Core Case Study: Lake Washington

1. What was being dumped into Lake Washington by the mid-1950s? *wastewater*
2. What did the growth of cyanobacteria do to the lake?
   The cyanobacteria grew quickly and darkened the water due to the high phosphorus levels from the wastewater. This eventually led to the decrease of fish populations.

3. What was done to help rectify the situation?
   The wastewater effluent was diverted to the Puget Sound so that the tides could mix and dilute it with ocean water

What are the Causes & Effects of Water Pollution

Define water pollution: *any chemical, biological, or physical change in water quality that harms living organisms or makes water unusable for desired uses.*

Point Source	WATER POLLLUTION	Non-Point Source
-comes from a single point *-easy to identify, monitor, and regulate* *-developed countries have laws to regulate most of this*	What Is It?	*-broad and diffuse areas from which pollutants enter water or air* *-difficult to identify and control* *-there has been little progress to control this type of pollution*
-pollution from drainpipes, ditches, or sewer lines *-factories, sewage treatment plants, underground mines, oil tankers*	Examples	*-runoff of chemicals and sediments from croplands, feedlots, logged forests, urban streets, parking lots, lawns, and golf course*

What are the 3 biggest sources of water pollution?

1. *Agricultural* activities
   - *Sediment eroded* from agricultural lands is the largest source
   - *Fertilizers* & *pesticides*
   - Bacteria from *livestock* & *food processing waste*
2. *Industrial* facilities
   - *organic* & *inorganic* chemicals
3. Mining
   - *Erosion of sediments* & runoff of toxic chemical

How have parking lots become a major source of nonpoint pollution? *Grease, toxic metals, and sediments collect on the impervious surfaces and runoff into rivers and lakes*

A new form of water pollution is in the form of *plastics.* The polymers of plastic break down very slowly and pollute many waterways.

One of the major water pollution problems people face is exposure to *infectious disease organisms* through *contaminated drinking water*.

How many diseases can be spread through water vectors? *500*

3.2 million die every year from water diseases. Most are under age *5*.

1.2 billion worldwide have no access to clean drinking water (this almost is 1 in every 7!!)

The consequence of *diarrhea* and dehydration is the major killer from these diseases.

This table is extremely important for this chapter!

Type and Effect	Examples	Major Sources
PATHOGENS- cause disease	*Bacteria, viruses, protozoa, parasites*	*Human and animal waste*
OXYGEN DEMANDING WASTE- depletes DO needed by aquatic species	*Biodegradable animal wastes and plant debris*	*Sewage, animal feedlots, food processing facilities*
PLANT NUTRIENTS- excessive algae growth (algal blooms)	*Nitrates and Phosphates*	*Sewage, animal waste, inorganic fertilizer*
ORGANIC CHEMICALS- adds toxins to aquatic systems	*Oil, gasoline, plastics, pesticides, cleaning solvents*	*Industry, farms, households*
INORGANIC CHEMICALS- adds toxins to aquatic systems	*Acids, bases, salts, metal compounds*	*Industry, households, surface runoff*
SEDIMENTS- disrupts photosynthesis and food webs	*Soil, silt*	*Land erosion*
HEAVY METALS- cause cancer, disrupt immune and endocrine system	*Lead, mercury, arsenic*	*Unlined landfills, household chemicals, mining refuse, industrial discharges*
THERMAL- makes some species vulnerable to disease	*Heat*	*Electric power plants (coal burning, nuclear, etc) and industrial plants*

List 4 diseases transmitted through water that cause diarrhea:

1. Typhoid Fever *2. Cholera* *3. Dysentery* *4. Giardiasis*

Science Focus: Testing Water for Pollutants

1. Fecal coliform bacteria from *human and animal waste* indicate water contamination. To be deemed safe for drinking, water can have *0* colonies; for swimming *200* colonies. Raw sewage has *several million colonies*.
2. Levels of *dissolved oxygen* (*DO*) can indicate the presence of bacteria.
3. Two indicator species for water pollution are *plants, like cattails,* and *bottom dwelling species, like mussels and other macroinvertebrates*.
4. Define turbidity: *the amount of suspended sediments in water; the cloudiness of water*

What are the Major Water Pollution Problems in Streams and Lakes?

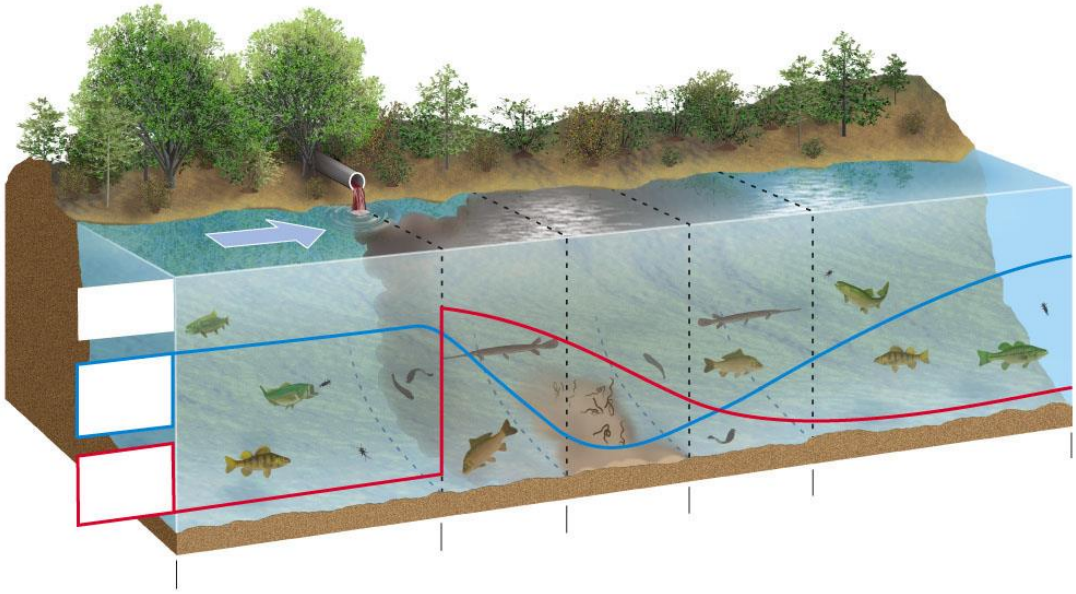
Rivers and streams can naturally recover from wastes through *dilution* and *biodegradation* by bacteria.

This recovery process does not work when: *streams become overloaded with pollutants, or when drought, damming, and water diversions reduce the flow of water.*

What is an oxygen sag curve? *In a flowing stream, the breakdown of biodegradable wastes by bacteria depletes DO and creates an oxygen sag curve.*

This reduces or eliminates the populations of organisms with high O_2 requirements until the stream is cleansed.

Label the diagram of the oxygen sag curve below:



Stream Pollution in Developed Countries

Water pollution laws were set in the *1970*s.

Successful clean ups of the *Cuyahoga River:*

It was once so polluted that it caught fire! The new laws limited industrial discharge of waste and funds were provided to improve wastewater treatment facilities.

Stream Pollution in Developing Countries

Most of the world's polluted river are in developing countries because they cannot *afford* to build wastewater/sewage treatment plants and/or do not have laws or the ability to enforce them.

80-90% of raw sewage is dumped directly into rivers, lakes, and streams

Industrial and sewage waste pollutes 2/3 of India's rivers

In China about *300 million* people do not have access to drinkable water

India's Ganges River:

According to the Hindu people, the Ganges is a *holy* river. People use it to *bathe*, *drink* from or take a dip. But it is highly polluted by the people and the industries in the *29* cities in the basin. Complicating the situation, Hindus believe they must *cremate* the dead. Putting the ashes in the Ganges increases chances of getting to

heaven. However, many people cannot afford enough *money* for cremation, so the bodies are dumped into the river.

** Decomposition of these bodies *depletes DO and adds disease* carrying bacteria and viruses to the water.

Another religious custom is to throw painted statues into the water which releases *toxic metals such as lead and mercury into the water*.

Lakes are less effective at diluting pollutants because:

1. *The stratified layers of the lake rarely mix vertically.*
2. *They have little no flow of water*

Define: Eutrophication- *the natural nutrient enrichment of lakes and estuaries*

**Cultural eutrophication is caused by HUMAN impact.

Oligotrophic- *a lake that is low in nutrients, therefore very clear water*

The most common culprits for cultural eutrophication are *plant nutrients* (nitrates and phosphates)

Explain how <u>cultural eutrophication</u> kills fish: (Remember we've done this before!)

1. High levels of *nitrates and phosphates* (from fertilizers, animal waste, and mining sites) cause algal blooms and overgrowth of aquatic plants.
2. The dense plant life then reduces the lake's *productivity* because of the sun's inability to penetrate the water.
3. When the algae die, they are *decomposed* by aerobic bacteria that use oxygen in order to function, therefore *depleting the water of dissolved oxygen.*
4. Aquatic life that needs oxygen will begin to die off.

**If excess nutrients continue to flow into the lake, then anaerobic bacteria take over and produce smelly, toxic hydrogen sulfide and methane.

How to fix cultural eutrophication:

1. Use *advanced wastewater treatment* to remove nitrates and phosphates before wastewater enters the lake.
2. Banning or limiting the use of *phosphate containing detergents.*

What two lessons can be learned from the story of Lake Washington?

1. Severe water pollution can be *reversed* in a fairly short amount of time if pollutant inputs are sharply reduced.
2. Citizen action and scientific research works to spark change.

Briefly describe the history of the Great Lakes as far as being affected by water pollution.

1960's- many areas are suffering from *cultural eutrophication*, fish kills, and contamination from bacteria and toxic industrial waste

Since 1970's- US and Canada have spent more than $20 billion on pollution control by upgrading sewage treatment plants, better treatment of industrial waste, and

bans on detergents and cleaners that contain phosphates.

2000's- Scientists report that:

- *raw sewage* is still being dumped or overflowing into the lakes.
- There has also been an increase in *runoff of fertilizer and pesticides* fueled by population growth.
- Biological Pollution- *invasion of zebra mussels* threaten native species
- Half of the toxic compounds entering the water are coming from *atmospheric deposition*.
- Water is filled with toxic flame retardant chemicals and *pharmaceuticals.*

What Are the Major Pollution Problems Affecting Groundwater and Other Drinking Water Sources?

Name several common pollutants that pollute groundwater:

-fertilizers *-pesticides* *-gasoline* *-organic solvents*

Describe why it is difficult and costly to remove contaminants from groundwater.

-flows very slowly so contaminates are not diluted or dispersed.
-very low levels of DO and small populations of decomposing bacteria
-the cold temperature of groundwater slows down decomposing chemical reactions

Toxins dumped underground pose a risk to our aquifers:

The EPA says that *1/3* of the industrial waste ponds in the US have no liners, therefore toxic waste is likely leaking underground.

2/3 of our liquid hazardous wastes are injected into deep disposal wells that can leak into aquifers.

Inside those leaky tanks are: gasoline, oil, *MBTE* (a gasoline additive and carcinogen), and *nitrate* ions.

- Nitrate ions in drinking water can cause *Blue Baby Syndrome* which kills infants because the blood can't carry oxygen.

How does drinking water become polluted with arsenic?

Naturally: *Arsenic can contaminate drinking water if a well is dug in an area with rocks and soil that are naturally rich in arsenic.*

Human Caused: *Mining and ore processing*

Arsenic can cause: *skin, lung, and bladder cancer*

Describe prevention and cleanup solutions to groundwater pollution.

Prevention*: Install monitoring wells near landfills, require leak detectors in underground tanks, store harmful liquids above ground*

Clean Up: *pump groundwater to surface, clean, and return water to aquifer, inject micro-organisms to clean the water*

Describe how each purifies drinking water:

Developed Countries	Sewer Wastewater	Tropical Countries	The LifeStraw
-water is left in a reservoir and then pumped to a purification plant to be treated	*-some areas are directly purifying their wastewater into drinking water* *"toilet to tap" system*	*-expose a clear, plastic bottled to intense sunlight* *- the UV rays can kill infectious microbes* *-decreases chance of diarrhea by 40%*	*-portable water filter that removes viruses and parasites* *-used in Africa* *-you can even buy one online for hiking!*

How has New York City protected its watershed in order to have pure water?

Several major cities have avoided spending $ on water treatment facilities and have instead *invested in protecting the watershed and wetlands*.

Forests cover ¾ of New York's watershed and underground tunnels transport water to the city.

What is the US Safe Water Drinking Act? Is it working?

The EPA has established national drinking water standards, however it is estimated that 1/5 of Americans are drinking water from facilities that violate these safety standards. Scientists are also hoping in the future this law will ban lead from being used in the water pipes.

Is drinking bottled water worth it?

Probably not… About *¼* of bottled water is actually just ordinary tap water.

Government testing standards are much *lower* for bottled water than for tap water.

List a few harmful impacts bottled water has on the environment.

The plastic bottles thrown away each year could circle the equator 8 times!

Toxic gases and liquids are released during the manufacturing of the bottles.

What are the Major Water Pollution Problems Affecting Oceans?

40% of the world lives on or near the coast, with *14* of the world's 15 largest metro areas being on the coast.

80% of marine pollution is from the land.

3 Examples of Sources of Marine Pollution		
1. Industry	*2. Farms*	*3. Urban Sprawl*
-NOx from cars and smokestacks, heavy metals from effluents flow into bays and estuaries	*-runoff of pesticides, manure, and fertilizers add toxins and excess nitrates and phosphates*	*-bacteria from sewers contaminate beaches, fertilizer runoff from lawns adds nitrates and phosphates*

How are cruise ships contributing to marine pollution?

Cruise ships generate as much waste as a small city. Toxic pollutants from dry cleaning, benzene from paints and solvents, plastic garbage and human waste are sometimes illegally dumped into the sea.

What causes oxygen-depleted zones?

Runoff of sewage- *aerobic decomposers work overtime to break down waste, thus depleting the water of dissolved oxygen, waste can also contain high levels of nitrates and phosphates which also lead to algal blooms and oxygen depletion*

Runoff of fertilizers- *adds excess nitrates and phosphates into the water which sparks algal blooms, the algae blocks sunlight and uses up all of the nutrients, once algae and plants begin to die, the aerobic decomposers have to work overtime to break down the dead waste, thus depleting the water of oxygen.*

Red Tides- *excessive nitrogen causes explosive growth of toxic algae that poisons fish and some marine mammals*

Ocean Oil Pollution:

What happened to the Exxon Valdez oil tanker in 1989?

The oil tanker went off course, hit rocks, and released 10 million gallons into Alaska's Prince William Sound. The oil killed a large number of seabirds, fish, and otters. The cleanup and settlement claims cost the company over $4 billion!

What is actually the largest source of ocean oil pollution?

Oil spills get a lot of publicity, but urban and industrial runoff is actually the largest source of oil pollution in the ocean.

What affect does oil have on marine life?

Volatile Organic Hydrocarbons immediately kill many aquatic organisms, globs of oil coat the feathers of birds and fur of marine mammals which destroys their natural heat insulation and buoyancy, causing many of them to drown.

Heavy oil that sinks to the bottom of the ocean smothers benthic organisms like crabs, oysters, mussels, and clams.

Oil slicks that wash onto beaches can have a massive economic impact.

Options for cleaning up Oil Spills:

Floating booms, skimmer boats, dispersant chemicals, fire, oil eating bacteria

List prevention and cleanup solutions to coastal water pollution.

Prevention: *Ban dumping of waste by ships, reduce input of toxic chemicals, separate sewage and storm lines, ban ocean dumping of hazardous materials*

Clean Up: *Improve oil spill cleanup capabilities, use nanoparticles on sewage to dissolve the sewage, require secondary treatment of coastal sewage water, use wetlands to treat sewage*

How Can We Best Deal With Water Pollution?

Ways to reduce water pollution from nonpoint sources:

Reduce soil erosion by keeping cropland covered with vegetation.
Reduce fertilizer runoff by using slow release nitrogen fertilizer, not using fertilizer on steeply sloped land, and planting buffer zones (riparian zones).
Organic farmers use manure instead of synthetic nitrogen based fertilizers.
Apply pesticides only when needed and use an Integrated Pest Management (IPM) Plan as often as possible.
Farmers control runoff of animal waste by planting buffers and locating feedlots away from sloped land, surface water, or flood zones.

What is the Clean Water Act and what types of improvements has it led to since1992?

Sets standards for allowed *levels* of key water pollutants and requires polluters to get *permits* limiting how many pollutants can be discharged into aquatic systems.

- *# of Americans served by community water systems that met federal standards increased from 79% to 94%*
- *% of streams that are swimmable and fishable increased from 36% to 60%*
- *Amount of topsoil erosion cut by 1 billion tons/year*
- *US population served by sewage treatment increased from 32% to 74%*
- *Annual wetland losses decreased by 80%*

Some homes have septic tanks. Describe how this works.

Septic tanks are sometimes used in *rural and some surburban areas.*

Household sewage is pumped into a settling tank where grease and oil rise to the top and solids fall to the bottom where they are decomposed by bacteria. The partially treated wastewater is then discharged into an absorption field where the soil filters out pollutants and soil bacteria continue to decompose waste.

Ever few years, the tank become full and must be *pumped* where it is then taken to a *sewage treatment facility*.

**Chlorine bleaches and antibacterial soaps shouldn't be used in these systems! Why do you think that is? The chlorine and antibacterial soaps will kill the needed bacteria.

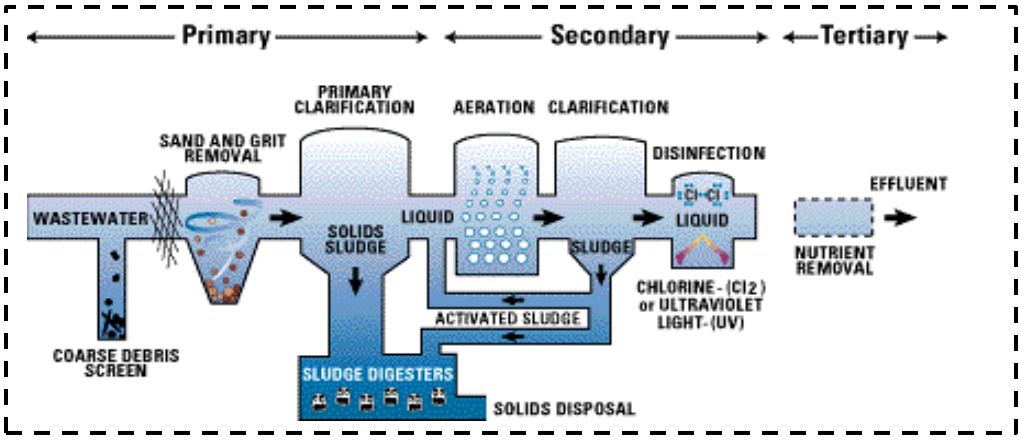
Many homes send their wastewater to sewage treatment plants. The steps are:

- **STEP ONE: *PRIMARY* Sewage treatment is a *physical* process.**
  - Goal: *removes solids*
  - Pieces: *by using screens, grit tanks, and settling tanks*
  - Does not remove: *pathogens, nitrates, phosphates, salts, radioisotopes, or pesticides*
- **STEP TWO: *SECONDARY* Sewage treatment is a *biological* process.**
  - Goal: *aerobic bacteria removes oxygen demanding waste, most toxic metals, most nitrates and phosphates*
  - Pieces: *aeration tanks with bacteria, settling tanks, chlorine disinfection tanks that kills the bacteria that was put into the water during this step*
  - Does not remove: *pathogens, some pesticides, radioisotopes*
- **BEFORE DISCHARGE:** water is subject to *bleaching (to remove color from water)* or *disinfection* to remove *bacteria and viruses.*

  This is mostly done with *chlorine*, however this chlorine can react with other organic materials to form chlorinated hydrocarbons that can cause cancer, increase the risk of miscarriage, and damage the nervous and endocrine system.

  Some treatment plants are using *ozone or UV light* to disinfect the water instead.
- **STEP THREE: *TERTIARY (ADVANCED)* Sewage treatment is a *chemical* process.**
  - Goal: *removes specific pollutants left in the water*
  - Pieces: *special filters and chemicals to remove nitrates and phosphates*

  ** This is not widely used because of the cost and it is not required by law.



Describe a few issues that may arise in wastewater treatment plants in the US.

- By law, the sewage treatment plants must have the primary and secondary treatment but in some cases towns can be exempt from secondary treatment if the cost becomes too much of a burden.
- Removing the chlorine disinfecting step (for fear of cancers and body system damage) can increase risk of diseases like cholera!
- Some cities have combined stormwater drains and sewer drains because it is cheaper. However, heavy rains can cause overflow and sewage contamination.

Solutions to Water Pollution:

-prevent groundwater contamination, reduce nonpoint runoff, reuse treated wastewater for irrigation, work with nature to treat sewage

CHAPTER 15 Air Pollution

Core Case Study: South Asia's Massive Brown Cloud

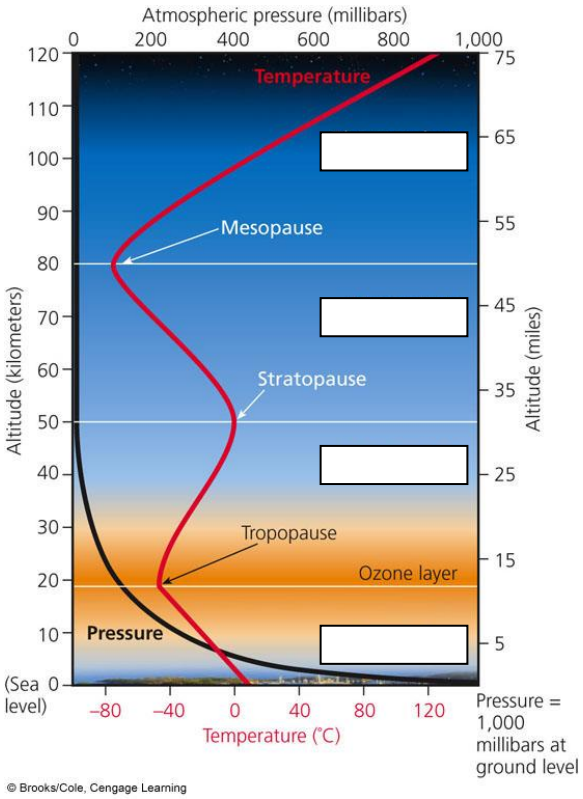
1. The Asian Brown Cloud covers India, Bangladesh, parts of China, and the open sea. What is in this brown cloud? *Dust, smoke, and ash, acidic compounds, soot, toxic metals (like mercury and lead), and organic compounds*
   This cloud is 2 miles thick and covers an area about the size of the US!

2. Describe negative effects the Asian Brown Cloud has had on life in these areas and other areas.
   Reduction in photosynthesis
   Acids in the haze fall the ground and damage crops, trees, and aquatic life
   Warms the atmosphere above the cloud
   Pollutants spread to other regions of the world

What Is the Nature of the Atmosphere?

The layers of the atmosphere are characterized by abrupt changes in *temperature*, differences in absorption of *solar* energy, *density*, and atmospheric *pressure*.

Air density and atmospheric pressure *decrease* with altitude.



The Four Layers of the Atmosphere:

Stratosphere:
- Concentration of ozone (O3) is *higher* here called the *ozone* layer
- Describe how stratospheric ozone is produced: *when O_2 interacts with UV radiation, O_3 is produced*
  $3O_2 + UV \rightarrow 2O_3$
- Why is ozone called the "global sunscreen?"
  Keeps about 95% of the sun's harmful UV rays from reaching the Earth
- Ozone in this layer of the atmosphere protects us from: *sunburns, skin and eye cancer, cataracts*

Troposphere:
- *80%* of earth's air mass
- Closest to the surface of earth
- Air we breathe is 78% *Nitrogen* and 21% *Oxygen*
- Air currents and wind cause *weather* and climate to happen in this layer

What Are the Major Outdoor Air Pollution Problems?

Air pollution is the presence of *chemicals in the atmosphere high enough to harm organisms, ecosystems, or human-made materials.*

Natural Sources	Sources of Air Pollution	Human Sources
-dust blown from *wildfires* and *volcanic eruptions* -*Volatile Organic Compounds* (VOCs) released by plants		-most are generated by burning *fossil fuels* in industrial plants (*stationary* source) and cars (*mobile* source).

Case Study: Air Pollution in the Past- The Bad Old Days

Air pollution probably began when humans discovered *fire* and were breathing in unhealthy smoke and soot.

The *Industrial* Revolution (late 1700's) brought even worse air pollution when *coal* was burned to power factories and heat homes. This brought an increase in cases of *asthma, bronchitis, and allergies*.

History of Air Pollution in London-

1880: prolonged *coal* fog killed 2,200 people in London.

1905: the word *smog* was invented to describe the mixture of *smoke* and *fog*

1952: a dangerous yellow fog lasted *5* days and killed nearly *10,000* Londoners

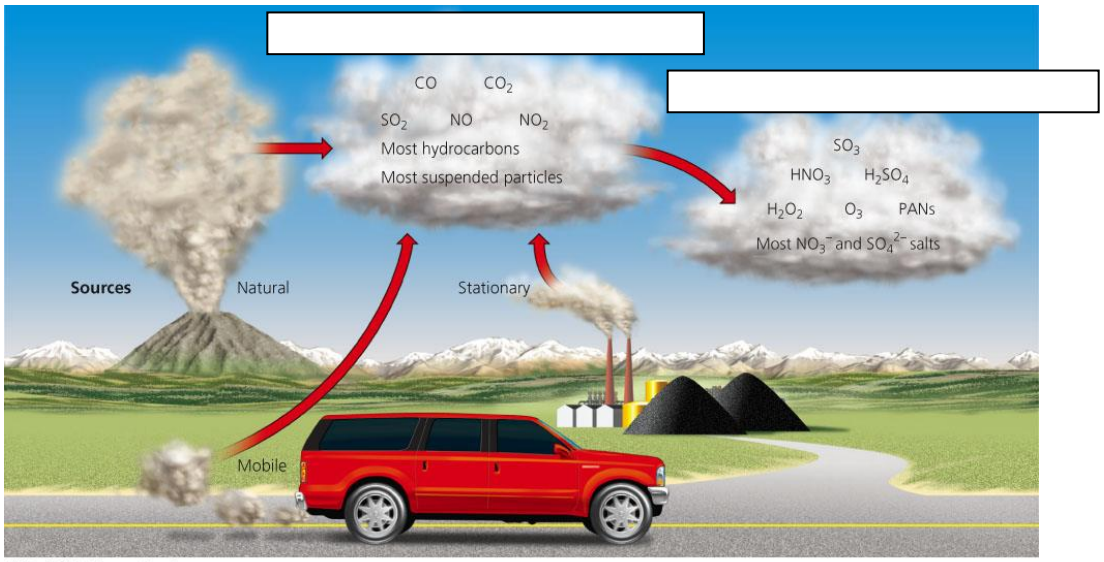
*This tragedy prompted the *Clean Air Act* of 1956.

History of Air Pollution in the US-

1948: *Donora*, Pennsylvania- pollution from coal burning factories, zinc smelter, and a sulfuric acid plant became trapped in dense *fog* that stagnated over the area for 5 days. 6,000 became ill and 20 died. This was the result of a *temperature inversion.*

Primary Pollutants	Categories of Air Pollution	Secondary Pollutants
-harmful chemicals emitted *directly into the air* from natural processes and human activity		-happens when *primary* pollutants *react* with each other and form *new* harmful chemicals

If there are more factories and cars in urban areas, why do rural areas still have to deal with some primary and secondary pollutants? *Prevailing winds can spread air pollutants from urban areas to rural areas.*



Major Outdoor Air Pollutants			
Name	*Characteristics*	*Sources*	*Effects*
Carbon Oxides	CO- *colorless, odorless gas; highly toxic* CO_2- *colorless, odorless gas*	CO- *car exhaust, burning forests or grasslands, tobacco smoke, open fires, inefficient stoves* CO_2- *most is from the result of the natural carbon cycle; the rest is from burning fossil fuels, clearing CO2 absorbing forests*	CO- reacts with *hemoglobin* in red blood cells and reduces blood's ability to transport O_2. Chronic exposure leads to asthma, emphysema, mental impairment, coma, death CO_2- *global warming* and climate change Catalytic Converters- *converts dangerous CO emissions from cars to* CO_2
Nitrogen Oxides and Nitric Acid NO_x refers to NO and NO_2	NO- *colorless gas that forms when nitrogen and oxygen gas react* In the air, NO reacts with O_2 to form NO_2 (a reddish brown gas) Nitrogen Dioxide- NO_2 *reacts with water vapor to form nitric acid (component of acid rain)* N_2O - *greenhouse gas*	NO- *combustion engines and coal burning power plants* (Lightening and bacteria can also produce NO as part of the nitrogen cycle.) N_2O- *emitted from fertilizers, animal waste, and from the burning of fossil fuels*	NO- *photochemical* smog, can irritate *eyes, nose, and throat and aggravate asthma* , suppress *plant* growth Nitric Acid- *photochemical* smog, acid *deposition* N_2O- *leads to an increase in global warming*
Sulfur Dioxides and Sulfuric Acid	SO_2- *colorless gas with irritating odor* Sulfuric acid- SO_2 *in the air is converted to sulfuric acid* (H_2SO_4) *and sulfate salts*	SO_2- *combustion of coal, oil refining, and smelting of sulfur oxides*	Both SO_2 and Sulfuric Acid- acid *deposition*, reduce *visibility*, aggravate *breathing* problems, damage *crops, trees, soil and aquatic life*, corrode *metals*, and damage paint and *stone* on buildings and statues.

Name	*Characteristics*	*Sources*	*Effects*
Particulates	*Suspended Particulate Matter (SPM)* *Variety of solid particles and liquid droplets that remain suspended*	*Most comes from natural sources like dust, wildfires, and sea salt* *Human sources- coal burning plants, industrial plants, cars, unpaved roads*	*SPM is linked to adverse respiratory effects, reduce visibility, corrode metals* Fine Particles- *<10micrometers in size* Ultrafine- *<2.5micrometers in size* These are the most dangerous particulates: irritates nose and throat, damages lungs, asthma, *Toxic* Particulates- lead, cadmium, and PCBs can cause mutations, reproductive problems, etc
Ozone	*O_3- Colorless, highly reactive gas- major component of photochemical smog*	*Secondary pollutant* Humans are *INCREASING* ozone in the troposphere and *DECREASING* ozone in the stratosphere	Ozone in the *TROPOSPHERE*= BAD ozone -breathing problems, aggravate lung and heart disease, irritate eyes, damages plants Ozone in the *STATOSPHERE*= GOOD ozone -protects us from harmful UV rays
Volatile Organic Compounds (VOCs)	*-Exist as gases in the air* *-Most are hydrocarbons* *-Benzene*	*Plants, wetlands, termites, rice paddies, landfills, oil wells, cows belching* *Industrial solvents, dry cleaning fluids, gasoline, plastics, paints*	Can cause *leukemia (from benzene exposure)*, *blood* disorders, dizziness, death

Case Study: Lead is a Highly Toxic Pollutant-

Lead (*Pb*) is a potent *neurotoxin* that does *not* break down in the environment. Exposure causes *nervous* system impairment, lowered *IQ*, shortened attention span, etc.

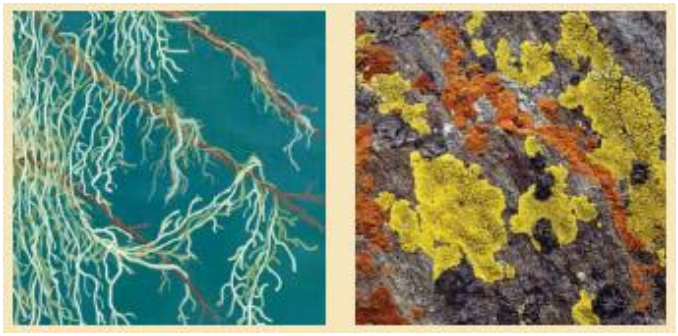
Between 1976 and 2000, there has been a huge drop in lead poisoning cases because the government banned *leaded gasoline and leaded paint*.

Some children are still being exposed because of: *leaded paint found in homes built before 1960 and illegal use that continued through 1978 as well as toys that are made overseas in countries that have not banned lead paint.*

Science Focus: Detecting Air Pollutants

One way to detect air pollutants is through a *biological* indicator- *Lichen*
Lichen forms from a *mutualistic* relationship between *fungi* and *algae*.
They are good indicators because they continually absorb *air*.

Highly Polluted Area= *grey-green crusty* lichen or none at all
Moderate Air Pollution= *orange crusty* lichen
Clean Air Areas= *leafy* lichen on walls and trees



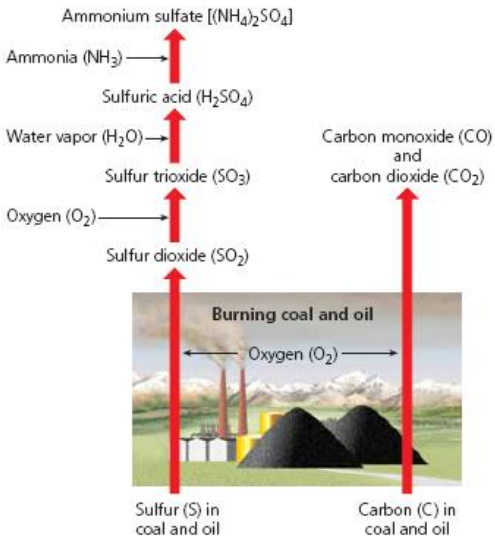
"Old Man's Beard" Lichen and "Evernia" Lichen are sensitive to *sulfur dioxide*.

Burning coal produces *INDUSTRIAL SMOG*:

-When coal and oil are burned:

1. Carbon is converted to *CO* and *CO_2*
2. Sulfur reacts with O_2 to produce *SO_3*
3. Some of the SO_2 reacts with water vapor to produce *sulfuric acid (H_2SO_4)*
4. Some of the H_2SO_4 reacts with *NH_3* to form solid ammonium sulfate
5. Unburned carbon goes into atmosphere is known as *particulates (soot).*

*All of these chemicals and particulates give smog the *gray* color.



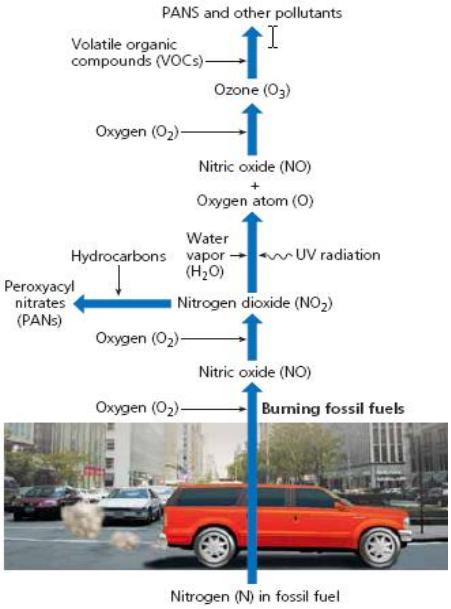
-Today Industrial smog is less of problem in *developed* countries because of pollution control, such as tall smokestacks to blow pollution downwind to *rural* areas. It is still a problem in *developing* countries that still burn coal in houses and factories with inadequate pollution control. *China* has highest levels of industrial smog.

PHOTOCHEMICAL SMOG- mixture of primary and secondary pollutants under the influence of *UV* radiation.

1. Exhaust from car releases *NO* & *VOCs*, and the NO is converted to a reddish brown NO_2.
2. UV radiation causes a reaction between NO_2 and VOCs
3. The resulting photochemical smog is a mixture of *ozone*, nitric acid, aldehydes, PANs. Collectively, these chemicals oxidize certain compounds in the atmosphere & your *lungs*!

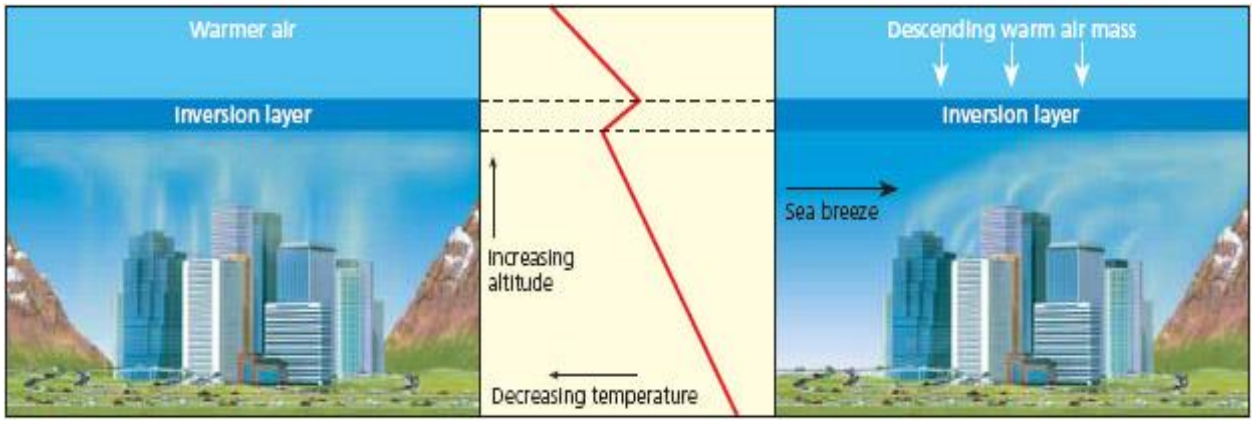
Hotter days leads to higher levels of smog.

*Cities in *sunny and dry* climates with lots of cars have higher levels of smog. Ex: *Los Angeles, Denver*



Factors that REDUCE Air Pollution		*Factors that INCREASE Air Pollution*
1. Particles *heavier* than air settle due to gravity 2. Rain and snow *cleanse* the air of pollutants 3. Salty sea spray from oceans wash out pollutants from air that flows over the ocean 4. *Winds* sweep pollutants away, diluting it with cleaner air 5. Some pollutants are removed by *chemical reactions*	Natural Factors That Influence Outdoor Air Pollution	1. Urban buildings can *slow* wind speed and reduce dilution of pollutants 2. Hills and *mountains* reduce flow of air in valleys so pollutants build up at ground level 3. High *temperatures* promote photochemical smog 4. Emissions of *VOCs* from certain trees and plants helps form photochemical smog 5. *Grasshopper* Effect- air pollutants are transported by evaporation and winds to the *polar* regions 6. Temperature *Inversions* (see below)

TEMPERATURE INVERSION



Temperature Inversions- can cause pollutants to build to a high level
Cities that are built in *valley* are subject to temperature inversions that can *trap* pollutants over a city for days or weeks. This occurs when a layer of *warm* air sits atop cooler *polluted* air over a city and prevents the *cool* air from rising and dispersing the pollutants. Cities with a sunny climate, light winds, and mountains on *3* sides (*ex: Los Angeles*) are also vulnerable.

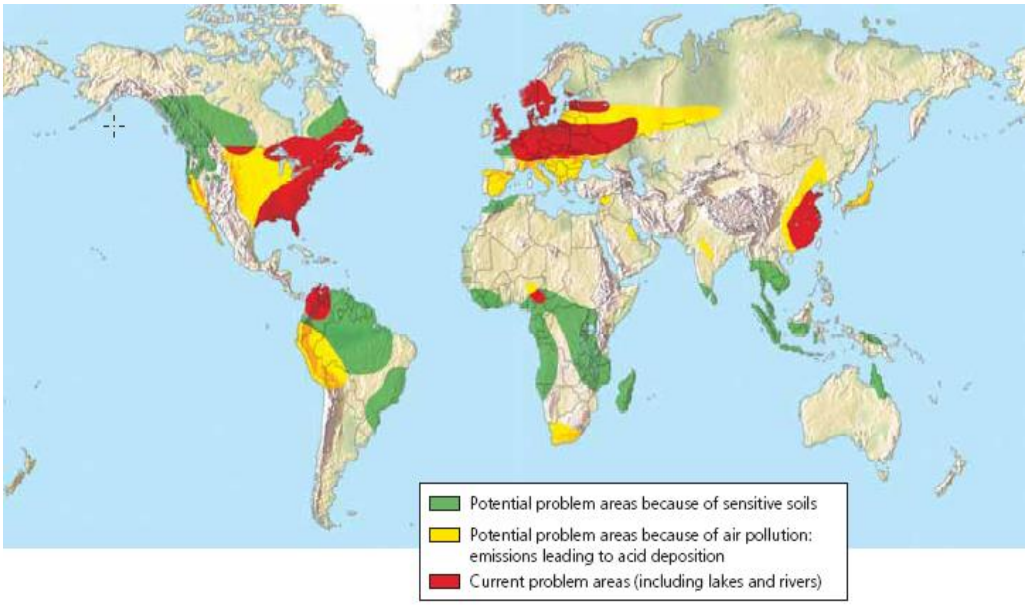
What is Acid Deposition (aka *Acid Rain*) and Why Is It a Problem?

Acid Deposition is the result of humans disrupting the *Sulfur* and *Nitrogen* cycles.

Tall Smokestacks are used to emit SO_2, particulates, and NO_x high into the air where *wind* can mix, dilute, and disperse them. This reduce *local* air pollution, but increases *regional* air pollution downwind.

As primary pollutants are emitted and travel downwind, they mix and form *secondary pollutants* like sulfuric acid and nitric acid vapor.

- These *acidic* substances remain in the air for days and can descend to the earth's surface in 2 ways:
  1. *Wet* Deposition – acidic rain, snow, fog, cloud vapor with a pH <5.6
  2. *Dry* Deposition- acidic particles



It is a regional problem for areas *downwind* from coal burning facilities and urban areas.

Some soils contain *basic* compounds (like $CaCO_3$ or limestone) that act as a *buffer* to *neutralize* acid.

Areas with thin, *acidic* soil and areas that have lost buffering ability due to decades of acid rain are most *sensitive to acid deposition.*

Harmful Effects of Acid Deposition
- *Respiratory* disease - damages statues, monuments, buildings, metals, car finishes - decrease *visibility* - can *leach* toxic metals (lead and mercury) from soils and rocks into *lakes* and accumulates in the tissues of organisms (pregnant women shouldn't eat fish for risk of mercury contamination) - makes some aquatic ecosystems too *acidic*- most fish can't live below a pH of *4.5* - harm *crops* if soil pH is below *5.1* - affects forests by leaching essential plant nutrients (*calcium* and *magnsium*) from soils and releasing aluminum, lead, and mercury which are *toxic* to trees- weakens the trees; mountain top trees are the hardest hit

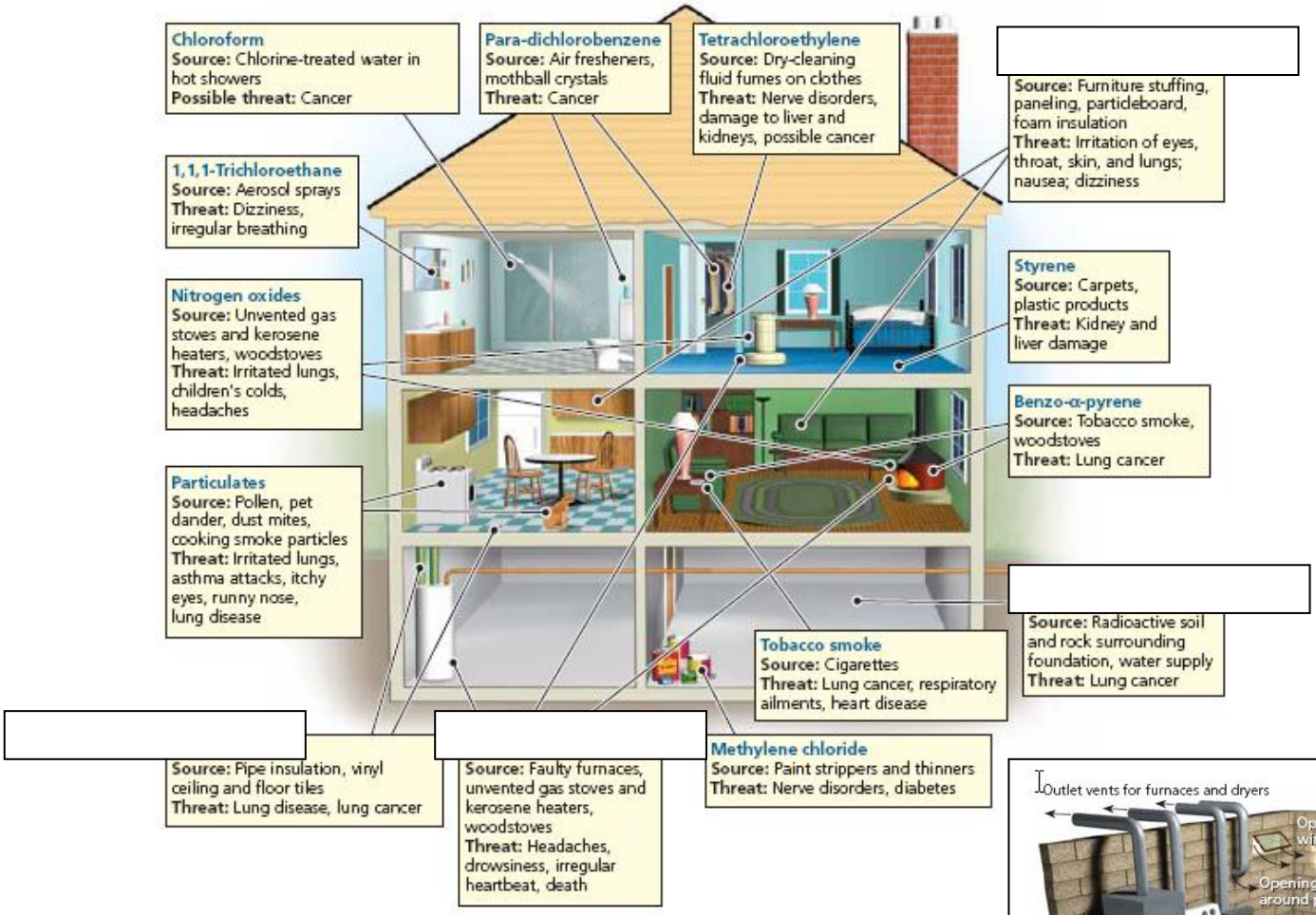
SOLUTIONS TO ACID DEPOSITION	
Prevention	Clean Up
1. Reduce *coal* use 2. Burn *low-sulfur* coal 3. Increase use of renewable energy sources 4. Remove SO_2 and NO_x from *smokestack* gases 5. Remove NO_x from *car* exhaust 6. *Tax* emissions of SO_2	1. Add lime to *neutralize* acidified lakes 2. Add *phosphate* fertilizer to neutralize acidified lakes

What Are the Major Indoor Air Pollution Problems?

Indoor Air Pollution:

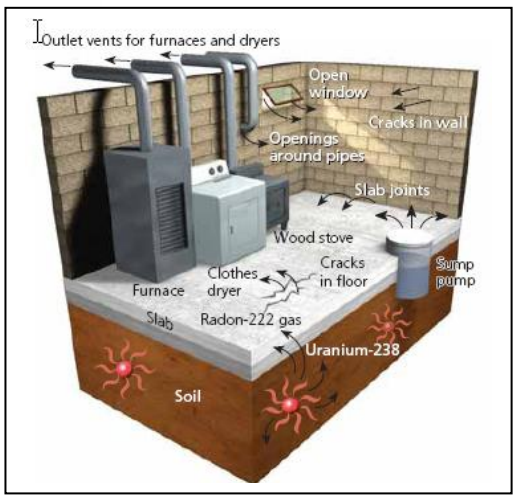
- Biggest pollution threat to the *poor* in *developing* countries
- caused by *burning* wood, charcoal, etc.in poorly ventilated areas
- *Sick* Building Syndrome- buildings that have air pollutant counts high enough to cause *health* issues

Examples of Indoor Air Pollutants
1. Pesticides and lead brought in your *shoes* 2. Living organisms and their excrements - *dust* mites , cockroach droppings 3. Airborne spores of *mold* and *mildew* 4. *Tobacco* smoke 5. Formaldehyde- causes most difficulty in people in *developed* countries 6. Radioactive *radon* gas from natural decay of uranium in the soil 7. Very fine *particles* 8. *Mold- thrives in dark, damp places*

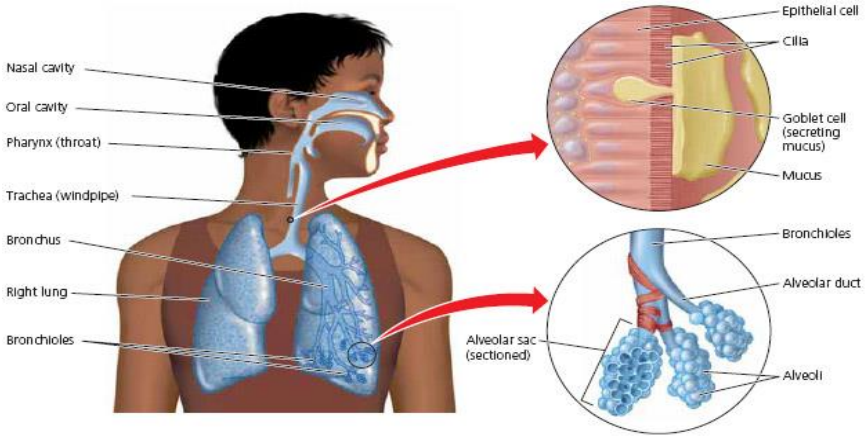


Case Study- Radioactive Radon Gas

- Produced by natural radioactive *decay* of *Uranium-238* in rocks and soils
- Enters a home through the *cracks* in the foundation and walls
- Constant exposure can lead to *lung* cancer

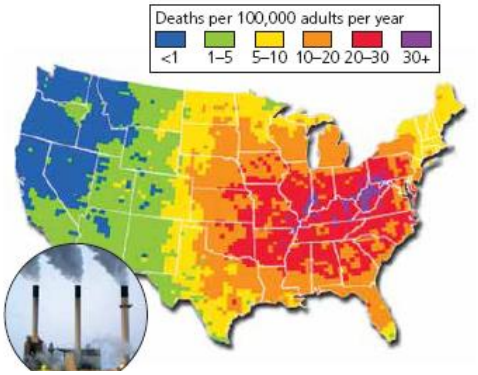


What Are the Health Effects of Air Pollution?



The *Respiratory* System is a good line of defense against air pollution:
- *Nose hair* filters large particles
- *Mucus* captures smaller particles
- *Sneezing* and coughing expel air pollutants too
- small, hair-like *cilia*

Prolonged exposure to air pollutants can overload or break down these natural defenses. Fine and Ultrafine (most dangerous) *particulates* get lodged deep in the *lungs* and contribute to lung cancer, asthma, and emphysema.



Air Pollution is a Big Killer:
- The World Health Organization (*WHO*) estimate that *2.4* million people die each year due to the effects of air pollution.
- 2.2 million of those deaths are due to *indoor* air pollution.

How Should We Deal with Air Pollution?

EPA has established

*The 6 outdoor criteria air pollutants:

1. *Carbon Moxide*
2. *Particulates*
3. *Sulfur Dioxide*
4. *Nitrogen Dioxides*
5. *Ozone*
6. *Lead*

*Hazardous Air Pollutants (HAPS)- emissions standards

*Toxic Release Inventory (TRI)- factories, mines, refineries must report their release of toxic chemicals

Congress has passed *air pollution laws*, but there is room for improvement:

1. US relies mostly on pollution *clean up*, rather than *prevention*
2. We have failed to increase *fuel efficiency* in cars
3. Little regulation of oceangoing ships
4. *Airports* are exempt from regulations
5. Laws don't regulate emissions of CO_2
6. *Ultrafine* particles are not regulated
7. Does not deal with *indoor* air pollution

Outdoor	Air Pollution Solutions	Indoor
1. Emissions Trading (aka: *Cap and Trade*) allows major "polluters" to *buy and sell* emissions allotments to help reduce SO_2 emissions 2. Burn low *sulfur* coal 3. Disperse emissions above *thermal inversion* layer with tall smokestacks. 4. Use mass transit 5. Give large *tax* breaks for those who buy low polluting vehicles 6. Inspect car *emissions* throughout the year 7. Rely more on *renewable* energy sources 8. Improve energy efficiency 9. Carbon Capture and Storage (aka *Carbon Sequestration)*- captures CO_2 emissions from power plants, transports that CO_2, and then stores it underground.		1. Ban *smoking* 2. Stricter *formaldehyde* emissions from carpet and furniture companies 3. Use office machines in well *ventilated* areas 4. Less polluting *cleaning* supplies 5. Circulate buildings air through *rooftop* greenhouses 6. Use exhaust hoods for stoves 7. Prevent *radon* infiltration 8. Distribute cheap, efficient stoves or solar cooker to *developing* countries 9. Develop cheap *tests* for indoor air pollutants 10. *Radon* detectors

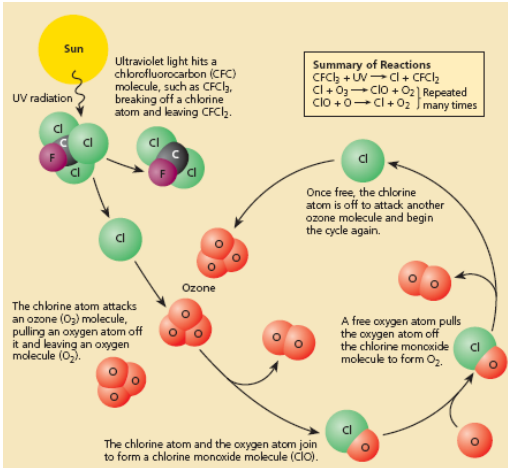
How Have We Depleted Ozone in the Stratosphere and What Can We Do about It?

Not only is there considerable thinning of the ozone in the polar regions, but there is overall thinning everywhere as well. Ozone depletion in the *stratosphere* poses a serious threat to *humans*, animals, and *primary producers*.

Chlorofluorocarbons (CFCs)

*Discovered in *1930s* and use expanded rapidly
*Trade name = *Freons*
*Thought to be the dream chemical because it is chemically unreactive, *nonflammable*, nontoxic, *inexpensive*, and *noncorrosive*
*Became popular as *coolants* in ACs, refrigerators, cleaners for electric parts, propellant in spray cans, etc.
*Too good to be true: 1974- "CFCs destroy *ozone* in stratosphere" said Rowland and Molina

-CFCs rise and remain in atmosphere
-Once CFCs reach atmosphere, it breaks down under the influence of the *UV light* which releases a highly reactive *chlorine* which break O_3 into O_2 and O
-CFCs persist in atmosphere for *65-385* years depending on conditions
-It took Rowland and Molina 14 years to convince DuPont to stop production



How Can We Reverse Stratospheric Ozone Depletion?

1. Stop use of all *ozone depleting* chemicals
2. Montreal Protocol- treaty's goal is to cut *CFCs* emissions by 35%

Why Should We Worry about Ozone Depletion?

1. More damaging *UV-A* and *UV-B* radiation reaches the Earth's surface.
2. Sunburns, skin *cancer*
3. Destroy *phytoplankton*- they play a key role in removing *CO_2* (primary producer)

Core Case Study: E-waste- an Exploding Problem

What is e-waste?

Discarded TVs, cell phones, computers, electronic toys, etc

Where does most e-waste end up and why is that an issue?

Most e-waste ends up in landfills and incinerators. This waste includes high-quality plastics and valuable metals. E-waste is also a source of toxic and hazardous pollutants like PVS, brominated flame retardants, lead, and mercury that can contaminate the soil, air, and water.

70% of e-waste is shipped to China, India, and parts of Africa where labor is cheap And environmental laws are almost non-existent.

The European Union uses a "cradle-to-grave" approach. What does this mean?

Cradle-to-Grave requires manufacturers to take back electronic products for repair, remanufacture, or recycle. The EU has also banned e-waste from landfills and incinerators.

Since recycling and reuse won't be enough to deal with the issue, what should electronic companies focus on doing to help deal with this problem?

The only real long term solution is prevention that gets toxic metals out of ewaste through green design.

What Are Solid Waste and Hazardous Waste, and Why Are They Problems?

Why is there no waste in nature?

The waste of one organism becomes nutrients for another.

How do humans differ from this principle?

Humans produce a tremendous amount of waste that goes unused and pollutes the environment.

Categories of Waste	Definition
1. Solid Waste	*Any unwanted or discarded material that is not liquid or gas*
2. Industrial Solid Waste	*Produced by mines, agriculture, and industries*
3. Municipal Solid Waste (MSW)	*aka "garbage" from homes and businesses* *EX: paper, cardboard, food waste, cans, glass, yard waste, plastic, etc*
4. Hazardous (Toxic) Waste	*Threatens human health or the environment because it is poisonous, dangerously chemically reactive, corrosive, or flammable.* *EX: industrial solvents, hospital medical waste, batteries, incinerator ash, radioactive waste from nuclear power plants*

**In developed countries, most MSW is buried in *landfills or burned in incinerators*.
In developing countries, most MSW ends up in *open dumps or surface water*.

Two reasons to sharply reduce the amount of solid and hazardous wastes we produce:

1. *At least ¾ of these materials represent unnecessary waste.*
   Instead, we collect, mix, crush, and bury many potentially valuable resources.
2. *In producing the products we use and often discard, we create huge amounts of air pollution, greenhouse gases, water polluter, and land degradation.*

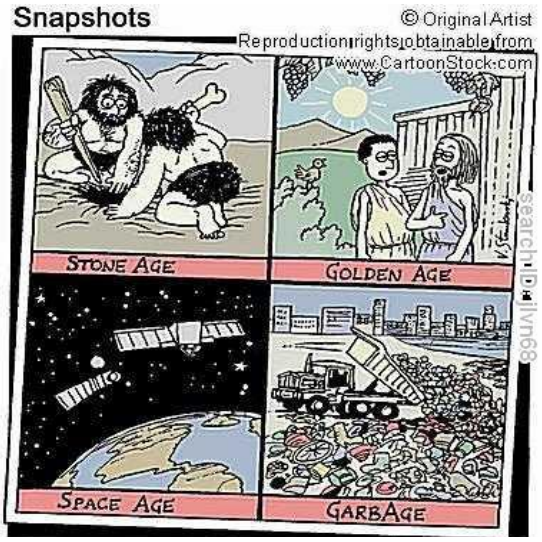
The US leads the world in producing *solid waste.* Most solid waste produced in the US is *mining waste (76%), agriculture (13%), and industry (9%)*.
A desktop computer requires *700* different materials. 1 lb of electronics creates *8,000 lbs* of solid and liquid wastes!
The US leads the world in trash production. Each day the average American produces *4.5 lbs* of MSW. The good news is that production of MSW has leveled off due to *increased recycling* and *lighter products*.

Case Study: Trash Production and Recycling in NYC

Describe why trash has decreased in NYC since 1940.

1. *MSW used to be really high because of the amount of coal ash produced from people burning coal in the home for heat and cooking.*
2. *NYC passed a mandatory recycling law in 1999.*

***In 2001, NYC ran out of landfill space and now trucks all of their trash to New Jersey, Pennsylvania, and Virginia…*



How Should We Deal with Solid Wastes?

Dealing with Solid Wastes:

Waste Management	*Attempt to reduce the impact of MSW without trying to reduce the amount of waste produced*
Waste Reduction	*Attempt to reduce waste and pollution; the waste is viewed as a resource that can potentially be reused, recycled, or composted.*
Integrated Waste Management	*A variety of strategies for waste management and waste reduction* First Priority: *Primary Pollution and Waste Prevention* *-change industrial processes to eliminate use of harmful chemicals* *-use less of the harmful product* *-reduce packaging* *-make products last longer* Second Priority: *Secondary Pollution and Waste Prevention* *-reuse, repair, recycle, compost* Last Priority: *Waste Management* *-treat waste to reduce toxicity* *-incinerate waste* *-bury waste in landfills*

Waste Reduction is based on 3Rs

Reduce	Reuse	Recycle
-Consume less *-Live simpler*	*-Rely more on products that can be used repeatedly* *-Use refillable cups*	*-separate and recycle paper, glass, cans, plastics, metal, etc* *-buy only recyclable products*

Seven strategies individuals and communities can reduce resource use, waste, and pollution:

1. *Redesign manufacturing processes and products to use less material and energy*
2. *Redesign manufacturing processes to produce less waste and pollution.*
3. *Develop products that are easy to repair, reuse, remanufacture, compost, or recycle.*
4. *Eliminate or reduce unnecessary packaging.*
5. *Use fee-per-bag waste collection systems.*
6. *Establish cradle-to-grave laws*
7. *Restructure urban transporation.*

Why is Reusing and Recycling Materials So Important?

Name some examples of reuse.

Reuse involves cleaning and using materials over and over.

-salvaging auto parts from junkyards, yard sales, flea markets, thrift stores, rechargeable batteries

What are the 5 major types of materials that can be recycled?

1. *Paper products*
2. *Glass*
3. *Aluminum*
4. *Steel*
5. *some Plastics*

Two types of recycling:

Primary (closed loop) Recycling:	Secondary Recycling:
Materials are recycled into new products of the same type *EX: turning an aluminum can into a new aluminum can*	*Waste materials are converted into different products* *EX: used tires can be shredded and turned into road or playground surfaces*

Switzerland and Japan recycle *50%* of their MSW.
The US recycles *25%* of their MSW.

Approaches to dealing with recycling:

Materials Recovery Facilities (MRFs or "murfs")	Source Separation	Fee-Per-Bag
-machines or workers separate the mixed waste to recover valuable materials *-the remaining waste is recycled or burned to produce steam that spins a turbine to create electricity to run the facility! (However, this does not solve the issue of toxic pollutants from burning trash)*	*-requires homes and businesses to separate their own trash into recyclable categories* *-this approach saves time, money, and produces less water and air pollution* *-however, some people may not be willing to do this and will just throw it away instead*	*-charges homes and businesses for the amount of waste picked up by the trash company* *-it does not charge for separated recyclable materials*

What is it?	Composting	What is the end product?
A form of recycling that mimics nature's recycling of nutrients by allowing decomposers to recycle yard waste, food waste, and other biodegradable materials		*Organic soil fertilizer, topsoil, or landfill cover*

Case Study: Recycling Paper

Which type of paper is easiest to recycle? *Newspaper and cardboard*

What is the process for recycling paper?

-the ink, glue, and coating is removed and then reconverted into pulp

Case Study: Recycling Plastics

How many different types of plastics are used? *46*

What problems occur when plastic is thrown away?

Plastic often ends up as litter on the ground or in water causing problems with wildlife ingesting the plastic.

3 reasons why we don't recycle plastic very much:

1. *Many plastics are hard to isolate from other waste. The resin is hard to separate.*

2. *Recovering individual plastic resins does not yield much material.*

3. *Inflation adjusted price of oil used to produce petrochemicals for making plastic resins is low enough to make the cost of making virgin plastic resins much lower than that of recycle resins.*

Advantages		Disadvantages
-reduces air and water pollution *-saves energy* *-reduces mineral demand* *-reduces greenhouse gas emissions* *-reduces solid waste production and disposal* *-helps protect biodiversity* *-can save landfill space*	Recycling	*-can cost more than burying waste in an area with ample landfill space* *-may lose money for items such as glass and some plastics* *-reduces profits for landfills and incinerator owners* *-source separation is inconvenient for some people*

Science Focus: What are bioplastics?

-made from biologically based chemicals like soybeans, corn, and switchgrass

How can we encourage reuse and recycling?

Government can increase subsidies and tax breaks for reusing and recycling materials and decrease subsidies and tax breaks for making items from virgin resources.

Use the fee-per-bag waste collection system.

Label products as recyclable or not.

What Are the Advantages and Disadvantages of Burning or Burying Solid Waste?

Advantages		Disadvantages
-reduces trash volume by 90% *-less need for landfills* *-low water pollution* *-concentrates hazardous substances into ash for burial*	Burning Solid Waste	*-expensive to build* *-costs more than short distance hauling* *-difficult to site because of citizen opposition* *-older facilities release large amounts of air pollution* *-creates dioxin (a super toxin that is a carcinogen)*

Describe the process of waste to energy incinerator.

The MSW is burned to make steam to spin a turbine to create energy.
The ash is sent to a landfill.
A scrubber and electrostatic precipitator are used to reduce SO2 emissions and particulate emissions.

Two types of Landfills:

Open Dumps	Sanitary Landfills
-fields or holes in the ground where garbage is deposited *-very rare in developed countries, but widely used in developed countries*	*-solid wastes are spread out in thin layers, compacted, and covered daily with a fresh layer of clay that helps keep the material dry and reduces leakage of contaminated water (leachate)*

How Should We Deal With Hazardous Waste?

Describe the Integrated Management of Hazardous Waste Approach:

Produce Less Hazardous Waste	Convert To Less or Non-Hazardous Substances	Put in Perpetual Storage
-Change industrial processes to reduce or eliminate hazardous waste production	*-Natural decomposition* *-Incineration* *-Chemical, physical, and biological treatment* *-Dilution in air or water*	*-landfill* *-underground injection wells* *-surface impoundments* *-underground salt formations*

Case Study: What is e-waste and why is it a problem?

e-waste recycling programs in poor nations often involve child workers that are being exposed to toxic chemicals

workers usually do not wear masks or gloves and work in rooms with no ventilation

some electronics are burned to expose copper, lead, and other metals

after the valuable metal is removed, the leftover parts are burned or dumped

Ways to detoxify hazardous waste:

Physical Method	Chemical Method	Biological Method	Phytoremediation	Plasma Arc Torch
Using charcoal or resin to filter out harmful solids and distilling liquids to filter out toxins *Deadly waste can be encapsulated and stored in secure storage sites*	*Converts hazardous chemical waste into less hazardous chemicals* *Cyclodextrin can remove solvents and pesticides from contaminated soil or groundwater*	*Bioremediation- uses bacteria and enzymes to destroy toxins to convert to harmless compounds* *Takes longer, but costs less*	*Uses natural or genetically modified plants to absorb, filter, and remove contaminants from soil and water* *EX: Sunflowers, willow trees, poplar trees*	*Passes hazardous waste through an electrical current at a very high temperature to create plasma* *This decomposes hazardous waste into ions and atoms that can be converted to a syngas*

Describe in detail the different types of Phytoremediation.

1. *Rhizofiltration*- roots of plants, such as sunflowers, can absorb radioactive strontium and cesium, and various organic chemicals.
2. *Phytostabilization*- plants, such as willows and poplars, can absorb chemicals and keep them from reaching groundwater
3. *Phytodegredation*- plants, such poplars, can absorb toxic organic chemicals and break them into less harmful compounds
4. *Phytoextraction*- roots of plants, such as Indian mustard, absorb toxic metals like lead and arsenic and then store them in their leaves

Storage of Hazardous Waste:

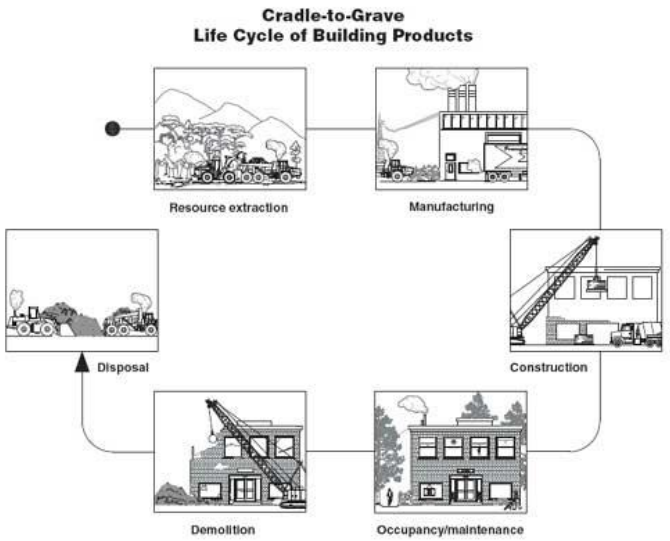
Deep Well Disposal	Surface Impoundments	Secure Hazardous Landfills
Liquid hazardous waste is pumped through a pipe into dry, porous rock formations beneath the aquifer. *Theoretically, the liquids soak into isolated rock, however there are cases where leakage into groundwater has occurred.*	*Ponds, pits, or lagoons are lined and hazardous waste is stored within.* *As the water evaporates, the waste settles to the bottom.* *These can leak into groundwater if the liner fails and heavy storms can cause it to overflow.*	*Hazardous waste is put into drums or other containers that are buried and carefully designed and monitored*

Case Study: Hazardous Waste Regulation in the US

Resource Conservation and Recovery Act-

Sets standards for management of hazardous waste and issues permits to companies allowing them to produce and dispose of a certain amount of waste

Companies will use the cradle-to-grave system.



CERCLA- *aka Superfund Act*

Goal is to identify sites where hazardous waste has contaminated the environment and to clean them up on a priority basis.

The cost of cleaning up 10,000 sites would cost $1.7 trillion!

Citizens have also been given the right to know what toxic chemicals are present in their community= *Toxic Release Inventory*

Brownfields= abandoned industrial and commercial sites such as factories, junkyards, and gas station

-can be cleaned up and turned into a park, nature reserve, etc

How Can We Make the Transition to a More Sustainable Low-Waste Society?

How have grassroots led to better waste management?

Individuals have organized to prevent the construction of hundreds of incinerators, landfills, treatment plants for hazardous and radioactive waste, etc near their communities. This has forced companies to look for better/more efficient methods.

What is environmental justice and why is it important?

Every person is entitled to protection from environmental hazards, regardless of race, gender, age, national origin, incomes, social class, etc.

Studies show that a disproportionate amount of polluting factories and waste dump sites are located in communities population by the poor.

What are POPs?

Persistent Organic Pollutants that biomagnify through the food chain and persist in the environment for a very long time.

What is the "dirty dozen?"

It is a list of 12 POPs that includes DDT, PCBs, dioxins, and furans. The long term health effects are widely unknown.

Core Case Study: The Global HIV/AIDS Epidemic

Describe why people die of AIDS if AIDS itself is not deadly.

AIDS destroys the immune system, therefore people will die from other diseases that the body could not fight off.

List 3 ways the virus is transmitted person to person.

1. *Unsafe sex* 2. *Sharing needles* 3. *Infected mothers pass to babies*

Explain how AIDS has impacted the populations of African regions.

-*AIDS has reduced the life expectancy in Africa from 62 to 47 years old.*
-The premature death of teachers, healthcare workers, soldiers, etc has led to diminished education, healthcare, and food production.
-Millions of children are orphans.

What Major Health Hazards Do We Face?

Define: Risk- *probability of suffering harm from a hazard that can cause injury, disease, death, economic loss, or damage*

Risk Assessment- *using statistical methods to estimate how much harm a hazard has to human health or the environment*

Risk Management- *deciding whether or how to reduce a risk and at what cost*

5 Major Types of Hazards:

Biological Hazards	*from more than 1,400 pathogens that infect humans EX: bacteria, viruses, protozoa, parasites, fungi*
Chemical Hazards	*from harmful chemicals in the air, water, soil, and food*
Physical Hazards	*fire, earthquakes, volcanic eruptions, floods, and storms*
Cultural Hazards	*unsafe working conditions, unsafe travel, poverty*
Lifestyle Choices	*moking, eating too much, drinking too much alcohol, unsafe sex*

What Types of Biological Hazards Do We Face?

Disease	Caused By…	Examples
1. Nontransmissible	*something other than a living organism and does not pass person to person*	*heart disease, most cancers, asthma, malnutrition*
2. Infectious	*A pathogen, such as bacteria, viruses, or parasites, that invade the body multiplies in its cells and tissues*	*Flu, HIV, tuberculosis, measles*
-Transmissible	*An infectious disease that can be transmitted from one person to another*	*Flu, HIV, tuberculosis, measles*

The 3 major causes of death are:

cardiovascular disease, infectious disease, cancers

Why has the average life expectancy increased in most countries?

The #1 cause of death used to be from infectious disease. This has been reduced by better healthcare, the use of antibiotics, and the development of vaccines.

List the major pathways for infectious diseases in humans:

pets, livestock, wild animals, insects, food, water, air, other humans

Epidemic vs. Pandemic

-large scale outbreaks in one region or country

-a global outbreak

Tuberculosis:

Prevalence:	Why has there been an increase in TB?	How can we slow the spread of TB?	What is multi-drug resistant TB?
9.2 million people per year	*-too few TB screenings and control programs* *-many strains have developed genetic resistance to antibiotics* *-increased global travel*	*-early identification and treatment* *-use of 4 inexpensive drugs that must be taken for 6-8 months*	*A deadly and incurable strain of TB has formed because it is now resistant to medication. Those infected must be quarantined.*

Science Focus: Genetic Resistance to Antibiotics is Increasing

1. What is causing bacteria to become resistant to antibiotics?
   -bacteria multiplies rapidly, increased international travel, availability of antibiotics without a prescription are taken improperly, antibacterial handsoaps

2. What is MRSA and why has it become a problem?
   -MRSA is a staph infection that has become resistant to antibiotics and is being found more often in public places.
   -The infection causes painful, pus filled bumps on the skin.
   -MRSA can cause a form of pneumonia, flesh eating wounds, and death if it gets into the blood.

Describe each of the deadly viruses below:

Influenza	HIV	Hepatitis B	West Nile	SARS

Malaria:

Prevalence:	Caused by:	Symptoms:	Malaria-prone areas:	Why is malaria increasing?	What is being done to help?
Kills 1-2 million per year	*The parasite, plasmodium, infects mosquitos that bite humans*	*Destroys red blood cells causing fever, chills, anemia, abdominal pain, weakness*	*Sub-Saharran Africa, India, South Ameria*	*-clearing of tropical forests* *-the Anopheles mosquito has become resistant to insectidies* *-global warming*	*-development of new antimalarial drugs, vaccines, and biological control* *-genetically engineering a malaria resistant mosquito that will outcompete the other mosquitos* *-mosquito nets*

Solutions to infectious diseases do you believe are most important?

-increase research on tropical diseases and vaccines
-reduce poverty
-decrease malnutrition and improve drinking water
-reduce unnecessary use of antibiotics
-reduce antibiotic use in livestock

What types of Chemical Hazards Do We Face?

List the 5 most toxic substances to human health:

1. arsenic 2. lead 3. mercury 4. vinyl chloride 5. PCBs

Describe the 3 major types of toxic agents:

Carcinogens	Mutagens	Teratogens
-causes cancer *EX: arsenic, benzene, chloroform, formaldehyde, PCBs, radon, UV light*	*-causes mutations in DNA* *EX: some preservatives in food*	*causes harm or birth defects to a fetus or embryo* *EX: ethyl alcohol, lead, formaldehyde, mercury, PCBs*

PCBs:

1. What was it used for? *A class of 200 chlorine containing compounds that were widely used as lubricants, hydraulic fluids, electrical insulators, ingredient in paints, fire extinquishers, fire retardants in fabrics, and pesticides.*

2. Why was it banned? *Banned in 1977 by the US Congress because it has been linked to liver cancer and learning disabilities in children*

3. Why are PCBs still causing issues even after it has been banned? *PCBs are persistent chemicals that breakdown very slowly and are fat soluble and can be biomagnified. Therefore, it can still be found in our soil, air, and water.*

Briefly describe how chemicals affect each of the body systems:

Immune System	Nervous System	Endocrine System
-some chemicals like arsenic, methylmercury, and dioxins weaken the immune system to the point where it can't fight off diseases	*-chemicals that are neurotoxins can cause behavioral changes, learning disabilities, retardation, ADD, and paralysis*	*-Endocrine disruptors* *-some chemicals are HAA (hormonally active agents) that mimic hormones that impair reproductive development as well as physical disorders* *EX: atrazine, DDT, PCBs, BPA* *-some chemicals are hormone blockers*

Mercury:

1. Where does it come from?
   Natural Sources- released from rocks, soil, volcanos
   Human Sources- coal burning power plants, waste incinerators, metal ore smelters
2. Why is New York a hotspot for Mercury?
   -coal burning power plant emissions
3. How are humans exposed to Mercury?
   1. *Inhale vaporized mercury*
   2. *Eat fish that are contaminated (mercury biomagnifies through food chain)*
4. What problems can Mercury cause?
   -it is a teratogen and neurotoxin
5. List 3 solutions to Mercury Pollution.
   1. *Phase out waste incineration*
   2. *Remove mercury from coal before it is burned*
   3. *Switch to more renewable sources of energy*

Bisphenol A (BPA):

1. Where can BPA be found?
   Found in plastics, baby bottles, plastic bottles, microwave dishes, etc
2. What is its effect on humans?
   Brain damage, prostate disease, breast cancer, early puberty, type 2 diabetes

How Can We Evaluate and Deal with Chemical Hazards?

Define: Toxicology- *study of harmful effects of chemicals*

Toxicity- *measure of how harmful a substance is*

Dose- *amount of chemical that has been ingested or absorbed*

Persistence- *a chemical's resistance to breaking down*

Biological Magnification- *the concentration of some toxins increase as it moves through the foodchain*

Response- *the damage to health caused by chemicals*

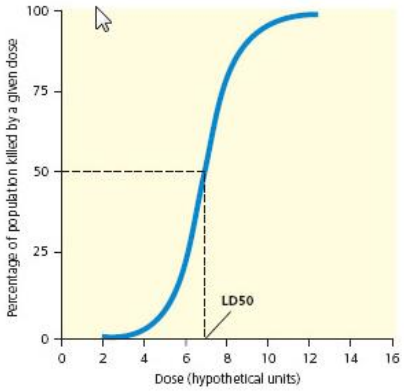
Why are infants and young children most susceptible to effects of toxic substances?
less developed immune systems; kids eat, drink, and breathe more per unit of body weight; more likely to put toys and soil into their mouths

Why are mice and rats widely used in laboratory testing?
Mice and rats are mammals that have body systems similar to ours and reproduce rapidly.

Dose-Response Curve:

What is LD50 and why is it an important number?
LD50= lethal dose to 50% of population

The dose response curve helps scientists determine the effects of various doses.



Non-threshold dose- any dosage causes harm
Threshold dose response- a certain dosage must Be reached before any harm is detected.

Describe 4 potentially harmful chemicals that could be found in your home.

1. *Vinyl toys contain phthalates*
2. *Water bottles can contain BPA*
3. *Mattress contains flame retardant chemicals*
4. *Imported fruit contains pesticides*

Chemical Toxin	Sources	Human or Wildlife Health Impact
PCBs	• Used as electrical insulators, fire retardant materials, pesticides, and as adhesives	• Neurotoxin causing brain damage in fetuses • Endocrine disruptor causing reproductive cancers
DDT	• A commonly used pesticide in the US prior to banning it in 1972 • Still used in developing countries to control malaria and pests	• Biomagnifies in the food chain of ecosystems • Causes reproductive damage and cancers in avian (bird) populations
Phthalates	• Group of chemicals used in the production of plastics • Used as solvents in many products such as vinyl flooring, adhesives, detergents, and some personal care products like shampoo and soap	• Causes reproductive damage and cancers
Atrazine	• One of the most widely used pesticides in the US • Herbicide primarily used to control weed populations in the Midwest	• This pesticide is currently being monitored by the EPA to determine if it is linked to endocrine cancers
Bisphenol A (BPA)	• A chemical building block for plastic consumer goods such as water bottles, food containers, and microwavable dishes	• Some evidence suggests exposure can lead to neurological damage and reproductive cancers
Heavy Metals (mercury, arsenic, lead, cadmium)	• Heavy metal pollution is often generated from smelting metals and incineration of municipal waste • Elemental mercury is used in batteries and fluorescent lights • Inorganic mercury released from coal burning is converted to toxic methyl mercury by bacteria	• Heavy metals often biomagnify in the food chain • Cause neurological damage especially to fetuses • Can be carcinogenic
Benzene	• Emissions from burning coal and oil and tobacco smoke	• Short-term exposure causes dizziness and nausea • Long-term exposure causes damage to the liver and reproductive system, cancer, and birth defects
Vinyl Chloride	• Is a precursor to making PVC, which is commonly used in building materials and many consumer products	• Causes cancers, especially liver cancers • Can do damage to central nervous system • Is known to cause birth defects
Asbestos	• A naturally occurring silicate mineral formerly used in insulation materials for its fire-retardant properties	• Known to cause cancer
Dioxins	• A class of chemical compounds formed during incineration of waste materials and also in the manufacturing process of some herbicides	• Accumulate in fatty tissue of organisms (bioaccumulation) • Carcinogen • Causes reproductive damage