ENV 207
Environmental Degradation and Pollution

Lecture 2

Criteria Air Pollutants

Recap

- Structure of our atmosphere
- Types of air pollutants
- Criteria air pollutants

Lecture Outline

- Major air pollutants: their sources and description

Recommended Book:
Understanding Environmental Pollution, By Marquita K Hill. Cambridge University Press. 2010.

Table 20.1 Major Air Pollutants

Pollutant	Composition	Primary or Secondary	Characteristics
Particulate matter			
Dust	Variable	Primary	Solid particles
Lead	Pb	Primary	Solid particles
Sulfuric acid	H_2SO_4	Secondary	Liquid droplets
Nitrogen oxides			
Nitrogen dioxide	NO_2	Primary	Reddish-brown gas
Sulfur oxides			
Sulfur dioxide	SO_2	Primary	Colorless gas with strong odor
Carbon oxides			
Carbon monoxide	CO	Primary	Colorless, odorless gas
Carbon dioxide*	CO_2	Primary	Colorless, odorless gas
Hydrocarbons			
Methane	CH_4	Primary	Colorless, odorless gas
Benzene	C_6H_6	Primary	Liquid with sweet smell
Ozone	O_3	Secondary	Pale blue gas with acrid odor
Air toxics			
Chlorine	Cl_2	Primary	Yellow-green gas

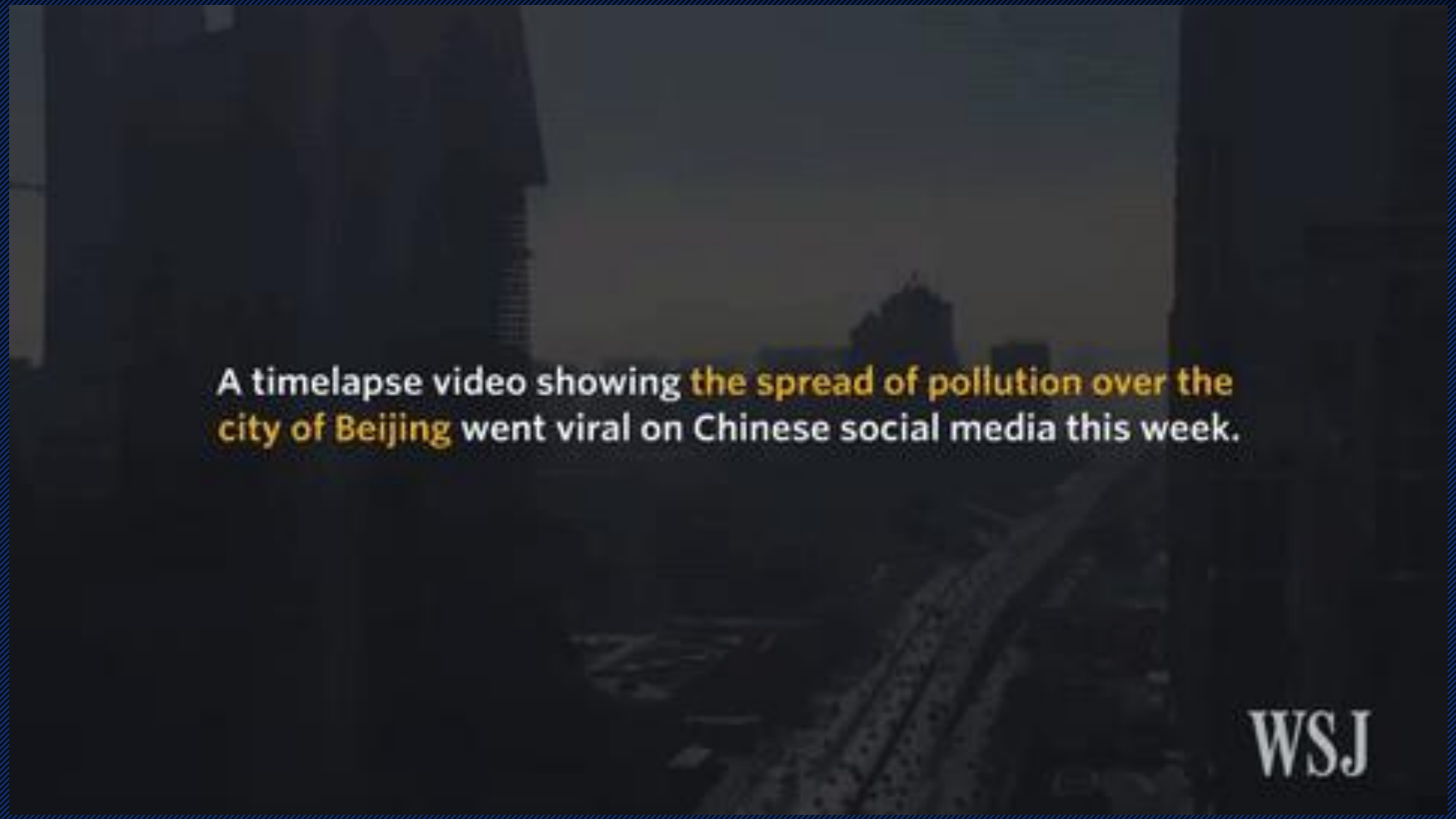
* Discussed in Chapter 21.
Source: Environmental Protection Agency.

Particulate Matter

- **Particulate matter (PM)** describes a wide variety of airborne material.

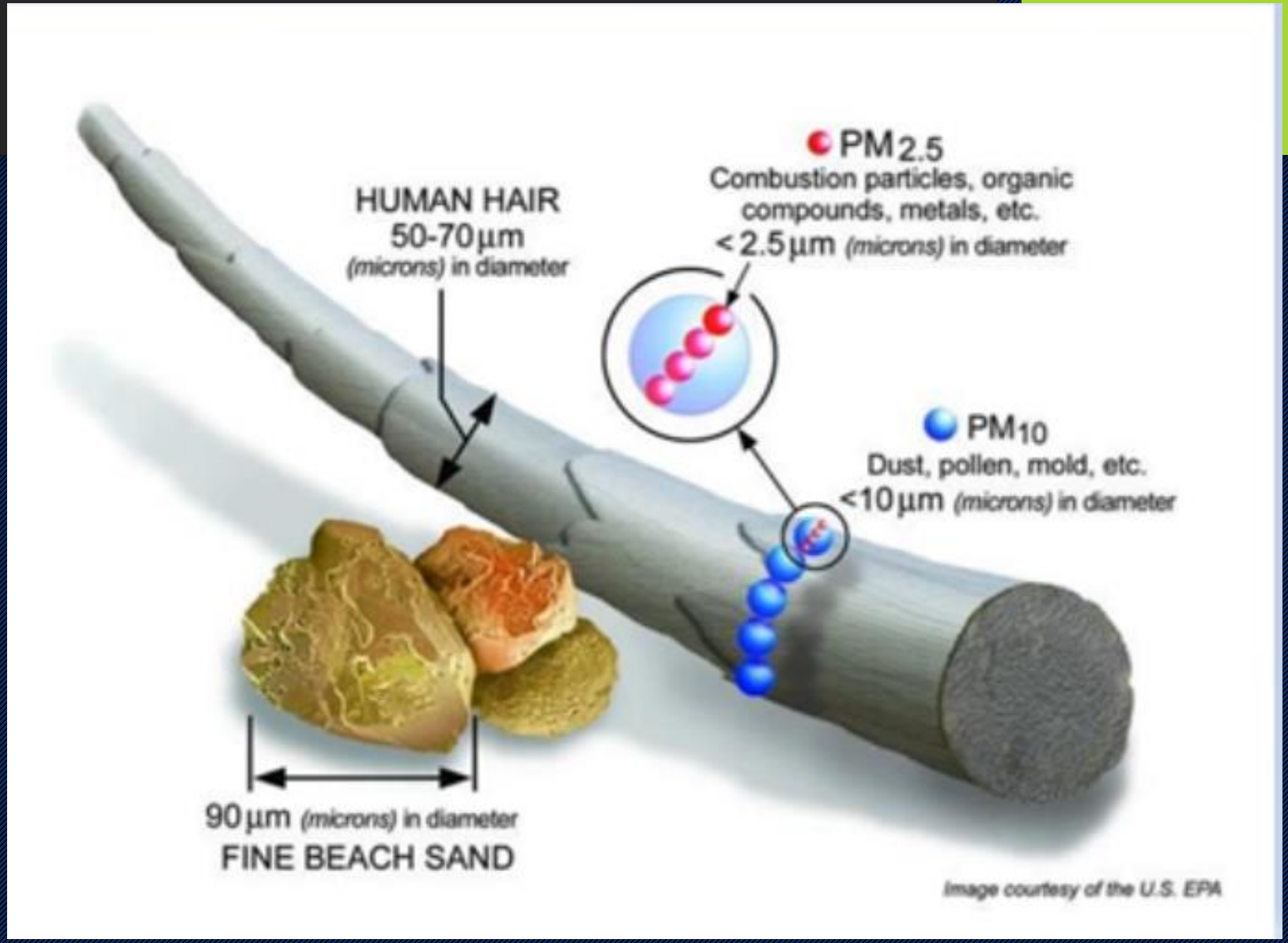
PM pollution consists of materials (including **dust, dirt, smoke, aerosol, liquid droplets,** and **soot**), that are directly emitted into the air or result from the transformation of gaseous pollutants.

Air Pollution in Beijing



PM 2.5 and PM 10

Image Source: Book



What Adverse Health Effects Have Been Linked to PM?

- Premature death
- Lung cancer
- Development of chronic lung disease
- Heart attacks
- Hospital admissions and ER visits for heart and lung disease
- Respiratory symptoms and medication use in people with chronic lung disease and asthma
- Decreased lung function
- Pre-term birth
- Low birth weight

Carbon Monoxide (CO)

- CO is a **colorless**, **odorless**, **flammable** gas
- A product of **incomplete combustion** produced when a carbon-containing material is burned
- CO accounts for more than **50%** of air pollution by weight nationwide and worldwide

Sources of CO

- **Major Sources:**
  - Motor vehicles in urban areas (95%)
- **Other sources:**
  - Cigarette smoke
  - Burning biomass
  - Burning fossil fuel

Why is CO deadlier than CO_2 ?

- Burning things (especially fuels) produces carbon dioxide, **incomplete (?)** burning produces carbon monoxide

- If you breath in **carbon monoxide**, it sticks to your hemoglobin and takes up all the oxygen binding sites. Your blood loses all its ability to transport oxygen, and you suffocate

Why CO is of Concern?

- Carbon monoxide has 250 times greater affinity for the iron atom in hemoglobin – it displaces oxygen from blood
- Long term exposure may lead to coma and death
- Undetectable

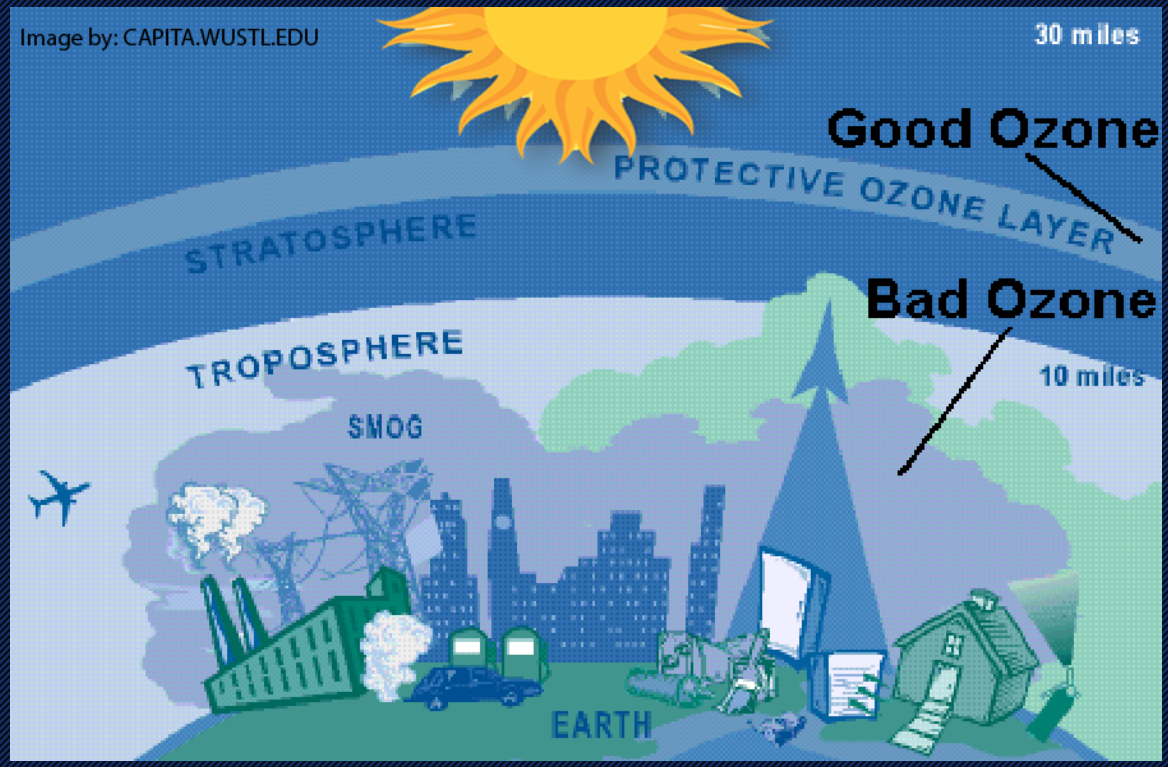
Carbon Monoxide (CO) vs. Carbon Dioxide (CO_2)

Carbon Monoxide	Carbon Dioxide
A byproduct of burning fuels	Gas exhaled with normal breathing
A poison even at low doses	An asphyxiant at high doses

An asphyxiant gas is a nontoxic or minimally toxic gas which reduces or displaces the normal oxygen concentration in breathing air

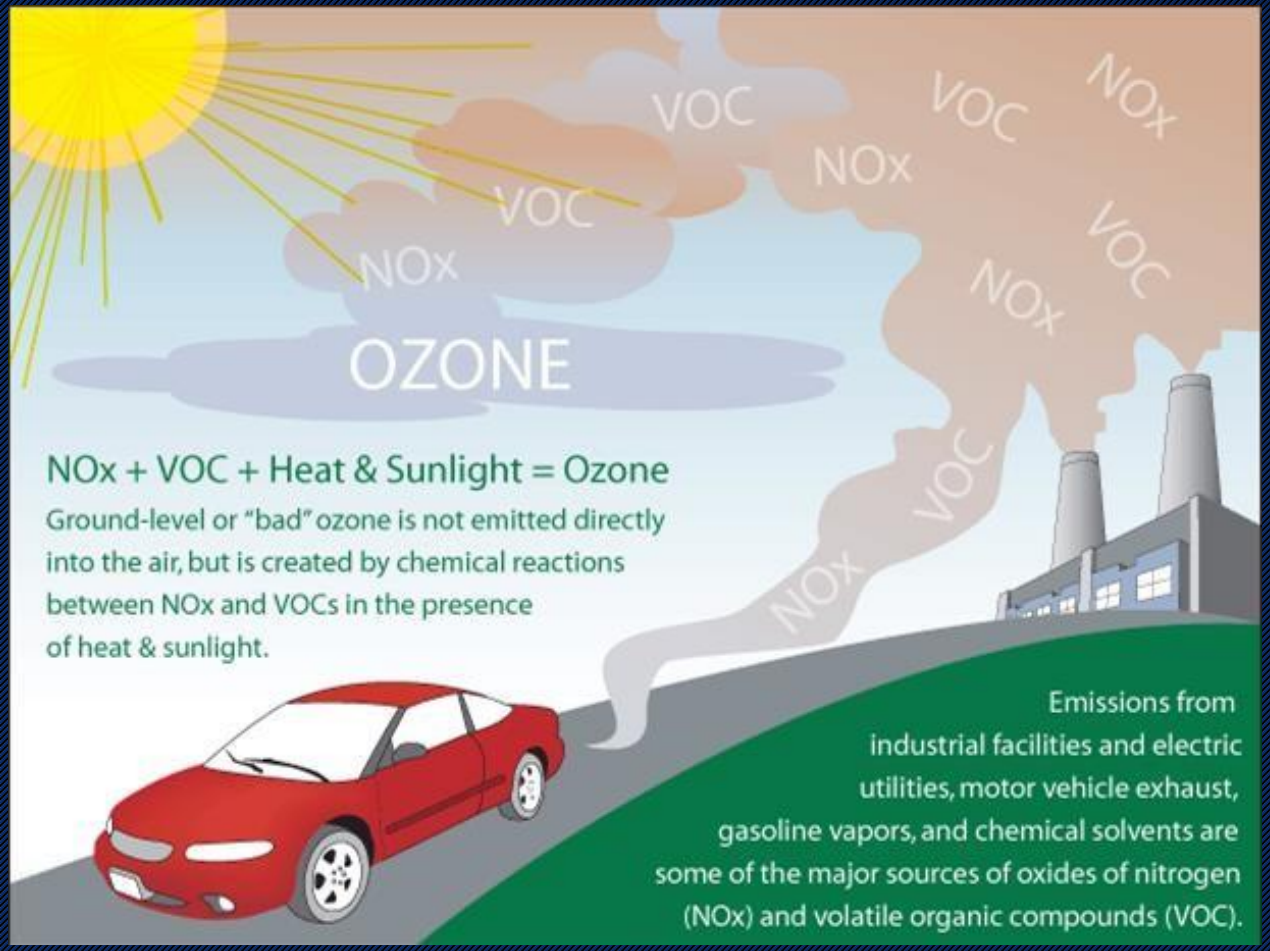
Ground Level Ozone

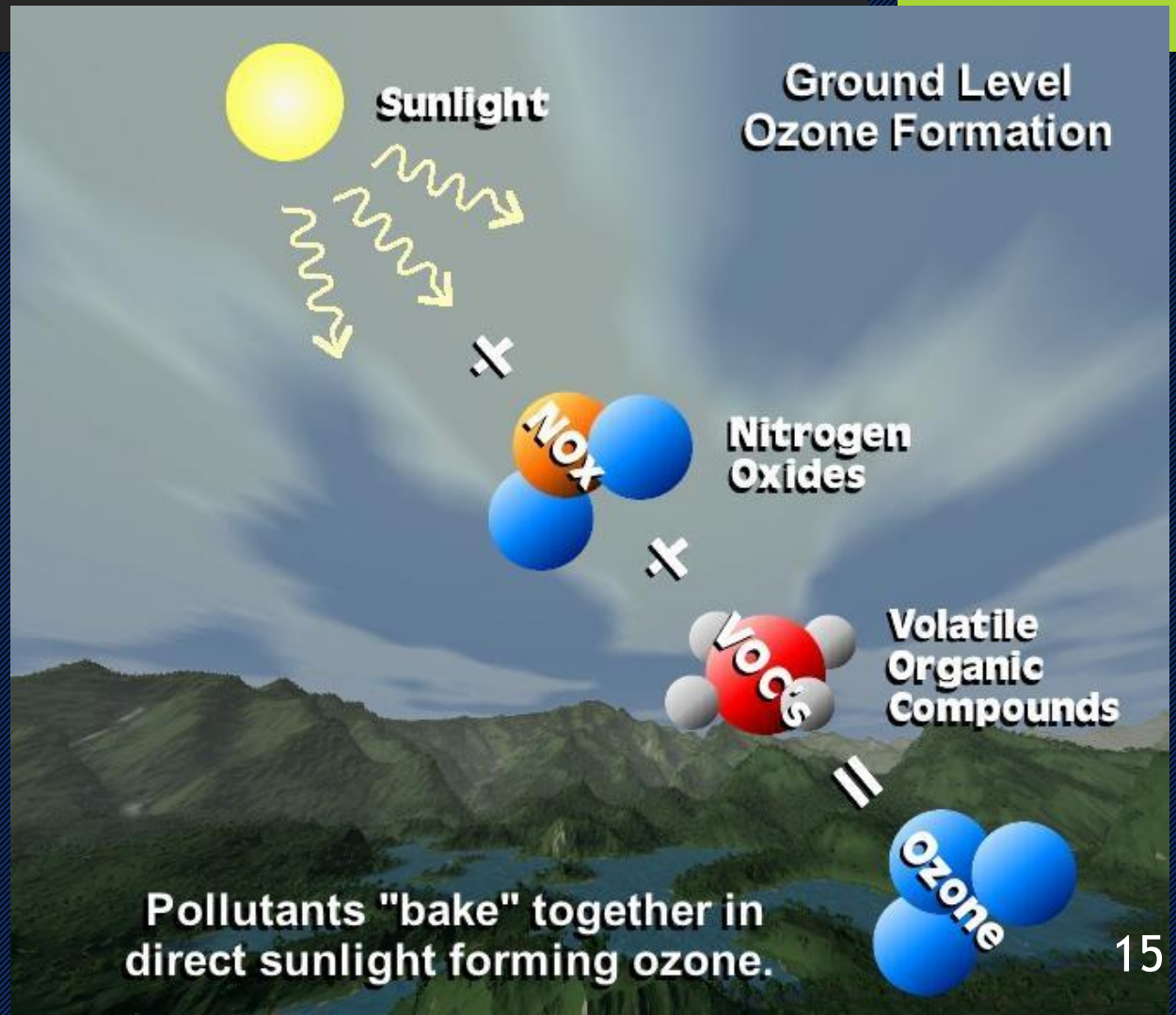
- Ground level ozone and ozone in the stratosphere
- Ozone is more reactive than oxygen



Ground Level Ozone Formation

Image collected
From NASA website





The Ozone Problem: Good up High, Bad Nearby!

- Ozone in the stratosphere is produced NATURALLY- **GOOD OZONE**

It forms a protective layer that shields us from the sun's harmful, biologically damaging ultraviolet rays

UV-radiation causes:

1. Increase in skin cancer & cataracts.
2. Decrease in crop yield.
3. Breakdown of the immune system.
4. Decrease in phytoplankton.

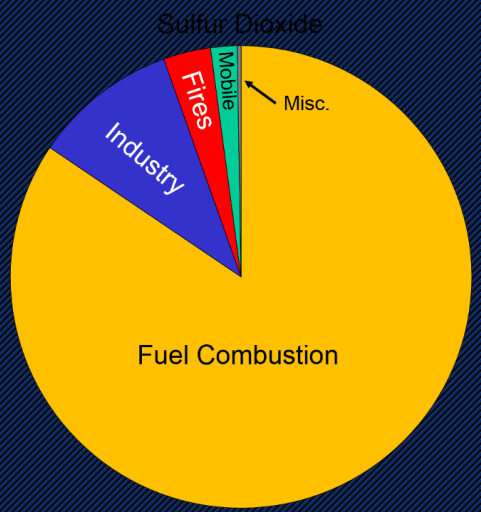
- Ozone in the troposphere (ground level) is produced through chemical reactions of man-made pollutants – **BAD OZONE**

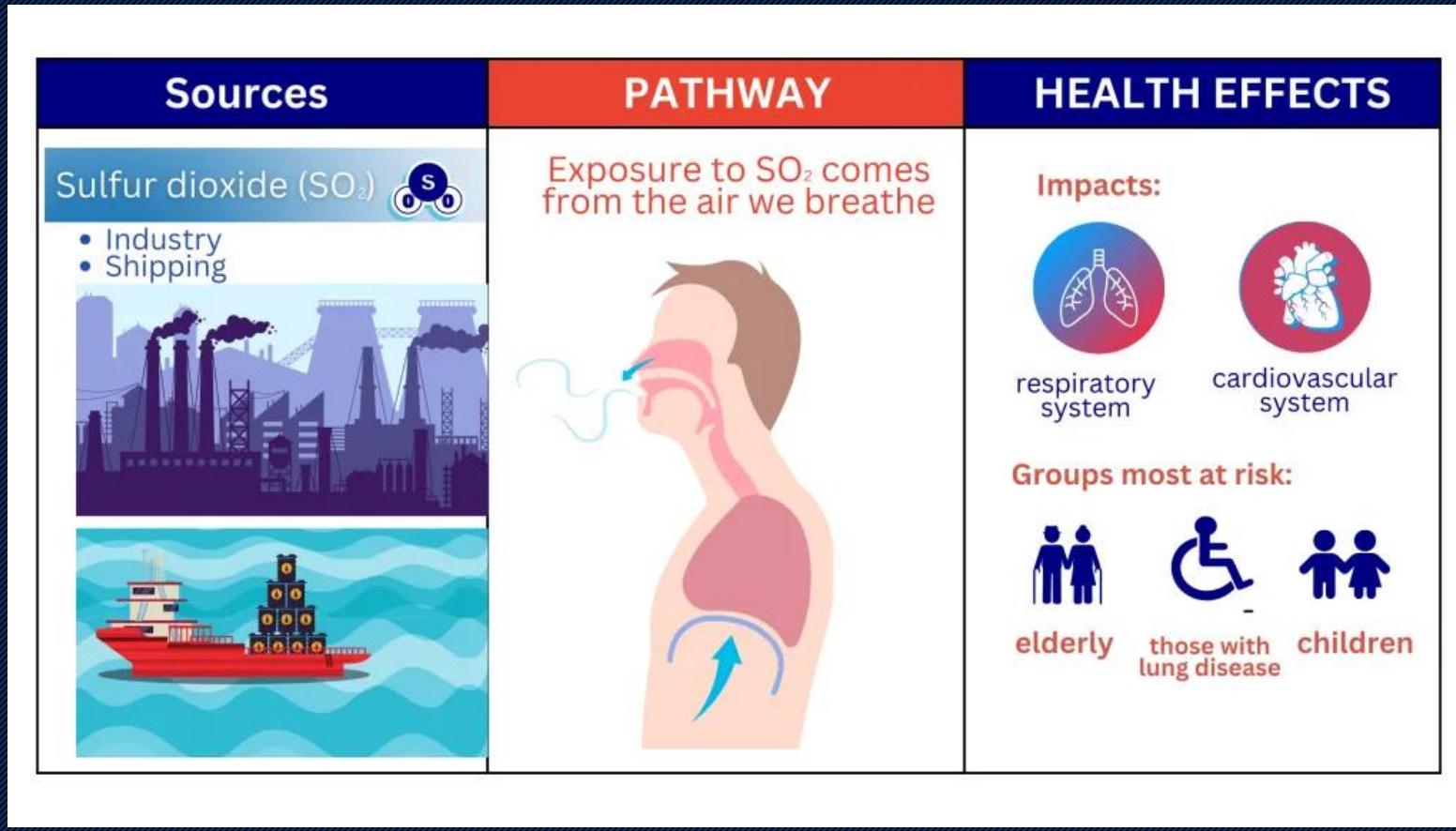
Ozone at ground level is a harmful air pollutant. It causes:

- Coughing, chest pain, and throat irritation
- Aggravates asthma, bronchitis, etc.
- Reduces resistance to cold and pneumonia

Sulfur Dioxide

- Corrosive acid gas, colorless with pungent and suffocating odor
- Accounts 18% of global air pollution





How does SO_2 form from combustion?

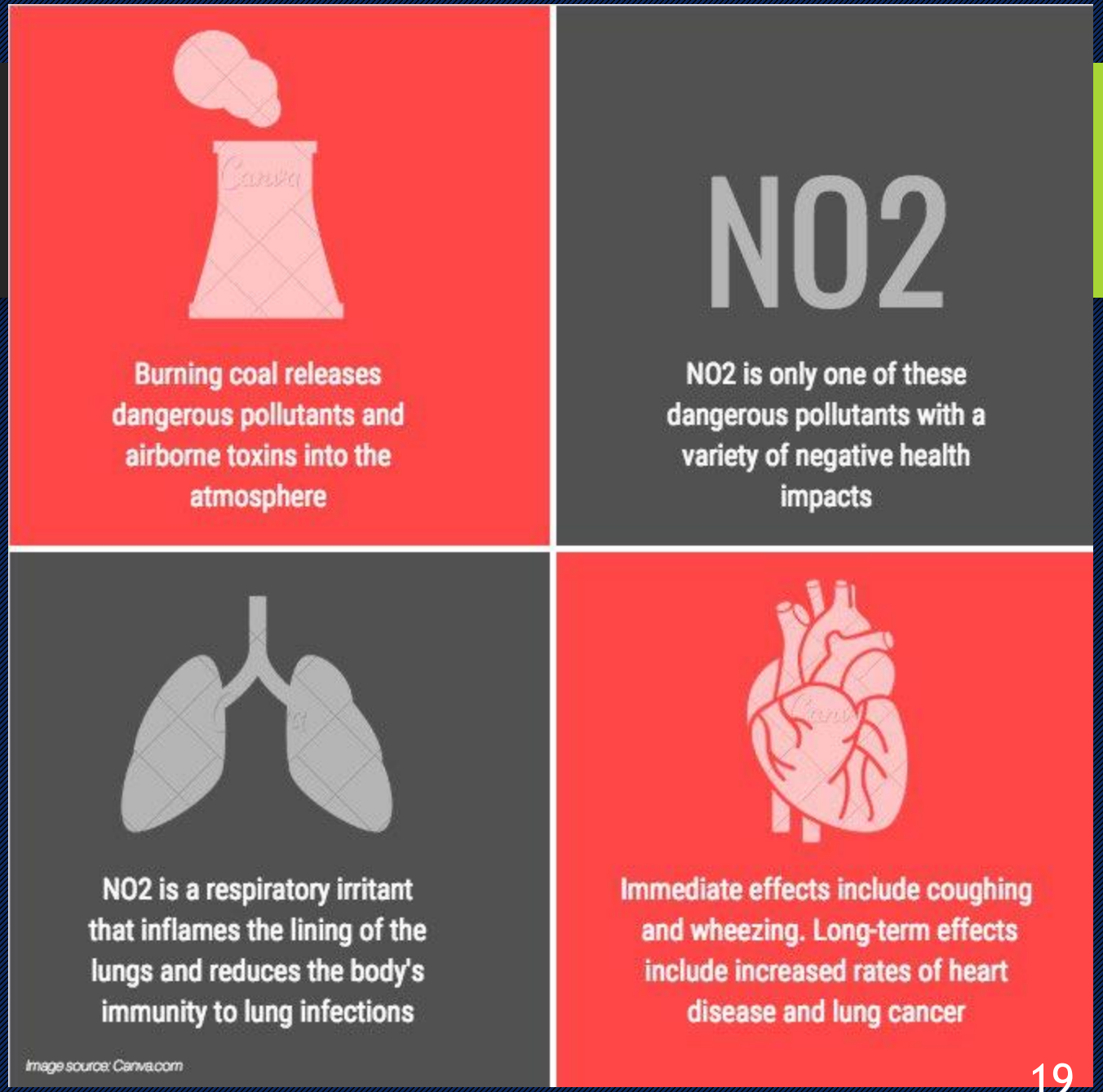
- Sulphur dioxide is created because sulphur is an impurity in most coal and oils. When the fuel is burned the hot sulphur reacts with oxygen in the atmosphere to form sulphur dioxide.

- So how can we resolve this problem?

Nitrogen Oxides

- Reddish brown gas with pungent odor

https://phys.org/news/2020-06-traffic-density-air-stratification-pollutant.html

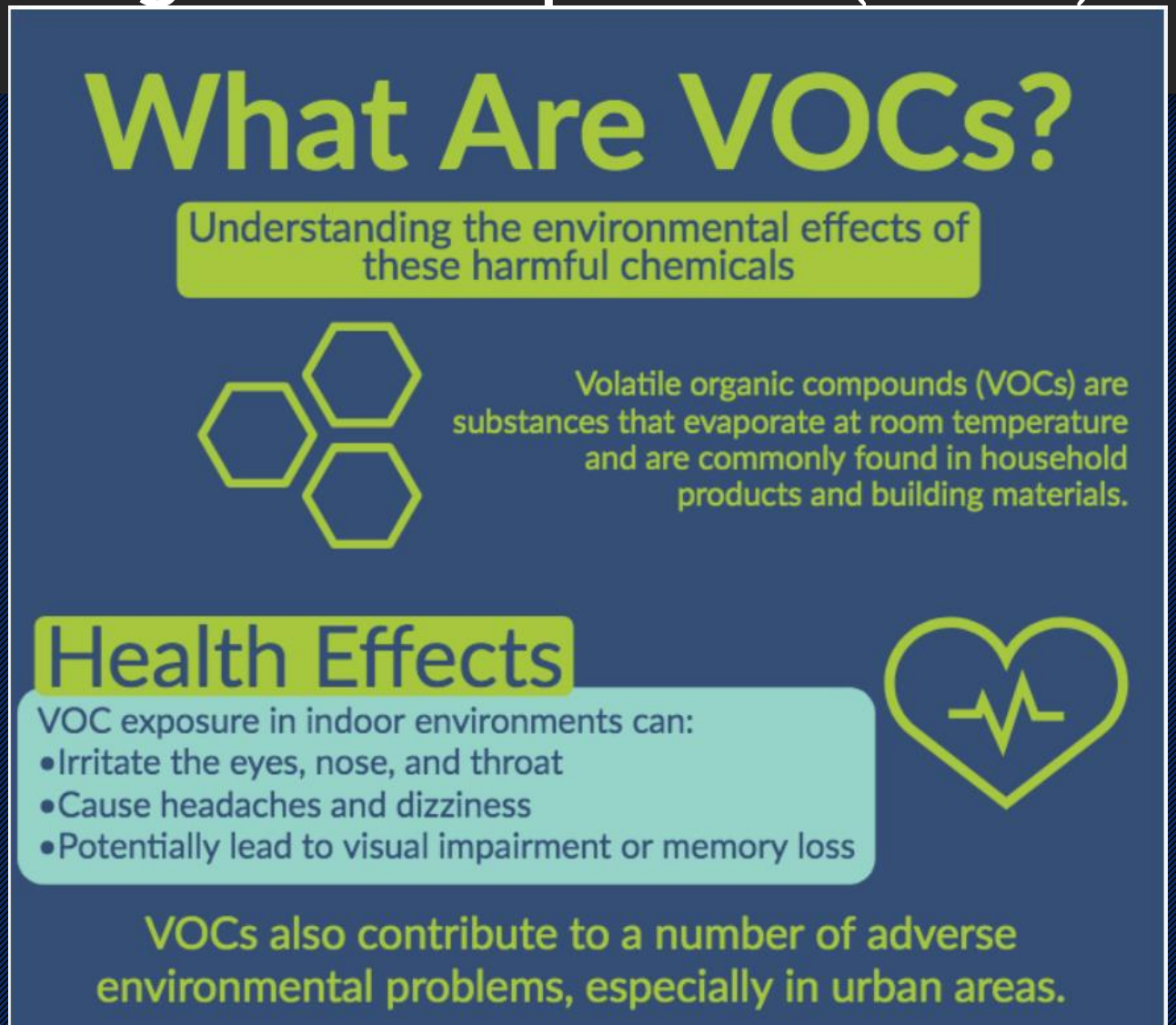


How does NO_2 form?

- Anthropogenic: The air in the cylinder of an internal combustion engine is only about 21% oxygen but contains roughly 78% nitrogen. When nitrogen and oxygen are combined at high temperatures (such as those found inside the engine), the bonds in the oxygen and nitrogen molecules are broken and reformed to make nitrogen dioxide. This isn't the intended result, so nitrogen oxide is merely a by-product.

- What about natural sources?

Volatile Organic Compounds (VOCs)



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

Natural Air Pollutants

- Natural but produced by human activity: Examples (?)

Natural Pollutants	Pollution induced by human activities
Radon	Nuclear power plant
Arsenic	Boreholes in Bangladesh
Asbestos	Rapid urban growth in California

*Borehole is a deep, narrow hole made in the ground, especially to locate water or oil.