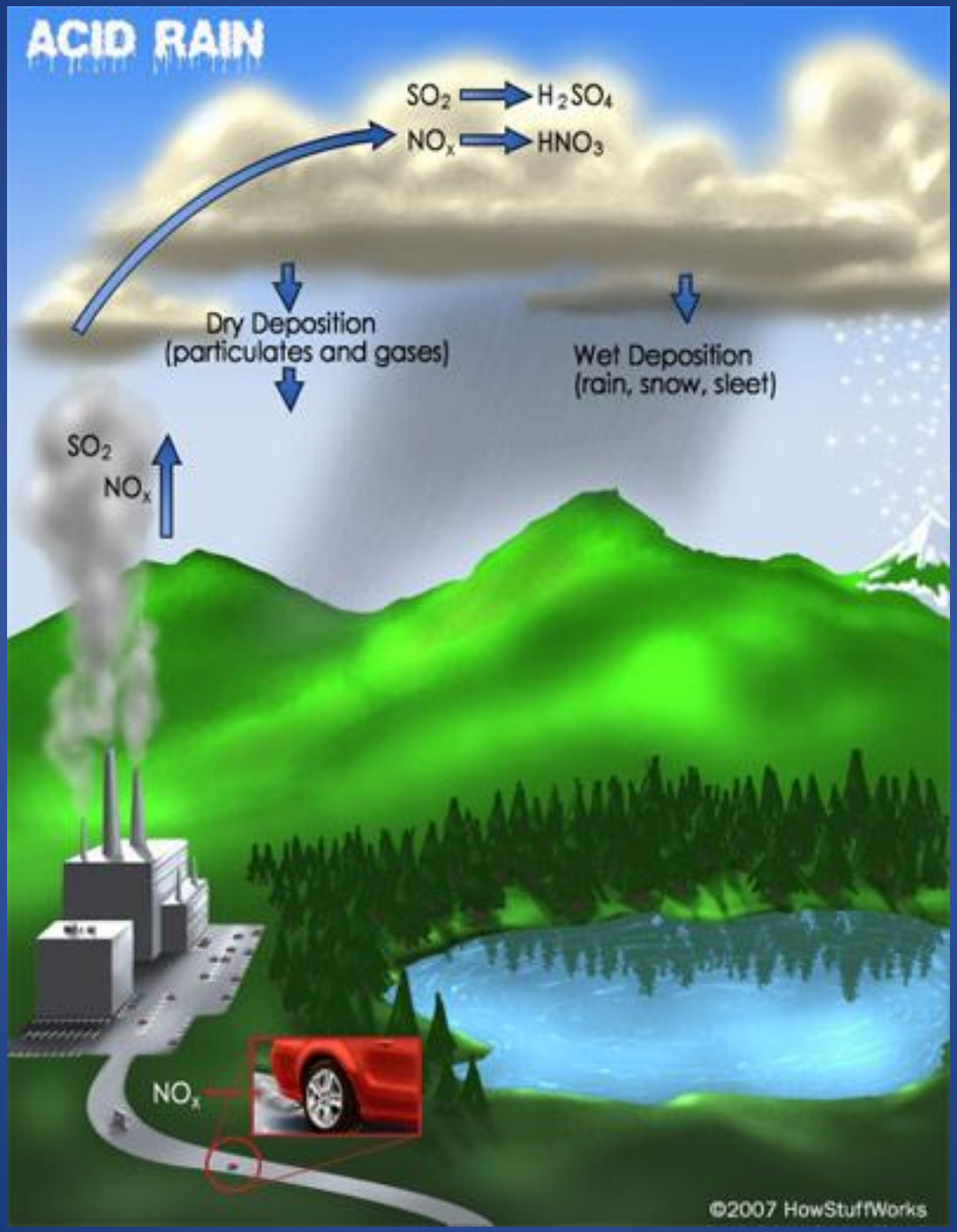
Acid Rain

Acid Deposition

- Acid Rain refers to the deposition of acidic components in either wet or dry forms
- Defined by the pH of the liquid. Less than 7 pH is acidic, more than 7 is basic
- Natural acid rain can be caused by volcanic emissions and biological processes
- “Clean” rain has a natural acidity of about 5.2 on the pH scale due to water reacting with carbon dioxide in the air to form carbonic acid


ACID RAIN
$SO_2 \rightarrow H_2SO_4$
$NO_x \rightarrow HNO_3$
Dry Deposition
(particulates and gases)
Wet Deposition
(rain, snow, sleet)
SO_2
NO_x
NO_x
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Human Attribution

- Human emissions of sulfur dioxide and nitrogen oxides contribute to the acidification of rain
- Emissions began during the industrial revolution, remaining unchecked until the 1970s
- Biggest contributor is the burning of coal

The Coal Power Plant Problem

- Burning coal is extremely cheap and efficient but dirty, releasing sulfur dioxide which becomes sulfuric acid in the atmosphere
- Areas downwind of power plants receive heavy acid rain
- Smoke stacks built to counteract direct deposition of sulfuric acid only spread the problem

Effects of Acid Rain

- Not many things can grow in acidic conditions
- Low pH and high aluminum concentrations can damage or kill fish and aquatic populations
- Soils can be damaged by the hydronium ion, which mobilizes aluminum and encourages leaching of minerals such as magnesium essential for plant life
- Forests suffer from soil damage, however most food crops are unharmed because the nutrients lost are replaced in fertilizer

Other Effects

- Monuments made of Calcium Carbonate (limestone and marble) will react with acid rain to form Gypsum
- Increases the oxidation rate of metals such as copper and bronze

Prevention

- Coal burning power plants use Flue gas desulfurization requiring a reaction tower that extracts the sulfuric acid by reacting it with lime or limestone slurry and removing the product with scrubbers
- Reduction in automotive emissions cuts down on nitrogen oxides
- Emissions trading put into practice to put economic incentive into cleaning industrial activities

Importance of the ozone layer

Near ground level (trochosphere) - pollution

Form photochemical smog and acid rain

In the stratosphere (15 - 50 km) - ozone layer screen out harmful Ultra-violet radiation from the sun.

Formation of ozone layer

Ozone (O_3)

Chemically forms when UV hits on stratosphere

Oxygen molecules dissociate into atomic oxygen

$$O_2 + \text{sunlight} \rightarrow O + O$$

Atomic oxygen quickly combines with other oxygen molecules to form ozone

$$O + O_2 \rightarrow O_3$$

A pollutant on ground level

A component of photochemical smog

Important for our survival

Absorbs some of the potentially harmful UV radiation which can cause skin cancer and damage to vegetation

Split and regenerate repeatedly

Highest concentration in the upper atmosphere

Concentration decreases at lower altitudes

Made up of three oxygen atoms

Occurs naturally as a layer in the stratosphere

The layer is thinnest around the equator and the concentration increases towards the poles

The amount of ozone above a point on the earth's surface is measured in Dobson units (DU)

~ 260 DU near the Tropics

higher elsewhere

What is CFCs?

Chlorofluorocarbons (CFCs)

Composed of elements chlorine, fluorine, and carbon

Developed in 1930 by DuPont

CFCs were welcomed by industries:

Low toxicity

Chemical stability

Cheap

Usage:

As refrigerants,As blowing agents,For making flexible foam,As cleaning agents,As propellants

Destruction of ozone layer

Chlorine atoms from CFCs attack the ozone, taking away ozon and forming chlorine monoxide (ClO).

$$O_3 + Cl \rightarrow O_2 + ClO$$

Chlorine monoxide then combines with

another oxygen atom to form a new oxygen molecule and a chlorine atom.

$$ClO + O \rightarrow Cl + O_2$$

The chlorine atom is free to destroy up to 100,000 ozone molecules

Causes of ozone depletion

Details are not fully understood

Catalyzed by halocarbons (carbon compounds containing fluorine, chlorine, bromine and iodine)

Examples: CFCs and $ClONO_2$

Halogen atoms catalyze ozone layer depletion by destroying ozone molecules and forming oxygen molecules.

Much more serious in Antarctica than other regions on the planet

Consequences of less ozone

Because CFCs has long life span and very stable, it continuous to attack the ozone layer and more UV-B reach our earth.

Health

Sunburn, eye diseases (cataract), skin cancer.

Reduce our immune system → other diseases

Food supply

Reduce photosynthesis - crops affected.

Kills plankton → fish ↓

Impacts on other animals

Reduces plankton population

Reduces penguin population

Reduces the percentage of hatching of frog eggs