as manure & fertilisers. It can react with other pollutants to produce particulate matter. It also has the ability to over-enrich ecosystems with nitrogen.



VOCs

VOCs (volatile organic compounds) are emitted naturally by vegetation. Amongst significant human sources is road transport, as well as solvents. They can contribute to formation of ground-level ozone and smog.



OZONE

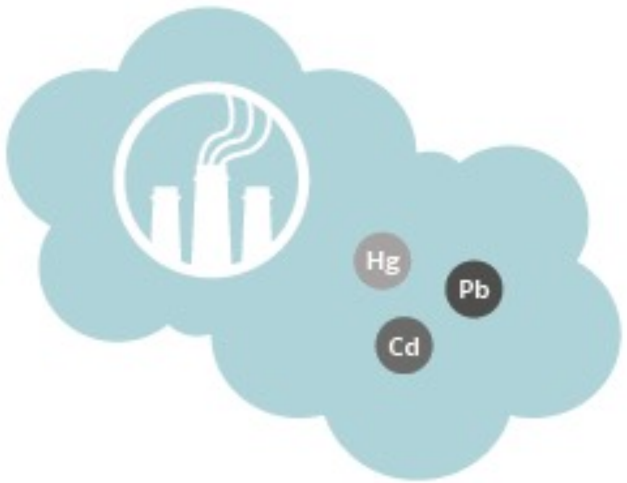
The ozone layer shields us from UV radiation, but ground-level ozone is a major pollutant. It's formed from other pollutants in the presence of sunlight. Ozone is a major component of smog, and can also cause health effects.

POPs

POPs (persistent organic pollutants) are volatile chemicals released into the atmosphere, often from agricultural or industrial uses. They persist in the environment and can have health effects on both wildlife & humans.

PARTICULATE MATTER

Particulate matter is composed of a huge number of different components. Some are directly emitted, while others are generated by reactions in the atmosphere. They cause haze and can also cause lung problems if inhaled.



HEAVY METALS

Heavy metals are released into the atmosphere from a range of sources, including burning of fossil fuels and road transport emissions. Some, such as mercury and lead, have toxic health effects in humans.

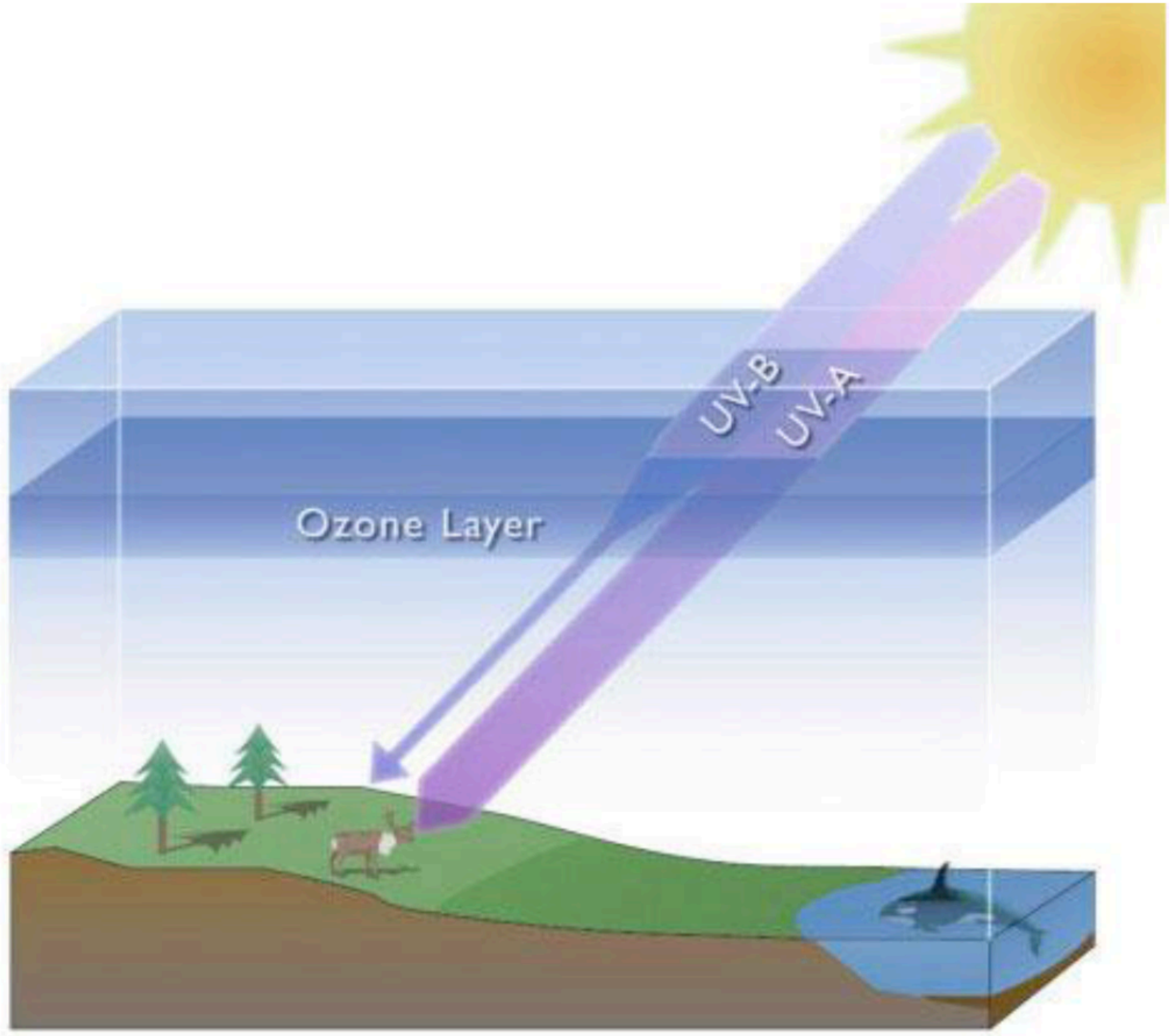
4 Types of fossil fuels

What are the 4 types of fossil fuels?

Petroleum, coal, natural gas and orimulsion are the four fossil fuel types. They have a variety of physical, chemical and other essential properties in general, but the most vital thing regarding fossil fuels, perhaps, is that they are not green. Fossil fuels are made from plants and animals that decompose.

So, why is the ozone layer important to life on Earth?

- **The stratospheric ozone layer completely stops the penetration of UV-C rays and eliminates most of the UV-B rays.**
- **Therefore, the ozone layer protects life on Earth from the harmful effects of solar radiation on a daily basis.**



©2004, ACIA

The SUN

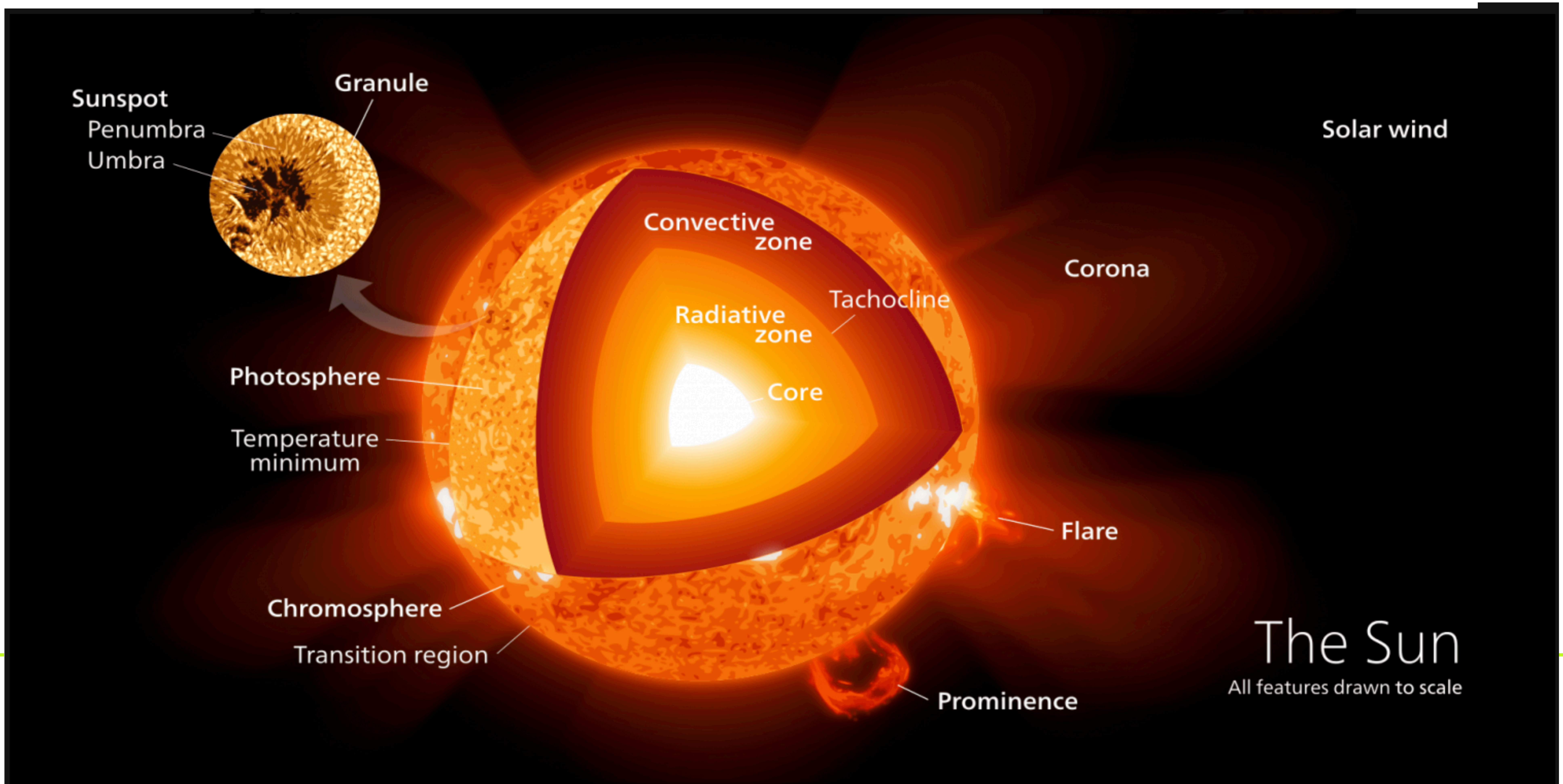
The simple answer is that the Sun, like all stars, is able to create energy because it is essentially a massive fusion reaction. Scientists believe that this began when a huge cloud of gas and particles (i.e. a nebula) collapsed under the force of its own gravity – which is known as Nebula Theory. This not only created the big ball of light at the center of our Solar System, it also triggered a process whereby hydrogen, collected in the center, began fusing to create solar energy.

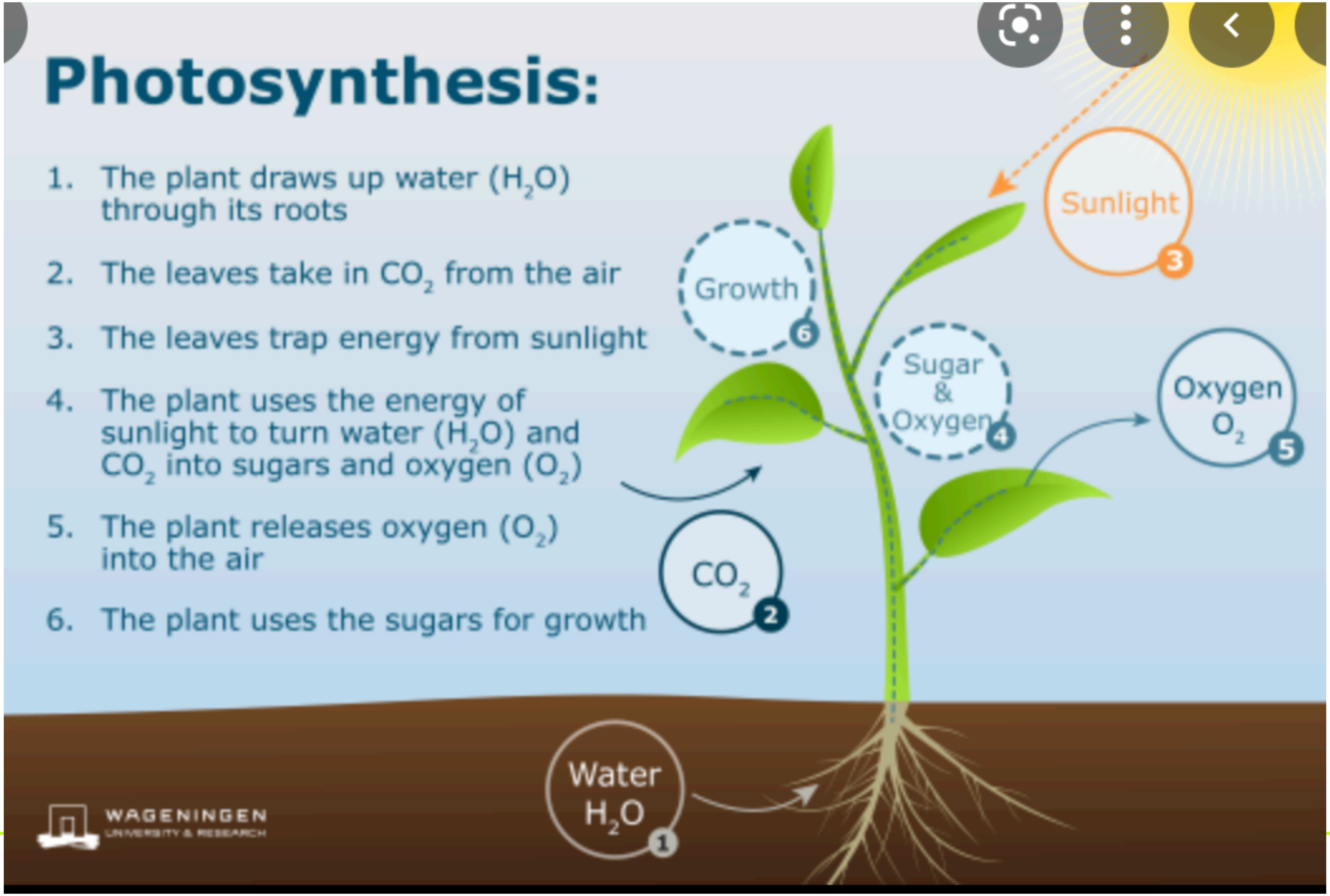
- The SUN is the Natural Source of Light Energy

Sun: It is the natural source and is considered as the oldest source of light energy. Sunlight is an essential source for many natural processes such as water cycle, photosynthesis, sterilization, sanitation etc. The energy on the sun is generated because of hydrogen fusion. The light from the sun reaches planets and other bodies which includes earth.


How did our solar system come to be?
National Aeronautics and Space Administration
NASA
It all began about 4.6 billion years ago in a wispy cloud of gas and dust.
At some point, part of the cloud collapsed in on itself—possibly because the shockwave of a nearby supernova explosion caused it to compress.
The result: a flat spinning disk of dust and gas.
4.6 Billion Years Ago
Energy
Hydrogen
Helium
Fusion
Hydrogen
Energy
When enough material collected at this disk's center, nuclear fusion began. Our sun was born. It gobbled up 99.8% of all the material.
These clumps became planets, dwarf planets, asteroids, comets, and moons.
Credit: Gemini Observatory/AURA
This cloud was a small part of a much bigger cloud.
Nuclear fusion occurs when hydrogen atoms fuse into helium.
The material left behind by the sun clumped together into bigger and bigger pieces.
Present
Only rocky things could survive close to the sun, so gaseous and icy material collected further away. That's how our solar system came to be the place it is today!
Comets and asteroids are the left over remains of the solar system's formation.
Space Place

Sun: It is the natural source and is considered as the oldest source of light energy. Sunlight is an essential source for many natural processes such as water cycle, photosynthesis, sterilization, sanitation etc. The energy on the sun is generated because of hydrogen fusion. The light from the sun reaches planets and other bodies which includes earth.





Photosynthesis:
1. The plant draws up water (H_2O) through its roots
2. The leaves take in CO_2 from the air
3. The leaves trap energy from sunlight
4. The plant uses the energy of sunlight to turn water (H_2O) and CO_2 into sugars and oxygen (O_2)
5. The plant releases oxygen (O_2) into the air
6. The plant uses the sugars for growth
Sunlight 3
Growth 6
Sugar & Oxygen 4
Oxygen O_2 5
CO_2 2
Water H_2O 1
WAGENINGEN
UNIVERSITY & RESEARCH

Sources of light energy

“Light energy is the only visible form of energy”

Light is a form of energy which our sense of sight can detect. It is made of electro-magnetic radiation and travels in a straight path. In everyday we use the word “light” for at least 10 times a day!! Have you ever think about the energy we get from the light. Light is all around us. It has the ability to tan or burn our skins, it can be harnessed to melt metals, or heat our food. Light energy posed a huge challenge for scientist up to the 1950's.

For our purposes we will use light to mean all of the frequencies of radiation, known as the electromagnetic spectrum or EMS. Light is always in motion and cannot be stored, so it is a kinetic type of energy.

You might say that light is essentially “pure” energy, since it theoretically has no mass. Light is simultaneously a wave and a particle. The higher the frequency, the more energy the light or electromagnetic radiation contains. The greater the frequency, the more energy each particle, called the photon. **Light energy comes from different sources**. Different sources of light energy are discussed below.

Sources of light energy

“Light energy is the only visible form of energy”

Light is a form of energy which our sense of sight can detect. It is made of electro-magnetic radiation and travels in a straight path. In everyday we use the word “light” for at least 10 times a day!! Have you ever think about the energy we get from the light. Light is all around us. It has the ability to tan or burn our skins, it can be harnessed to melt metals, or heat our food. Light energy posed a huge challenge for scientist up to the 1950's.

For our purposes we will use light to mean all of the frequencies of radiation, known as the electromagnetic spectrum or EMS. Light is always in motion and cannot be stored, so it is a kinetic type of energy.

You might say that light is essentially “pure” energy, since it theoretically has no mass. Light is simultaneously a wave and a particle. The higher the frequency, the more energy the light or electromagnetic radiation contains. The greater the frequency, the more energy each particle, called the photon. **Light energy comes from different sources**. Different sources of light energy are discussed below.

Sun: It is the natural source and is considered as the oldest source of light energy. Sunlight is an essential source for many natural processes such as water cycle, photosynthesis, sterilization, sanitation etc. The energy on the sun is generated because of hydrogen fusion. The light from the sun reaches planets and other bodies which includes earth.

We are not here by chance. We are the product of this story, of the mutations that transformed bacteria into people, of the cataclysmic accidents that redefined the conditions on our planet, of the climatic and geologic changes that unfolded over billions of years.

Knowing this doesn't make us smaller, as many believe. Quite the contrary, it sends us to the top of this extended chain of life, as we are the only creatures we know capable of reconstructing our past with such detail and, at the same time, of asking questions about our future.

On the other hand, we must realize that being at the top doesn't mean we can despise those below. From power comes responsibility, which, in this case, means to work to protect life and our planet, understanding that we are part of the same chain that connects bacteria to whales. If our knowledge makes us strong, we remain fragile when confronting nature's power. If we plan to remain here for a few more thousands of years, the only option we have is to treat Earth with humility and respect.

Carbon monoxide

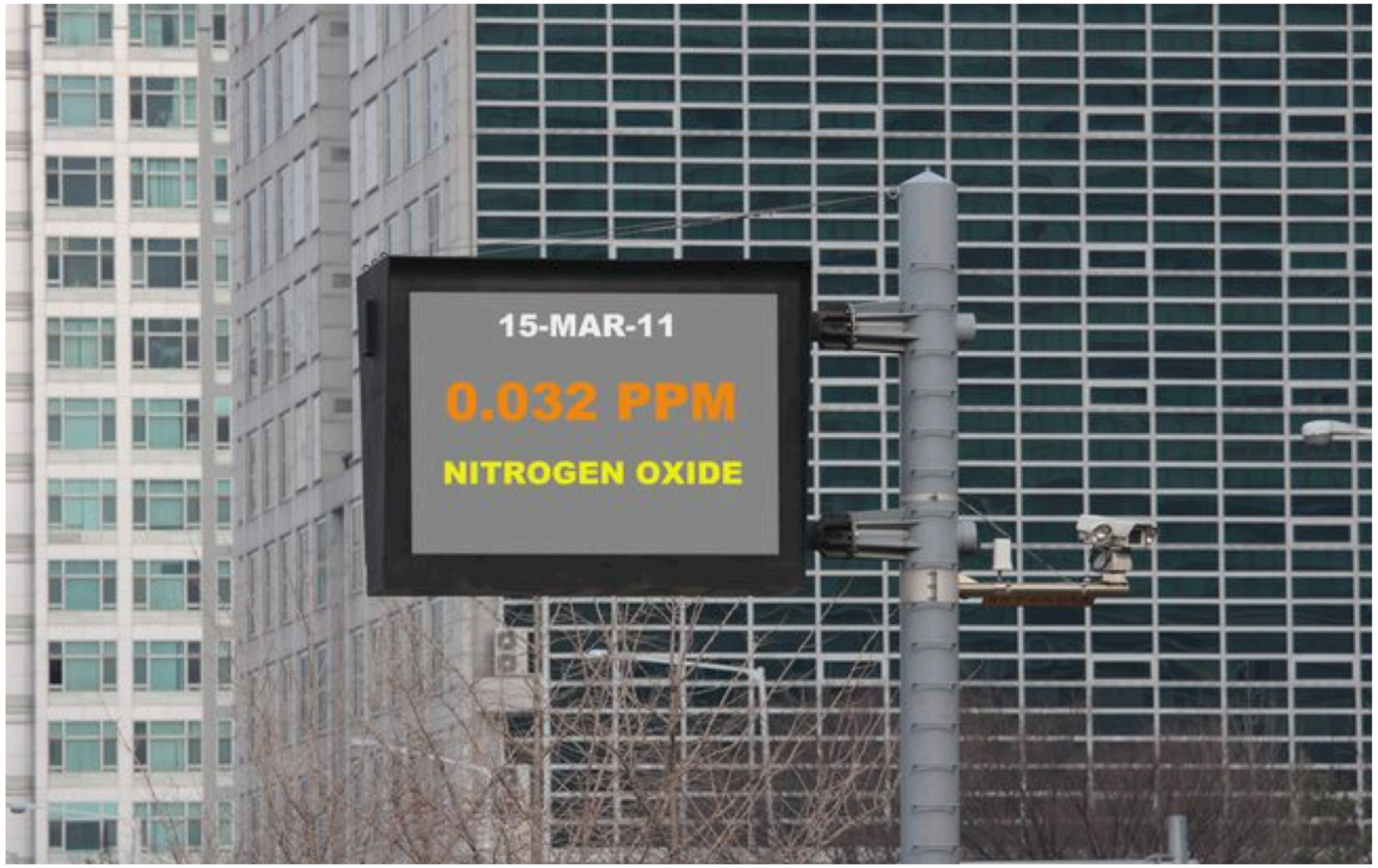
Carbon monoxide (CO) is an odorless, colorless, non-irritating but very poisonous gas emitted from combustion processes that can reduce oxygen delivery into the body's tissues and organs, including the heart and brain, when inhaled. At high levels, carbon monoxide can cause death. Most carbon monoxide emissions in ambient air come from mobile sources.

Sulfur dioxide

Part of a group known as sulfur oxides (SO_x), sulfur dioxide (SO_2) is a chemical compound produced by volcanic eruptions and industrial processes. The largest sources of sulfur dioxide emissions are from fossil fuel combustion at power plants. In the presence of a catalyst like nitrogen dioxide, sulfur dioxide can oxidize into acid rain. It, too, is linked to many adverse health effects on the respiratory system.

Nitrogen oxides

Nitrogen oxides



A road sign shows the level of nitrogen oxide in the air. RAGMA IMAGES/Shutterstock

The group of highly reactive gases known as nitrogen oxides (NOx) are emitted by high-temperature combustion and often appear as a brown dome of haze over cities. Of the group of nitrogen oxides, which also includes nitrous acid and nitric acid, nitrogen dioxide (NO2) is of the greatest concern to the EPA. It contributes to the formation of ground-level ozone and fine particle pollution, and is linked to adverse effects on the human respiratory system.

Lead

Lead is a toxic heavy metal, found naturally in the environment. It's a common pollutant in manufactured products. Motor vehicles and industries are the largest source of lead emissions, and while these emissions dramatically dropped by 95 percent between 1980 and 1999 thanks to regulatory efforts, they are still a concern. The highest levels of lead in the air are currently found near lead smelters. Lead can affect the nervous system, kidney function, immune system, reproductive and development systems and the cardiovascular system.

WHAT ARE VOLITLE ORGANIC COMPOUNDS?

What are VOCs?

- VOCS are organic chemicals that evaporate at room temperature.
- VOCs have high vapor pressure and low boiling point.
- VOCs are both human-made and natural occurring chemical compounds.
- VOCs may have long term adverse effects to both humans and the environment.

VOC=Volatil Organic Compound

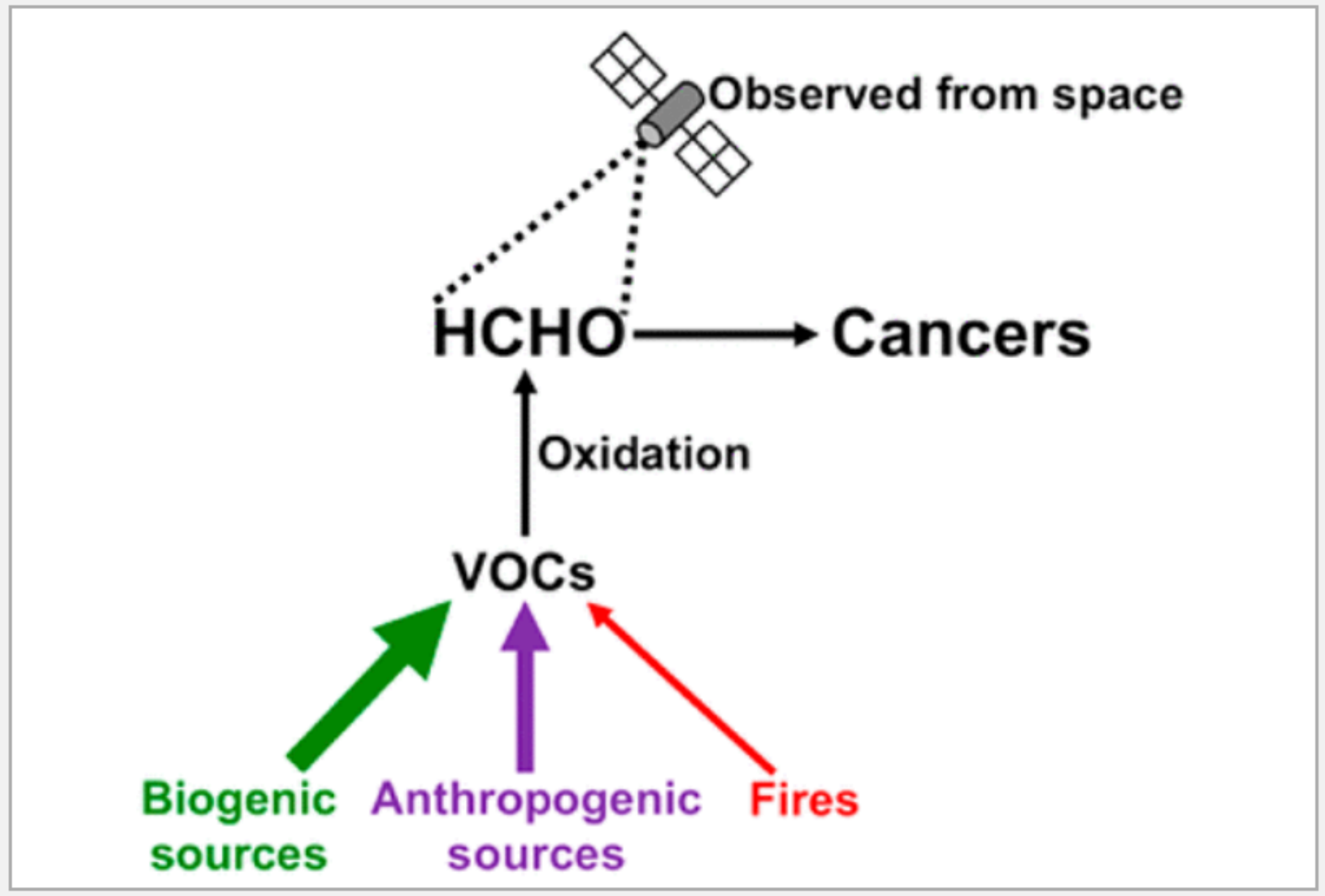
What are VOCs?

- A VOC is any compound that contains carbon and participates in atmospheric photochemical reactions.

- Volatile Organic Compounds are compounds that have a high vapor pressure and low water solubility.
- many are human-made chemicals and produced as paints, pharmaceuticals,refrigerants.
- VOCs common ground water contaminants
- VOC’s are components of petroleum fuels, paint thinners and dry cleaning agents, pesticides copiers printers glues organic solvents cosmetics -there are many in our home indicating that we can expose ourselves and others to very high pollutant levels!!
- paints, solvents, aerosol sprays, disinfectants ,moth repellents ,air fresheners ,automotive products ,hobby supplies ,dry-cleaned clothing ,pesticides

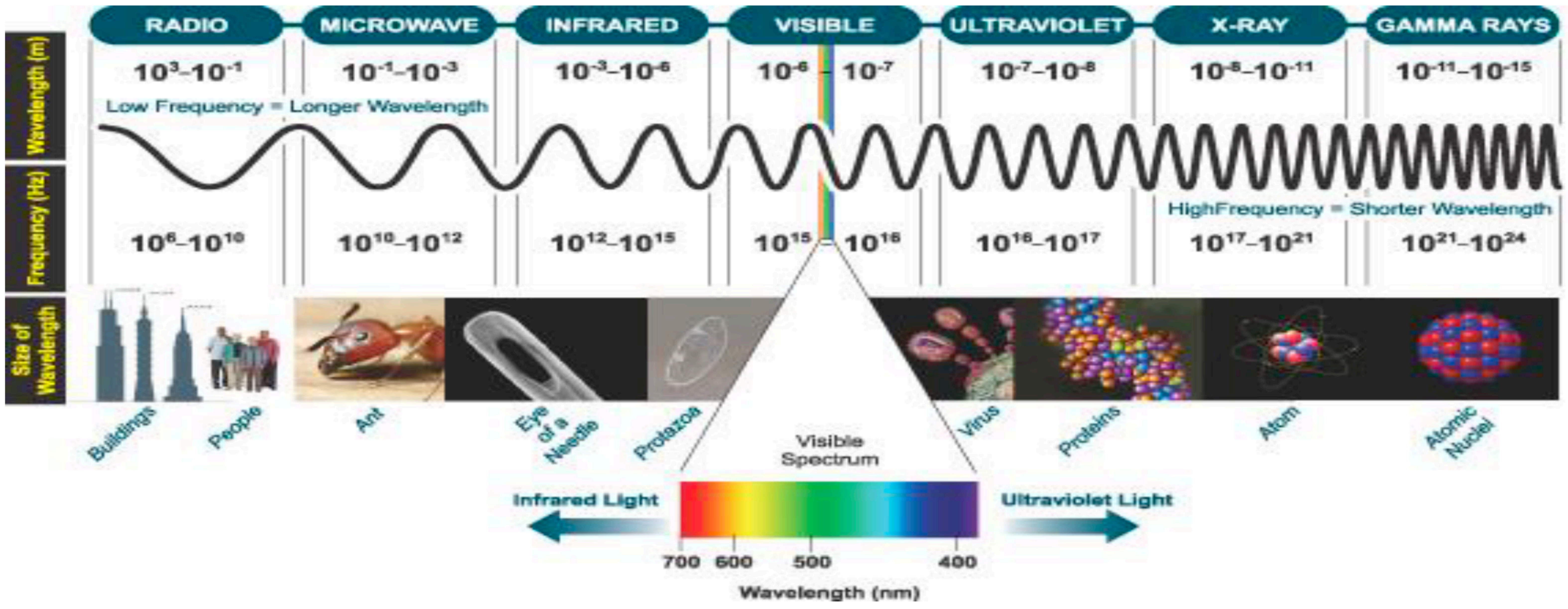
Abstract

Formaldehyde (HCHO) is the most important carcinogen in outdoor air among the 187 hazardous air pollutants (HAPs) identified by the U.S. Environmental Protection Agency (EPA), not including ozone and particulate matter. However, surface observations of HCHO are sparse and the EPA monitoring network could be prone to positive interferences. Here we use 2005–2016 summertime HCHO column data from the OMI satellite instrument, validated with high-quality aircraft data and oversampled on a 5×5 km^2 grid, to map surface air HCHO concentrations across the contiguous U.S. OMI-derived summertime HCHO values are converted to annual averages using the GEOS-Chem chemical transport model. Results are in good agreement with high-quality summertime observations from urban sites (−2% bias, $r = 0.95$) but a factor of 1.9 lower than annual means from the EPA network. We thus estimate that up to 6600–12500 people in the U.S. will develop cancer over their lifetimes by exposure to outdoor HCHO. The main HCHO source in the U.S. is atmospheric oxidation of biogenic isoprene, but the corresponding HCHO yield decreases as the concentration of nitrogen oxides ($NO_x \equiv NO + NO_2$) decreases. A GEOS-Chem sensitivity simulation indicates that HCHO levels would decrease by 20–30% in the absence of U.S. anthropogenic NO_x emissions. Thus, NO_x emission controls to improve ozone air quality have a significant cobenefit in reducing HCHO-related cancer risks.



Why is it important to life on Earth?

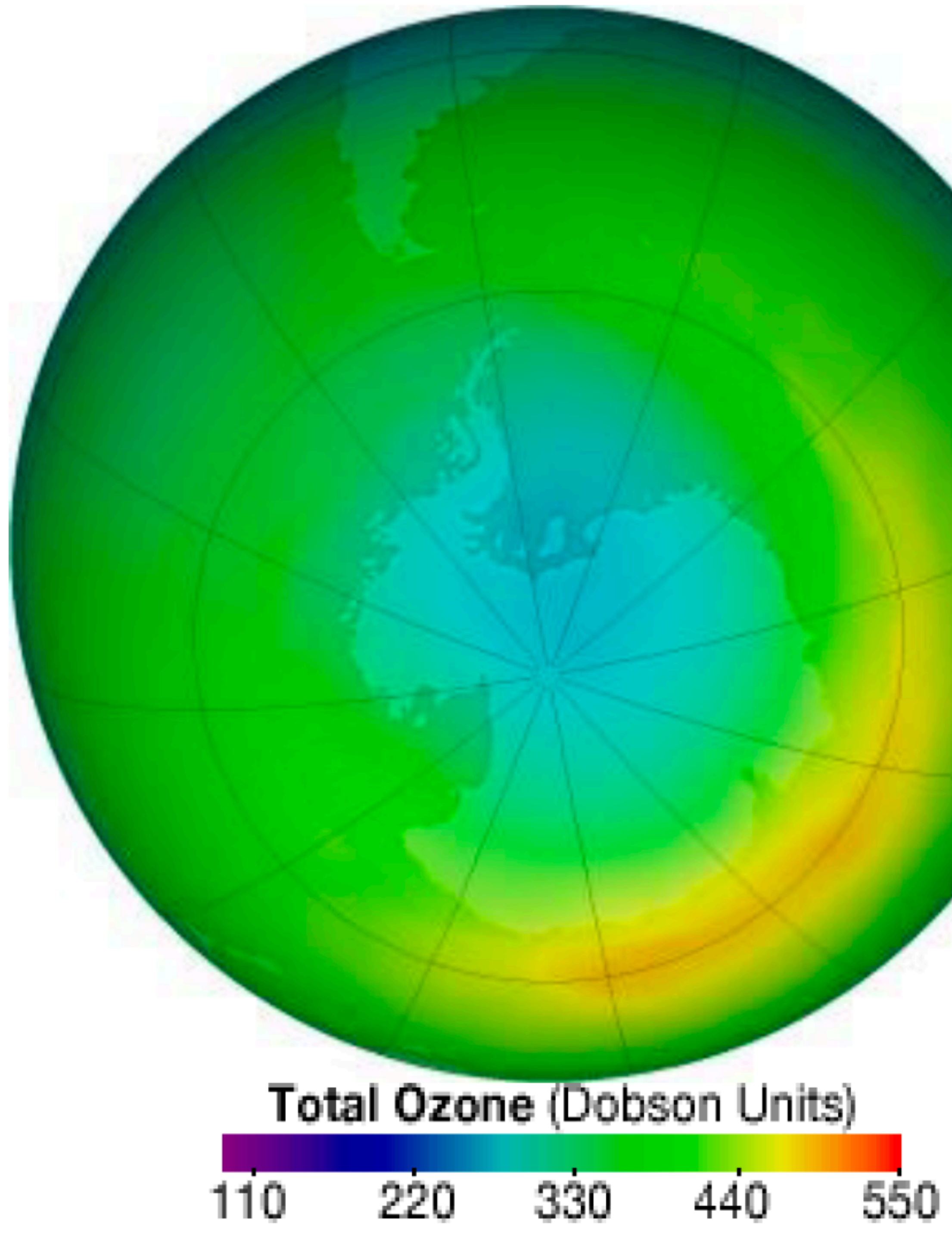
- On a daily basis, the sun radiates its energy toward Earth. One form of this energy is UltraViolet radiation, also known as UV rays.
- UV rays are relatively high energy waves that provide Earth with the warmth it needs to support life as we know it.



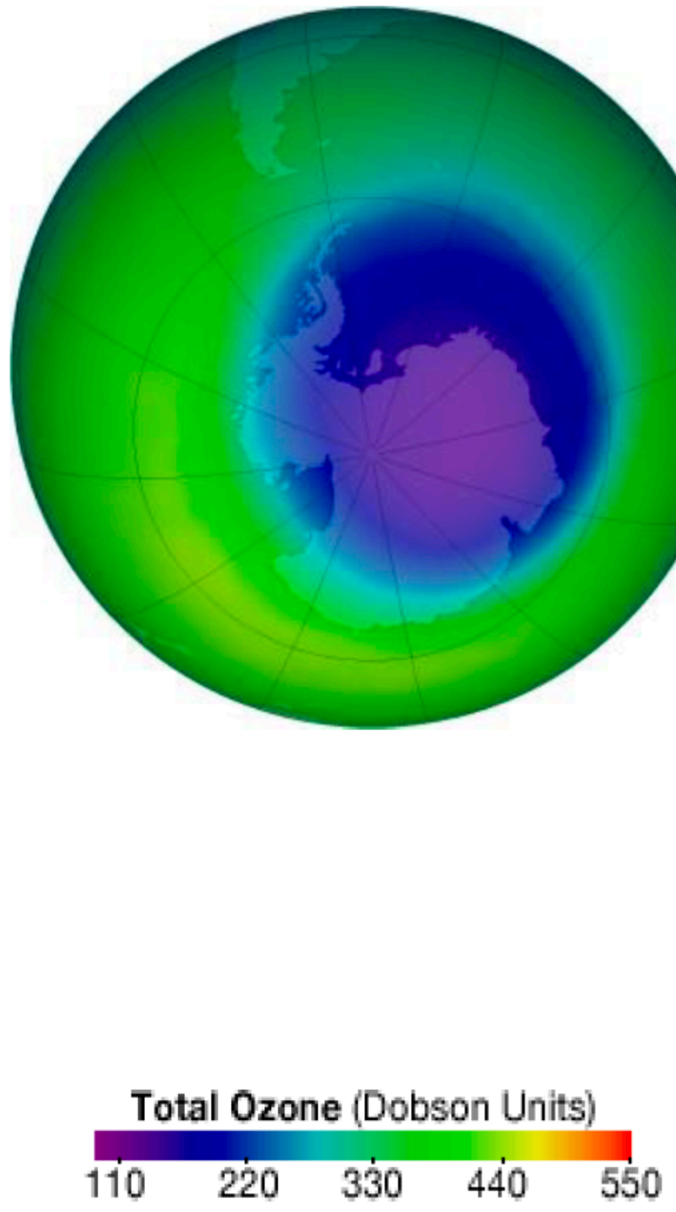
The Ozone Hole

- **Since the 1970's the ozone hole has been increasing in size over the Antarctic.**
- **For the first time, in September of 2000, the ozone hole became so large it actually left populated areas of southern Chile fully exposed to the effects of the Sun's UV rays.**

So what about the hole in the ozone layer?

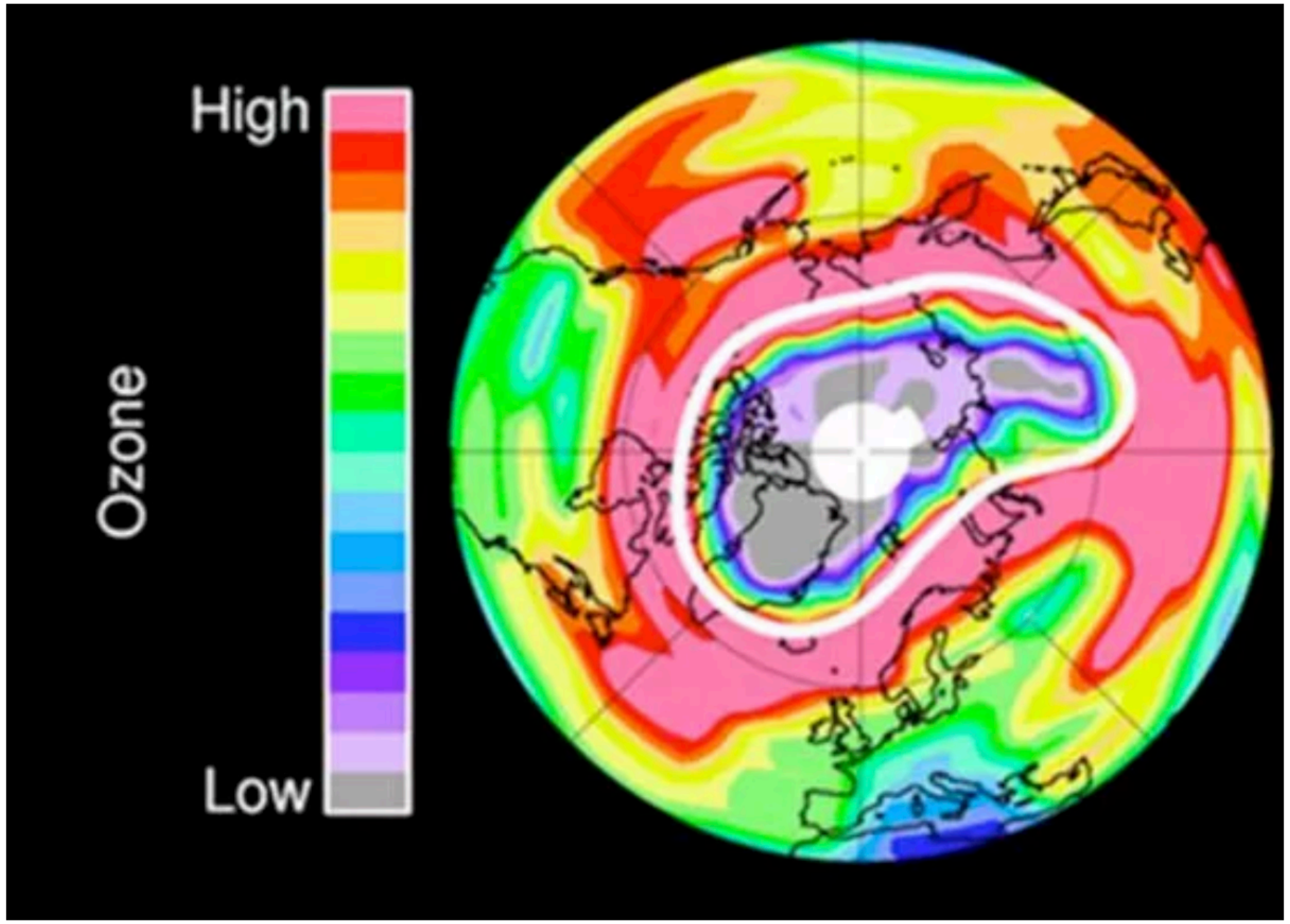


October 1979



October 2007

Ozone-Protector vs Destructive



Ozone is necessary and good, but only high in the atmosphere. (Image credit: NASA/JPL-Caltech)

Actually, it's both, depending on what altitude you find it at …

Ninety percent of Earth's ozone is found in the stratosphere (the second layer of the Earth's atmosphere, just above the one in which we dwell, the troposphere). This ozone forms the ozone layer, which shields everything on the planet's surface from the sun's harmful ultraviolet rays.

But when ozone forms at the surface (when pollution from cars reacts with UV rays), it is a pollutant itself, and can damage forests, crops and can irritate human lungs.

Why is the ozone layer important?

Stratospheric ozone is a naturally occurring gas that filters the sun's ultraviolet (UV) radiation. A diminished ozone layer allows more UV 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 yield and disruptions in the marine food chain. Learn about the health and environmental effects of ozone layer depletion.

Photochemical smog is formed when pollutants like hydrocarbons and nitric oxide interact with sunlight to form chemicals like NO_2, Peroxyacyl nitrate (PAN), ozone, acrolein and formaldehyde. Nitrogen dioxide formed is a brown gas which contributes to the haze.

Harmful effects of photochemical smog

The components of photochemical smog are ozone, nitric oxide, acrolein, formaldehyde and peroxyacyl nitrate (PAN). It affects our health and also causes damage to industrial materials

Both ozone and PAN cause eye irritations. Ozone and nitric oxide (NO) can irritate the nose and throat and their high concentration causes a headache, chest pain, dryness of the throat, cough and difficulty in breathing. Photochemical smog leads to cracking of rubber and extensive damage to plant life. It also causes corrosion of metals, stones, building materials, rubber and painted surfaces.

Controlling photochemical smog

How are we as humans affecting the ozone layer?

- Since 1928, Chlorofluorocarbons have been produced, originally as nonflammable refrigerants for use in refrigerators, and eventually for use in fire extinguishers, dry cleaning agents, pesticides, degreasers, adhesives, and as propellants for aerosol products.
- As these CFCs have been released into the atmosphere, the level of ozone in the stratosphere has decreased.
- CFCs have an estimated lifespan of more than 100 years.

How does ozone depletion affect global warming and ultimately climate change?

- **As ozone levels in the stratosphere are depleted, more solar radiation penetrates the Earth's atmosphere.**
- **This affect results in an increase in solar radiation reaching the Earth's surface adding to an increase in surface temperature.**
- **In turn, global warming actually results in a warming of the troposphere, but a cooling of the stratosphere, hindering the ozone layer's natural chemistry for repairs.**

Fossil Fuels

Fossil fuels are fuels made by geological processes acting on ancient dead organisms. These dead organisms were buried hundreds of millions of years ago. The world gets roughly 5/6ths of its primary energy from fossil fuels, and this use leads to climate change. Fossil fuels are not considered a renewa

What are the 7 fossil fuels?

Fossil fuels include **coal, petroleum, natural gas, oil shales, bitumens, tar sands, and heavy oils**. All contain carbon and were formed as a result of geologic processes acting on the remains of organic matter produced by photosynthesis, a process that began in the Archean Eon (4.0 billion to 2.5 billion years ago).

The 4 types of Fossil Fuels

What are the 4 types of fossil fuels?

Petroleum, coal, natural gas and orimulsion are the four fossil fuel types. They have a variety of physical, chemical and other essential properties in general, but the most vital thing regarding fossil fuels, perhaps, is that they are not green. Fossil fuels are made from plants and animals that decompose.

What do fossil fuels look like?

As earth shifted, oil and natural gas became trapped in folds of rock. Crude oil is liquid that can be very thick or thin and has **various shades from dark brown to black**, or sometimes it is even a colorless liquid.

Apr 25, 2017

II. Ozone Depletion

When chlorine and bromine atoms come into contact with ozone in the stratosphere, they destroy ozone molecules. One chlorine atom can destroy over 100,000 ozone molecules before it is removed from the stratosphere. Ozone can be destroyed more quickly than it is naturally created.

Some compounds release chlorine or bromine when they are exposed to intense UV light in the stratosphere. These compounds contribute to ozone depletion, and are called ozone-depleting substances (ODS). ODS that release chlorine include chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), carbon tetrachloride, and methyl chloroform. ODS that release bromine include halons and methyl bromide. Although ODS are emitted at the Earth's surface, they are eventually carried into the stratosphere in a process that can take as long as two to five years.

In the 1970s, concerns about the effects of ozone-depleting substances (ODS) on the stratospheric ozone layer prompted several countries, including the United States, to ban the use of chlorofluorocarbons (CFCs) as aerosol propellants. However, global production of CFCs and other ODS continued to grow rapidly as new uses were found for these chemicals in refrigeration, fire suppression, foam insulation, and other applications.

What is photochemical smog and how does it form?

- Key Components:
  - Sunlight
  - NO_2
  - Oxygen
  - VOC's
  - Ozone

Photochemical smog in Denver!

SOURCES FOR PHOTOCHEMICAL SMOG

- vehicles emitting smoke
- industrial emitting smoke
- volatile organic compound released from paints and adhesives
- power plants
- unburnt hydro carbons
- trees which emit isoprene and terpene
- PAN are secondary pollutants formed from peroxyacid radicals and NO_2 .

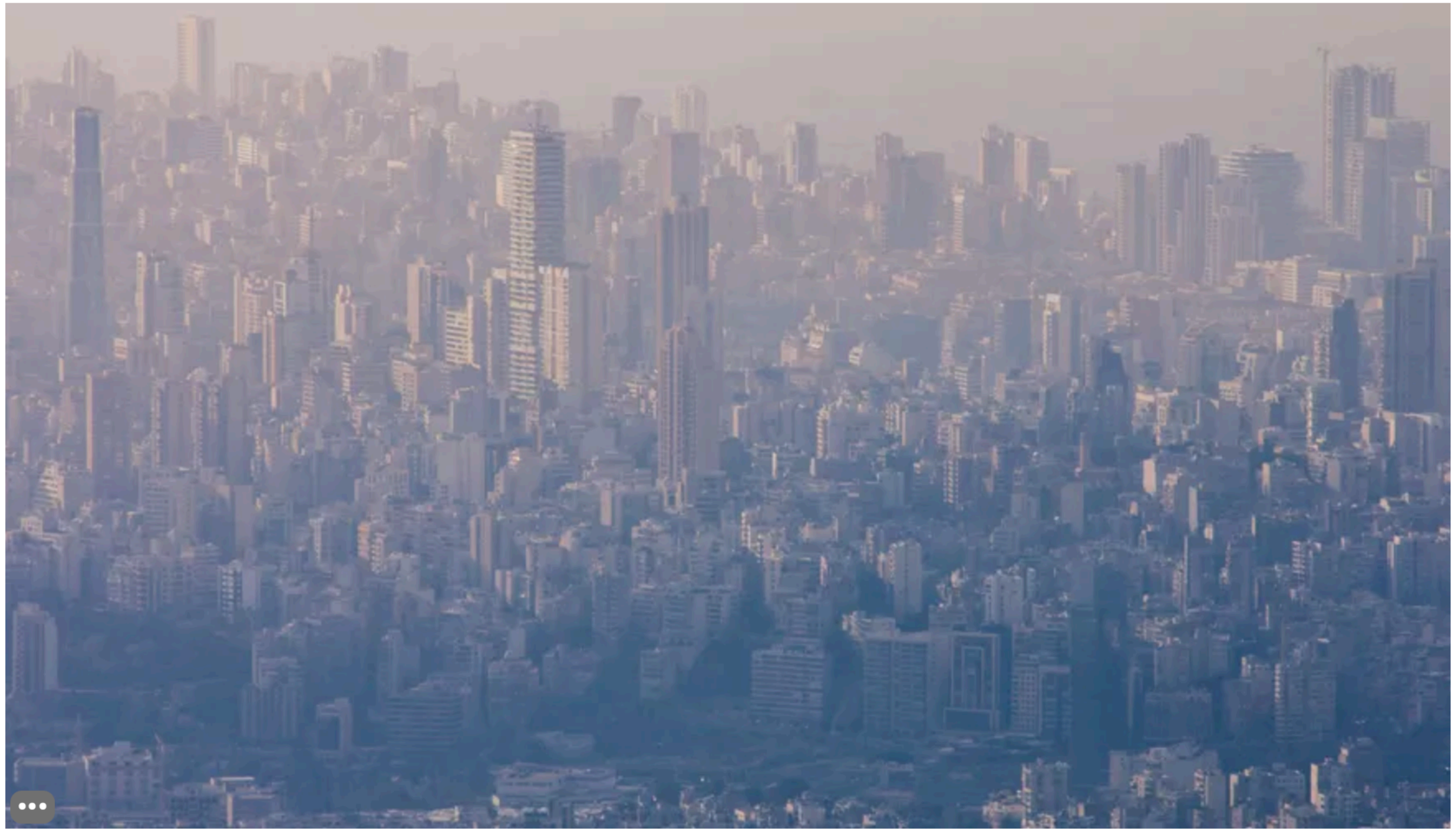
$$CH_3CHO + OH^{\bullet} \rightarrow CH_3C^{\bullet}O + H_2O$$

$$CH_3C^{\bullet}O + O_2 \rightarrow CH_3C(O)OO^{\bullet} \text{ (acetylperoxy)}$$

$$CH_3C(O)OO^{\bullet} + {}^{\bullet}NO_2 \rightarrow CH_3C(O)OONO_2 \text{ (PAN)}$$

Gases that cause Air Pollution

Gases That Cause Air Pollution



Burning of fossil fuels

Burning of fossil fuels

The burning of fossil fuels refers to the burning of oil, natural gas, and coal to generate energy. We use this energy to generate electricity, and to power transportation (for example, cars and planes) and industrial processes. Ever since the invention of the first coal-fired steam engines of the 1700s, our burning of fossil fuels has steadily increased. Across the globe each year we now burn over 4,000 times the amount of fossils fuels burnt during 1776. The effects of the burning of fossil fuels, especially carbon dioxide, are having far-reaching effects on our climate and ecosystems.

Fossil Fuels come from

Fossil fuels form over millions of years from the burial of **photosynthetic** organisms, including plants on land (which primarily form coal) and plankton in the oceans (which primarily form oil and natural gas). To grow these organisms removed carbon dioxide from the atmosphere and the ocean, and their burial inhibited the movement of that carbon through the **carbon cycle**. The burning of this fossil material returns this carbon back into atmosphere as carbon dioxide, at a rate that is hundreds to thousands of times faster than it took to bury, and much faster than can be removed by the carbon cycle. Thus, the carbon dioxide released from the burning of fossil fuels accumulates in the atmosphere, some of which then dissolves in the ocean causing **ocean acidification**.

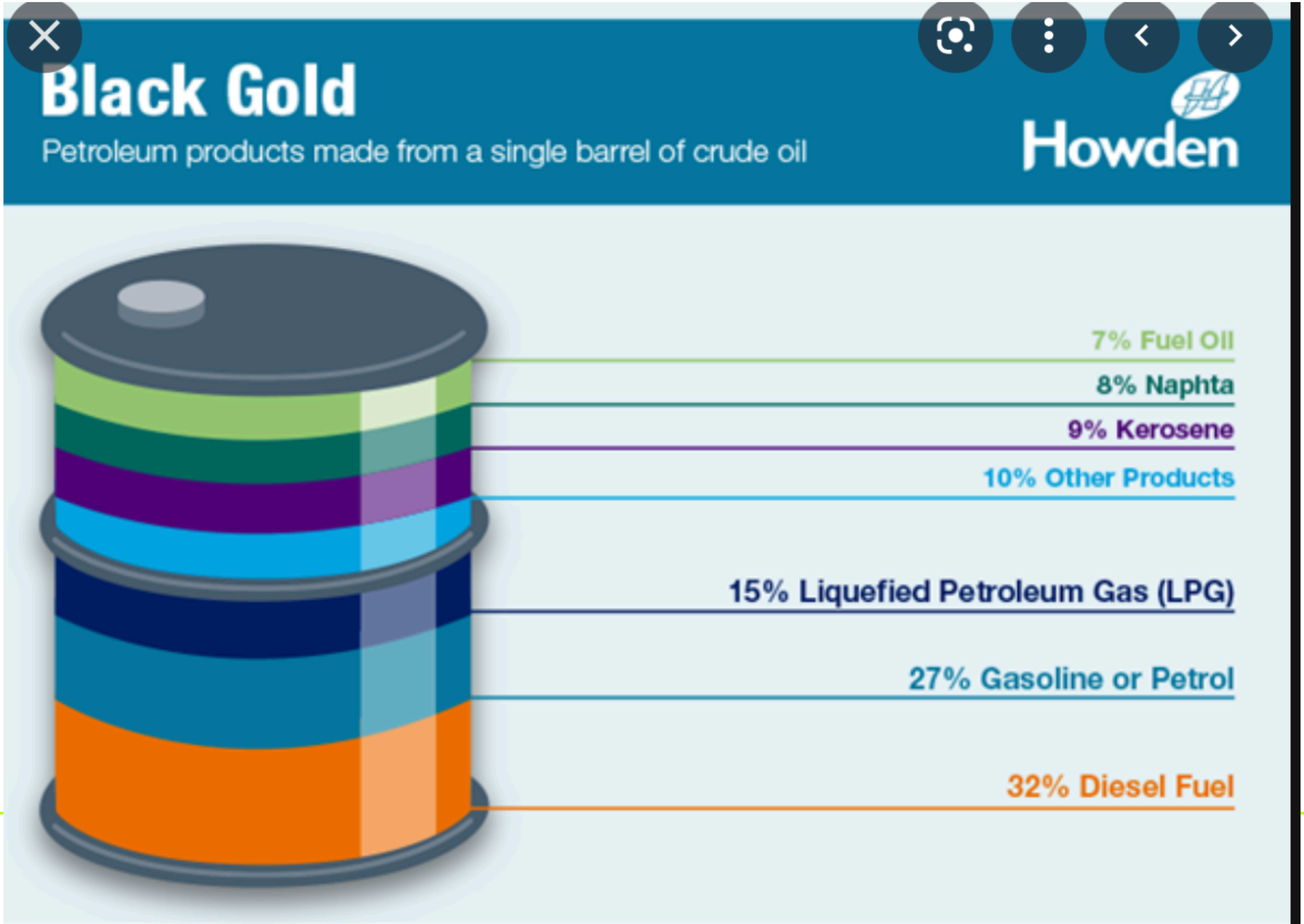
Burning fossil fuels affects the Earth system

The burning of fossil fuels affects the Earth system in a variety of ways. Some of these ways include:

- Releasing the greenhouse gases carbon dioxide (CO_2) and nitrous oxide (N_2O) into the atmosphere, which intensifies the **greenhouse effect** (the **re-radiation of heat** in the atmosphere), increasing the Earth's average **air temperatures**. These greenhouse gases can remain in the atmosphere for decades to hundreds of years.
- Emitting an array of **pollutants** that reduce **air quality** and harm life, especially sulfur dioxide, nitrogen oxides, and **airborne particles** such as soot. Poor air quality can cause respiratory **disease**.
- The **airborne particles** also increase the **reflectivity** of the atmosphere, which has a slight cooling effect. The reason is that the **airborne particles**, such as soot and sulfate aerosols (from sulfur dioxide), **reflect** some sunlight back into space, increase **cloud** formation, and make **clouds** more reflective. The net effect of burning fossil fuels is warming because the cooling is small compared with the heating caused by the greenhouse effect, in part because airborne particles only stay suspended in the atmosphere for a few days to months, while greenhouse gases that cause warming remain in the atmosphere for many decades to hundreds of years.

Understanding Global Change

- Changing patterns of **snow and ice** melt. **Airborne particles** (especially soot) that settle on snow increase the **absorption** of sunlight due to their dark color, heating the surface of the snow causing melting. In certain parts of the world, the presence of soot (in addition to global warming) has caused winter ice and snow melts earlier and faster today than in previous decades, which also changes local patterns of **freshwater availability**.
- Increasing the acidity of **precipitation**. Sulfur dioxide (SO_2), nitrogen oxides (NOx), and carbon dioxide (CO_2) react with water vapor, oxygen, and other chemicals to form acid rain. Acid rain can contaminate **freshwater** sources, resulting in harmful algal blooms that reduce **water oxygen levels** and harm fish **populations** and other wildlife. Additionally, acid rain increases chemical **weathering** of rocks, including manmade structures.
- Using large amounts **freshwater**. Power plants that burn fossil fuels cool their systems by removing freshwater from local rivers and lakes. The warm water returned to nearby ecosystems can cause stress for local species.


Black Gold
Petroleum products made from a single barrel of crude oil
Howden
7% Fuel Oil
8% Naphta
9% Kerosene
10% Other Products
15% Liquefied Petroleum Gas (LPG)
27% Gasoline or Petrol
32% Diesel Fuel

> **DID YOU KNOW?** According to BP'S **2019 World Energy Review**, the world's largest proven oil reserves are located in:
>
> - Venezuela: 303 billion barrels
> - Saudi Arabia: 298 billion barrels
> - Canada: **168 billion barrels**
> - Iran: 156 billion barrels
> - Iraq: 147 billion barrels
>
> The Alberta oil sands hold an estimated **164 billion barrels** of recoverable oil. A list of the top 15 countries can be found on the Energy Statistics page.

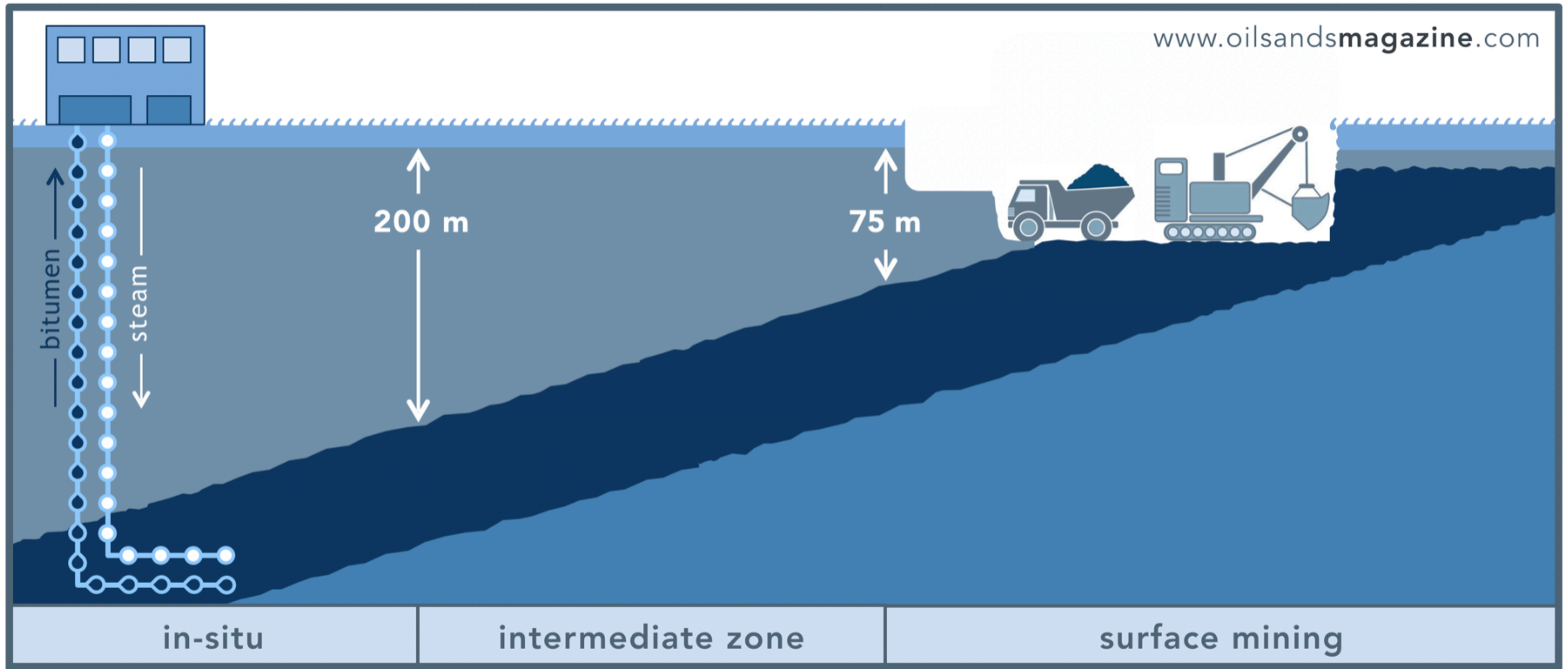
Bitumen

EXTRACTING BITUMEN FROM THE OIL SANDS

There are 2 basic methods of bitumen extraction used in the oil sands: surface **mining** and **in-situ**. The method used depends on the depth of the reservoir.

Deposits located at a depth of less than **75 meters** can technically be surface mined, although most mining operations operate at depths of less than 50 meters below grade. Surface mining (or open-pit mining) is only viable for a small portion of bitumen located in the Athabasca region, north of Fort McMurray. This represents about 20% of total recoverable reserves.

The remaining 80% of the bitumen is too deep to be mined and can only be extracted in-situ (or in-place) using steam. Most of Alberta's operating in-situ facilities currently extract bitumen from a depth of at least 300 meters.



BITUMEN EXTRACTION FROM THE OIL SANDS: MINING VERSUS IN-SITU

The bitumen recovery process is quite different for mining versus in-situ facilities. Mined oil sands requires large amounts of water to separate the bitumen from the sand, while the in-situ facilities require less water but greater volumes of steam. In both cases, the resulting bitumen product can either be sent to an upgrader, for conversion into synthetic crude oil, or diluted and sold directly to refineries.

Carbon Oxides

Carbon Oxides

Carbon oxides are among the most well-known greenhouse gases contributing to the air pollution plaguing the Earth's atmosphere. Carbon monoxide is a poisonous gas -- highly dangerous due to its lack of odor and color -- released into the atmosphere with the incomplete combustion of fuels, such as coal, wood or other natural sources, as well as exhaust from automobiles.

Carbon dioxide is the greenhouse gas most scientists consider the main air pollutant of the Earth's atmosphere. Even though carbon dioxide is essential to support living organisms, it is also a dangerous air pollutant, generated mostly by human activities such as deforestation and the fossil fuel combustion. Responsible for more than half of the world's global warming trends, carbon dioxide creates an invisible layer that keeps the sun's infrared rays trapped in the atmospheric bubble around the Earth.

Nitrogen Oxides

Nitrogen Oxides

Nitrogen oxides are air pollutants that contribute contaminants to the Earth's atmospheric. Like carbon oxides, vehicle emissions are a major source of nitrogen oxides. These air pollutants are easily recognizable by the brown plume or haze that forms over areas with high concentrations of these gases. Nitrogen dioxide is one of the most prominent and dangerous air pollutants, and this toxic gas is easily identifiable by its reddish-brown color and distinctive, sharp odor.

Sulfur Oxides

Sulfur Oxides

Sulfur oxides include another group of gases that pollute the Earth's atmosphere. Of grave concern is sulfur dioxide, one of the major components of smog -- and a primary cause of acid rain. While sulfur dioxide occurs naturally when volcanoes erupt, the combustion of sulfur-containing fuels such as petroleum oils and coal results in a dangerous air pollutant eating away at the Earth's fragile atmosphere. Dangerous to both plants and animals, sulfur oxides can injure organic matter in high concentrations and can cause respiratory problems by irritating air passages and lungs.

Types of Pollutants

Man is at least partially at fault for most of the world's major air pollutants. Carbon dioxide is one of the most highly prevalent, comes from the combustion or burning of fossil fuels and other organic materials. Nitrogen oxide and dioxide, while both natural components of the Earth's atmosphere, occur in greater amounts due to human actions and are the cause of smog and acid rain.

Pollutants also include chlorofluorocarbons (CFCs), were widely used as refrigerants and aerosol propellants. These chemicals damage the ozone layer, which is why the Environmental Protection Agency banned them in 1978.

Particulates, microscopic particles of soot, pose yet another common hazard. Smoke from burning coal and diesel fuel has been one major source of particulate emissions. In addition to being harmful to breathe, particulates form a dark film on buildings and other structures.

CAUSES OF AIR POLLUTION

Causes of Air Pollutants

The burning of fossil fuels such as coal and gasoline is the single largest source of air pollutants. Fossil fuels continue to be in wide use for heating, to operate transportation vehicles, in generating electricity, and in manufacturing and other industrial processes. Burning these fuels causes smog, acid rain and greenhouse gas emissions.

Burning fuels also increases some heavy metal contaminants and the amount of soot in the air. Power plants and factories emit much of the sulfuric air pollutants. In all, industrialized nations – particularly the United States and the Soviet Union – are responsible for most of the world's air pollutants.

300 million years ago

The coal we burn today got its start some 300 *million* years ago. Back then, dinosaurs roamed the Earth. But they didn't get incorporated into coal. Instead, plants in bogs and swamps died. As this greenery sunk to the bottom of those wet areas, it partially decayed and turned into *peat*. Those wetlands dried out. Other materials then settled down and covered the peat. With heat, pressure and time, that peat transformed into coal. To extract coal, people now have to dig deeply into the earth.

Petroleum — oil and natural gas — comes from a process that started in ancient seas. Small organisms called plankton lived, died and sank to the bottom of those oceans. As debris settled down through the water, it covered the dead plankton. Microbes dined on some of the dead. Chemical reactions further transformed these buried materials. Eventually, two substances formed: waxy *kerogen* and a black tar called *bitumen* (one of the ingredients of petroleum).

Kerogen tranforms into Crude oil

The kerogen can undergo further changes. As debris buries it deeper and deeper, the chemical becomes ever hotter and subjected to more pressure. If conditions become just right, the kerogen transforms into the hydrocarbons (molecules formed from hydrogen and carbon) that we know as *crude oil*. If temperatures become hotter still, kerogen becomes the even smaller hydrocarbons that we know as natural gas.

Explainer: All crude oil is not alike

What is Acid Rain?

Acid rain, or acid deposition, is a broad term that includes any form of precipitation with acidic components, such as sulfuric or nitric acid that fall to the ground from the atmosphere in wet or dry forms. This can include rain, snow, fog, hail or even dust that is acidic.

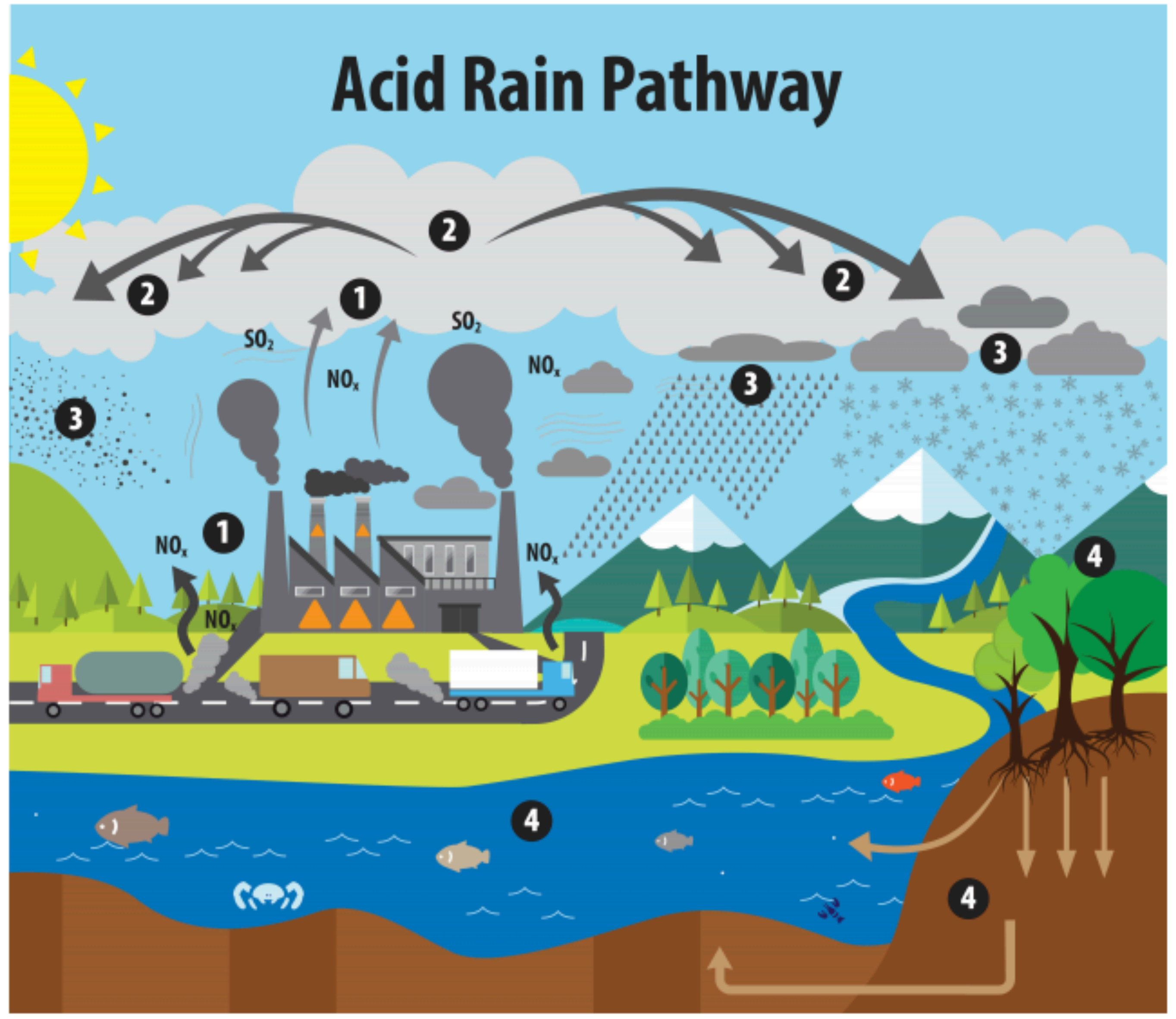
What Causes Acid Rain?

Acid rain results when sulfur dioxide (SO_2) and nitrogen oxides (NO_X) are emitted into the atmosphere and transported by wind and air currents. The SO_2 and NO_X react with water, oxygen and other chemicals to form sulfuric and nitric acids. These then mix with water and other materials before falling to the ground.

While a small portion of the SO_2 and NO_X that cause acid rain is from natural sources such as volcanoes, most of it comes from the burning of fossil fuels. The major sources of SO_2 and NO_X in the atmosphere are:

- Burning of fossil fuels to generate electricity. Two thirds of SO_2 and one fourth of NO_X in the atmosphere come from electric power generators.
- Vehicles and heavy equipment.
- Manufacturing, oil refineries and other industries.

Winds can blow SO_2 and NO_X over long distances and across borders making acid rain a problem for everyone and not just those who live close to these sources.

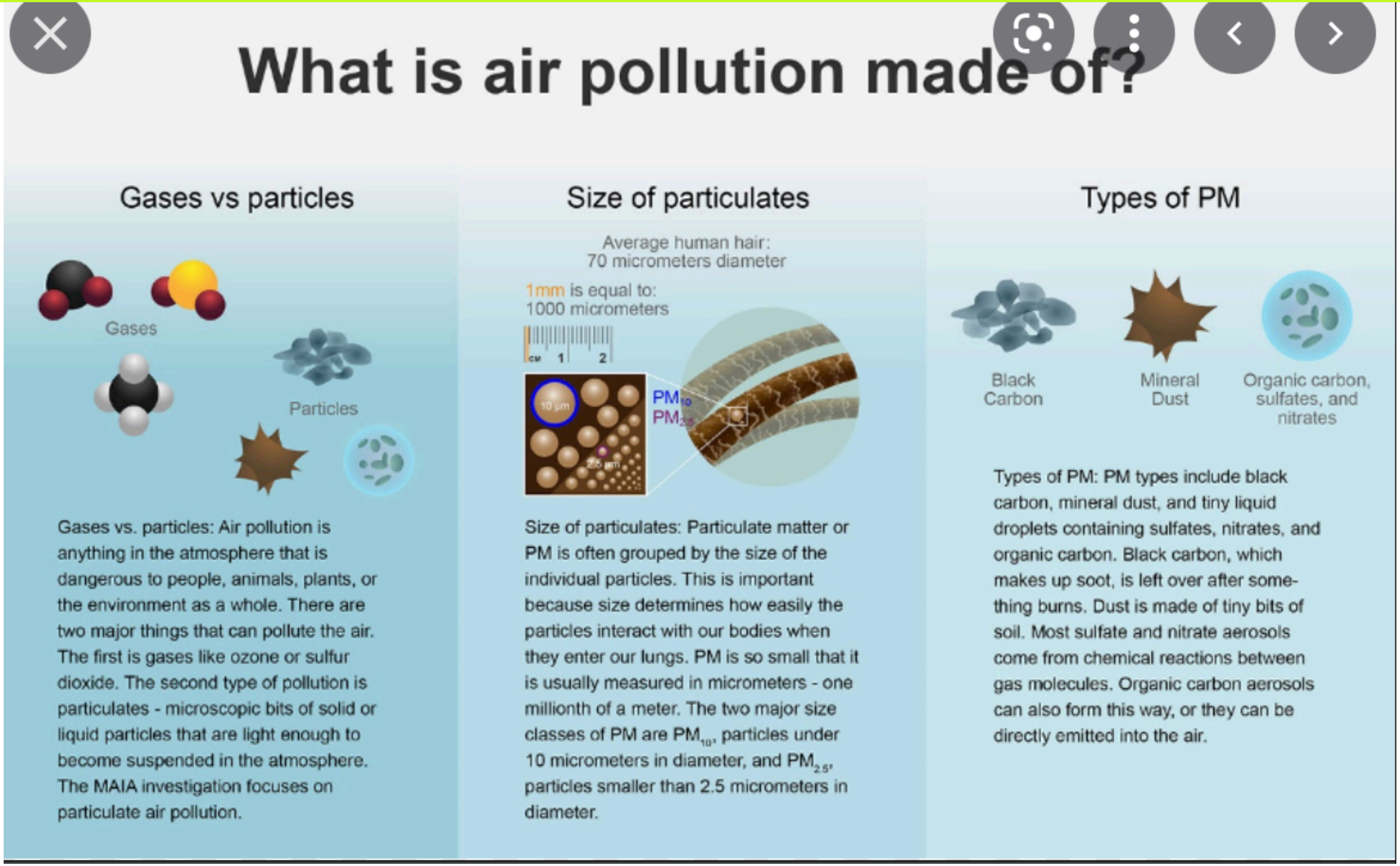


This image illustrates the pathway for acid rain in our environment: (1) Emissions of SO2 and NOx are released into the air, where (2) the pollutants are transformed into acid particles that may be transported long distances. (3) These acid particles then fall to the earth as wet and dry deposition (dust, rain, snow, etc.) and (4) may cause harmful effects on soil, forests, streams, and lakes.

The burning of fossil fuels

The burning of fossil fuels creates carbon dioxide and other greenhouse gases. These can contribute to climate change and global warming. For that reason, many scientists have warned that people should stop using fossil fuels. Alternatives, such as wind and solar power, don’t produce greenhouse gases.

Giving up fossil fuels entirely, though, won’t be easy, at least in the near future, Tutuncu says. These substances are used for more than just producing energy. Plastics and many other products include fossil fuels in their recipes. Scientists and engineers will have to come up with environmentally friendly replacements for all those products if society chooses to wean itself off of its current reliance on fossil fuels.


What is air pollution made of?
Gases vs particles
Gases
Particles
Gases vs. particles: Air pollution is anything in the atmosphere that is dangerous to people, animals, plants, or the environment as a whole. There are two major things that can pollute the air. The first is gases like ozone or sulfur dioxide. The second type of pollution is particulates - microscopic bits of solid or liquid particles that are light enough to become suspended in the atmosphere. The MAIA investigation focuses on particulate air pollution.
Size of particulates
Average human hair: 70 micrometers diameter
1mm is equal to: 1000 micrometers
PM_{10}
$PM_{2.5}$
Size of particulates: Particulate matter or PM is often grouped by the size of the individual particles. This is important because size determines how easily the particles interact with our bodies when they enter our lungs. PM is so small that it is usually measured in micrometers - one millionth of a meter. The two major size classes of PM are PM_{10}, particles under 10 micrometers in diameter, and $PM_{2.5}$, particles smaller than 2.5 micrometers in diameter.
Types of PM
Black Carbon
Mineral Dust
Organic carbon, sulfates, and nitrates
Types of PM: PM types include black carbon, mineral dust, and tiny liquid droplets containing sulfates, nitrates, and organic carbon. Black carbon, which makes up soot, is left over after something burns. Dust is made of tiny bits of soil. Most sulfate and nitrate aerosols come from chemical reactions between gas molecules. Organic carbon aerosols can also form this way, or they can be directly emitted into the air.

ozone, particulate matter, carbon monoxide, nitrogen oxides sulfur dioxide and lead

Air pollutants are found in the form of solid particles, liquid droplets or gases, and many of them are created by human activity. According to a recent report by the American Lung Association, State of the Air 2011, toxic air pollution hovers above almost every major city, and remains a real threat to the health of the American public despite strong progress in the past few decades. More than half of all Americans live in areas with dangerous levels of air pollution.

The U.S. Environmental Protection Agency (EPA) has named the six most common air pollutants, which are found all over the United States. These pollutants are ozone, particulate matter, carbon monoxide, nitrogen oxides, sulfur dioxide and lead. Of these six, ozone and particulate matter are the most prevalent and the most harmful to human health and the environment.

Sources of PM

These particles come in many sizes and shapes and can be made up of hundreds of different chemicals.

Some are emitted directly from a source, such as construction sites, unpaved roads, fields, smokestacks or fires.

Most particles form in the atmosphere as a result of complex reactions of chemicals such as sulfur dioxide and nitrogen oxides, which are pollutants emitted from power plants, industries and automobiles.

Particulate matter 2

Particulate matter

Otherwise known as soot, particulate matter is a mixture of both tiny solid particles and liquid droplets made up of any number of potentially hazardous components including acids, organic chemicals and toxic metals as well as soil or dust particles. Particulate matter falls into two categories:

- Inhalable coarse particles are between 2.5 micrometers and 10 micrometers in diameter. They are found near roadways and dusty industries.
- Fine particles are 2.5 micrometers or smaller and are emitted during forest fires, and can also form when gases emitted by power plants, factories and automobiles react in the air. Both categories can pass through the throat and nose and enter the lungs.