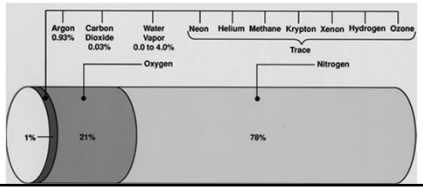
Air Pollution

Does it adversely affect our health?

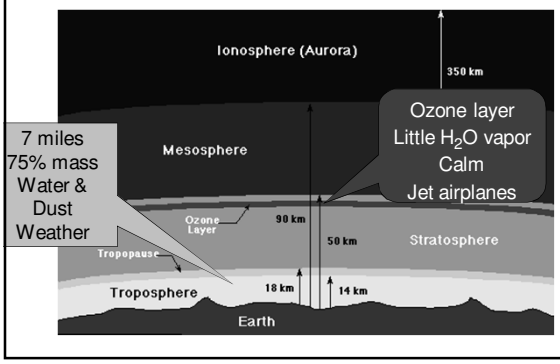
Miller chapter 19

The Composition of the Atmosphere

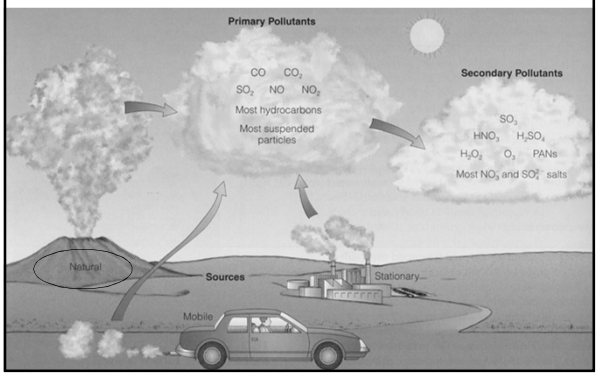
- 78 % nitrogen
- 21 % oxygen
- 0.93 % argon
- 0.03 % carbon dioxide
- 0.04 % of other gases.



The Layers of the Atmosphere

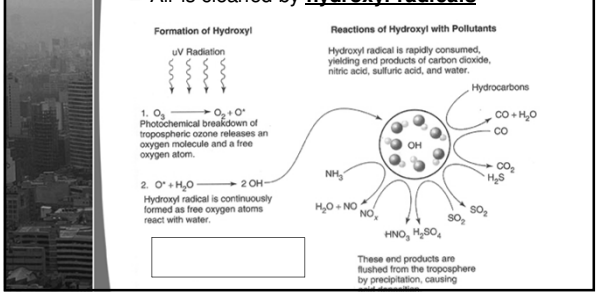


The two types of air pollutants
natural and anthropogenic

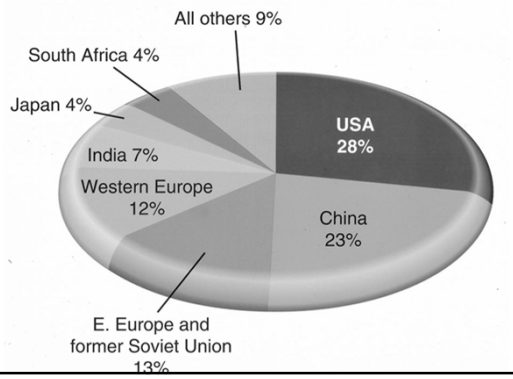


Sources can be Natural or Anthropogenic

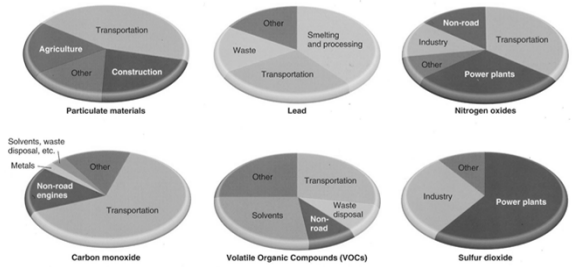
- Anthropogenic sources have increased since industrial revolution
- Air is cleaned by **hydroxyl radicals**

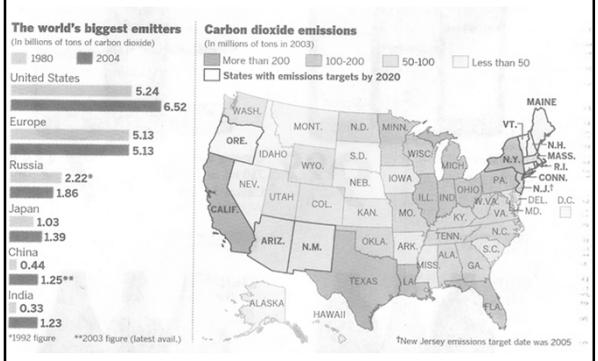


Carbon dioxide source by country



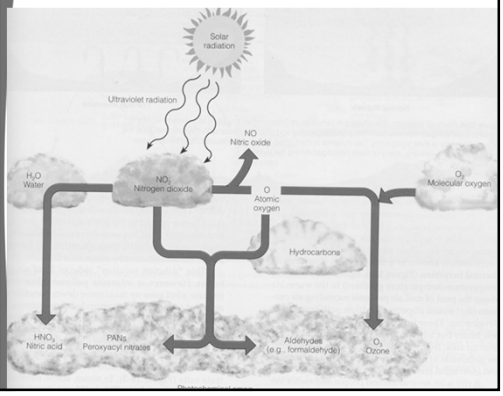
Anthropogenic source of Major pollutants



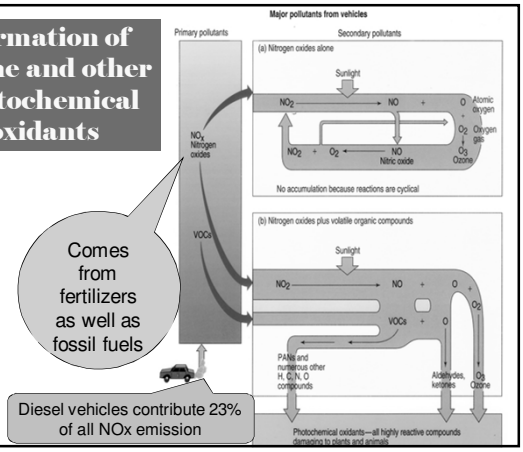


Photochemical Smog

Photochemical Smog



Formation of Ozone and other photochemical oxidants



Comes from fertilizers as well as fossil fuels

Diesel vehicles contribute 23% of all NOx emission

The bad tropospheric Ozone

Ozone (O_3) Chemistry

- Ozone formation occurs in the presence of nitrogen dioxide (NO_2)
- NO_2 + Sunlight → NO + O
- $O + O_2 \rightarrow O_3$
- Ozone destruction occurs in the presence of NO
- $NO + O_3 \rightarrow NO_2 + O_2$
- This natural cycle creates a balanced amount of ozone. (Steady State)

Ozone (O_3) Chemistry

- VOC converts NO back to NO_2.
- $NO \rightarrow NO_2$
- As NO levels drop, Ozone accumulates
- ~~$NO + O_3 \rightarrow NO_2 + O_2$~~

Summary reactions for ozone O_3

- **<u>High Temperatures</u> (internal combustion engines)**

  $N_2(g) + 2O_2(g) \rightarrow 2NO_2(g)$

- **<u>Sunlight reaction</u> forming ozone**

  Reversible

  $NO_2(g) + O_2(g) \leftrightarrow NO(g) + O_3(g)$

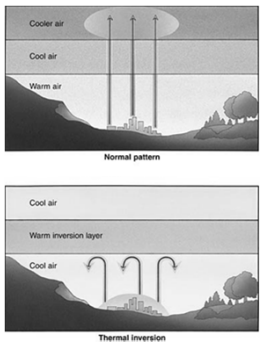
- **VOC's remove NO and Ozone remains**

  Non-reversible

  $NO_2(g) + O_2(g) \rightarrow NO(g) + O_3(g)$

Thermal Inversion Layers

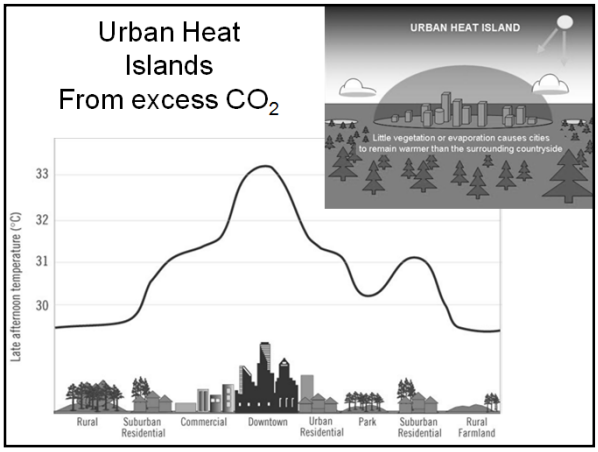
- When temperature increases with altitude, it is referred to as a **temperature or thermal inversion**. **Cool air becomes trapped under warmer layer**.
- Forms in areas where the flow of air is geographically blocked by mountains



Thermal Inversion in Los Angeles

- At surface, air cooled by the California current comes ashore on cool sea breezes.
- The dense cool air sinks into the basin as it comes onto land.
- The mountains to the east prevent air from moving out of the vicinity of the basin.
- With cool air at the surface and the warm layer aloft, inversion conditions take hold.
- The inversion limits the height to which pollutants generated by industrial activities and motor vehicles are moved.
- Under cloudless skies, insolation initiates photochemical reactions in the urban atmosphere to create the infamous smog problem that Los Angeles has.

Urban Heat Islands From excess CO_2



Industrial Smog

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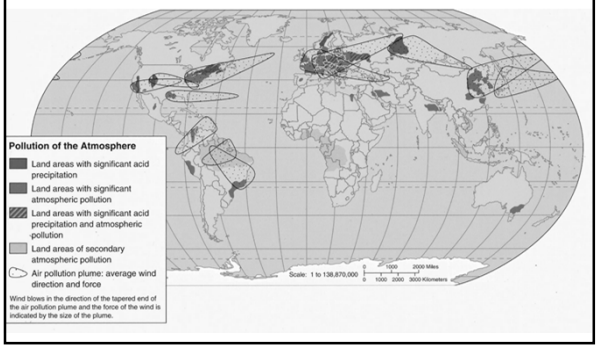
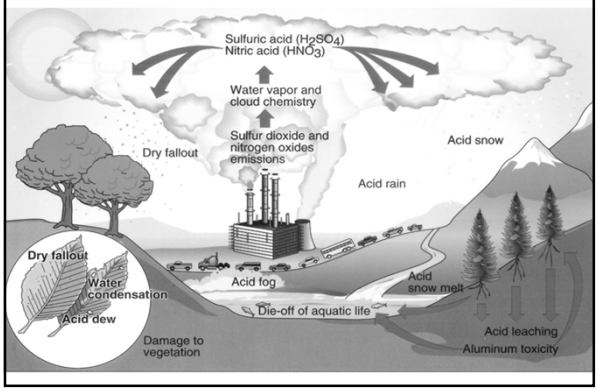
AIR POLLUTION AROUND THE WORLD



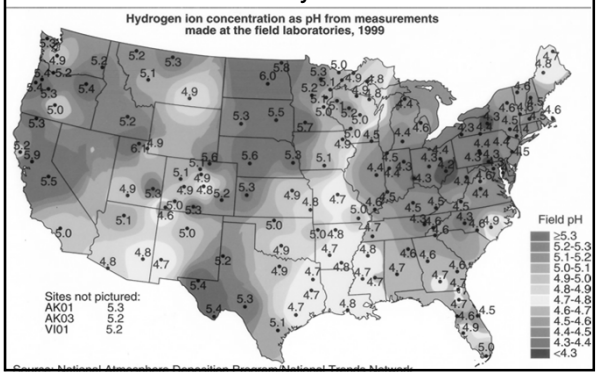
Acid Deposition

- **Regional problem**
- **Sulfuric acid (H_2SO_4) and nitric acid (HNO_3) form from primary pollutants SO_2 (coal) and NOx (vehicles)**
- **Carried on prevailing winds**
- **Enters environment as dry acid deposition or acid rain**
- **Lakes in shallow soil low in limestone become acidic**
- **Lakes in deep soil high in limestone are buffered**

Consequences of Acid Deposition



Where is the threat of acid rain the greatest? Why?

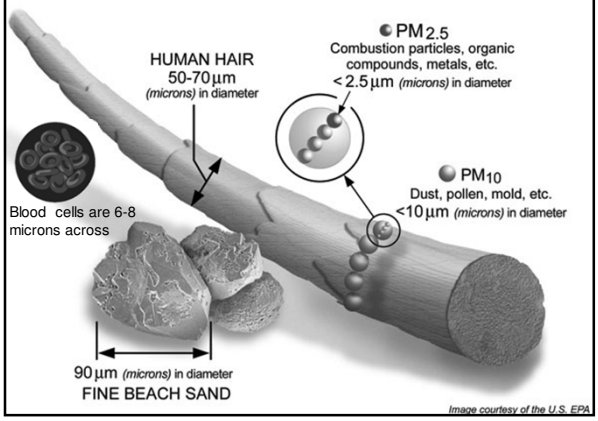


How do we reduce acid deposition?

Suspended Particulate Matter

- Particulate matter (PM) is both plain old dust, from roads, fields or wood, and particles formed through chemical actions.
- Other air pollutants form PM – SO_2, NOx, VOC's, and ammonia.
- The size of the particle is related to the cost of removing the particle

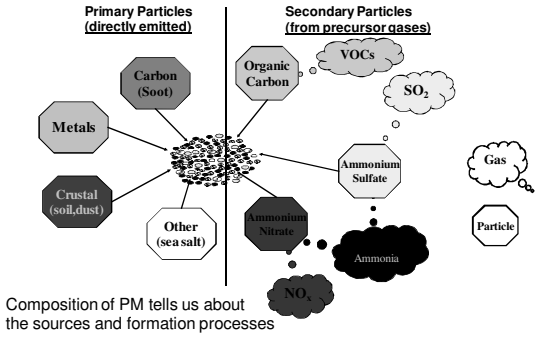
Particles Come in Different Shapes and Sizes



Particulate Sources

- Combustion
  - Smoke,
- Friction
  - Metal pieces,
- Wind
  - Sea
- Life
  - Skin cells,

PM Sources and Formation



Composition of PM tells us about the sources and formation processes

Getting Rid of PM

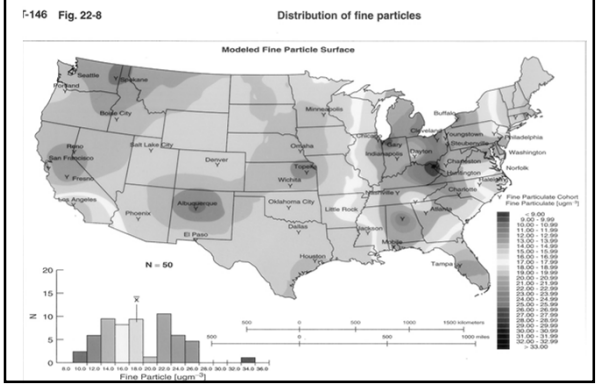
- ☑ ***Sedimentation*** (settling out) only works for Coarse particles (above 2.5 µm)
  - ☑ Residence time: seconds to one day
- ☑ ***Condensation*** (via rain, fog, etc) works for Fine (2.5 µm) and larger particles
  - ☑ Residence time: days to weeks
- ☑ ***Coagulation*** (clumping to form larger particles) is the only thing that works for ultrafine particles
  - ☑ Residence time: weeks to …?

Health Effects of Particulates

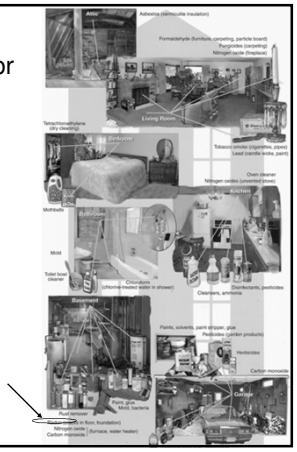
- *Exposure to fine particulates can cause up to a 20% permanent decrease in lung capacity*
- Living in heavily polluted areas is just as hazardous as living with a smoker
- Death rates among sick, frail, elderly and infants increase on high particulate days

Research courtesy of Dr. Peters, UC Riverside

Particulate Pollution
Where is it the Greatest?

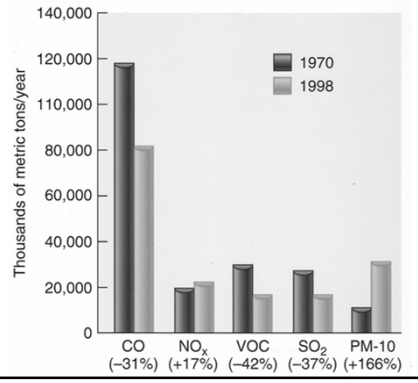


Remember indoor air pollution is generally worse than outdoor air pollution

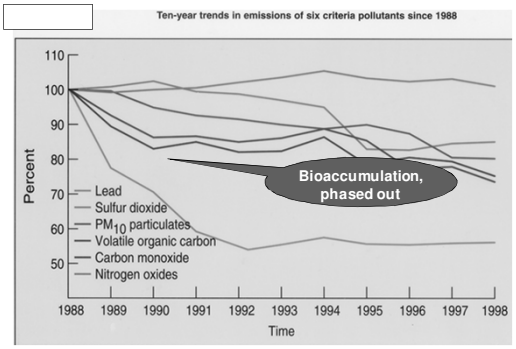


Clean Air Act 1970

Shift in major pollutants 1970 to 1998

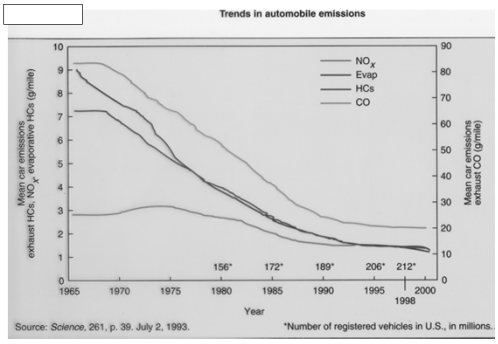


10 Year Trends in Air Pollution



Why has the level of lead decreased?

Trends in Automobile Emissions



Is this the influence of the catalytic converter?!!