Introduction…

- Anything in the atmosphere that decreases quality of life for organisms
- Can be chemical, particulate, biological
- Generally restricted to the troposphere
- Both natural and anthropogenic causes
- Air pollution spreads both locally and globally through global wind currents
  - Can deposit pollutants from one part of the world onto others (Asian smog to American acid rain)

Natural Air Pollution

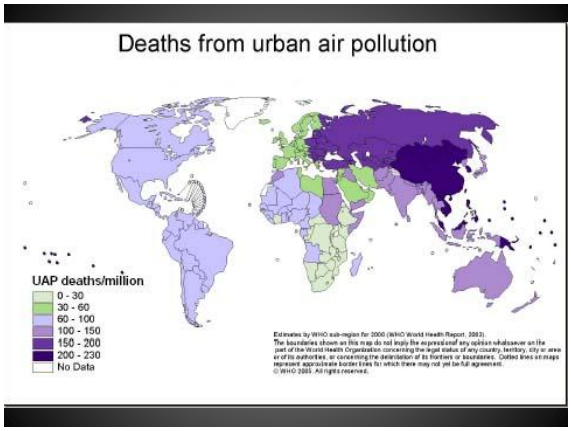
- Volcanoes, lightning, and plants all give off pollution
- This pollution can range from potentially dangerous (volcanoes contribute to acid rain) to completely harmless

Anthropogenic Air Pollution

- Human generated pollution is at least monitored in most parts of the world
- In the US, EPA required to establish minimum quality standards for our air
- Groups or companies that pollute the atmosphere can be sanctioned just as with hydro or lithosphere polluters

Air Pollution Around the World

- Legislation cleans up air—MEDCs then tend to have less air pollution
- North America and Europe have much cleaner air, even though the most industrialized parts are polluted
- Newly Industrialized Countries (NICs) the largest overall contributor to serious global air pollution

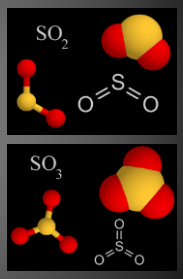


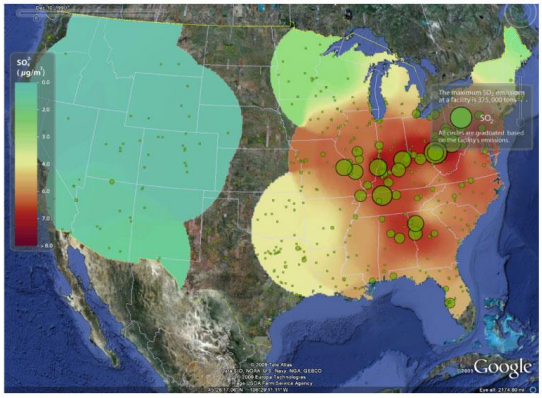
Classes of Pollutants

- Many different kinds, both physical and chemical, as with other spheres
- Pollutants can travel through the atmosphere and change form/sphere of location
- 6 main "criteria*" pollutants outlined by the Clean Air Act of 1970 to indicate pollution particularly harmful to humans or ecosystems

Sulfur Oxides

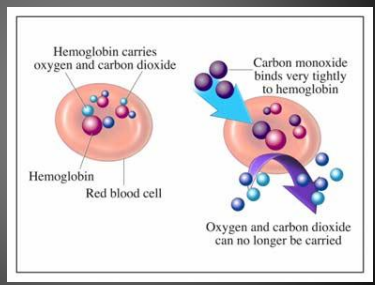
- Sulfur dioxide* (SO_2) generated by combusting fuels with trace amounts of sulfur
  - Irritant to human respiratory system
  - Can deposit as acid rain
  - Also large amounts from volcanic eruptions
- Sulfur trioxide (SO_3)
  - Industrial pollutant
  - Major component of acid rain

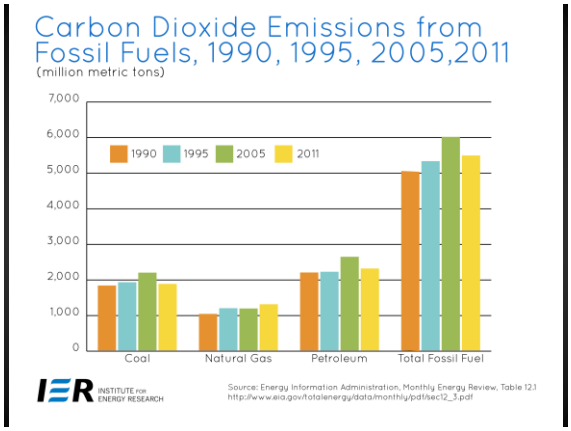


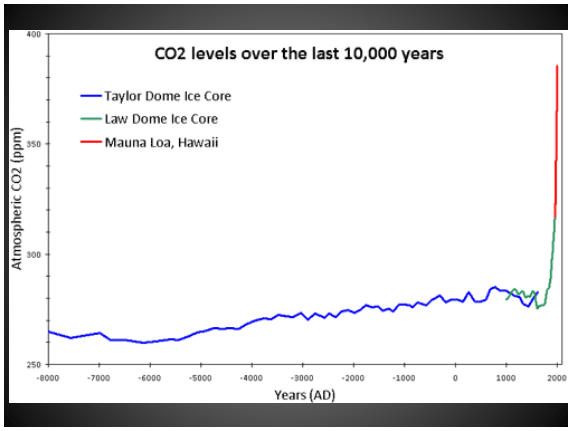


Carbon Oxides*

- Generated from combusting organic molecules (primarily fossil fuels)
- Complete combustion yields CO_2, incomplete yields CO
- CO toxic to humans because it bonds semi-permanently with haemoglobin in our blood
- CO_2 has MAJOR, serious issues—global climate change (more to come!)
- CO_2 not originally considered a major pollutant, but was ruled one in 2007 due to its role in global climate change

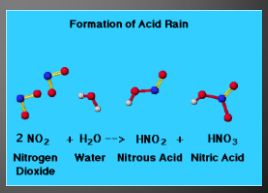




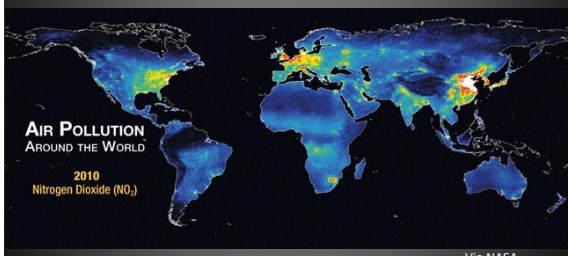


Nitrogen Oxides*

- NO and NO_2
- Naturally in atmosphere from combustion reactions with Nitrogen gas (N_2)
- Also from automobiles and other fossil fuel combustion
- Can contribute to generation of tropospheric ozone and acid rain



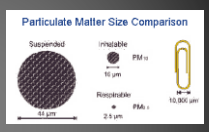
Nitrogen Dioxide

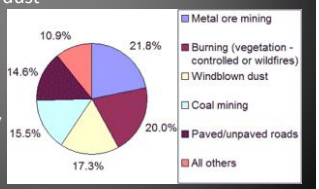


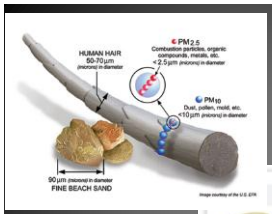
Via NASA

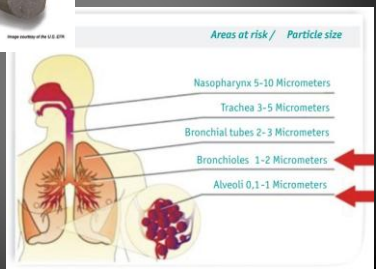
Particulate Matter*

- Small particles of solids and liquids in the atmosphere
- From combustion of fuels (ash, smog) as well as any activity that generates dust
- Enough of it can filter sunlight and decrease photosynthetic efficiency
- Can lead to respiratory diseases in humans

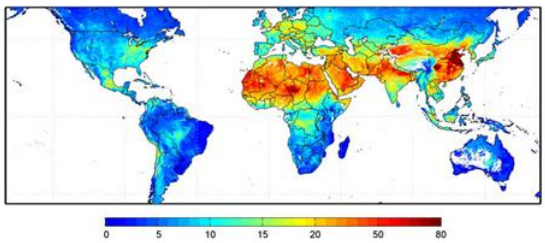




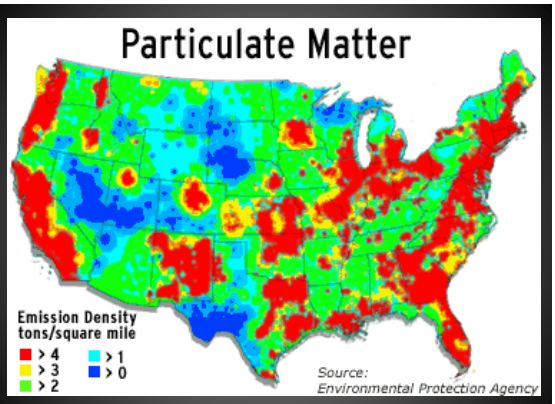




Particulate matter increases…

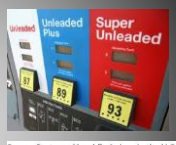


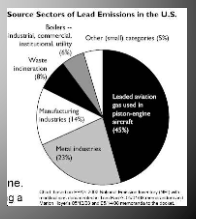
Via NASA

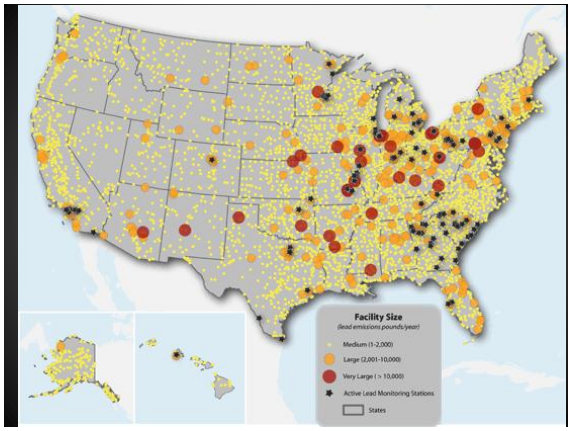


Heavy Metals

- Lead* is the biggest concern because of the neurological threats it poses
  - Used to be in all gasoline, but removed from US supplies in 1996→ atmospheric lead levels way down
  - Still used in LEDC and NIC parts of the world, though
- Mercury released through burning of impure coal (especially bituminous and sub-bituminous)
  - Levels are monitored but coal-burning electric plants don't have to do much in many parts of the world

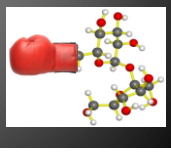






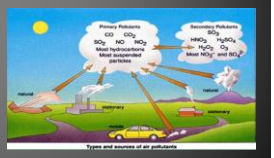
Volatile Organic Compounds

- Aromatic hydrocarbons—to be volatile is to vaporize readily
- Some are dangerous on their own (formaldehyde, benzene, components of paints or other chemicals)
- Many are harmless—almost anything you smell that comes from a living thing (vanilla, lemon, pine)
- Can be dangerous when they lead to photochemical smog



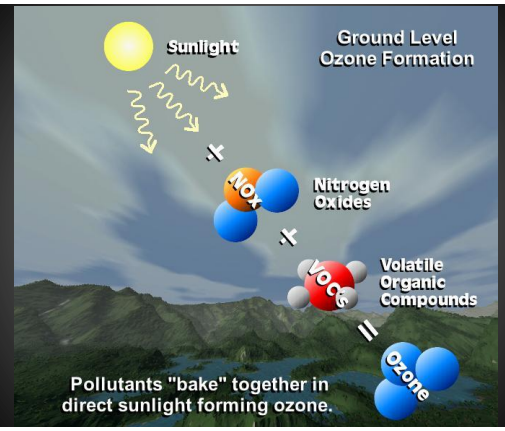
Primary vs. Secondary

- Two general types of pollutants when it comes to the atmosphere
- Primary: direct pollution from smoke stacks, burning fossil fuels, etc.
  - NO_x's, CO_x's, etc.
- Secondary: generated when a primary pollutant is transformed
  - Photochemical smog, ozone, etc.



Photochemical Oxidants

- Highly reactive chemicals formed by sunlight reacting nitrogen oxides with VOCs and others
- Tropospheric ozone* is the most well known
  - Ozone in the stratosphere good, but we can't breath it in so it's bad in the troposphere
- Can be harmful to lung health as well as cause ecosystem damage

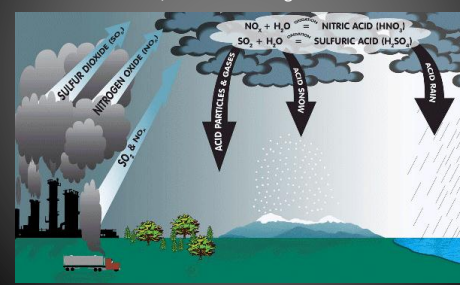


Other Types of Air Pollution: Smog

- Hazy, hard to breath air rich in photochemical oxidants, pollution, and especially ozone
- Hard to reduce because there are some natural sources that cause tropospheric ozone to linger

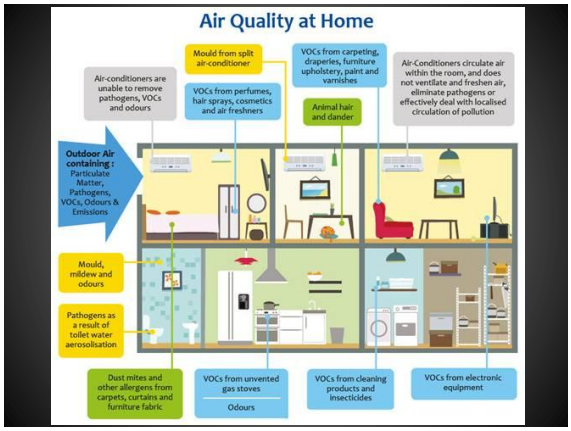
Acid Rain

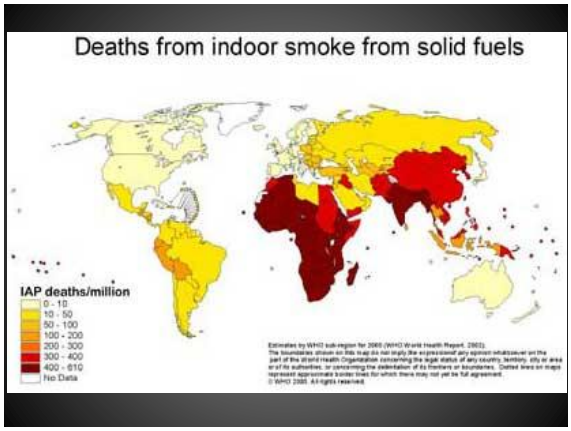
- Both direct and indirect effects
- Most serious threat to aquatic ecosystems→ tolerance!
- No harm to humans, but does damage human structures



Indoor Air Pollution

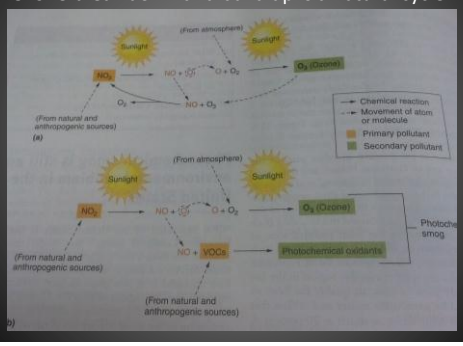
- More serious in developing countries because of lack of ventilation and what people burn in their homes
- Developed countries have a few major indoor pollutants, but are mostly cleaner
  - Asbestos, Radon, Carbon Monoxide, VOCs



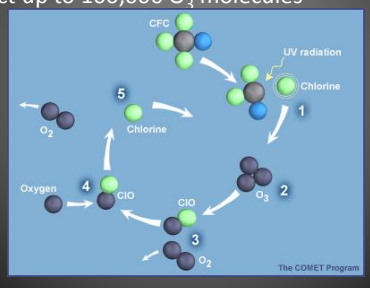


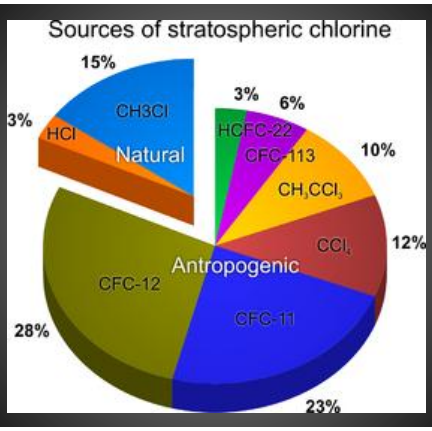
Stratospheric Ozone Depletion

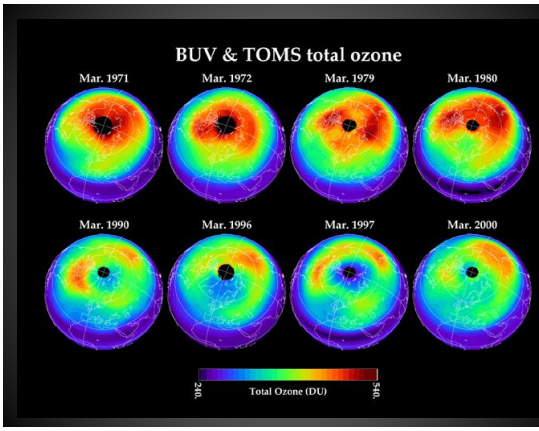
- Ozone break down and build up is a natural cycle:

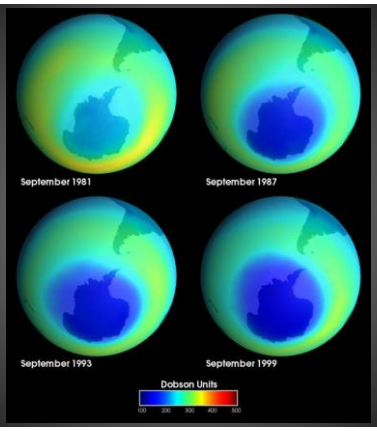


- Issue is when ozone is broken down faster than it can be built up.
- CFCs catalyze breakdown of ozone, and can react up to 100,000 O_3 molecules

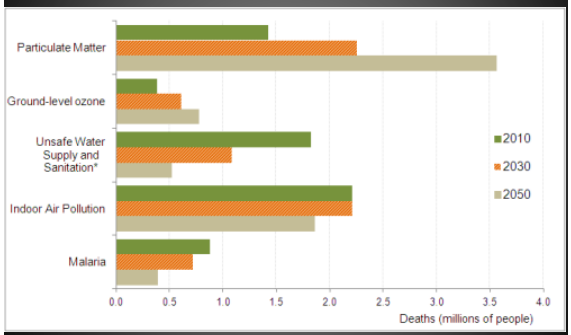








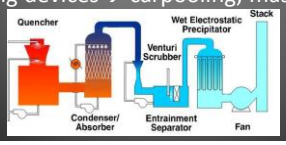
Future of Air Pollution?

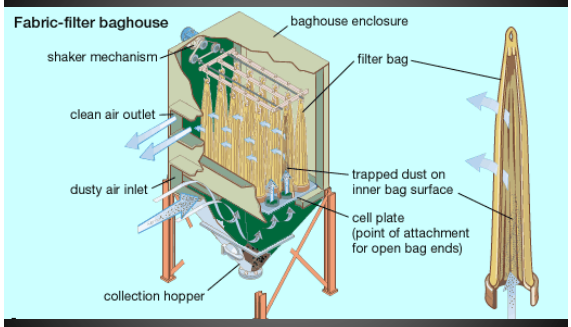


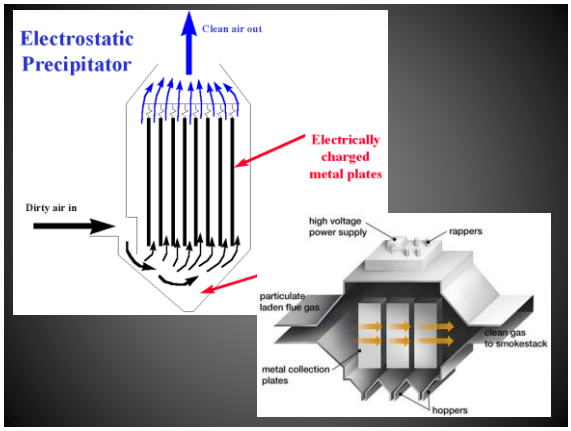
*Organization for Economic Co-operation and Development (OECD)

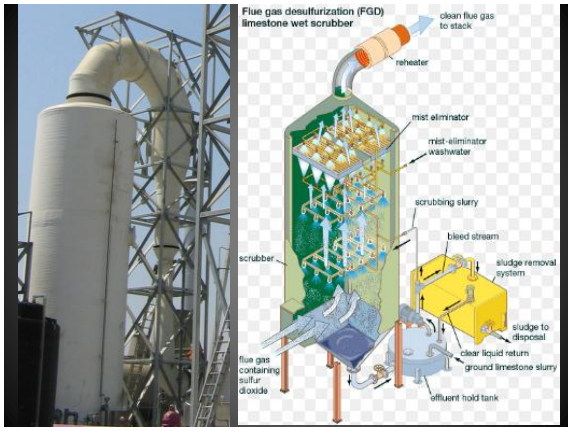
Pollution Control

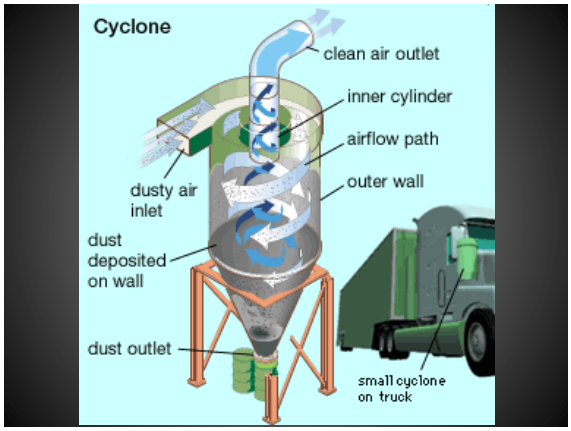
- Combination of legislation and cleaning
- 1970: Clean Air Act– "the Big One" for the US
  - Amended in the 90s for increased control
- Cleaning smoke and particulate matter is a major control method
- Also reducing individual use of emission-creating devices→ carpooling, mass transit, etc.










Cyclone
clean air outlet
inner cylinder
airflow path
outer wall
dusty air inlet
dust deposited on wall
dust outlet
small cyclone on truck