Day 1
Certificate Program in Air Quality Management

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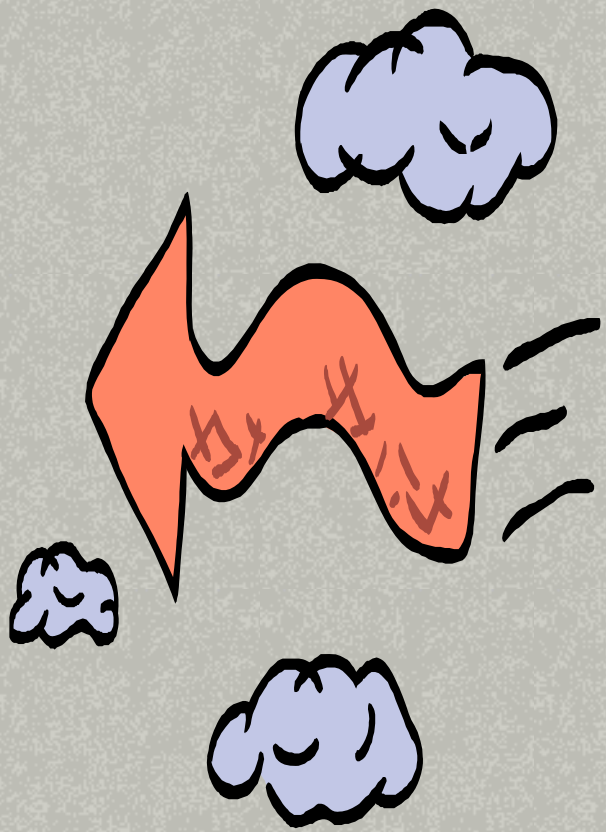
Outline: Air Quality Basics

- What is air?
- What is air pollution?
- Why do people pollute?
- How is pollution controlled?
- Factors affecting air pollution
- Health Effects (CalEPA video)
- Homework

What is air?

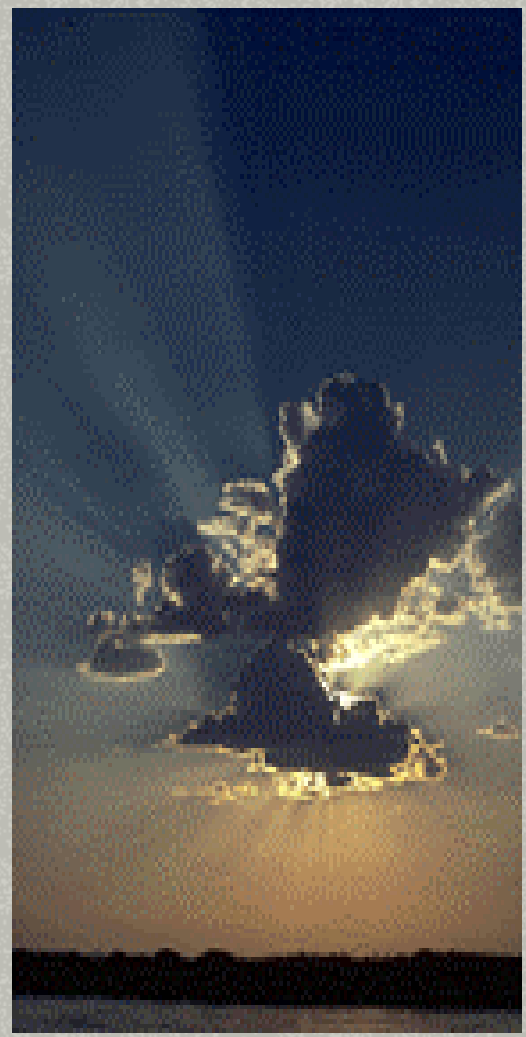


- Air is a mixture of gases, particles and droplets; “pure” air?
- Earth’s atmosphere consists of 78% nitrogen, 21% oxygen, 1% misc. (Ar)
- Atmosphere is a gaseous envelope held to earth by gravity; physical and chemical characteristics vary with altitude, location, and time of year

What is air? (cont.)

- Relative thickness of Earth's atmosphere comparable to thickness of skin on apple

- Some gases, particles & droplets are necessary for life & others occur at levels harmful to life & materials

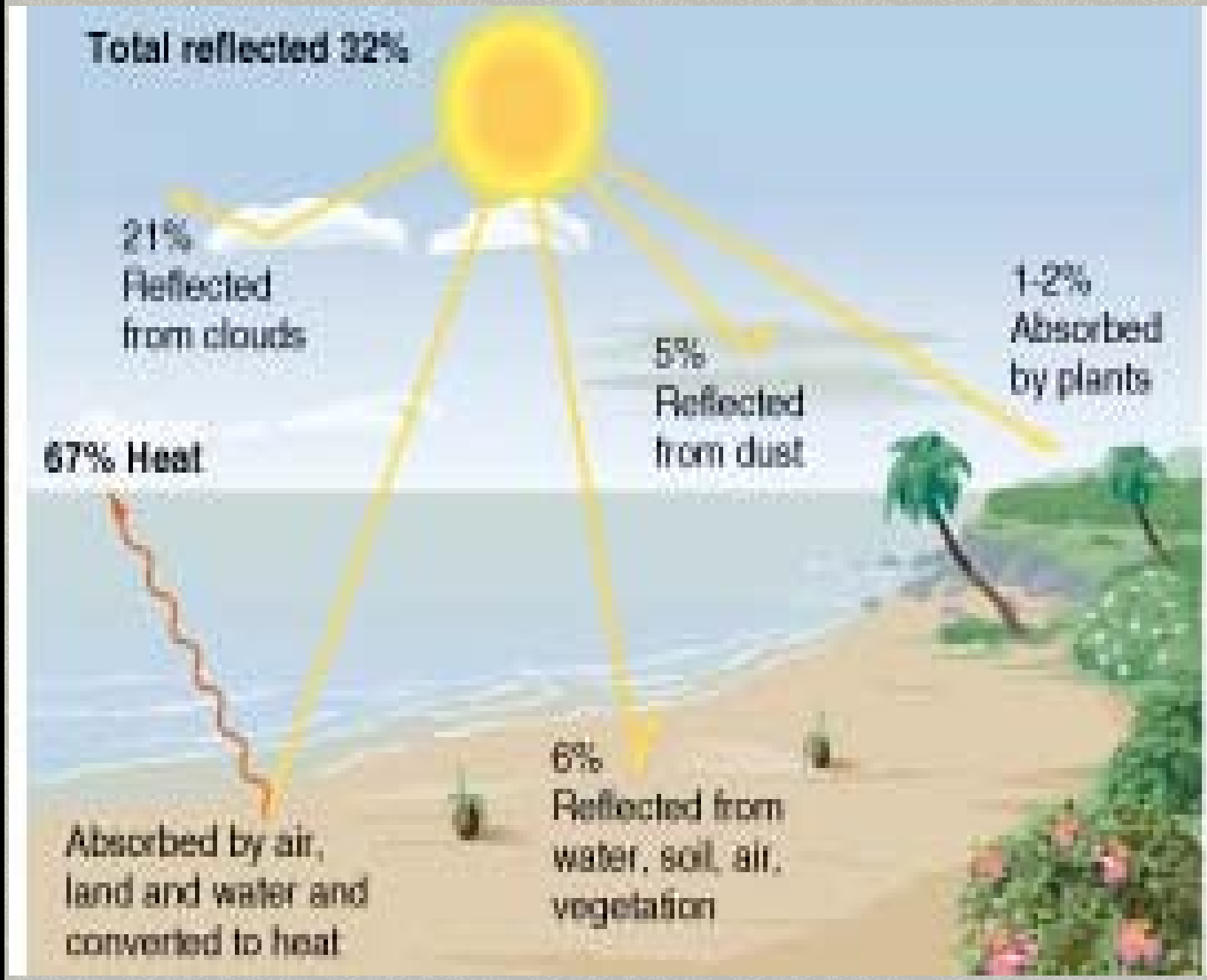


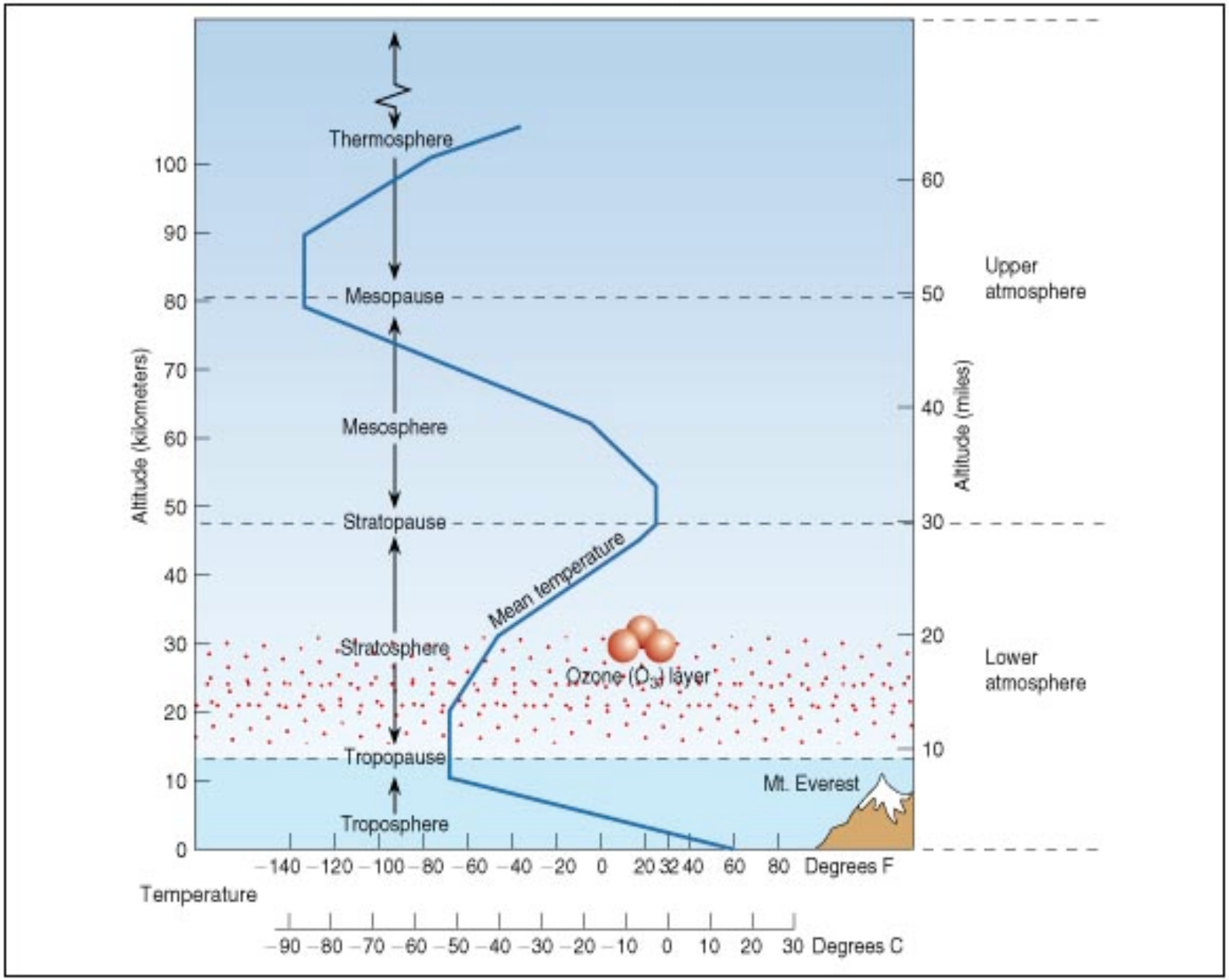
Humans and air

- Tactile: feel wind
- Visual: color of sky
- Smell: odors or aromas
- Hear: wind movement, thunder

Atmosphere

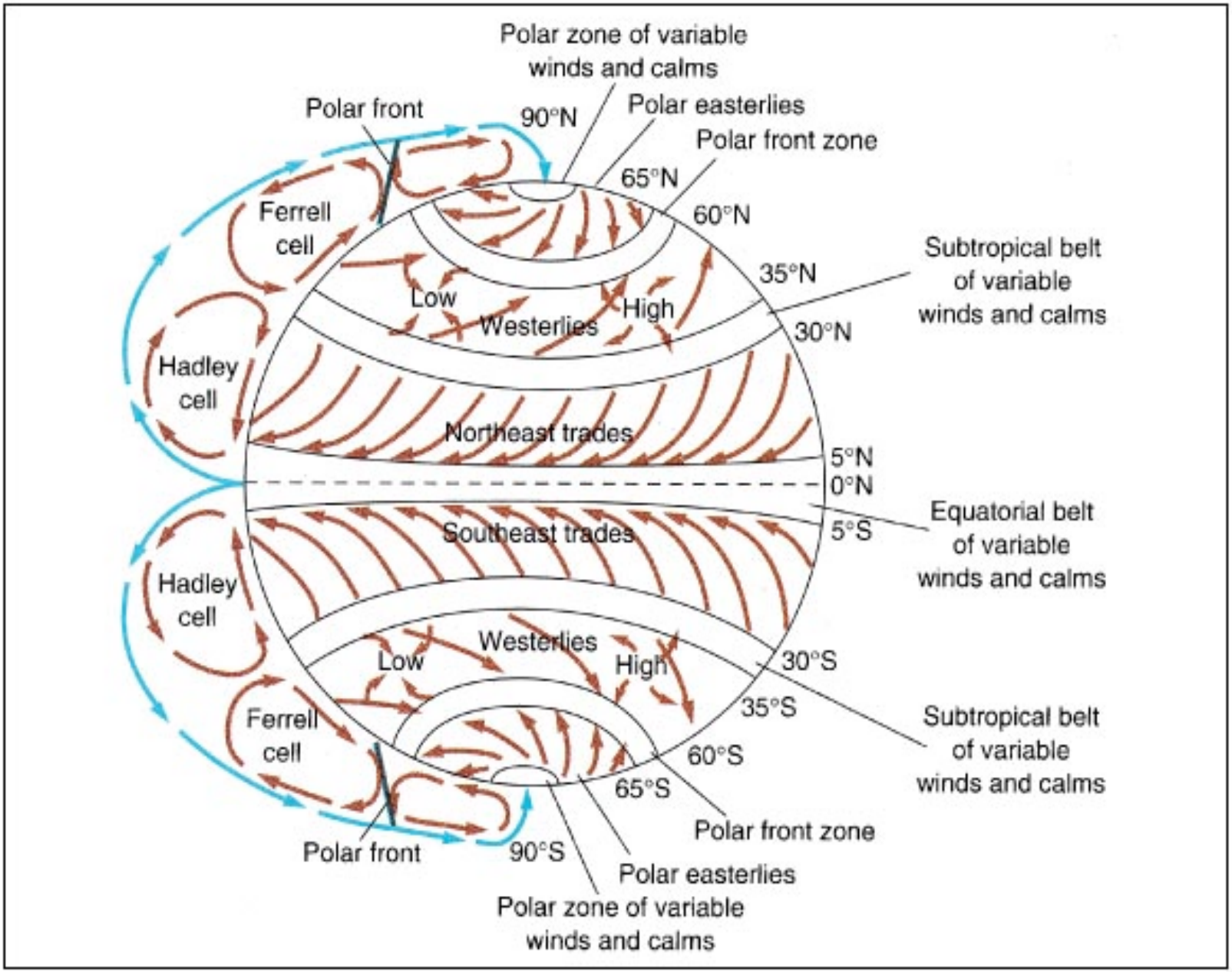
- Divided into layers depending on temp.
- Temperature declines w/ height from Earth's surface up to about tropopause
- Temperature increases w/ height in stratosphere & stratopause


Total reflected 32%
21%
Reflected
from clouds
5%
Reflected
from dust
1-2%
Absorbed
by plants
67% Heat
6%
Reflected from
water, soil, air,
vegetation
Absorbed by air,
land and water and
converted to heat


Thermosphere
Mesopause
Mesosphere
Stratopause
Stratosphere
Tropopause
Troposphere
Mean temperature
Ozone (O_3) layer
Mt. Everest
Altitude (kilometers)
Altitude (miles)
Upper atmosphere
Lower atmosphere
100
90
80
70
60
50
40
30
20
10
0
60
50
40
30
20
10
−140 −120 −100 −80 −60 −40 −20 0 20 32 40 60 80 Degrees F
Temperature
−90 −80 −70 −60 −50 −40 −30 −20 −10 0 10 20 30 Degrees C

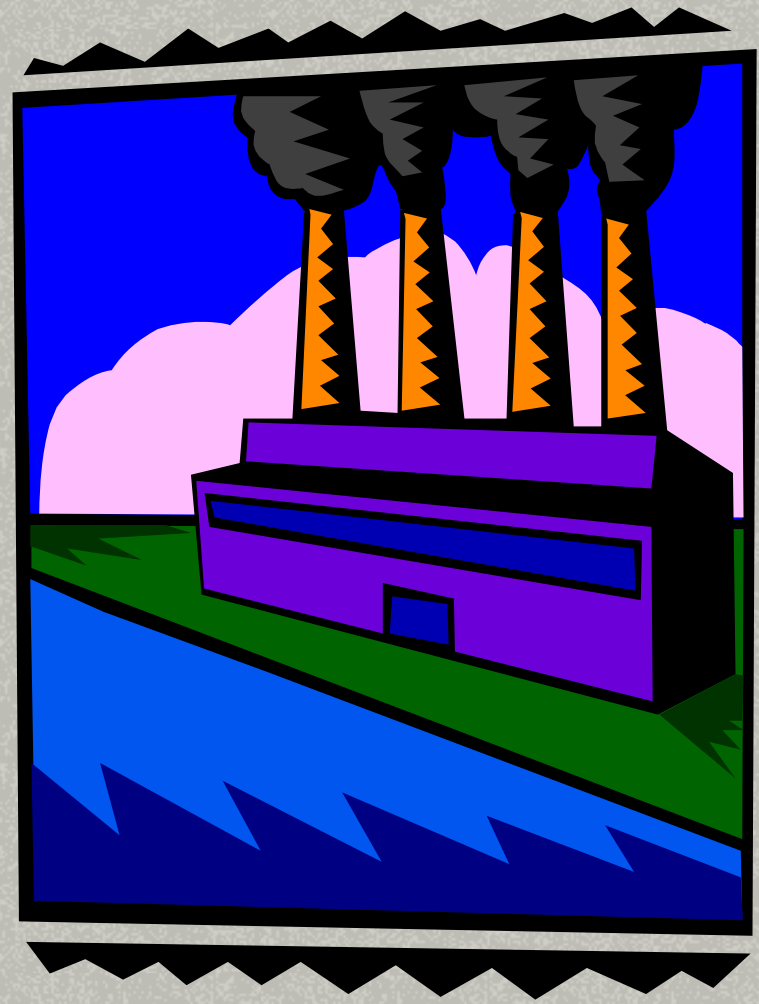
Atmospheric cycles

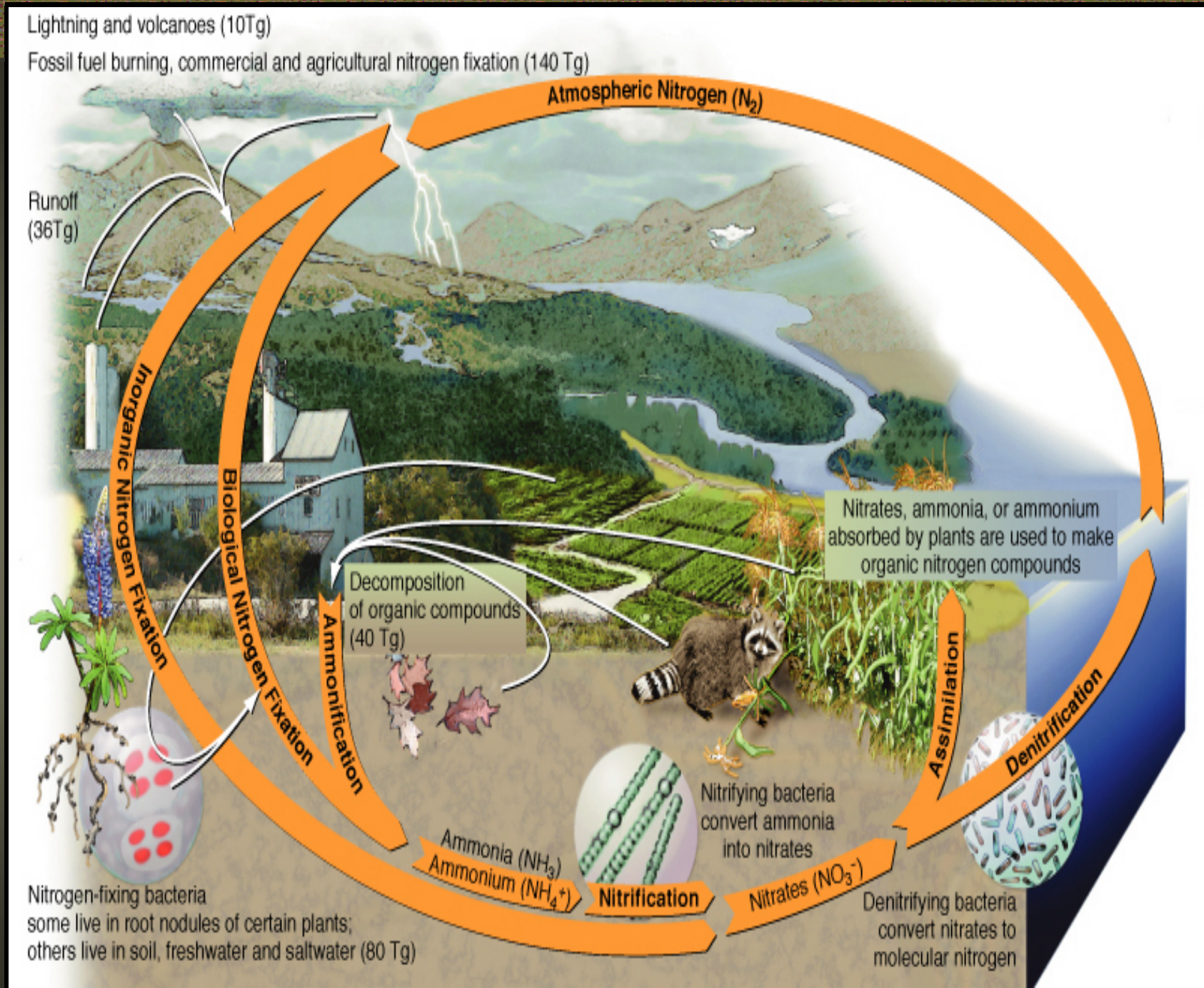
- Sun falls directly on equator, making it hotter
- Hot air rises & carries water vapor
- Cooler, dryer air flows in to fill void
- Rising air cools and loses ability to hold water; some sinks near 25-35^{o} N & S latitude, rest goes to poles


Polar zone of variable winds and calms
Polar front
90°N
Polar easterlies
Polar front zone
65°N
60°N
Ferrell cell
35°N
Subtropical belt of variable winds and calms
Low
Westerlies
High
30°N
Hadley cell
Northeast trades
5°N
0°N
Equatorial belt of variable winds and calms
Southeast trades
5°S
Hadley cell
Westerlies
Low
High
30°S
35°S
Ferrell cell
Subtropical belt of variable winds and calms
60°S
65°S
Polar front zone
Polar front
90°S
Polar easterlies
Polar zone of variable winds and calms

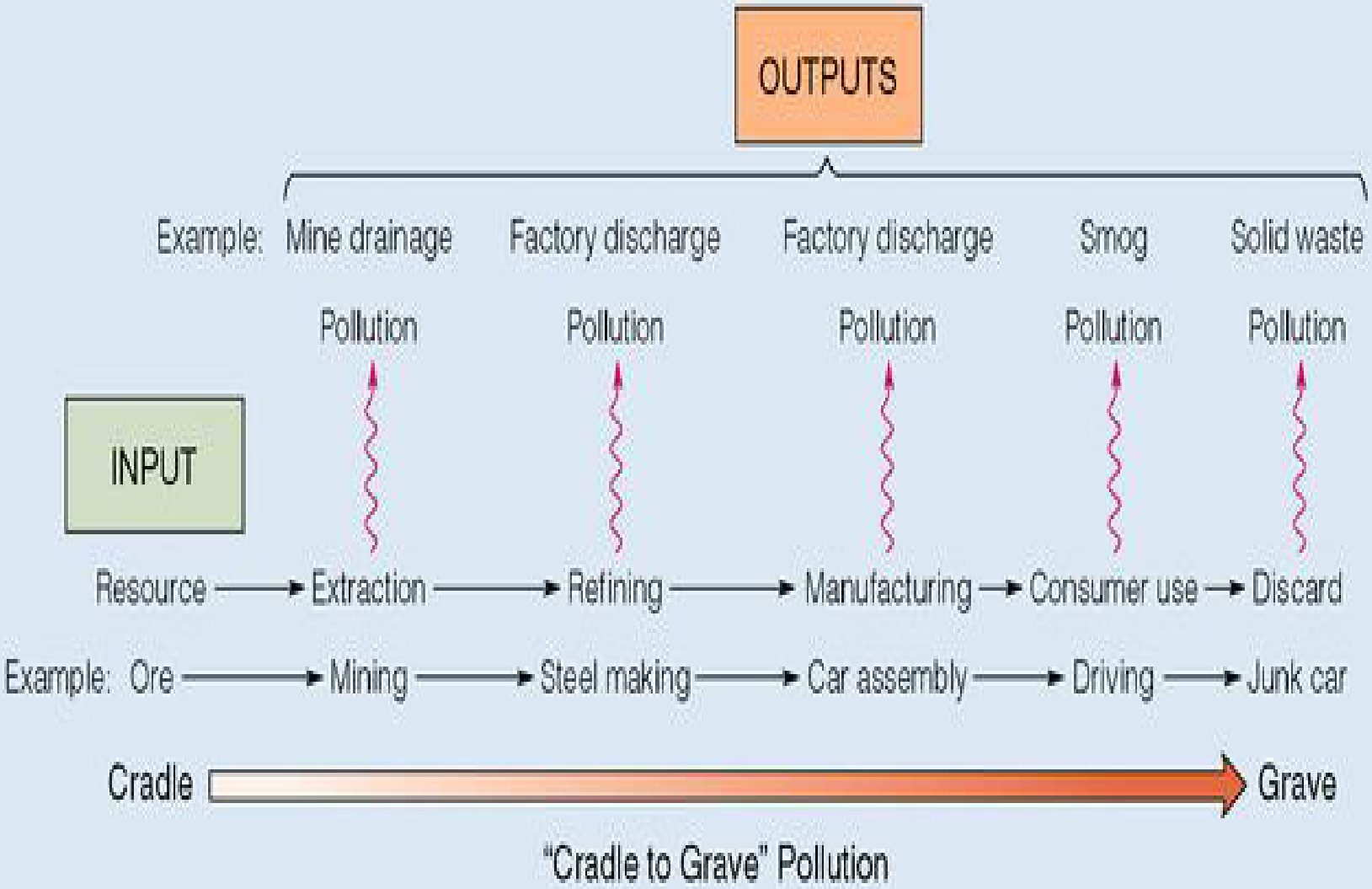
What is pollution?

- Matter or energy released by society into the environment at quantities damaging to life or property
- Local concentrations in the matter cycle or energy flow (e.g., heat, light, or chemicals)
- Accelerated natural process
  - Waste quantity
  - Waste quality (chemical & physical qualities)




Lightning and volcanoes (10Tg)
Fossil fuel burning, commercial and agricultural nitrogen fixation (140 Tg)
Atmospheric Nitrogen (N_2)
Runoff (36Tg)
Inorganic Nitrogen Fixation
Biological Nitrogen Fixation
Ammonification
Decomposition of organic compounds (40 Tg)
Nitrates, ammonia, or ammonium absorbed by plants are used to make organic nitrogen compounds
Assimilation
Denitrification
Nitrifying bacteria convert ammonia into nitrates
Ammonia (NH_3)
Ammonium (NH_4^+)
Nitrification
Nitrates (NO_3^-)
Nitrogen-fixing bacteria
some live in root nodules of certain plants;
others live in soil, freshwater and saltwater (80 Tg)
Denitrifying bacteria convert nitrates to molecular nitrogen

The many steps of pollution



Why pollute and deplete?

- “Tragedy of the Commons”—Hardin (1968)
- Commonly-held resources depleted through consumption
- Commonly-held sinks overwhelmed (carrying capacity)

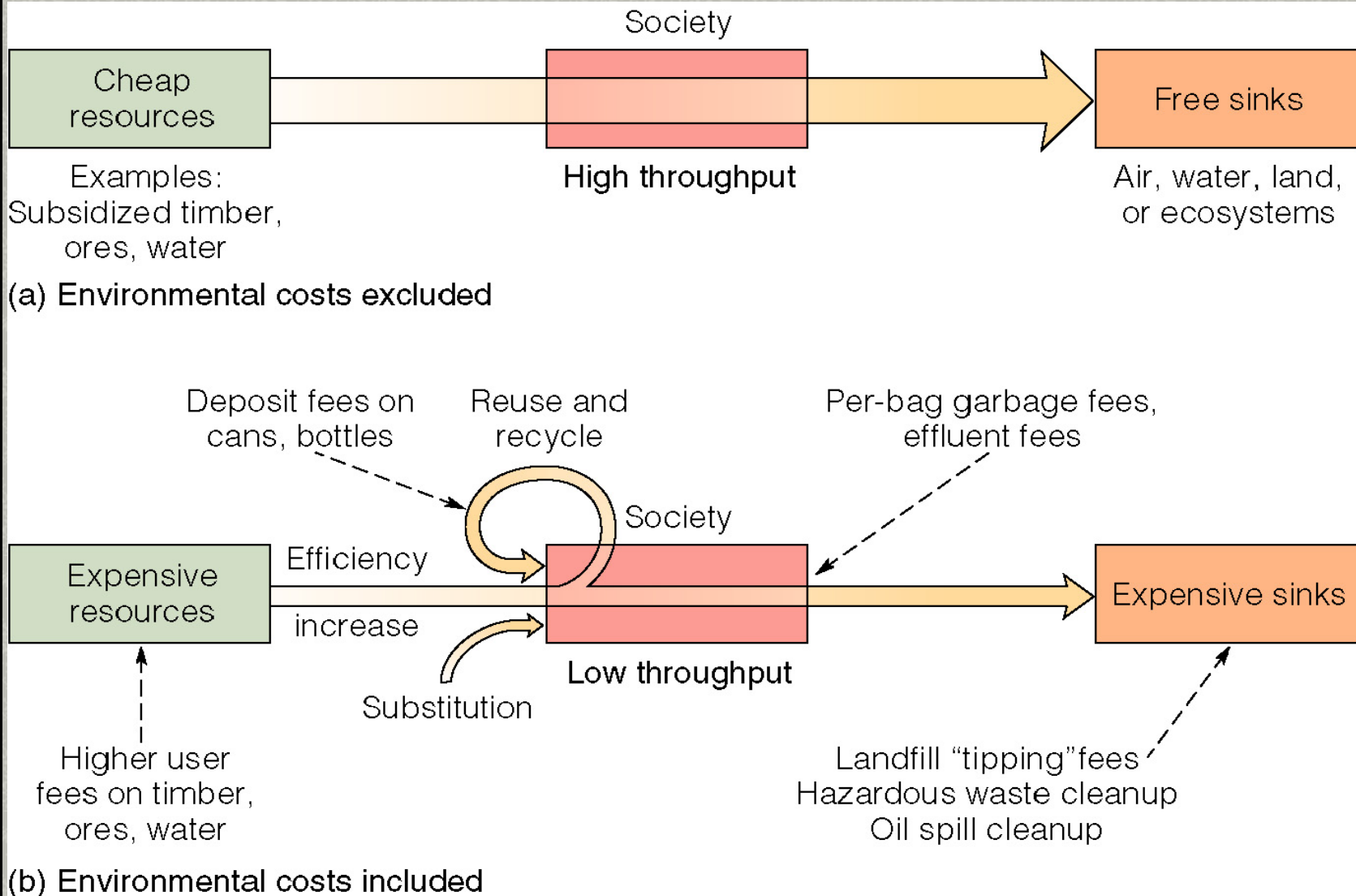
Reasons we pollute (cont.)

- Herdsman who overgrazes derives the most benefit from the resource
- Each animal added by herdsman benefits owner, but community bears the cost
- Commons rewards behavior that leads to deterioration
- Correct by having all pay true costs

Externalities: market failure

- Externalities: some costs are external to price of the product
- Society as a whole bears cost that should be paid by producer & consumer of product
- Example: Costs of damage from motor vehicle air pollution not paid by car driver
- “Leaks” in market—all costs not captured

Feedback loops reflect cost

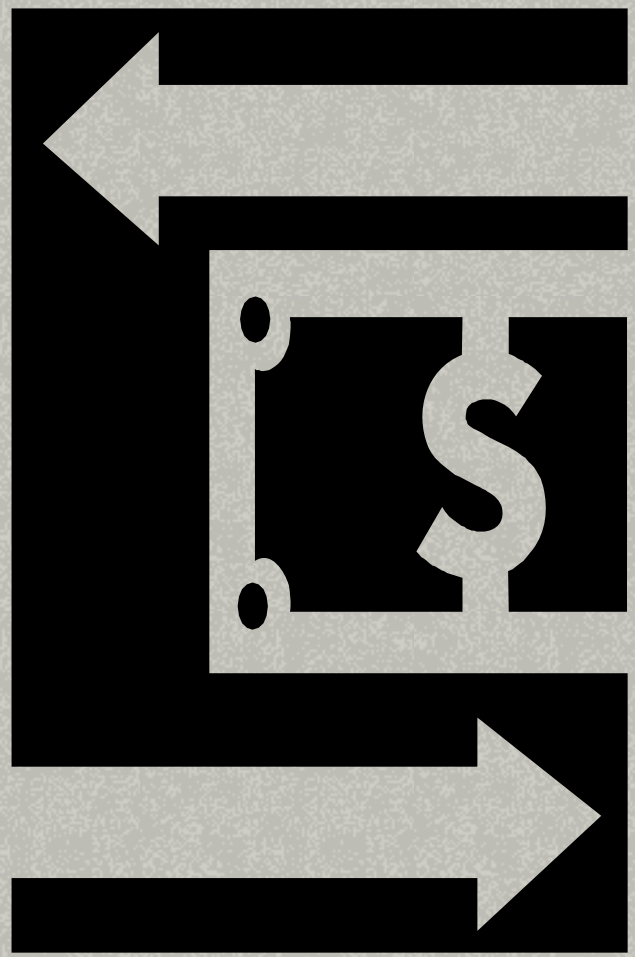


Approaching pollution control

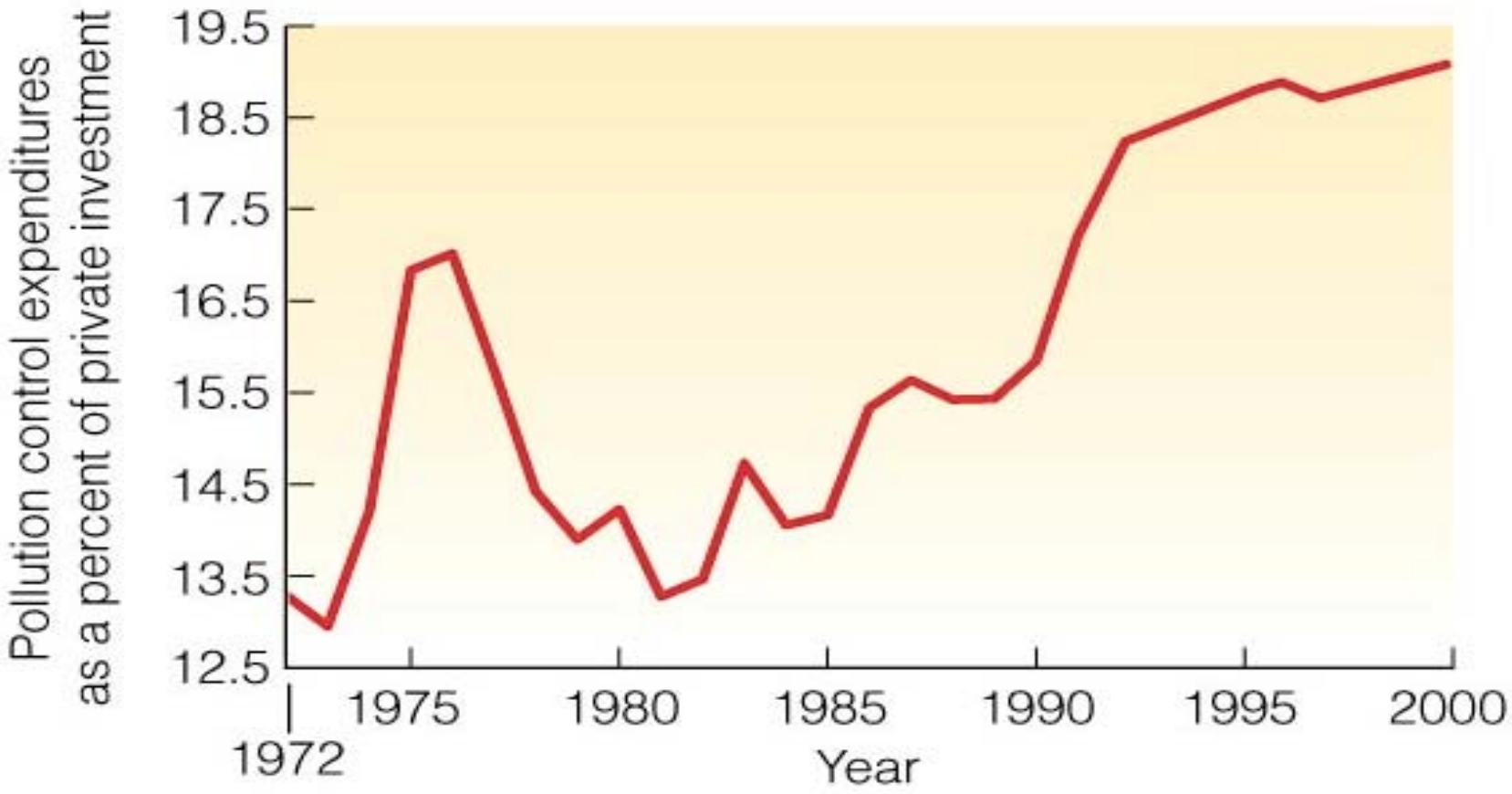
- Rights-based control: all individuals have right to be exposed to least possible pollution
- Technology-based control: reduce pollution as much as technology allows
- These methods can result in overprotection at unnecessarily high costs

Cost-benefit approach

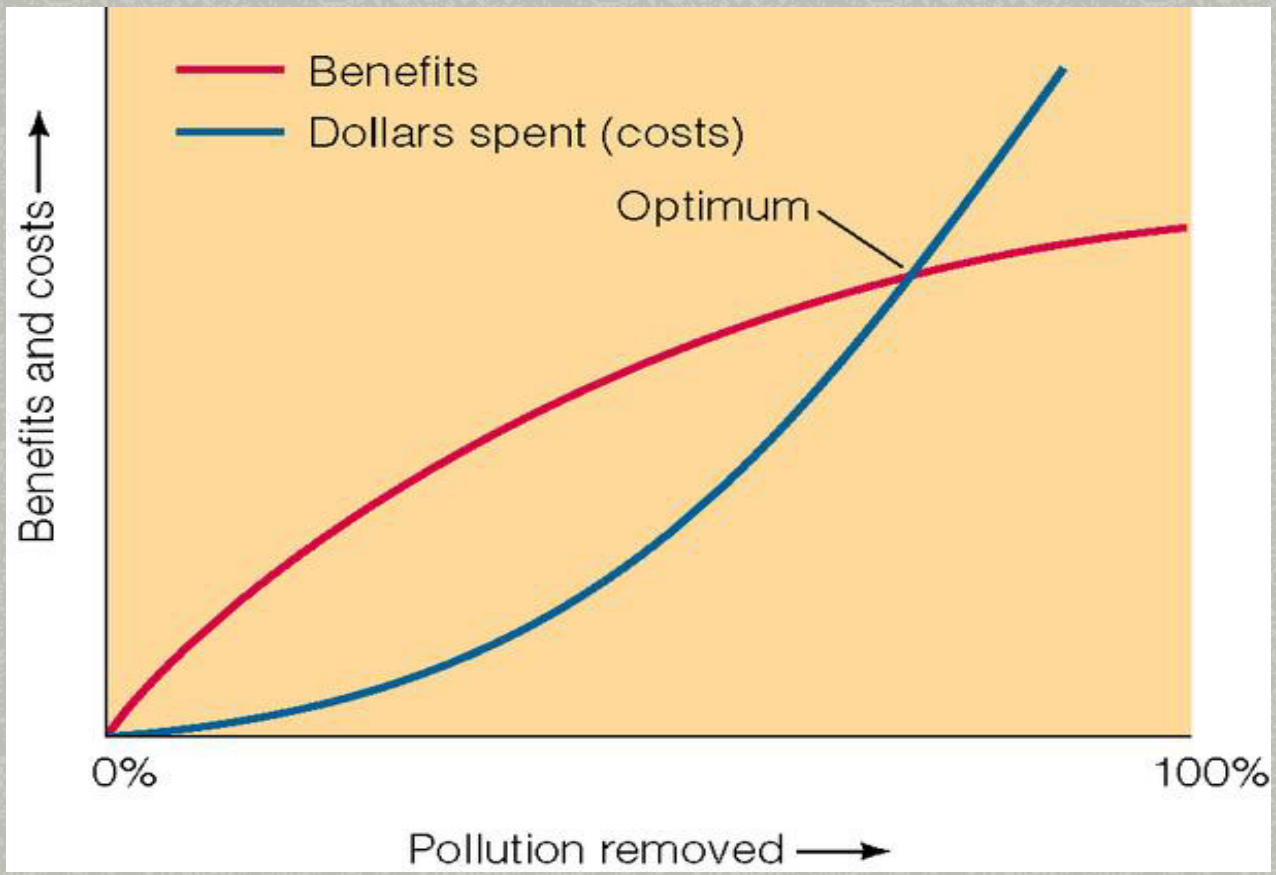
- Find greatest benefit @ least cost
- Driven by rising costs of pollution control
- Initial reduction in pollution is cheap, but costs rise steeply after certain point
- Need accurate estimates of benefits & costs



Trends in pollution control cost



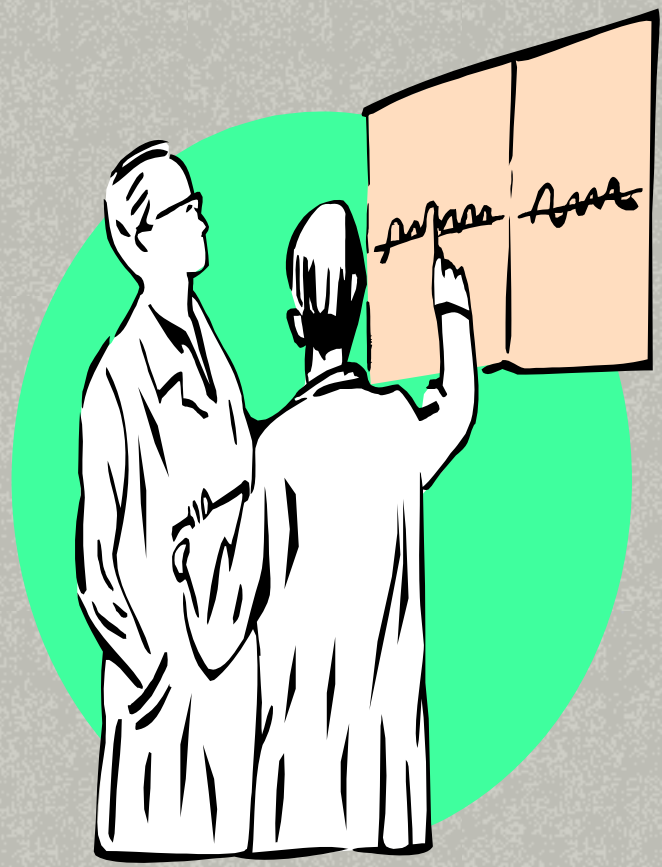
Generic benefit/cost curve



Benefit/cost analysis seeks optimum

Input vs. output controls

- Input reduction is best way to reduce pollution—waste prevention
- Output management addresses flow of matter & energy after they are waste
  - Control equipment/waste disposal
  - Remediation
  - Restoration
- Pollution management has historically emphasized output management



Pollution control

- Control involves collecting emissions & effluents (e.g., ash, sulfur dioxide, etc.) and then disposing of waste
- Expensive because you've paid to make the waste & now must pay for disposal
- More cost effective to not generate in first place
- Peter Coors/Henry Ford

The business of pollution

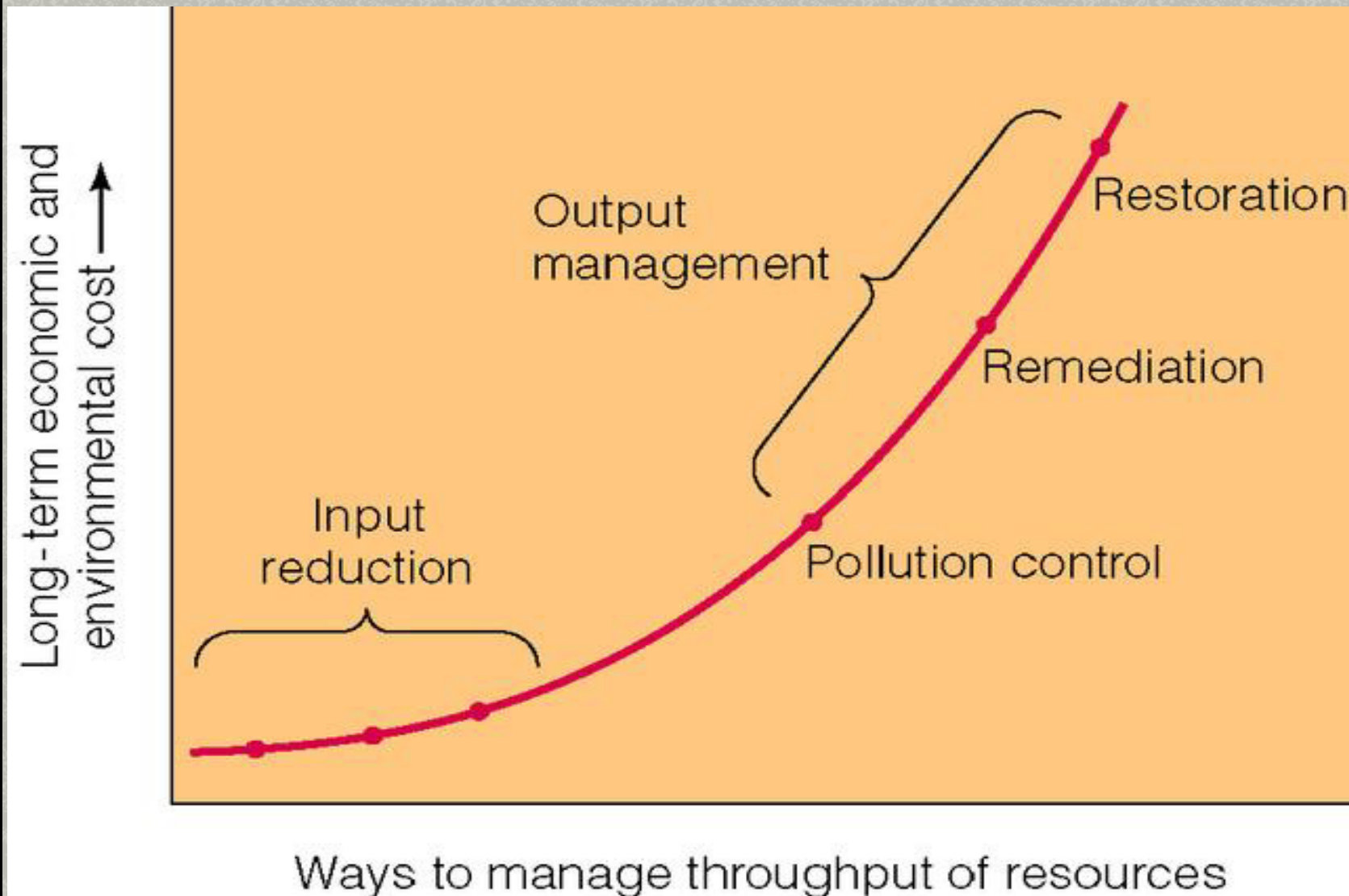
"Find pollution or waste and you've found something you paid for but can't sell."

Peter Coors, CEO, Coors Brewing Company

"Waste is not something which comes after the fact…Picking up and reclaiming the scrap left over after production is a public service, but planning so that there will be no scrap is a higher public service."

Henry Ford, Ford Motor Company, 1926

Input reduction vs. controls



Implementing pollution control

- Persuasion: ask people to change behavior that causes pollution; effective if accompanied by education; less expensive
- Regulation: pass & enforce laws that allow less pollution; involves inspections, data collection, record keeping, litigation
- Incentive: provide economic or other rewards for behavior that reduces pollution

Implementing pollution controls is often difficult because it entails a change in behavior

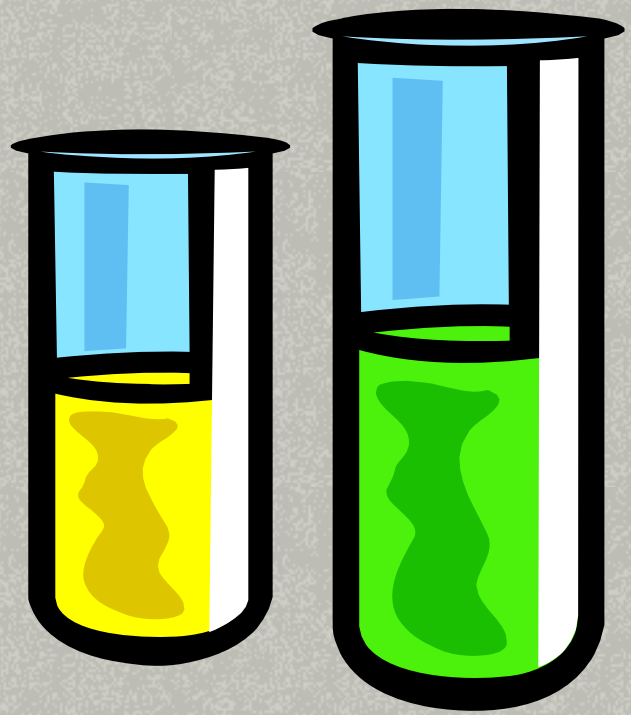
Air pollution control/air quality management

- Managing the atmospheric levels of trace chemicals identified as being harmful to human health, living things, property; safe levels set by standards
- Done by limiting the release of chemicals into the atmosphere
- Other approaches also used
  - Reducing temperature by tree planting
  - Limiting exposure during events

Air quality management

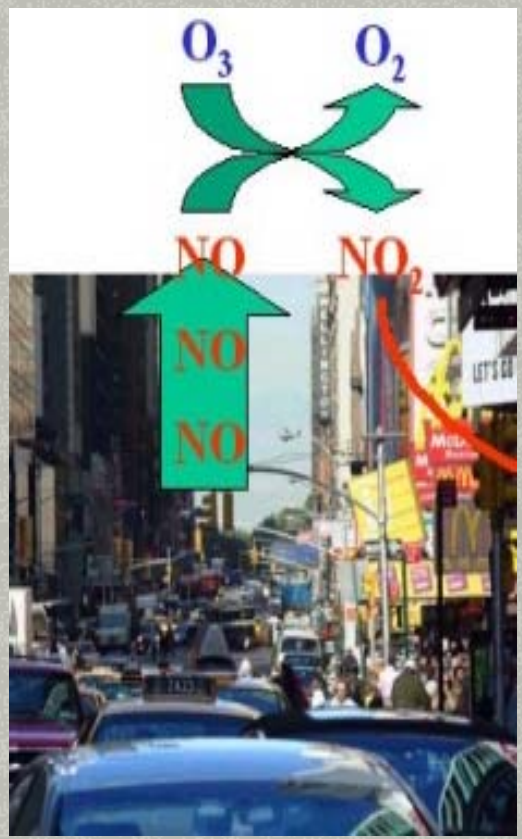
- Managing a large scale chemical reaction (2^o pollutants)
- Nature controls temperature, wind & other important factors
- Need to account for natural processes and meet standards

Chemicals in the air



- Criteria air pollutants: ozone and particulate matter are of interest for San Joaquin Valley
- Hazardous air pollutants
  - Toxic
  - Metabolic toxic
- Greenhouse gases

Fate of chemicals in the air



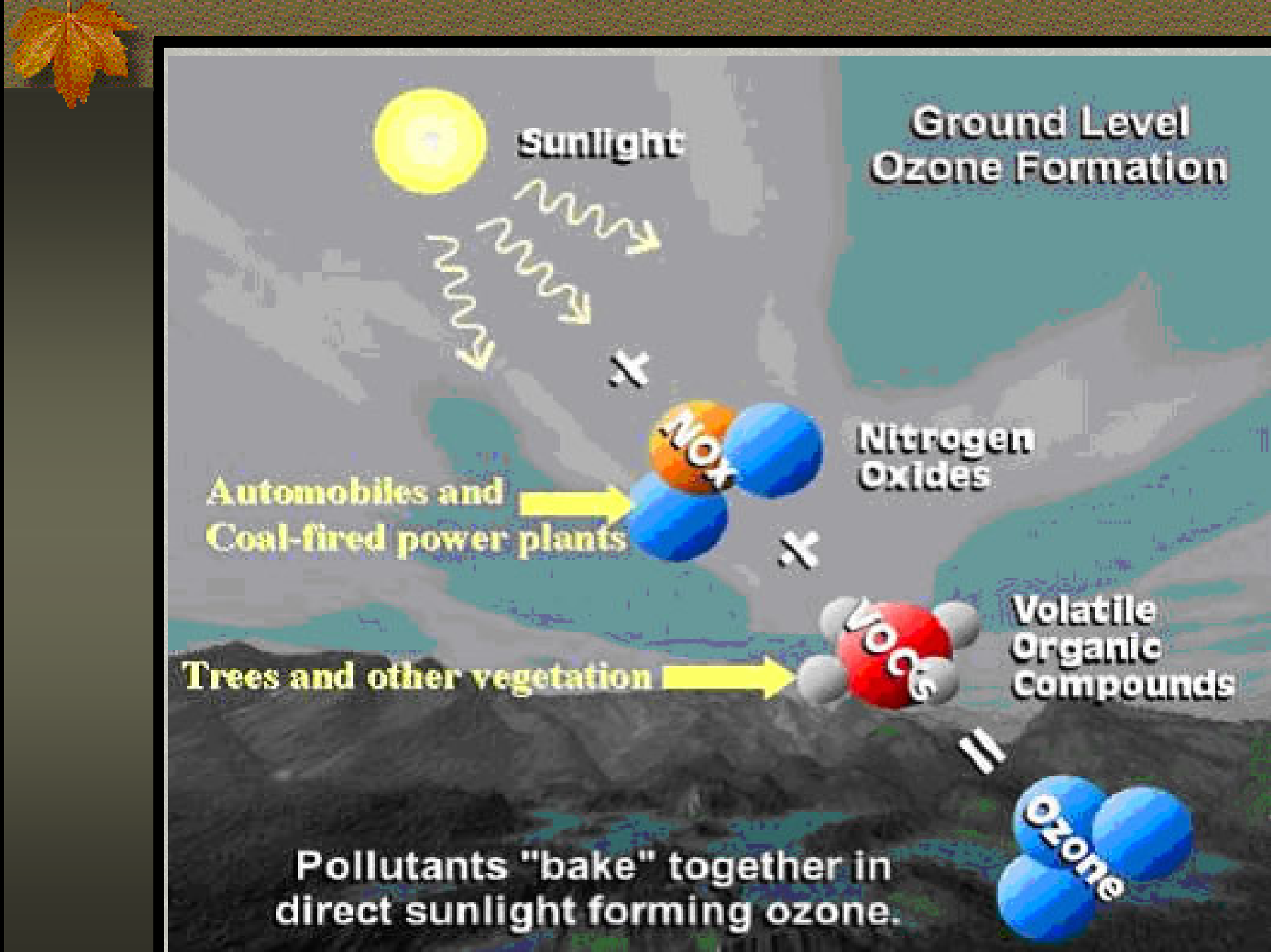
- Dilution: pollutant concentration becomes lower due to air mixing
- Chemical reaction:
  - More harmful
  - Less harmful
- Physical changes

Two types of pollutants

- Primary pollutants are emitted directly to the atmosphere and are measured in the atmosphere
  - Particulate matter
  - Carbon monoxide
  - NOx and SOx
- Secondary pollutants are formed in the atmosphere from chemical reactions among pollutants directly emitted
  - Ozone (NOx and VOC react)
  - Particulate matter (e.g., NOx & NH_3 react)

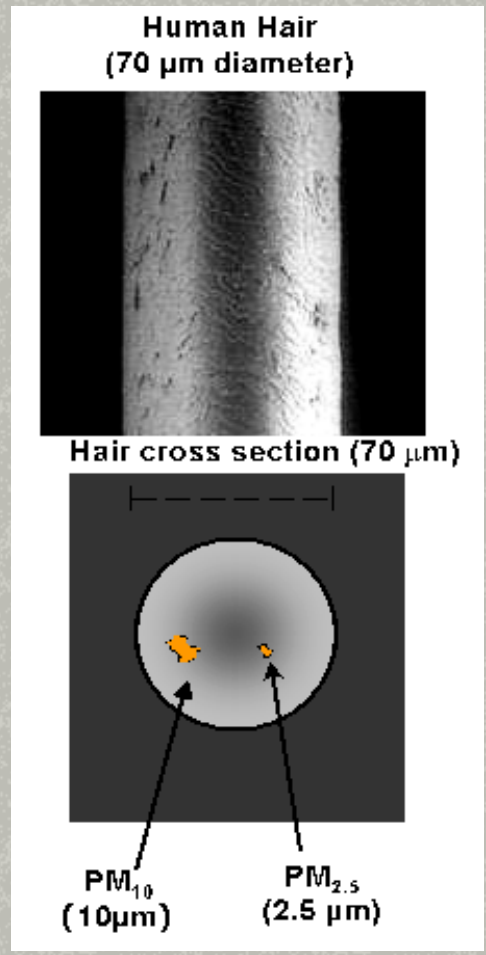
Ozone

- Summertime problem
- Component of “smog”
- Not emitted directly
- Forms when emissions from human activities react in sunlight
- 1-hour and 8-hour averages

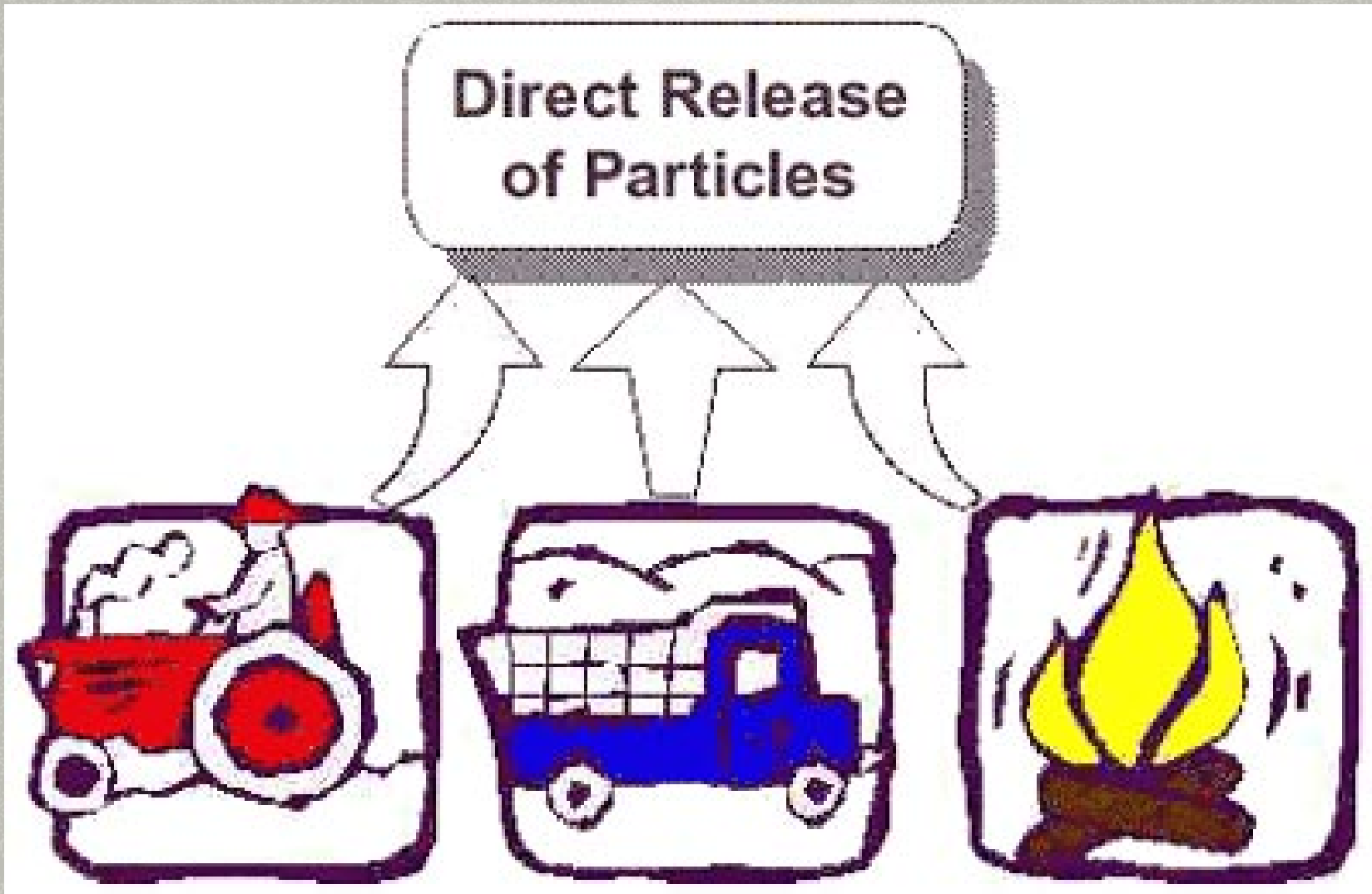

Ground Level
Ozone Formation
Sunlight
NOx
Nitrogen
Oxides
Automobiles and
Coal-fired power plants
VOCs
Volatile
Organic
Compounds
Trees and other vegetation
ozone
Pollutants "bake" together in
direct sunlight forming ozone.

Particulate Matter (PM)

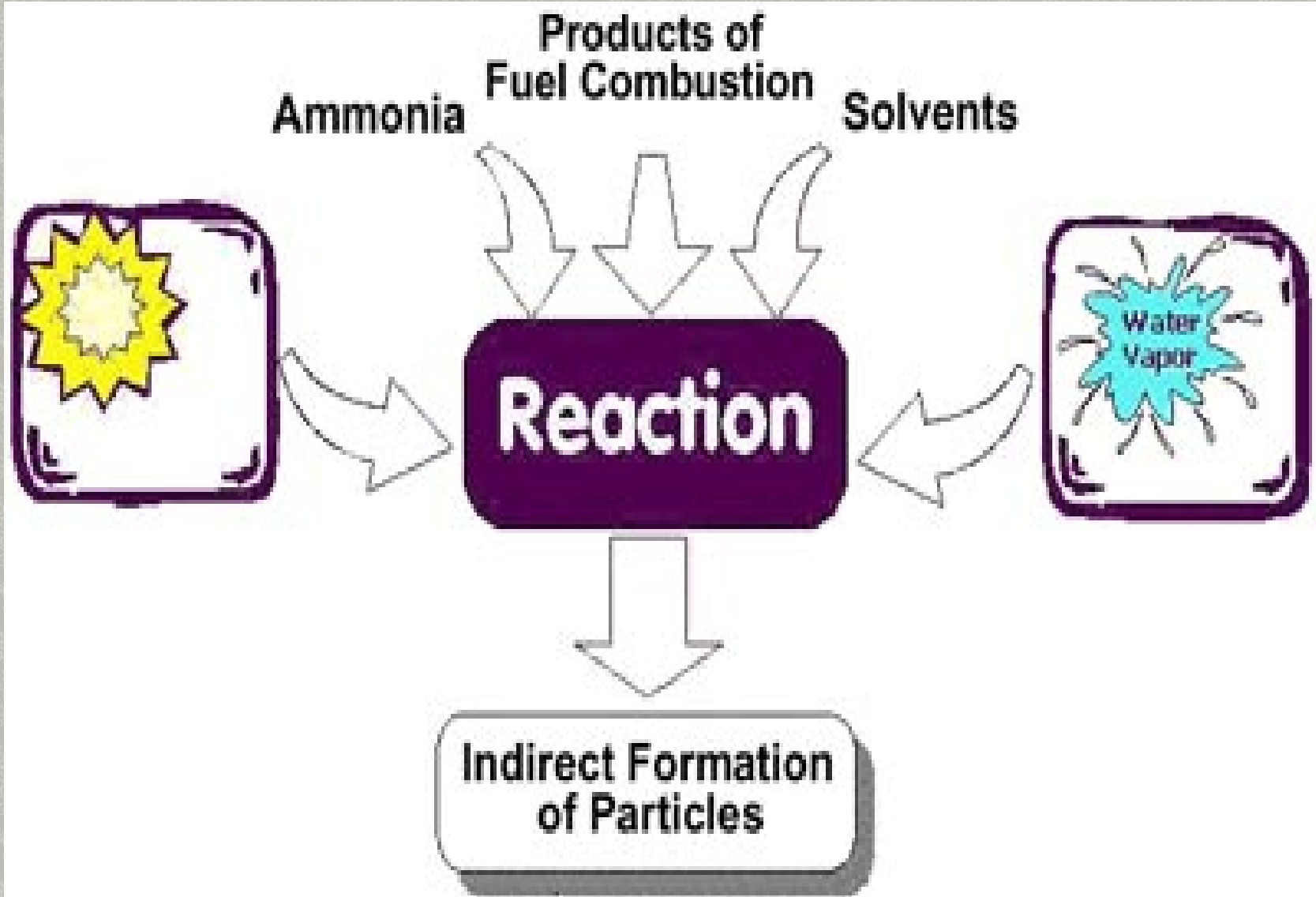
- Wintertime problem
- May be emitted as dust and soot
- May form in the atmosphere from other compounds
- PM10 and PM2.5



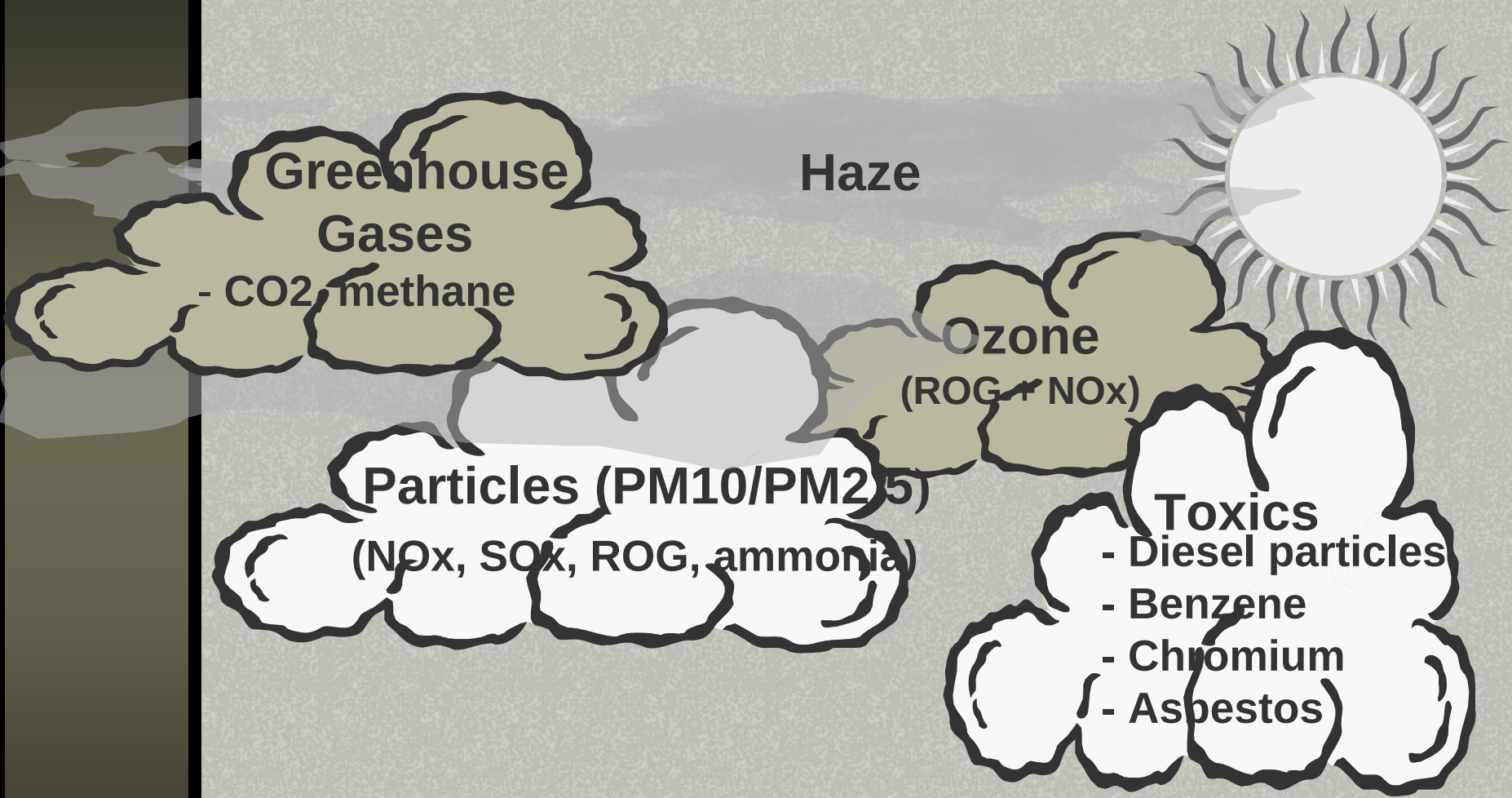
Directly emitted PM10



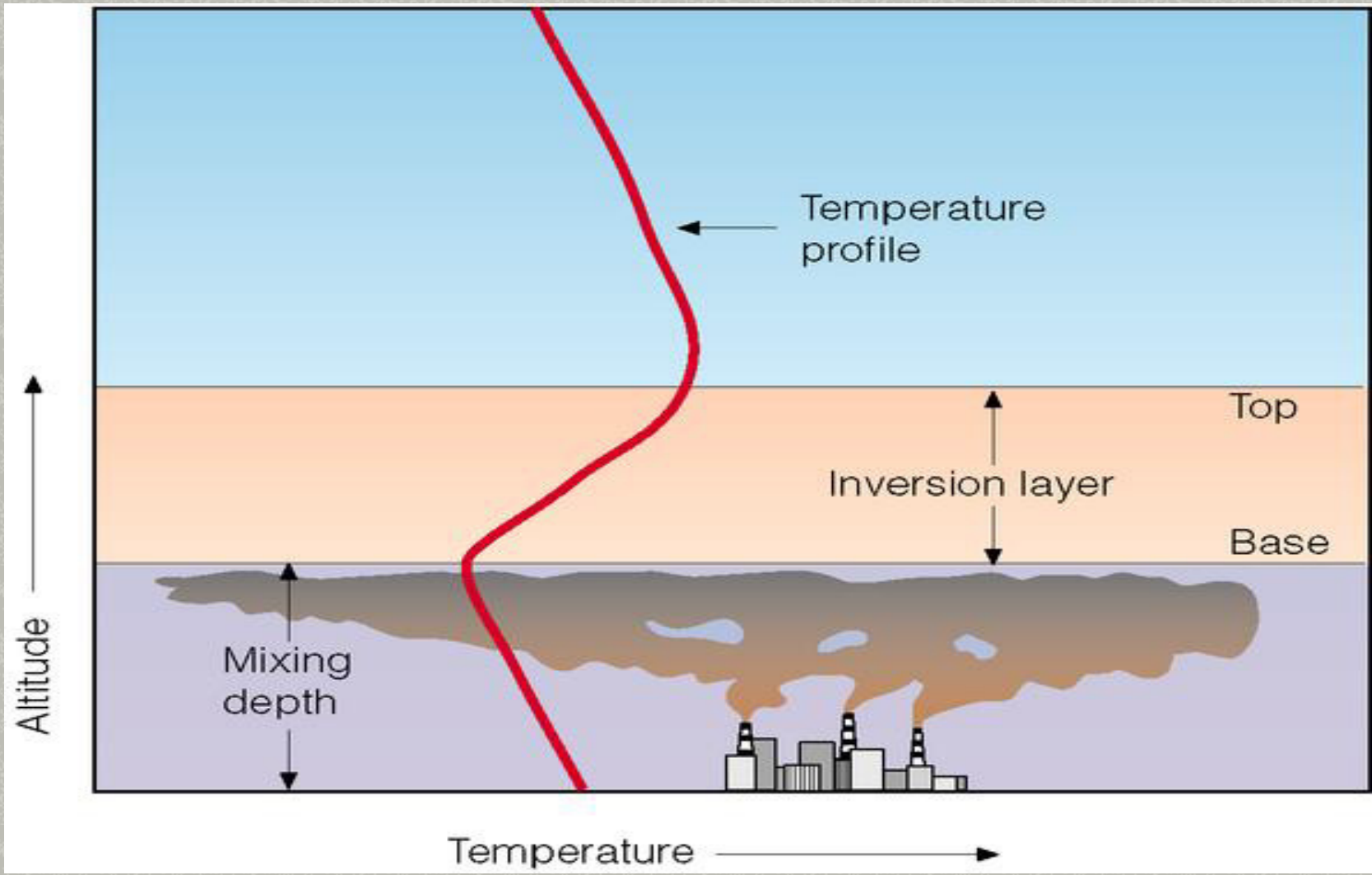
Secondary PM



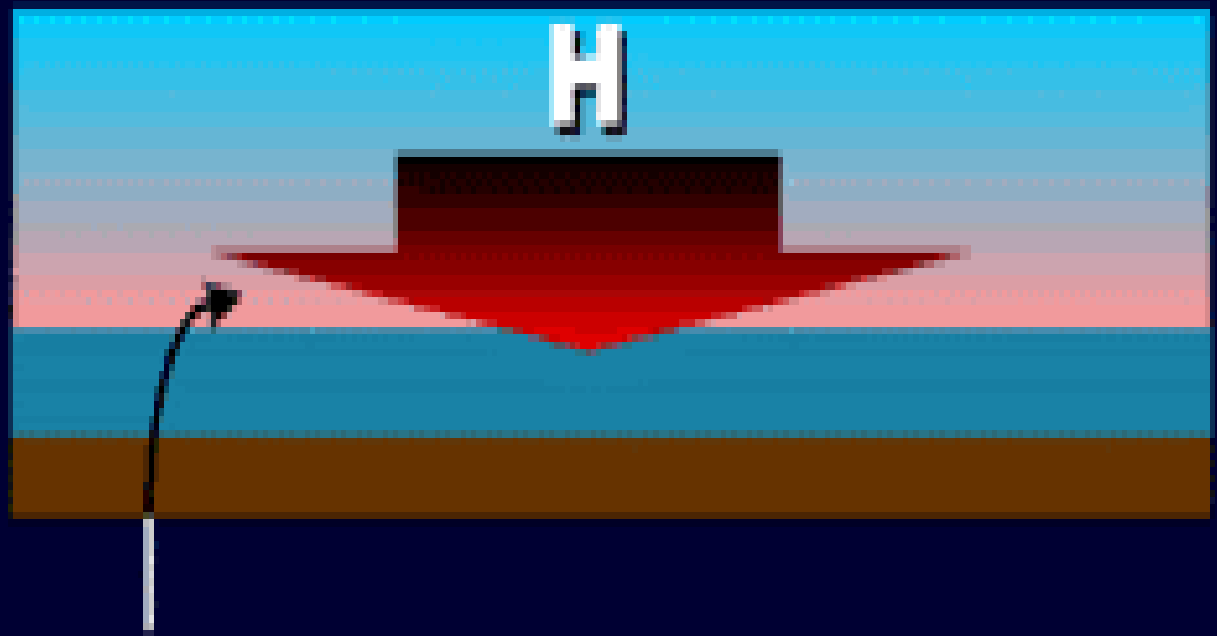
One atmosphere



Temperature inversion

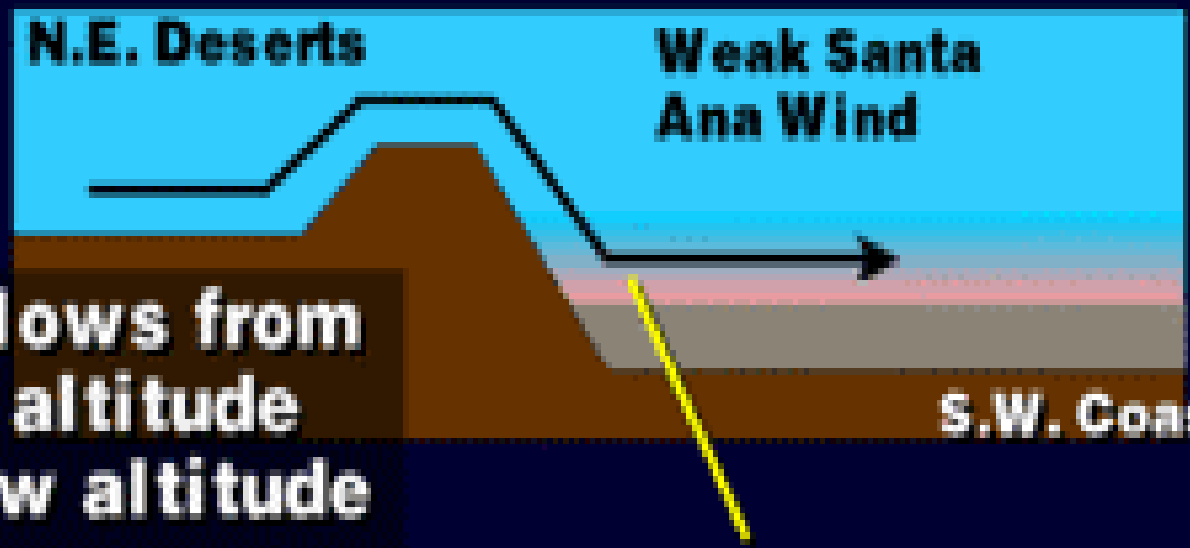


Large-Scale Subsidence Inversion



Air aloft sinks (subsides) and warms from adiabatic compression

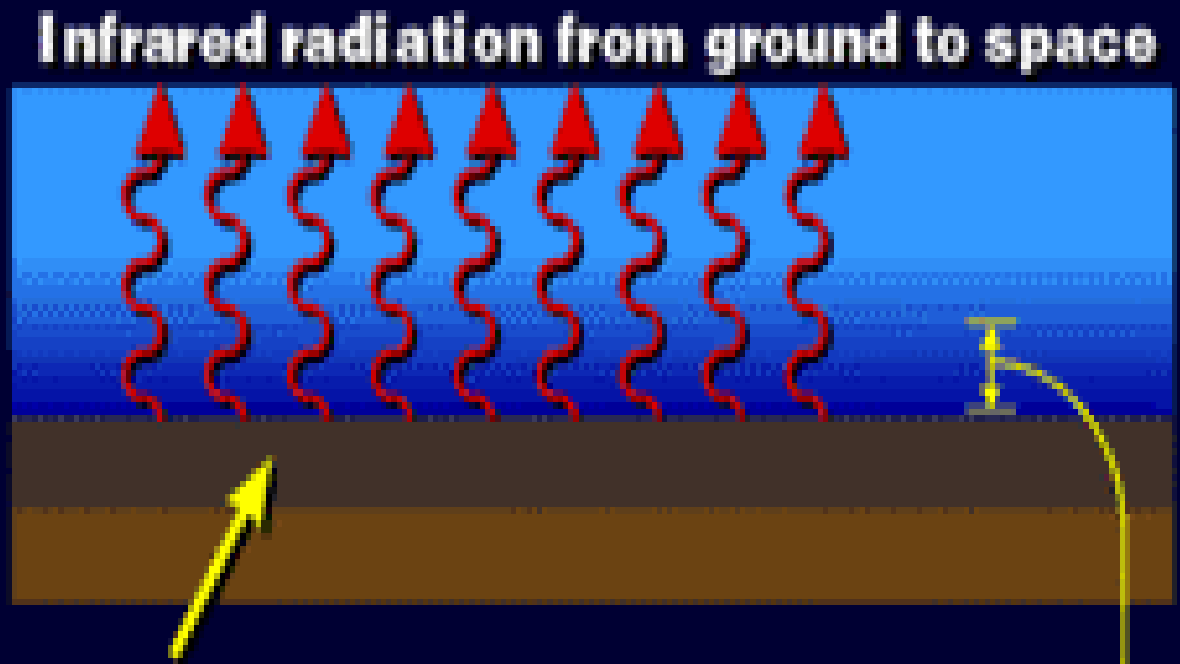
Regional Subsidence Inversion



Air flows from high altitude to low altitude

Air compresses adiabatically while descending

Radiation Inversion



Importance of topography

"Bummer of a birthmark, Hal."

Air Quality Management: A Team "Sport"

- Planning: charts the way, evaluates progress
- Rules, incentives, public education: reduce emissions
- Compliance and permits: carry out the rules and regulations

Homework

- Review the automotive section of any Valley newspaper in next two weeks and record any examples of consumer information on air pollutant emissions from various makes & models of vehicles
- Bring examples to next class for discussion