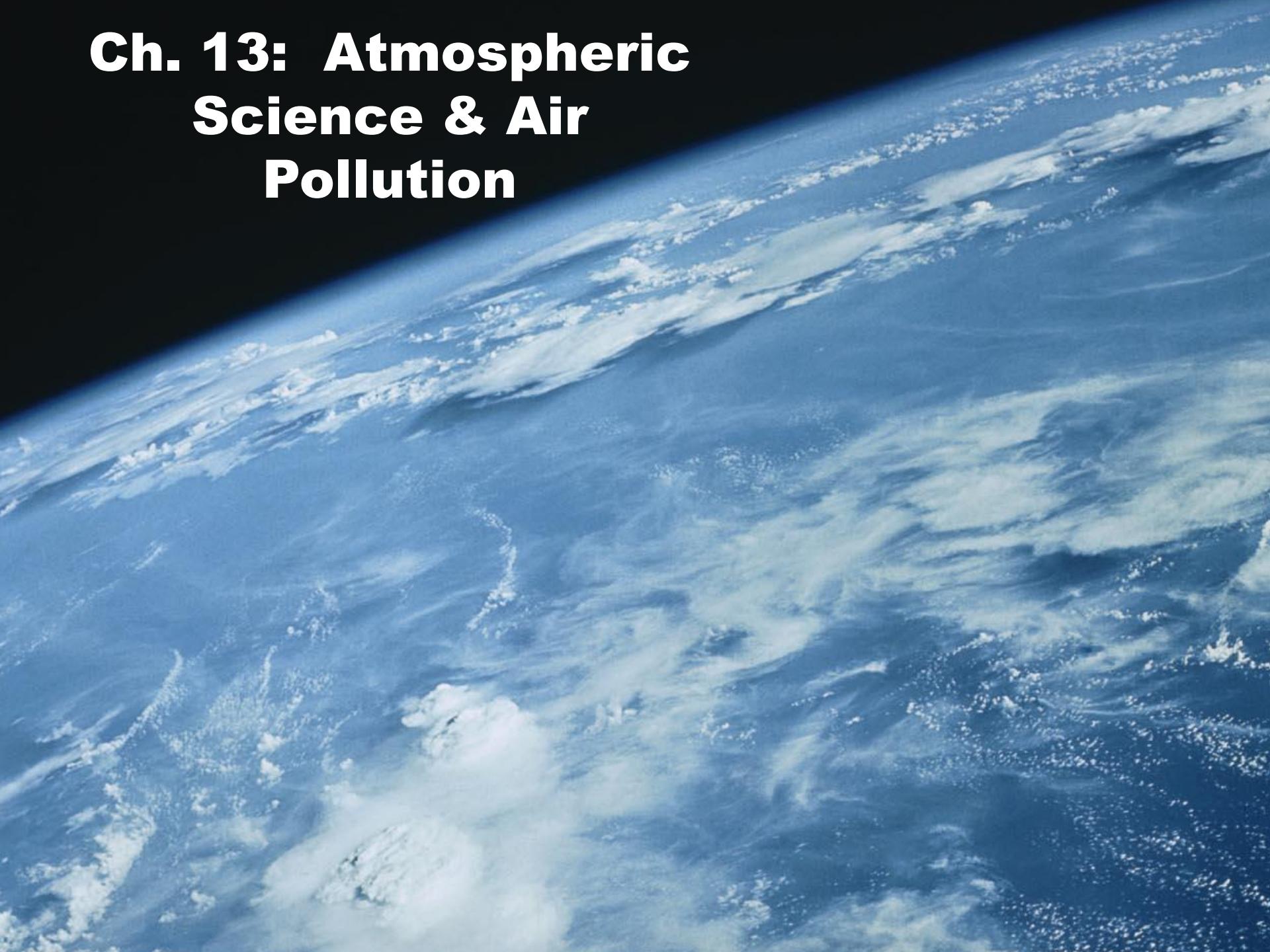
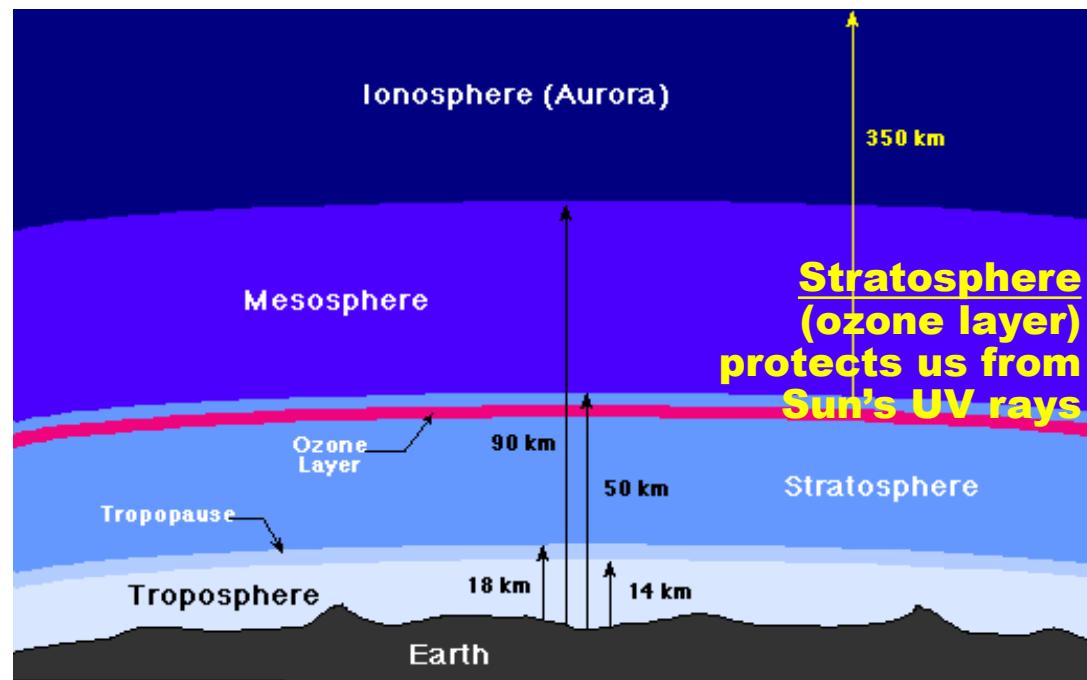


# **Ch. 13: Atmospheric Science & Air Pollution**



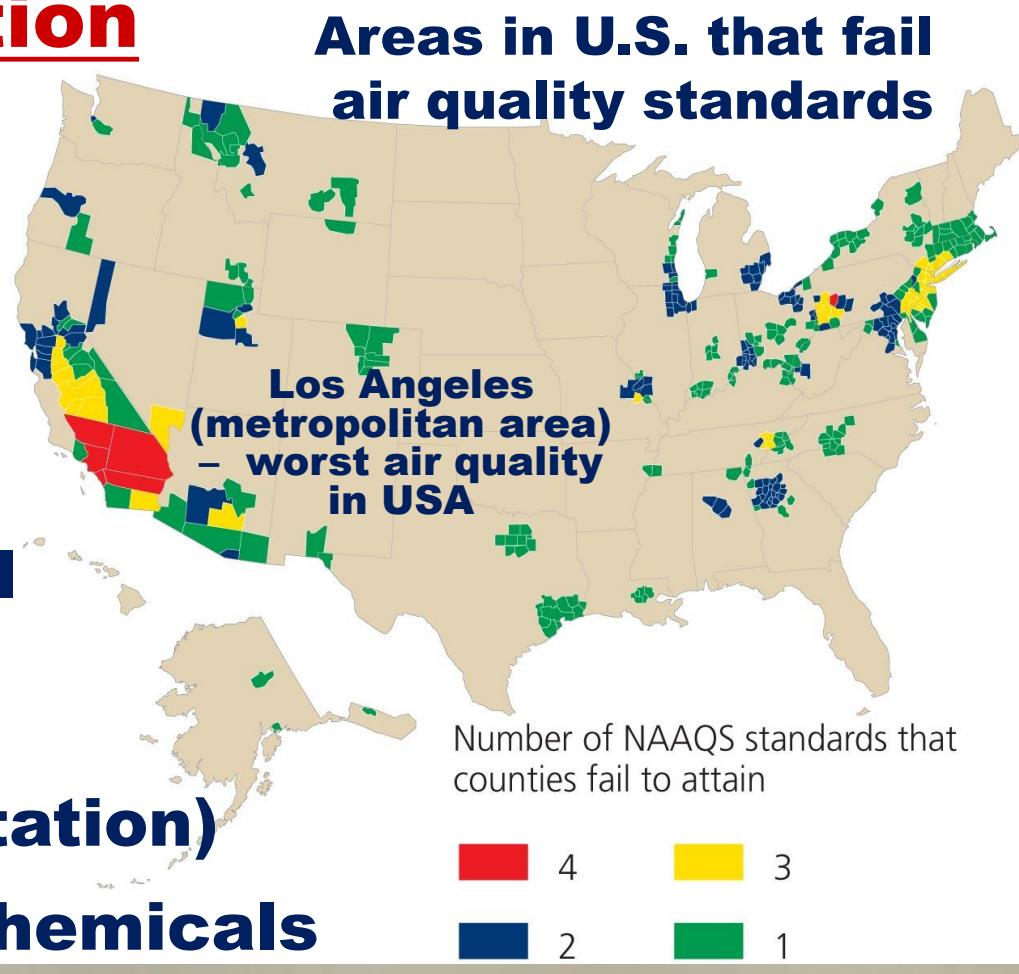
# The atmosphere

- The thin layer of gases around Earth, acts as a life support system, Life can't survive without it!
  - Breathe, it provides oxygen! Made up of 78% nitrogen ( $N_2$ ), 21% oxygen ( $O_2$ ), 0.04%  $CO_2$
  - Shields us from Sun's UV radiation & objects from space, holds in heat to moderate climate
  - Transports & recycles water, creates weather
- Human activity is changing the amount of some gases [ $CO_2$ , ozone ( $O_3$ ), methane]
- Harms our health & other organisms, puts our life support system at risk



# We create air pollution

- **Air pollutants:** gases & particulate material added to atmosphere that can affect climate or harm people & other organisms
- **Sources:** Burning Fossil Fuels (Transportation, power plants, industry)
- **Burning wood (deforestation)**
- **Industrial & personal chemicals**
- **Agriculture (livestock – methane, soil erosion)**



Air Pollution is regulated under the U.S. EPA's Clean Air Act, State EPAs, & local agencies (CA Air Resources Board). California has strictest air quality laws in USA, which often spread to other states.

Fossil Fuels = Coal, Oil (petroleum, diesel, crude), natural gas

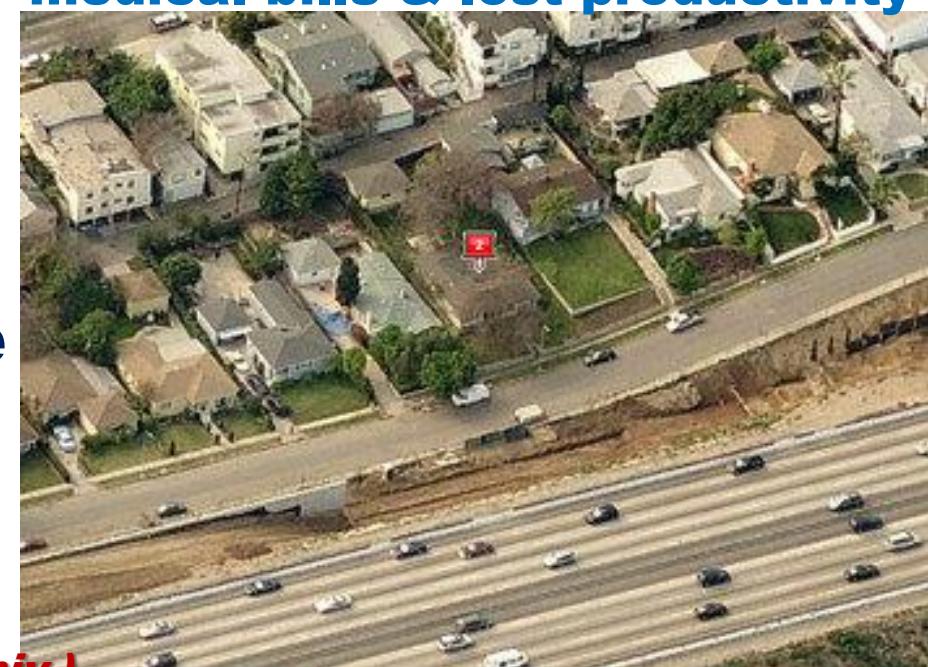
# Health Risks

- **Cardiovascular Disease: Artherosclerosis, heart attack, stroke, heart failure (#1 & #3 causes of U.S. deaths)**
  - **Particulates, Carbon monoxide, tropospheric ozone**
  - **Can affect heart rate, blood pressure, blood vessel function, blood clotting, heart rhythm**
  - **Respiratory: Lung cancer, emphysema, asthma, allergies**
- Pollutants breathed in enter lungs & then are transferred to the heart & the rest of the body through the blood**
- 
- The diagram illustrates the human circulatory system. It shows the heart at the center, with the superior vena cava entering from the top and the inferior vena cava entering from the bottom. The heart has four chambers: the right atrium, left atrium, right ventricle, and left ventricle. Arrows indicate the flow of oxygenated blood from the lungs through the pulmonary veins into the left atrium, and deoxygenated blood from the body through the superior and inferior vena cava into the right atrium. The heart pumps oxygenated blood through the aortic arch and descending aorta to the body, and deoxygenated blood through the pulmonary trunk and right and left pulmonary arteries to the lungs. A detailed inset shows an alveolus where oxygen (O<sub>2</sub>) diffuses into capillaries and carbon dioxide (CO<sub>2</sub>) diffuses out of the capillaries into the alveolus.

# Health Risks

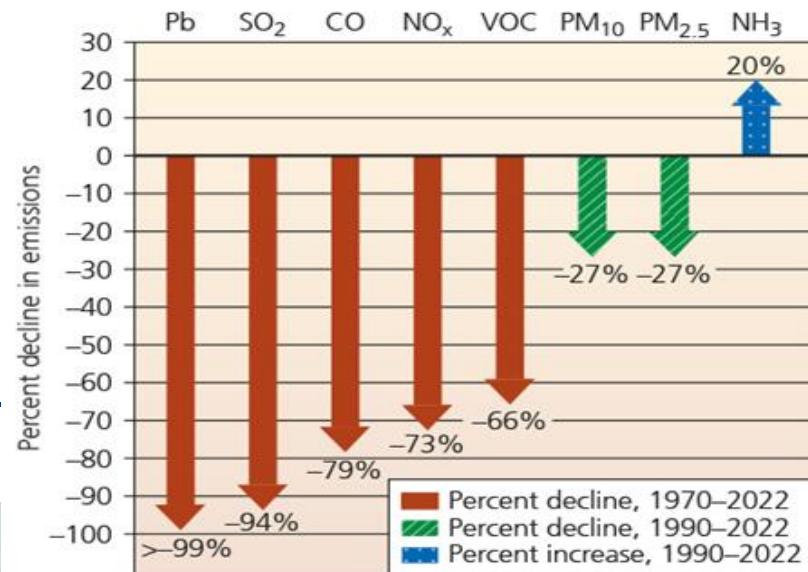
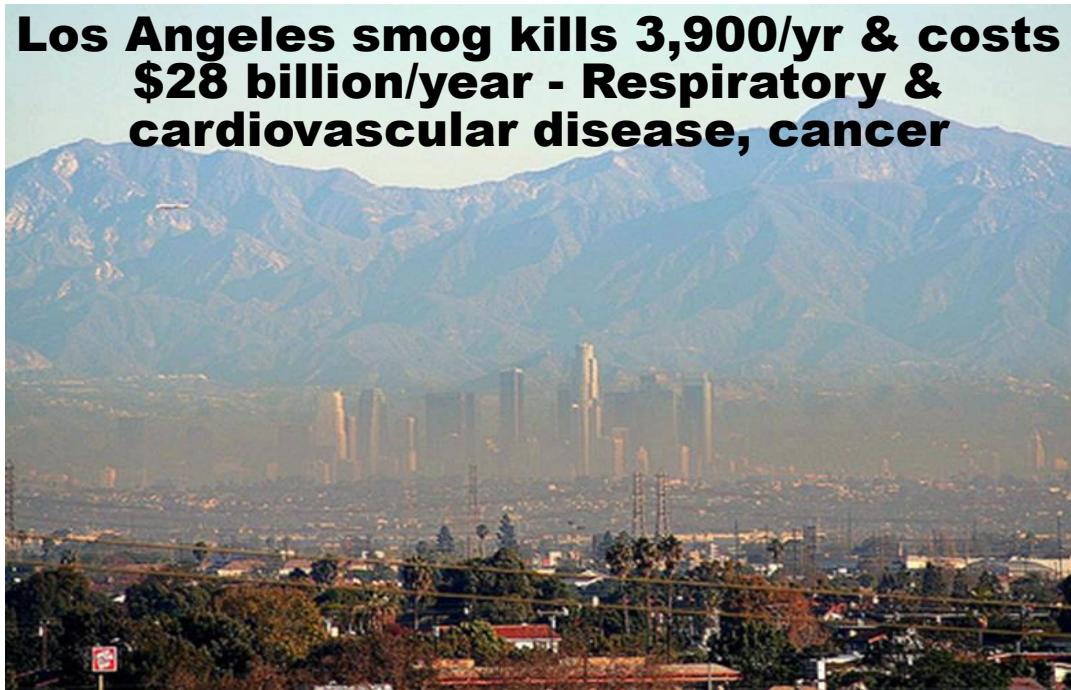
- **Nervous System:** ↓ vision, dexterity, learning, headaches, fatigue, dizziness
- **Cancer:** impacts all types (#2 cause of US death)
- **Reproductive:** infant mortality, low birth weight
- **Death:** Air pollution kills 3.3 million people worldwide annually
- In USA, power plants & traffic emissions are leading causes of air pollution deaths
- Switching to renewable energy would save California \$127.9 billion by 2050 from prevented deaths & illness  
*(Stanford Univ.)*

Air pollution kills 3,000/year in Hong Kong, costs \$5 billion/year in medical bills & lost productivity

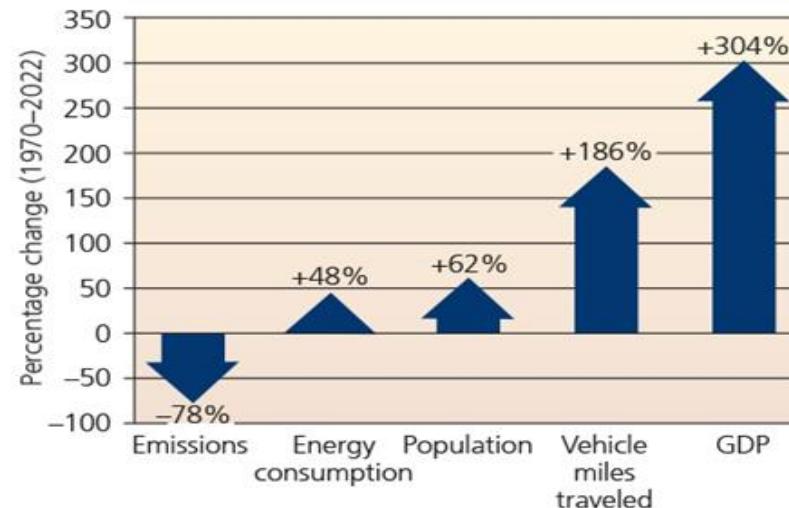


# We have reduced air pollution

- Total emissions of the 6 monitored pollutants have declined 60% since Clean Air Act of 1970
  - Despite increased population, energy consumption, miles traveled, & gross domestic product
  - Economy (GDP) improved while emissions reduced



(a) Declines in eight major pollutants

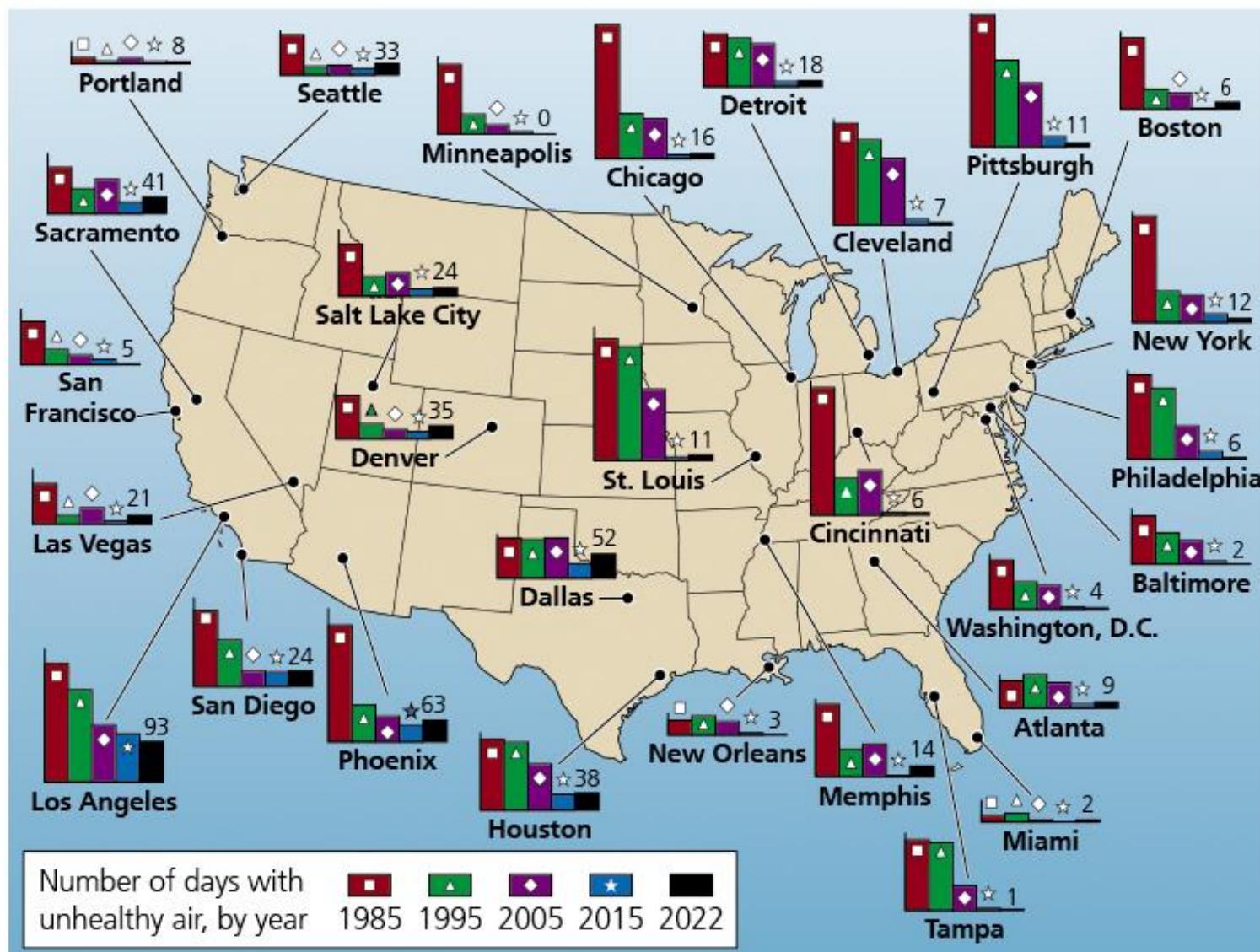


(b) Trends in major indicators

# Air Quality Has Improved Dramatically

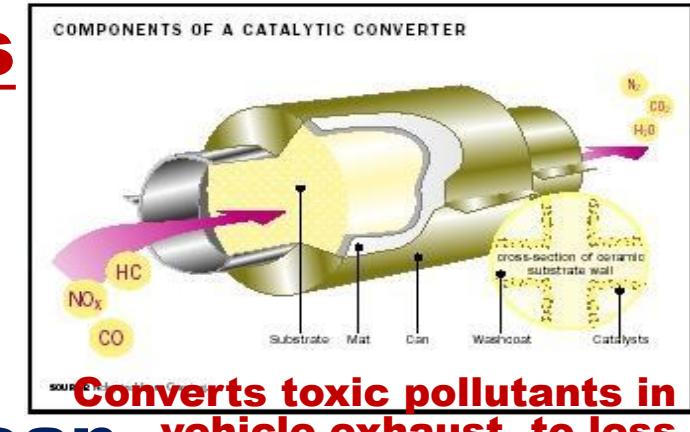
Overall, concentrations of criteria air pollutants across USA have steadily fallen since 1980

In most U.S. cities, air has become cleaner, but in places with population increases & often limited mass transit, it is rising again

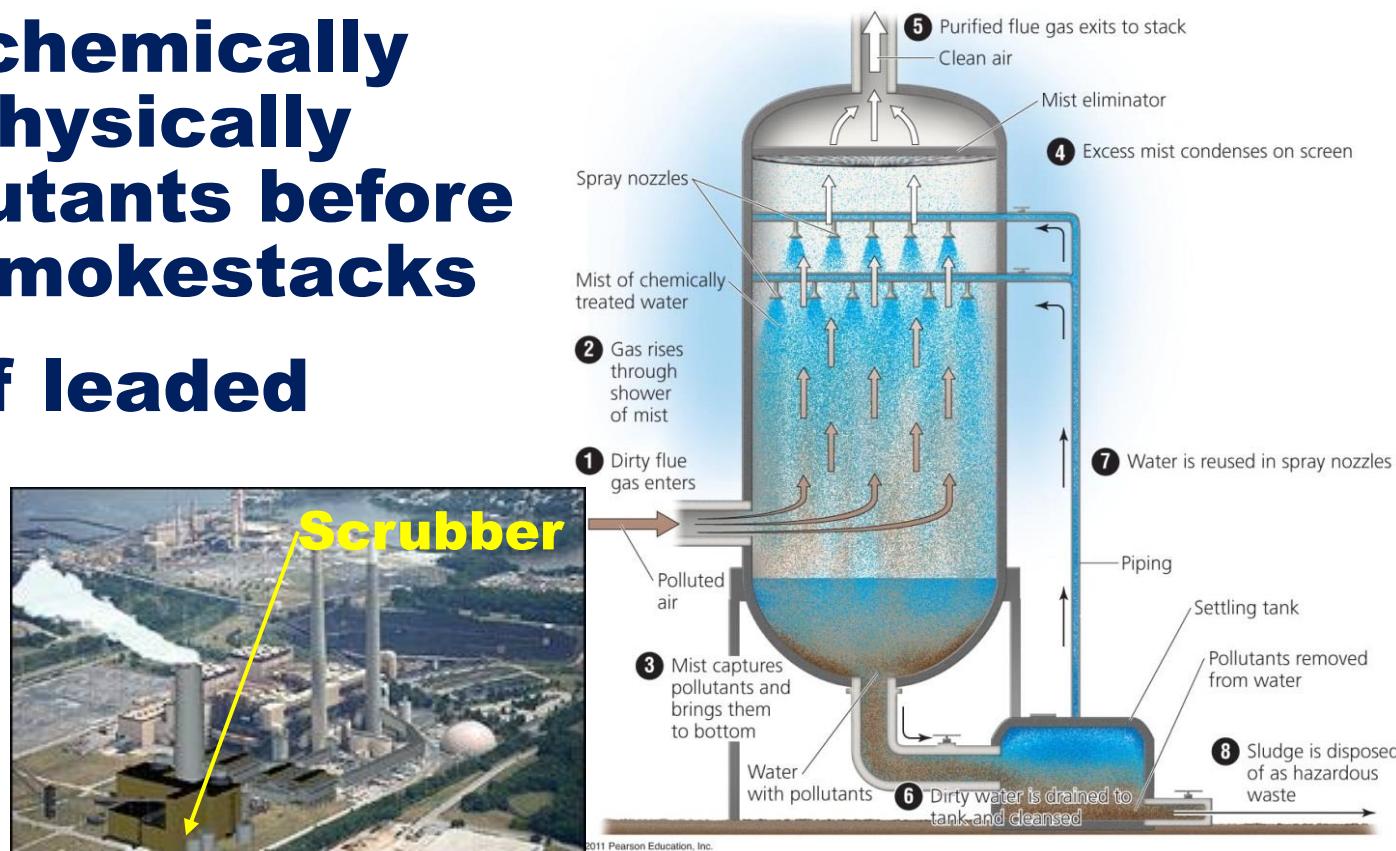


# How we reduced emissions

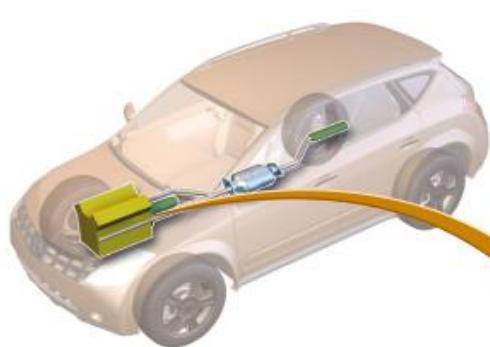
- Technology & federal policies
- Cleaner-burning engines & catalytic converters on cars
- Permit-trading programs & clean coal technologies reduce sulfur emissions
- Scrubbers: chemically convert or physically remove pollutants before they leave smokestacks
- Phase-out of leaded gasoline
- Gas caps, DMV emissions testing



Converts toxic pollutants in vehicle exhaust to less toxic substances

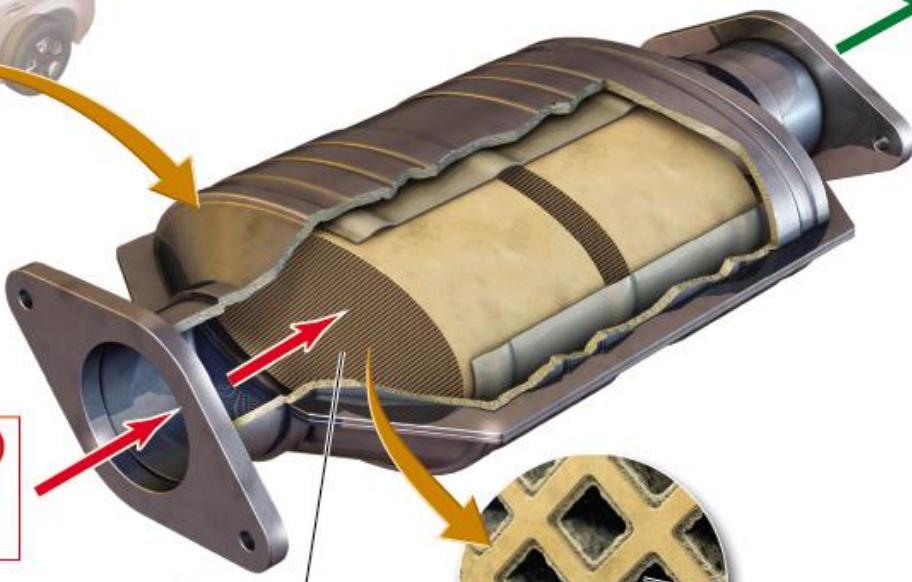


# We Have Reduced Emissions

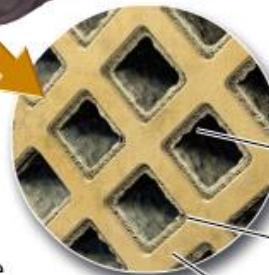


- 1 Pollutants from the engine flow into the catalytic converter.

Carbon monoxide (CO)  
Nitrogen oxides (NO<sub>x</sub>)  
Hydrocarbons



- 2 Honeycomb-like masses inside a stainless steel housing maximize surface area for contact with gases.



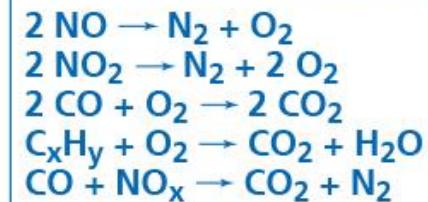
Catalytic metals (Pd, Rh, Pt)  
Washcoat (Al<sub>2</sub>O<sub>3</sub>)  
Substrate (metal or ceramic)

- 5 These less harmful gases are expelled from the vehicle's tailpipe.

Nitrogen gas (N<sub>2</sub>)  
Carbon dioxide (CO<sub>2</sub>)  
Water vapor (H<sub>2</sub>O)

- 4 Metals in the honeycomb help catalyze chemical reactions, which, with heat and oxygen, convert pollutants into nitrogen, carbon dioxide, and water vapor.

## Main chemical reactions:



- 3 The honeycomb structure is covered with aluminum oxide, palladium, rhodium, and platinum.

**Catalytic converters improve air quality by filtering pollutants from vehicle exhaust.**

# Air Pollution Solutions

- **Vehicle technology & increased fuel efficiency:**

**-Hybrid, plug-in, & electrics, low-sulfur diesel, better batteries, hydrogen fuel cells**

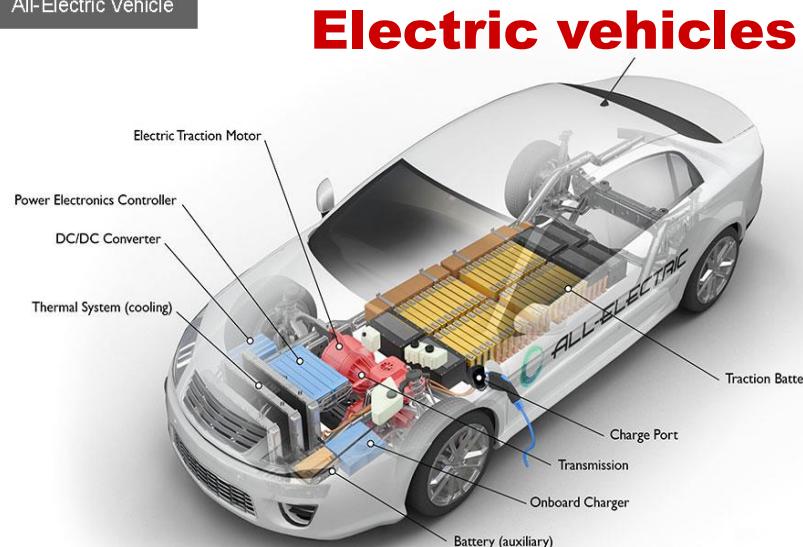


Toyota, Honda, Nissan, & Hyundai released 1st hydrogen cars in 2015

- **Renewable Energy (Wind, solar, geothermal, wave, biodiesel from algae, food or plant waste) + energy storage for renewables**

- Mass transit
- Conserve Energy
- Efficient electronics (LED & halogen lights)
- Decrease wood burning (deforestation)

All-Electric Vehicle





**We've got  
more work to  
do!**

**We saw how  
good air  
quality could  
be during  
Covid!**

