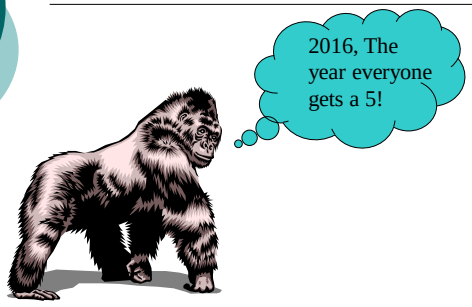
APES year in review

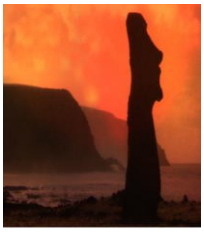


Introduction

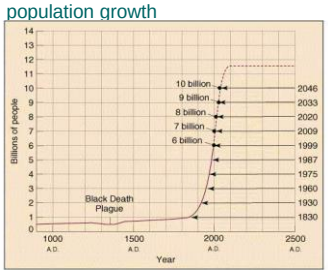
- Understand how natural world works
- Understand how human systems interact with natural system
- Accurately determine environmental problems
- Develop and follow a sustainable relationship with natural world

Easter Island

Sustainability
- A system/process can continue indefinitely without depleting resources used.
no sacrifice to future generations
Stewardship
Caring for something that does not belong to you
Sound Science
Use the scientific method



A. Human population growth



- More than 7 billion people currently
- last 25 yrs population grew by 2 billion
- projected that population will be 10 billion by 2050
- increase pop → increase need for resources

B. Soil degradation

- Demand for food destroys the soil
  - erosion
  - minerals in soil are depleted
  - salinization
  - increased use of pesticides
  - Overuse of fresh water

C. Global Atmospheric Changes

Global Warming
- CO_2 produced from fossil fuel burning acts like a blanket around the earth.
- Plants take CO_2 out of the atmosphere through photosynthesis
  - $6CO_2 + 6H_2O \Rightarrow 6O_2 + C_6H_{12}O_6$

Ozone depletion
- Chemicals released from the surface of the earth destroy our ozone shield.
- No stratospheric ozone, no protection from the UV rays of the sun.

D. Loss of Biodiversity

- Habitat destruction leads to a loss of many species starting with the plants
- exact # of species lost is unknown because not all species are identified
- strong ecosystems need biodiversity
- 1959-1980 25% of all prescription drugs from natural resources
- Wild species keep domestic species vigorous
- Aesthetics

•Rachel Carson was a scientist who wrote Silent Spring in 1962.
•It addressed the growing use of pesticides (DDT) and their unpredicted effects on song birds.
•Original users of pesticides did not know that the poisons used to kill insects would accumulate in other living things and kill them too.
BIOACCUMULATION

More Cool Environmentalists

- John Muir – Sierra Club
- Ansel Adams – Photography (Yosemite)
- Aldo Leopold – Sand County Almanac
- Henry David Thoreau – Walden
- Garrett Hardin – Tragedy of the Commons

Ecosystems

Levels of organization of matter
Universe
Ecosphere/biosphere
Ecosystems
Communities
Populations
Organisms
Cells
Atoms

Ecosystems

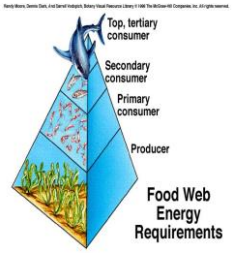
Plants and animals interacting with their abiotic environment. Ecosystems exist in biomes.

- Climate – ave temperature over time
- Weather – daily variations in temp and precipitation
- Microclimate and Other Abiotic Factors
  - light intensity
  - soil type
  - topography

Trophic Relationship

Food webs

- Trophic levels
  - producers
  - herbivores
  - primary carnivore



Biomass and Biomass Pyramid

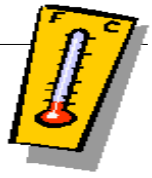
- All biomass gets its energy from the sun
- Only 10% of energy from one trophic level moves to the next trophic level
- Energy released is high potential energy molecules (like glucose) then converted to low potential energy molecules (like carbon dioxide)

* concept of eating lower on the biomass pyramid

Relationships

- Mutualism
  - *Flowers & insects
- Commensalism
- Predator/prey
- host parasite
- Competition
- habitat vs. niche

Limiting Factors



Temperature, light, oxygen, carbon dioxide, precipitation

- Optimum levels
- Zones of stress
- Limits of Tolerance
- Range of Tolerance

Synergistic effects – The interaction of two or more factors is greater than the sum of the effects when each acts alone. Example: pollution and disease

Ch 3: Ecosystems, how they work

- Recycle or Die
- All matter is recycled through the lithosphere, hydrosphere, and atmosphere.
- Nothing is created nothing is destroyed
- All stable ecosystems recycle matter and get energy from the sun

Physics

- Energy is measured in calories
  - Calorie – amount of heat needed to raise 1 gram of water 1 degree Celsius.
  - Kilocalorie = 1,000 calories
- 1st law of thermodynamics
  - Energy cannot be created nor destroyed, only change forms (light to chemical)
- 2nd law of thermodynamics
  - Energy transformation increases disorder (entropy) of the universe.
  - Heat is the lowest grade of energy.

Chemistry

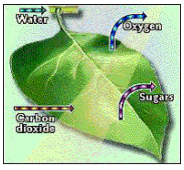
- **Atoms –** basic units of matter
  - Electron
  - Proton
  - Neutron
- **Chemical bonds -** how atoms are held together
  - **Ionic**
  - **Covalent**
- **Molecule/compound** – two or more atoms bonded together
- **pH scale**
  - Base/alkaline
  - Acid

Organic Compounds

- C-C bonds and/or C-H bonds
- They can be natural or synthetic
  - **Natural:** compounds that make up living systems
  - **Synthetic:** man-made compounds

Photosynthesis

- Very inefficient (Only 1% of the energy from the sun is used)
  - Chlorophyll – absorbs light to drive photosynthesis
- Plants use glucose to:
  - Construct other molecules
  - Build their cell wall
  - Store energy
  - Source of energy



Carbon cycle

- Remember the carbon cycle game
- Photosynthesis!
- Moving fossil fuels (which took millions of years to form) to the atmosphere (in hundreds of years) is a major component of global warming.
- Hydrocarbon fuels to CO_2

Nitrogen cycle

- Main reserve in the atmosphere
- Living things must get N from ammonium (NH_4) or nitrate (NO_3)
- N from the atmo must be fixed
  - Change N_2 into ammonium or nitrate
  - Rhizobium (bacteria living in roots of legumes)
  - Industrial
  - Lightning
  - Burning fossil fuels

Phosphorus cycle

- No gas phase, only solid and liquid
- Man-made fertilizers contain organic phosphates
- Because P is a limiting factor in aquatic systems, it leads to eutrophication
- The rain forest is very good at recycling P, except when we cut it down…

element	Main nonliving reservoir	Main living reservoir	Other nonliving reservoir	Human-induced problem
Carbon C	Atmo CO2	Carbohydrates (CH2O)n And all organic molecules	Hydro Carbonate (CO3-2) Bicarbonate (HCO3-) Litho minerals	Global warming Carbon from fossil fuels underground are burned and released into the air as CO2
Nitrogen N	Atmo N2	Proteins and other N-containing organic molecules	Hydro Ammonium NH4+ Nitrate NO3- Nitrite NO2-	Eutrophication Fertilizers contain human-made nitrates that end up in the water
Phos-phorous P	Litho rocks as PO4-3 *no gas phase	DNA ATP phospholipids	Hydro Phosphate PO4-3	Eutrophication Fertilizers contain human-made phosphates that end up in the water Cutting down rainforest stops recycling of P

Population and Succession

•Most abundant elements in living things (not in order)

* CHONPS

•Top 8 elements in the earths crust (in order)

* O, Si, Al, Fe (iron), Ca, Na (sodium), P, Mg

Only silly apes in college study past midnight.

Biosphere II

- Purpose: recreate conditions of Earth (Biosphere I)
  * to understand our world better
  * space travel
- 5 acres in Arizona, 4000 species, 10 humans
  * problem: 0_2 + CO_2 were absorbed by concrete
  * ants and cockroaches took over

Fires in Ecosystem

- Maintain balance of species and energy in ecosystems over the long run.
- Beneficial b/c provide nutrients for soil
- We avoid natural fires, but the problems like Crown Fires- (not natural) kill the whole tree
- 1988 Yellowstone fires changed climax ecosystems of white bark pine trees to huckleberries. Grizzlies eat both.

Succession - One species gradually replaced by another in an ecosystem

- Primary – new ecosystem where there were no living things before. Cooled lava, receded glacier, mud slide
- Secondary- ecosystem used to be there. Fire, humans clear an area
- Aquatic – lakes taken over by terrestrial ecosystem
- Climax ecosystem- in balance only changes if major interference

Primary succession

•Must create new soil for plants to grow
•The first plants to come in are called pioneer species
- •Lichen
- •Moss
- •Microbes

Evolutionary Change

Vocabulary that you need to know
- * DNA
- * Chromosome
- * Gene
- * Allele

Central Dogma:
DNA- blueprint
RNA- carpenter
Protein- house, wood

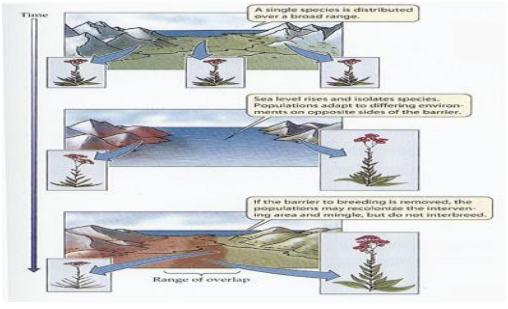
Mutations

- Mutations are naturally random events
  - * Normal variation
  - * Chemical
  - * UV
  - * Radiation
- Genetic Trait- only passed down if an organism reproduces

Why do species change?

- Environmental resistance and biotic potential
- Selective pressure on mutations
- Speciation
  - * creation of a new species based on reproductive isolation

Speciation (Galapagos Finches)

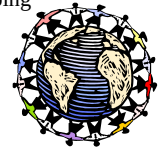


Geological Context (space and time for evolution)

- Plate tectonics
- Geological time scale
- Cambrian explosion
- Selective breeding
- Artificial selection
- Natural selection

The Human Population

- World population trends
- Calculations
- Demographic transition
- Age structure diagrams
- Developed vs. developing countries
- Fertility rates
- World bank
- 1994 UN conference in Cairo- program of action



Population Growth Rates

(b) crude birth rate= number birth per 1000 individuals
(d) crude death rate= number death per 1000 individuals
(r) growth rate = natural increase in population expressed as percent per years (If this number is negative, the population is shrinking.)

equation:

rate = birth – death

But other factors affect population growth in a certain area…

Population growth rates

increase population
births ➔
immigration ➔

decrease population
➔ deaths
➔ emigration (exit)

r = (birth - death)+ (immigration-emigration)

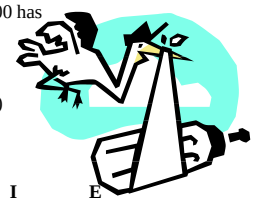
immigration = migration of individuals into a population from another area or country

emigration = migration of individuals from a population bound for another country

Growth Rate Example

r = (birth - death)+ (immigration-emigration)

example: population of 10,000 has
100 births (10 per 1000)
50 deaths (5 per 1000)
10 immigration (1 per 1000)
100 emigration (10 per 1000)



You try.

B D I E

r=(10/1000) – (5/1000) + (1/1000) – (10/1000)
r=(0.01-0.005) + (0.001 – 0.01)
r = 0.005 – 0.009 = -0.004 or –0.4% per year

If the growth rate is 1% and the population size is 10,000, how many years will it take to get to a population of 40,000?

Population doubling:

70/rate =70/1% =70 years to double

In 70 years the population will be 20,000

1 D.T. ⇒ 20,000

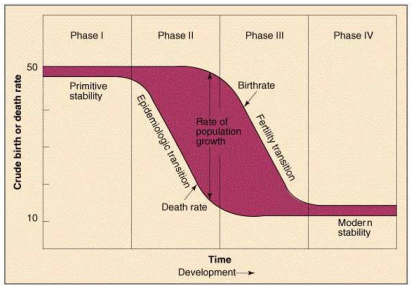
2 D.T. ⇒ 40,000

(70 years)(2) =140 years

In 140 years, the population will be 40,000 people.
SHOW YOUR WORK!!!!!!!!!

Demographic Transition

Demographic Transition



Bottom Line= as countries develop, first their death rate drops and then their birth rate drops

Reasons for the phases:

Phase II:
- medical care
- nutrition (births still high)
- technology

Phase III:
- birth control
- education (of women)
- lower mortality rate of infants
- less child labor

Developed vs. Developing

Developed Countries

- Canada, U.S., Australia, Western Europe (Denmark)

Developing Countries

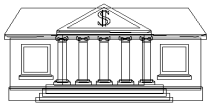
- Latin America, China, Africa (Kenya)
  - 1/5 of the world's pop. Lives in absolute poverty, illiterate, lack clean H2O and don't have enough food
  - 80% of world's pop. Lives in developing co. and growing

Fertility Rates

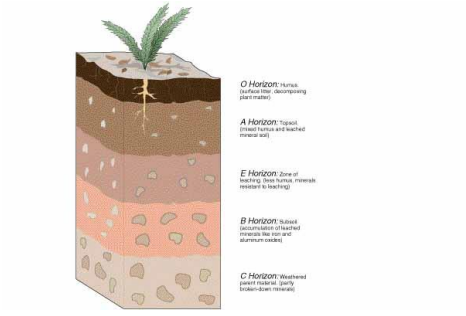
- Total fertility= avg. # of children born per woman
- For developed countries = 2.1
- For developing countries = 2.6
- Fertility of 2.0= replacement level
  - Under 2.0 = shrinking population
  - Over 2.0 = growing pop.
- For developed countries = 2.1
- For developing countries = 2.6(or higher)

World Bank

- Special agency of the United Nations
- Receives $$ from developed co. and loans $$ to developing co.
  - Sometimes this backfires by increasing debt
- Oversees all types of issues, not just environmental issues
  - Ex. electricity, roads, new modern technology

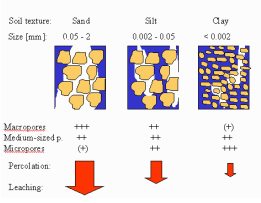


Soil
(Dust Bowl, Porosity, Permeability)



Texture

- Sand 2.0-.02 mm
- Silt .02-.002 mm
- Clay.002mm ≥ some microscopic



LOAM:

40%sand 40% silt 20% clay
Loam is theoretically the ideal soil

Classes of Soil

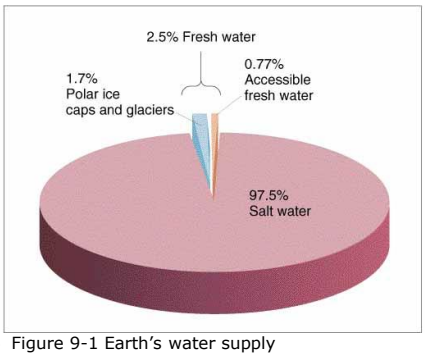
Mollisols- very fertile, dark, found in temperate grasslands, best agricultural soil, Deep A horizon

Oxisols- soil of tropical and subtropical rainforest layer of iron and Al oxides in B horizon, little O horizon

ALFISOLS- WEATHERED FOREST SOIL, NOT DEEP, BUT DEVELOPED OAE+B TYPICAL OF MOST TEMPERATE FOREST BIOME. NEED FERTILIZER FOR AGRICULTURE

Aridsols- dry lands + desert, lack of vegetation, lack of rain → unstructured vertically, irrigation leads to salinization b/c of high evaporation.

Water

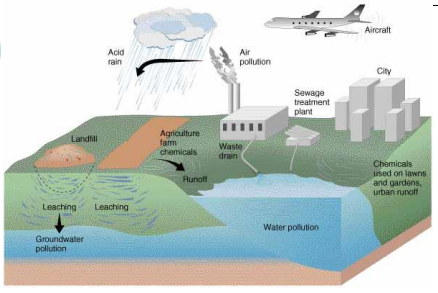


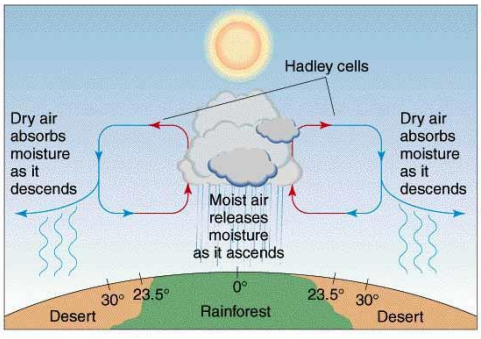
- Figure 9-1 Earth's water supply

Water Facts

- The primary use for fresh water in U.S. is for agriculture.
- In our homes, we use the most fresh water to wash, clean and flush.
- The typical person in an industrialized nation uses 700-1000 gallons per week!

Human effects on the Hydrologic Cycle





(a) Hadley cells at the equator

- Figure 9-5a Global air circulation

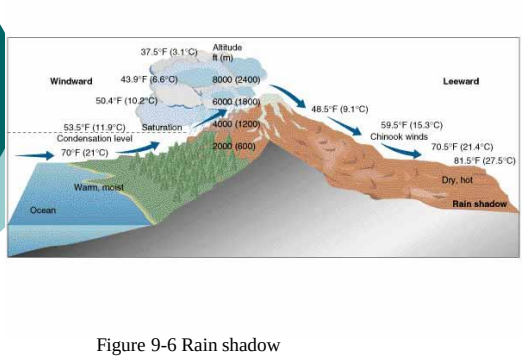


Figure 9-6 Rain shadow

The Ogallala Aquifer

Figure 9-16 Exploitation of an aquifer

Mono Lake

- Excellent example of human interference with the water supply.
- The water in the lake was diverted from the lake to the city of Los Angeles. It became a salt bed.
- ↑ Salt concentration due to evaporation

Three Gorges Dam in China

- China needs to meet the growing demand for energy
- Huge environmental impact
- Hundreds of thousands of people will be displaced (not to mention the ecosystems which will be flooded)

Food

Genetically altered food, Irish Potato Famine

Air
- Greenhouse gas emissions from fossil fuels
- Other air pollutants from fossil fuels
- Pollutions from pesticide sprays

Soil
- Erosion
- Loss of fertility
- Salinization
- Waterlogging
- Desertification

Water
- Aquifer depletion
- Increased runoff and flooding from land cleared to grow crops
- Fish kills from pesticide runoff
- Surface and groundwater pollution from pesticides and fertilizers
- Over fertilization of lakes » eutrophication

Major Environmental Effects of Food Production

Biodiversity Loss
- Loss and degradation of habitat from clearing grasslands and forests and draining wetlands
- Fish kills from pesticide runoff
- Killing of wild predators to protect live stock
- Loss of genetic diversity from replacing thousands of wild crop strains with a few monoculture strains

Human Health
- Nitrates in drinking water
- Pesticide residues in drinking water, food, and air
- Contamination of drinking and swimming water with disease organisms from livestock wastes

The Green Revolution

- To eliminate hunger by improving crop performance
- Movement to increase yields by using:
  - New crop cultivars
  - Irrigation
  - Fertilizers
  - Pesticides
  - Mechanization

Results:

- Did not eliminate famine
- Population still increasing
- Increase cost of production
- An increased negative environmental impact
- Didn't work for everyone

Protection of Biodiversity and Ecosystems

- Threatened – if the trend continues, the species will be endangered.
- Endangered – if the trend continues, the species will go extinct.
- Pharmaceuticals and native plants → Approximately 25% of drugs used as medicines come from natural plant sources.
- The Exxon Valdez Oil Spill (1989) → 300,000 birds died as a result of that particular oil spill. The area, Prince William Sound, is still recovering.

Know Specific Details about…

These Endangered animals (and check Barron's examples):

- Wild Turkey – a success story
- Whooping Crane- Eggs raised by sandhill cranes led to problems, but the efforts proved successful overall.
- Peregrine Falcon- DDT
- Spotted Owl- deforestation
- Fish living in George's Bank (off New England)-The marketable fish were over fished and other species took over. An example of poor management of fisheries.

Endocrine Disrupters

- Interfere with normal hormone action
- Can interfere with development
- Are often connected to cancer
- Can interfere with sexual activity (alligators)
- Are found in plastics and some pesticides

Fossil Fuels

Exxon Valdez, Drilling in ANWR

Coal-several (400) hundred years

Natural Gas – at least a 50 year supply in the United States

Oil- about a decade until supplies peak

Important energy facts

- Brief history of energy
  - *1700-1800 Fire wood
  - *1900-1920 Coal
  - *1950- now crude oil
- "production of crude oil" = with drawing it from reserves
- OPEC (pg 319) organization of petroleum exporting countries (Mid-east countries mainly)

More Energy Facts

- We get 50% of our crude oil from foreign sources
- Alaska pipeline built to help increase production of domestic crude oil
- Types of coal:
- Peat (not coal) → Lignite (brown coal) → Bituminous coal (soft coal with high sulfur) → Anthracite (hard coal with low sulfur)

Oil: The Most Important Fossil Fuel in the American Economy

Environmental Consequences

1. Production: local ecosystems damage possible
2. Transport: oil spills cause local and regional ecosystem damage
3. Use: photochemical smog, particulates, acid precipitation, carbon dioxide

Coal

- Environmental Consequences

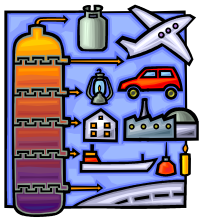
1. Production: ecosystem damage, reclamation difficult, acid mine runoff, mine tailings, erosion, black lung, radon
2. Transport: energy intensive because of weight and number of train cars needed
3. Use: fossil fuel with largest source of carbon dioxide and greatest quantity of contaminants, large volume of waste, acid precipitation

Natural Gas

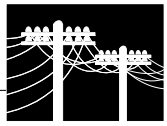
Possibly a transition fuel between fossil fuel and alternative energy sources.

- Environmental Consequences:

1. Production: local ecosystem damage possible if oil or coal is part of the deposit
2. Transport: can be explosive
3. Use: produces the least air pollutants of all the fossil fuels



Electricity



1. Electricity is a secondary energy source because it relies on another energy source to create the electricity.
2. Basic production of electricity-boil water to produce steam to turn turbines to generate electron flow through a wire.
3. Examples of primary sources for electrical production
   1. 20% from nuclear
   2. 57% from coal
   3. Oil, geothermal, solar, wind, hydroelectric (no boiling water required for these sources)

Is electricity a clean energy source?

Nuclear Power

A. Pros: No CO_2 emissions, no particulate emissions

B. Cons: Radiation can lead to damaged DNA, costs, radioactive waste, thermal pollution

C. Basically- the splitting of uranium's nucleus gives off heat that can be used to boil water and turn a turbo generator to create electricity.

D. Naturally occurring Uranium is mined.

Nuclear important facts

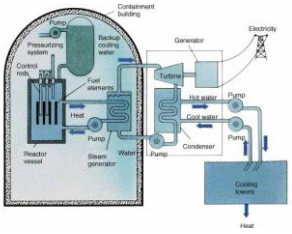
- Fusion- the combination of 2 atoms to form a larger atom
- Fission- splitting an atom
- Nuclear Regulatory Commission is the US governmental Agency that regulates nuclear power plants
- Radioisotope= unstable radioactive isotope

Uranium

- Uranium 235 has 92 protons and 143 neutrons. It is radioactive and used as fuel in nuclear reactors.
- When U235 is hit by a neutron, it is split (fission) into two smaller elements such as Kr and Ba plus three neutrons which sustain the chain reaction.
- Most (99.3%) of the naturally occurring uranium is U238.
- For a nuclear reactor, this must be purified to 4% U235 and 96% U238. (very expensive)

D. How does a Power Plant Operate?

a. Water moderator: slows down neutrons
b. Neutron-absorbing material- control rod
c. Fuel Rods- approximately one third replaced each year
d. Heat transfer system
e. Cooling system
f. Redundant safety systems

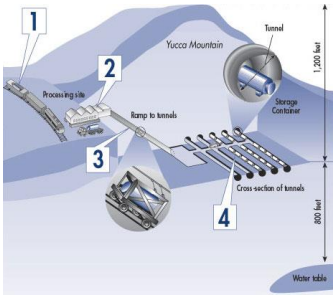


Waste Disposal

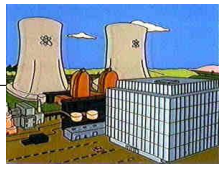
All fuel rods are still in cooling ponds at commercial nuclear facilities

Proposed site for disposal - Yucca Mountain in SE Nevada

Concerns: Geological active area, Intrusion of water table, distances for wastes travel, radioactive decay and half-lives



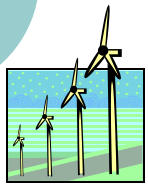
Accidents

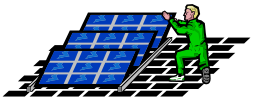


- Chernobyl:
  - 4/26/86
  - Ukraine
  - complete meltdown.
- Three Mile Island:
  - 3/28/79
  - Pennsylvania (Harrisburg)
  - partial meltdown, no one known to be hurt.

Renewable Energy

- Sunlight, wind, falling H_2O, geothermal
- Not fossil fuels, not nuclear





Indirect Solar power

- How does it affect…
- Wind?
- Hydropower?
- Firewood?
- Hydro carbon fuels?
- Nuclear and Geothermal are not indirect solar

Solar Energy

Passive solar

- Large south-facing windows, heavy drapes to trap heat at night, interior bricks to trap heat
- Shade windows in summer
- Even though back up systems are required, and solar heating may only lessen the need for heating oil a few %, it will help us adapt to diminishing oil supplies.

Active solar

- Photovoltaic (PV) panels can be used to convert the energy from the sun into electricity.
- Electrons from the silicon in the PV panel are "pushed" through a wire by photons from the sun creating an electric current.

Risks and Pests

Borneo (DDT), MTBE

Hazard - Anything that causes:

1. Injury, disease, or death to humans
2. Damage to property
3. Destruction of the environment

Cultural hazard - a risk that a person chooses to engage in

Risk

The probability of suffering (1, 2, or 3) as a result of a hazard

Perception

What people think the risks are

Cigarette Smoking

- Leading cause of cancer in U.S.
- Can cause cancer, lung disease, a bigger risk of death in addition with other types of air pollution.
- Highest health risk in U.S.

Insecticides/Pesticides

- Integrated pest management includes:
  - adjusting environmental conditions
  - chemical pesticides
  - disease resistant varieties
  - crop rotation
  - biological controls
- Insecticides kills plants, mammals, fish, birds
- A broad spectrum pesticide is effective towards many types of pests

- DDT accumulates in fat body tissues of animals
- DDT was not used for handling weeds
- DDT is, persistent, synthetic organic compound and a subject to biomagnifications in food chains

Diseases

- Lyme disease can be processed to humans through a bite from an infected tick
- Mosquitoes causes Malaria, the vector for Plasmodium
- The protozoan of the genus Plasmodium is the causative agent of malaria

Diseases cont'd

- Lack of access to safe drinking water is a major cause of disease transmission in developing countries.
- Epidemiology is the study of the presence, distribution and control of a diseases in a population
- Morbidity is the incidence of disease in a population
- Mortality is the incidence of death in a population

Water Pollution

- Sewage treatment is a common practice
- In the 1970's many cities were still dumping raw sewage into waterways
- In 1972, the Clean water act provided funding for upgrading sewage treatment plants
- Currently water ways are the much better
- 1°, 2° use preliminary but no more
- Test for sewage contamination in drinking H2O → Fecal Coliform test

Sewage Treatment

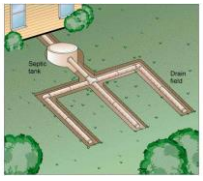
- Raw sewage (99% H2O)
  - → Preliminary Treatment- allow grit to settle
  - → 1° separating Raw Sludge from H2O
  - → 2° AKA Biological Treatment- bacteria feeds on the organic material
  - → Trickling filters contain bacteria → remove raw sludge from the H2O
- Raw Sludge <u>May</u> contain heavy metals

If it does it needs 3° treatment, to remove the toxic chemicals

Home Septic Systems:

→do not use Chlorine

- → Do use settling tank to settle organic solids
- → Lets waste water percolate into the soil bacterial decomposition



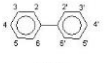
Municipal Solid Waste

- 210,000,000 tons of municipal solid waste (MSW) are disposed of annually in the United States.
- Most of that waste is paper.
- Fifty-five percent of MSW is disposed of in landfills.
- 17% of MSW is combusted, mostly in waste-to-energy (WTE) combustion facilities. What are the advantages and disadvantages of WTE combustion?
- The best solution to solid waste problems is to reduce waste at its source.
- More than 75% of MSW is recyclable. What role is recycling playing in waste management, and how is recycling best promoted?
- Much more can be done to move MSW management in a more sustainable direction. What are some recommendations to improve MSW management?

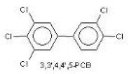
Hazardous Waste

Halogenated hydrocarbons

- Organic compounds with a halogen (bromine, iodine, ect.) replacing a hydrogen
- Used as pesticides
- Used to make plastic
- Resistant to biodegradation



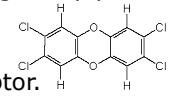
Biphenyl



3,3',4,4',5-PCB

Chlorinated hydrocarbons

- **<u>Chlorinated hydrocarbons</u>**
- Are synthetic organic compounds
- **<u>Dioxin</u>**
- Mainly caused by burning PVC pipe (medical waste)
- Linked to cancer.
- Also an endocrine disruptor.



2,3,7,8-TCDD

Love Canal, NY

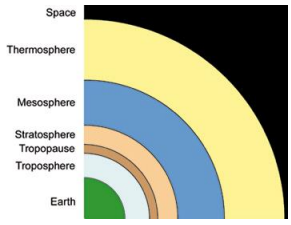
- The government allowed housing to be build over the toxic waste dump and people got sick
- Problem first discovered in 1978
- First national emergency in the US because of toxic waste
- Led to the superfund legislation.

<u>Superfund sites:</u>

- $ comes from taxes on chemical industries
- 50% of the $ spent on legal costs

Layers of the Atmosphere

- Troposphere
  ---------Tropopause
- Stratosphere
  --------- Stratopause
- Mesosphere
  --------- Mesopause
- Thermosphere



Composition of the troposphere

- 78% N_2
- 20% O_2
- Less than 2%
  - H_2O vapor (.01%-4%)
  - Argon gas (1%)
  - CO_2 (0.04%)
  - Trace gases

Global warming

The greenhouse effect is natural and important to deep the earth warm enough for life to exist

- Global warming occurs when humans contribute too much of these greenhouse gases leading to a small (1-3 degree C) but significant rise in the global average temperature.
- Analogy – Car on a sunny day

Ozone (O_3)

Tropospheric ozone is BAD
- If we breath it, it causes lung damage
- It is also a greenhouse gas

Stratospheric ozone is GOOD
- It shields us from the harmful UVB rays of the sun.
- Ozone depletion is the thinning of the stratospheric ozone shield (mostly over the South Pole, Australia story)
- Analogy – Stratospheric O_3 is like sunscreen for the earth.

Air pollution

- Expensive: health care costs, human lives
- -acute
  - Chronic
  - Carcinogenic
- Damages buildings, bridges, statues, books
- Aesthetics
- Damage to Plants
  - Agriculture – crops loss ~$5 billion/year
  - Forests

Acids and Bases

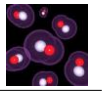
pH-log of hydrogen ions in a solution. Therefore each number higher on the pH scale is 10X more basic

- Basic- OH- (hydroxyl ions) over 7 on the pH scale
- Acidic-H+ ions under 7 on the pH scale
- Neutral- pure water is 7 on the pH scale
- Normal rain is slightly acidic-pH 6.4
- Acid rain is defined as less than a pH of 5.5

Indoor Air Pollutants

- 1. Types: benzene, formaldehyde, radon, cigarette smoke
- 2. Sources: off gassing from furniture, rugs and building materials, dry cleaning, cleaning fluids, disinfectants, pesticides, heaters
- 3. Buildings with too many indoor air pollutants are called "sick buildings" because more than 20% of the people are sick due to occupying the building.

Major Outdoor Air Pollutants



- Primary – direct products of combustion and evaporation
- Secondary – when primary pollutants undergo further reactions in atmosphere

1. Suspended particulate matter (primary)
2. Volatile Organic Compounds (secondary)
3. Carbon Monoxide (primary)
4. Nitrogen Oxides (can be both)
5. Sulfur Oxides(primary from combustion of coal)
6. Ozone and other photochemical oxidants (secondary)

Sources of air pollution

- Natural:

a. Sulfur: Volcanoes, sea spray, microbial

b. Nitrogen oxides: lightening, forest fires, microbial

- Anthropogenic (human caused)

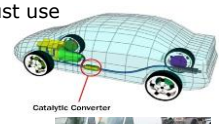
a. Sulfur oxides: coal burning plants, industry, fossil fuels.

b. Nitrogen oxides: power plants, industrial fuel combustion, transportation

c. Effect areas hundreds of miles from the source of emissions, generally not the whole globe

Solutions: Reducing Emissions

Best way = Conservation, just use less!



Input Control

a. Cleaner burning gasoline
b. increased fuel efficiency
c. alternative modes of transportation
d. decrease the number of miles driven
e. changes in land use decisions
f. catalytic converter

Output Control

A. Scrubbers: exhaust fumes through a spray of H_2O containing lime ($CaCO_3$) $SO_2 \rightarrow CaSO_3$

B. Coal washing to get rid of sulfur

C. Fluidized bed combustion (produces a waste ash that must be disposed of)