AP Environmental Science Comprehensive Study Guide

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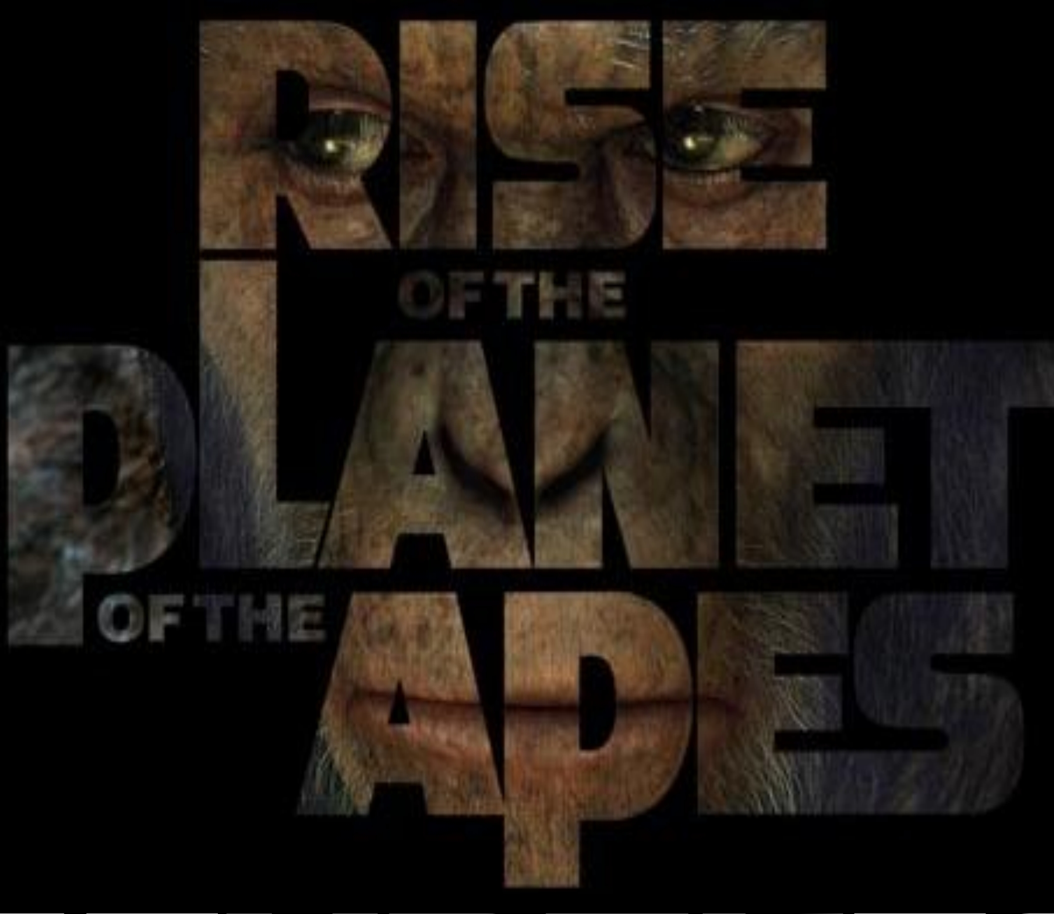
NOT A SUBSTITUTE FOR READING THE TEXTBOOK

(Some Info May Be Repetitive)



STUDENTS

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APES EXAM TOPIC OUTLINE

I. Earth Systems and Resources (10-15%)
A. Earth Science Concepts (Geologic time scale; plate tectonics, earthquakes, volcanism; seasons; solar intensity and latitude)
B. The Atmosphere (Composition; structure; weather and climate; atmospheric circulation and the Coriolis Effect; atmosphere-ocean interactions; ENSO)
C. Global Water Resources and Use (Freshwater/saltwater; ocean circulation; agricultural, industrial, and domestic use; surface and groundwater issues; global problems; conservation)
D. Soil and Soil Dynamics (Rock cycle; formation; composition; physical and chemical properties; main soil types; erosion and other soil problems; soil conservation)

II. The Living World (10-15%)
A. Ecosystem Structure (Biological populations and communities; ecological niches; interactions among species; keystone species; species diversity and edge effects; major terrestrial and aquatic biomes)
B. Energy Flow (Photosynthesis and cellular respiration; food webs and trophic levels; ecological pyramids)
C. Ecosystem Diversity (Biodiversity; natural selection; evolution; ecosystem services)
D. Natural Ecosystem Change (Climate shifts; species movement; ecological succession)
E. Natural Biogeochemical Cycles (Carbon, nitrogen, phosphorus, sulfur, water, conservation of matter)

III. Population (10-15%)
A. Population Biology Concepts (Population ecology; carrying capacity; reproductive strategies; survivorship)
B. Human Population
1. Human population dynamics (Historical population sizes; distribution; fertility rates; growth rates and doubling times; demographic transition; age-structure diagrams)
2. Population size (Strategies for sustainability; case studies; national policies)
3. Impacts of population growth (Hunger; disease; economic effects; resource use; habitat destruction)

IV. Land and Water Use (10-15%)
A. Agriculture
1. Feeding a growing population (Human nutritional requirements; types of agriculture; Green Revolution; genetic engineering and crop production; deforestation; irrigation; sustainable agriculture)
2. Controlling pests (Types of pesticides; costs and benefits of pesticide use; integrated pest management; relevant laws)
B. Forestry (Tree plantations; old growth forests; forest fires; forest management; national forests)
C. Rangelands (Overgrazing; deforestation; desertification; rangeland management; federal rangelands)
D. Other Land Use
1. Urban land development (Planned development; suburban sprawl; urbanization)
2. Transportation infrastructure (Federal highway system; canals and channels; roadless areas; ecosystem impacts)
3. Public and federal lands (Management; wilderness areas; national parks; wildlife refuges; forests; wetlands)
4. Land conservation options (Preservation; remediation; mitigation; restoration)

5. Sustainable land-use strategies
E. Mining (Mineral formation; extraction; global reserves; relevant laws and treaties)
F. Fishing (Fishing techniques; overfishing; aquaculture; relevant laws and treaties)
G. Global Economics (Globalization; World Bank; Tragedy of the Commons; relevant laws and treaties)

V. Energy Resources and Consumption (10-15%)
A. Energy Concepts (Energy forms; power; units; conversions; Laws of Thermodynamics)
B. Energy Consumption
1. History (Industrial Revolution; exponential growth; energy crisis)
2. Present global energy use
3. Future energy needs
C. Fossil Fuel Resources and Use
(Formation of coal, oil, and natural gas; extraction/purification methods; world reserves and global demand; synfuels; environmental advantages/disadvantages of sources)
D. Nuclear Energy (Nuclear fission process; nuclear fuel; electricity production; nuclear reactor types; environmental advantages/disadvantages; safety issues; radiation and human health; radioactive wastes; nuclear fusion)
E. Hydroelectric Power (Dams; flood control; salmon; silting; other impacts)
F. Energy Conservation (Energy efficiency; CAFE standards; hybrid electric vehicles; mass transit)
G. Renewable Energy (Solar energy; solar electricity; hydrogen fuel cells; biomass; wind energy; small-scale hydroelectric; ocean waves and tidal energy; geothermal; environmental advantages/disadvantages)

VI. Pollution (25-30%)
A. Pollution Types
1. Air pollution (Sources-primary and secondary; major air pollutants; measurement units; smog; acid deposition-causes and effects; heat islands and temperature inversions; indoor air pollution; remediation and reduction strategies; Clean Air Act and other relevant laws)
2. Noise pollution (Sources; effects; control measures)
3. Water pollution (Types; sources, causes, and effects; cultural eutrophication; groundwater pollution; maintaining water quality; water purification; sewage treatment/septic systems; Clean Water Act and other relevant laws)
4. Solid waste (Types; disposal; reduction)
B. Impacts on the Environment and Human Health
1. Hazards to human health (Environmental risk analysis; acute and chronic effects; dose response relationships; air pollutants; smoking and other risks)
2. Hazardous chemicals in the environment (Types of hazardous waste; treatment/disposal of hazardous waste; cleanup of contaminated sites; biomagnification; relevant laws)
C. Economic Impacts (Cost-benefit analysis; externalities; marginal costs; sustainability)

VII. Global Change (10-15%)
A. Stratospheric Ozone (Formation of stratospheric ozone; ultraviolet radiation; causes of ozone depletion; effects of ozone depletion; strategies for reducing ozone depletion; relevant laws and treaties)
B. Global Warming (Greenhouse gases and the greenhouse effect; impacts and consequences of global warming; reducing climate change; relevant laws and treaties)
C. Loss of Biodiversity
1. Habitat loss; overuse; pollution; introduced species; endangered and extinct species
2. Maintenance through conservation
3. Relevant laws and treaties

STANDARD GEOLOGIC TIME SCALE

EON	ERA	PERIOD	EPOCH	AGE (M.y.)	IMPORTANT EVENTS
PHANEROZOIC	CENOZOIC	Quaternary	Holocene	0.01 - present	Human civilization develops.
			Pleistocene	1.6 - 0.01	Continental glaciation in the northern hemisphere
		Tertiary	Pliocene	5.3 - 1.6	Humans appear for the first time.
			Miocene	23.7 - 5.3	Antarctic Ice Sheet develops.
			Oligocene	36.6 - 23.7	Himalaya Mountains begin to form.
			Eocene	57.8 - 36.6	The Alps form in Europe.
			Paleocene	66.4 - 57.8	Mammals become dominant land animals
	MESOZOIC	Cretaceous		144 - 66.4	Dinosaurs become extinct; Rocky Mountains begin forming.
		Jurassic		208 - 144	Atlantic Ocean begins to form between N. America & Africa.
		Triassic		245 - 208	1st dinosaurs; North America begins to separate from Africa.
	PALEOZOIC	Permian		286 - 245	All land masses joined to form a single supercontinent

					called Pangaea.
		Pennsylvanian		320 - 286	Appalachian Mountains & Ouachita Mountains formed by continental collision with Africa.
		Mississippian		360 - 320	Extensive deposits of coal developed worldwide.
		Devonian		408- 360	1st fossils of amphibians (animals which could live on land).
		Silurian		438 - 408	1st fossils of land plants.
		Ordovician		505 - 438	1st fossil fish; evidence of continental glaciation in Africa.
		Cambrian		545 - 505	Abundant fossils of marine organisms.
PROTEROZOIC	**PRECAMBRIAN**			2500 - 545	1st evidence of oxygen in atmosphere = 2.0 billion years ago.
ARCHEAN				4500 - 2500	Earliest evidence of life = 3.8 billion years ago. Earth forms = 4.5 billion years ago.

QUICK APES NOTES

Earth Science

- Earth made of core (solid inner, molten outer, iron), mantle (mostly solid rock, asthenosphere flowing), lithosphere (contains crust)
- Lithosphere broken into tectonic plates, largest is Pacific Plate

Plate Boundaries- where 2 plates touch
- Convergent boundary- pushed toward each other
- Divergent boundary- moving away from each other
- Transform fault boundary- slide from side to side

Volcanoes
- Volcano- mountains formed by magma from Earth's interior
- Active volcanoes- currently erupting or have erupted in recorded history
- Dormant volcanoes- never known to erupt
- Extinct volcanoes- never erupt again
- Rift volcanoes- plates move away from each other
- Subduction volcanoes- plates collide and slide over each other
- Hot spot volcanoes- found at areas where magma rises to surface, Hawaiian islands

Earthquakes
From vibrations of plate movements deep in Earth
- Focus- location where earthquake begins inside Earth
- Epicenter- spot on surface of earth directly above focus
- Seismograph- measures size or magnitude

Rock Cycle
- Sedimentary- sediments build up and compress, limestone
- Metamorphic- pressure and heat applied to rock inside Earth's mantle, slate
- Igneous- rock melts and resolidifies, magma comes to surface, emerges as lava, cools to make rock, basalt

Atmosphere

Layer of gases covering Earth = troposphere (weather, clouds), tropopause (temp increases), stratosphere (greenhouse effect from ozone), mesosphere (meteors burn up), thermosphere (aka ionosphere, absorbs solar wind from Sun)

Climate
- Weather- day to day temperature, pressure, sunlight, wind speed, humidity
- Climate- constant patterns of an area
- Tilt on Earth's axis causes seasons
- Convection currents- vertical currents that rise from warm gases expanding and becoming less dense
- Dew point- temperature water vapor condenses into liquid
- Precipitation- fallen condensation (frozen or liquid)

Weather
- Monsoon- hot air rises from hot land, creates low-pressure system, rising air cools and moisture falls, MASSIVE RAINFALL
- Rain shadow effect- air from body of water moves inland and runs into mountain, rises and on other side, no moisture left
- Hurricane- intense tropical storms (typhoon or cyclone in Pacific Ocean)

Water

- Watershed- where water from a particular stream collects and drains into
- Delta- where rivers meet ocean, made of deposited sediments
- Estuary- freshwater and saltwater mix, rich with species
- Wetlands- marshes, swamps, bogs, prairie potholes, flood plains, ecologically diverse
- Groundwater- water below ground, can be from wells or aquifers (layers of Earth or gravel with water)

Freshwater Layers
- Littoral- shallow water at shoreline
- Limnetic- open water, sunlight can penetrate
- Profundal- no sunlight (aphotic)
- Benthic zone- low temp and low oxygen

Ocean Layers
- Coastal zone- between shore and end of continental shelf
- Euphotic zone- upper layers of water
- Bathyal- no photosynthesis, middle region
- Abyssal zone- deep ocean, very cold, little dissolved oxygen, high nutrients

Soil

Horizons
- O horizon- surface and plant litter, lots organic matter, fungi, freshly fallen
- A horizon- topsoil, lots of organic matter, mineral material, humus, partially decomposed
- E horizon- zone of leaching, contains less organic material and little inorganic coloring material
- B horizon- subsoil, iron, aluminum, clay , humus, zone of accumulation
- (K horizon- calcium carbonate fills pore spaces)
- C horizon- regolith, partially broken down inorganic materials, parent material
- R horizon- bedrock, unaltered parent material

Vocabulary
- Humus- sticky, brown, insoluble residue from partially decomposed organisms
- Topsoil- A horizon, mineral particles mixed with organic material, under surface litter
- Subsoil- B horizon, accumulated clays and nutrients, sometimes develops hardpan layer
- Sheet erosion- thin layer taken off land surface
- Rill erosion- little rivulets of running water cut small channels in soil
- Gully erosion- bigger channels of water that erode
- Waterlogging- soil saturated with water, kills plants from lack of oxygen
- Salinization- mineral salts accumulate in soil, saline irrigation
- Soil Fertility- capacity to supply nutrients (nitrogen, phosphorus, potassium) for plant growth
- Soil Porosity/Infiltration- pore spaces filled with water= saturated, otherwise it is unsaturated
- Infiltration- water through soil
- Soil porosity- space between pores

Soil Properties
- Plasticity- high > soil likely to have excessively expand and contract on wetting and drying
- Strength- ability of a soil to resist deformation
- Cohesion- measure of the ability of soil particles to stick together
- Friction- high in sand, strength of forcing particles together
- Sensitivity- changes in soil strength resulting form disturbances such as vibrations or excavations
- Compressibility- tendency to consolidate, decrease in volume, coarse > low comp.
- Erodibility- ease with which soil materials are removed by wind or water
- Permeability- ease with which water moves through a material
- Corrosion- slow weathering or chemical decomposition that proceeds from surface into ground
- Ease of excavation- procedures required to remove soil during construction
- Shrink-swell potential- tendency of soil to gain or lose water

Soil Conservation Techniques
contour and strip plowing, terracing, planting perennial species, plant ground cover and use mulch, reduced tillage systems, vegetarian or locavore, join community-supported agriculture program, add legumes (nitrogen) to the soil

Ecosystems / Biomes

Deserts
Less than 25 cm rain per year, sandy soil
Lots of cacti b/c water-adapted
30 degrees north and south of equator

Chaparral
50-75 cm rain, shallow infertile soil
Small trees w/ big leaves, shrubs
Western North America, Mediterranean

Tundra
Less than 25 cm rain, permafrost for soil
Small herbaceous plants
Northern parts of North America, Europe, and Russia

Grasslands
10-60 cm rain, rich soil
Many types of grasses
N. America prairies, S. African velds, Russian steppes, Argentinean pampas

Deciduous Forest
75-250 cm, high rainfall, rich soil
Hardwood trees
N. America, E. Asia, Europe, Australia

Tropical Rainforest
200-400 cm, high rainfall, poor soil
Tall trees, vines
S. America, W. Africa, Southeast Asia

Taiga (Coniferous Forest)
20-60 cm rainfall, acidic soil
Coniferous trees
Northern parts of N. America and Eurasia

Energy flow

Producers
Convert sun energy or chemical energy into carbohydrates, photosynthesis or chemosynthesis

Consumers
- Primary consumer- herbivores, only eat producers
- Secondary consumer- eat primary consumer
- Tertiary consumer- eat secondary consumer
- Detritivore- eat dead animals or fallen leaves
- Decomposer- bacteria and fungi, break plant material, waste, and dead bodies into inorganic forms

Food chain- contains trophic levels of producers and consumers and decomposers, 10% energy passes on
Food web- multiple food chains in one, more realistic depiction

Ecosystem diversity

Biodiversity- number and variety of organisms in ecosystem, also variability between species
- Gives species greater chance of survival
- Aesthetic appeal
- Human health and pharmaceuticals
- More types of agriculture

Natural ecosystem changes

- Keystone species- very important, extinction would lead to extinction of many other species
- Indicator species- used to measure health of ecosystem, sensitive
- Indigenous species- occur naturally in an area
- Invasive species- alien, exotic, introduced species

Succession
- Primary succession- lichens grow in lifeless area
- Secondary succession- grasses, existing community has been cleared with soil leftover
- Pioneer species- species in first stages of primary or secondary succession
- Climax community- final stage of succession

Populations

Carrying Capacity

(K) is max population size that can be supported with resources available in particular region

Cultural & Economic

Countries with lower birth rates (and TFR- total fertility rate) generally have higher standard of living and higher gross domestic product per capita

Human Population Issues

Population Growth
Factors affecting this:
- Birth control
- Women's education
- Retirement systems
- Age of marriage / first baby
- Religious beliefs, culture, traditions

Hunger
- Malnutrition- poorly balanced diet, poor nutrition
- Undernourished- not enough quantity or quality of food
- Hunger- insufficient calories

Agriculture

Desertification- conversion of productive land to desert
Causes: overgrazing, deforestation, adverse soil erosion, poor drainage of irrigated land, overuse of water supplies
Symptoms: declining groundwater table, salinization of soil and near-surface water, reduction in surface water of streams, ponds, and lakes, unnaturally high rates of soil erosion, damage to native vegetation

- Traditional subsistence agriculture- just enough food for person's family
- Slash and burn- vegetation cut and burned down before being planted
- higher use of chemical fertilizers and pesticides now
- Salinization- repeated irrigation forces soil salts to the top
- GMO's can add nutrients and vitamins to plants, increase crop yield, cause deformities if bred with native species
- Monoculture- planting one crop
- Plantation farming- uses monoculture cash crops

Forestry

- Deforestation- removing trees for agri. or selling as lumber
- Old growth forest- never cut, growing for hundreds of years
- Second growth forests- cutting has occurred, new forest grew naturally
- Clear-cutting- removing all trees
- Selective cutting- removing some trees
- Agroforestry- trees and crops planted together

Fires are necessary for the health of forests (surface fires, not crown or ground fires)

Rangelands

- Overgrazing- animals eat grass faster than it grows

^ Tragedy of the Commons ^
Solution: rotate animals on different fields or control herd numbers
Animal waste is source of water pollution
Grazing animals eat 70% of grain in US

Other Land Use

- Conservation- management of resource so it can regenerate
- Preservation- maintaining species or ecosystem so it can regenerate, no concern for money
- Natural resources- ecosystems referred as this
- Ecosystem capital- economic value of natural resource
- Renewable resource- regenerated fast
- Nonrenewable resource- not regenerated during human existence

Mining

Excavating earth to extract ore or minerals
- Metallic minerals- metals can be extracted through smelting
- Nonmetallic minerals- used in natural state
- Mineral deposit- area where mineral is concentrated
- Gangue- waste material
- Tailings- piles of gangues
- Strip mining- stripping surface layer of soil and rock to get minerals

Zinc has highest production (9.6 million metric tons)

Fishing

- Capture fisheries- catch fish in wild
- By-catch- untargeted fish caught
- Driftnets- nets dragged through water that catch everything
- Long lining- lines with baited hooks that take lots of marine organisms
- Bottom trawling- ocean floor scraped with destructive nets

Tragedy of the Commons (again)
47-50% fish stocks fully exploited

Global Economics

- Cost-benefit analysis- weighing benefits to economy against hazards to environment
- Marginal costs- additional costs
- Marginal benefits- added benefits
- Externalities- unwanted or unanticipated consequences of using a resource

Types of Pollution

Air Pollution
Carbon monoxide, lead, ozone, nitrogen dioxide, sulfur dioxide, particulates
Industrial smog = gray smog
Photochemical smog caused by NOx, VOCs and ozone
Depletes ozone because of CFCs that release chlorine monoxide

Water Pollution
Cuyahoga River caught fire in 1969 because of pollution
- Dead zone- oxygen poor water
- Eutrophication- warm, nutrient-rich freshwater mixes with cold saltwater and makes plankton populations explode
- Hypoxic zone- noting that depends on oxygen can grow here
- Wastewater- any water used by humans

Thermal Pollution
Urban areas known as heat islands
Increased photochemical smog
Adding trees can lower temperature

Noise Pollution
Any noise that causes stress or can potentially damage human health

Impacts of pollution

Photochemical smog
Climate change
Risks to human health
Decreased aesthetic appeal of environment
Harmful to biodiversity
Ozone depletion
Acid rain

Economic impacts

United States legislature such as Superfund Act, cleans up hazardous waste sites
Pollutants that are human hazard have to be cleaned up, costs money
Hydrogen fuel cell vehicle? Not cheap enough yet to be economically viable

Energy Concepts

Units
Energy units: Joule, Calorie, British thermal unit, kilowatt hour
Power units: Watt and Horsepower

Laws of Thermodynamics
1. Energy cannot be created or destroyed, only transformed
2. Entropy increases because energy lost as heat in energy transformations

- Energy- capacity to do work
- Potential energy- energy at rest
- Kinetic energy- energy in motion
- Radiant energy- sunlight
- Convection- transfer of heat by movement of heated matter
- Conduction- transfer of energy through matter

Energy consumption

Fossil fuels provide 64% world's electricity
Nuclear energy provides 17% of world's electricity
Renewable energy sources provide 19%

Fossil Fuels

Coal
Purest- anthracite, then bituminous, then subbituminous, worst is lignite
Scrubbers remove sulfur dioxide
Fly ash and boiler residue are waste products

Oil
Crude oil is what is pumped out
Most environmental damage is from transporting thousands of miles

Natural Gas
Mostly methane, but also pentane, butane, etc
Comes from wetlands and livestock
Transported in gas tanks as Liquefied Natural Gas, compressed

Nuclear energy

Nonrenewable, non-fossil fuel
Use uranium-238 with a 3% uranium-235
Isotopes are split with fission
Two types of reactors- Boiling Water and Pressurized Water

Hydroelectric power

Moving water turns a turbine which generates elect.
Production releases no pollutants %uF04A
Does produce thermal pollution and dams rivers, which destroys habitats and changes river flow speed
Bad: huge buildup of sediment behind dam
Fish can't spawn unless they have fish ladders to go upriver

Energy conservation

Biofuel- fuel made of something other than fossil fuels, such as cooking oil
Important to find alternative fuel sources
CAFE, Corporate Average Fuel Economy, set standards for mile per gallon for cars
Hybrid vehicles run on electricity and gasoline only for starting and stopping car

Renewable energy

Hydroelectric, solar, wind, geothermal, ocean tides, hydrogen cells

Solar
- Passive solar energy collection- collect sunlight with windows and building placement
- Active collection- solar panels
- Photovoltaic cells- collect solar energy, produce electricity to store in batteries

Wind
- Turbine- wind turns blades, main part of wind turbine
- Nacelle- gearbox and generator to control turbine
- Wind farms- wind turbines put in groups

Geothermal
Energy from within Earth, take Earth's internal heat from heated water and steam

Global Change

Stratospheric Ozone

Ozone in stratosphere protects us against ultraviolet radiation
CFC's release chlorine which turns into chlorine monoxide that turns ozone into oxygen, thus depleting ozone layer
Layer is thinnest over Antarctica
Greatest in spring
Chlorine is catalyst, can continuously break down ozone without itself being destroyed
Montreal Protocol- end of CFC production

Global Warming

Greenhouse gases trap sun's energy in Earth's atmosphere and don't allow it to reradiate out into space like normal
Loss of ozone layer exposes us to more ultraviolet radiation = cancer, weak immune system, cataracts
Kills animals; can lead to their extinction

Loss of biodiversity

Increased UV rays kills phytoplankton and primary producers, which destroys the base of food chains
This ruins marine and terrestrial ecosystems since there are less fish and crops because they lost their producers (their food source)
It can potentially ruin entire food webs, especially as Earth heats up and ruins habitats
Melting ice caps kill penguins and polar bears

LONGER APES NOTES (Alphabetical by Topic)

AGRICULTURE AND FOOD

NUTRITION & FOOD SUPPLIES
~ although enough food is being produced to feed everyone, it is unevenly distributed
~undernourished: consuming less than enough calories needed for an active, healthy life
~over nutrition: too many calories, a problem in wealthy countries, greatest risk in the US affects 20% of the world, increases blood pressure, heart attacks, strokes, diabetes
~sub-Saharan Africa: food is becoming scarce (war, poor governments, drought, etc)
~800 million undernourished ~obese:30 lbs over (morbidly- 100 lbs over (5 million Americans)
~60% of Americans are obese (we consume 3500 calories/day)

Chronic Hunger and Food Security
~Undernourishment as a child can lead to stunted growth, mental development, and other disorders. Infectious diseases like diarrhea that are usually to no concern can become lethal.
~Food Security: ability to obtain sufficient food on a day-today basis, threatened by poverty, women are usually more effected than men
Other Essential Nutrients
~It is possible to have plenty of calories but still suffer from malnutrition (having a nutritional imbalance, or by lacking a dietary component)
~Kwashiorkor: a protein deficiency in children, mainly in West Africa, victims have reddish hair, puffy, discolored skin, and a bloated stomach
~Marasmus: caused by a diet low in calories and protein, the child is thin and shriveled
~Both diseases can cause anemia, lower one's resistance to infections, or cause stunted growth and mental retardation
~Vitamin A deficiencies can cause blindness, while lack of folic acid causes neurological problems in babies, such as small heads or no brains
~Anemia: most common dietary deficiency in the world (not enough iron), is a lack of hemoglobin in the blood
~A deficiency of iodine can cause goiter (a swollen thyroid gland) or cause brain damage
Eating a Balanced Diet
~Eating a balanced diet full of grains, fruits, and vegetables, with moderate meat, dairy, and fats will give you all the nutrients you need
Famines
~Large-scale food shortages, massive starvation, social disruption, economic chaos
~Even if condition improve, it will be hard to recover (they have ruined their resources in order to survive)
~Causes: politics, government failure, adverse weather, insects, war, natural disasters, poverty, political boundaries, democracies seldom have famines

MAJOR FOOD SOURCES
~Our diet: a dozen grains, 3 root crops, 20 fruits/veggies, 6 mammals, two fowl,
Major Crops
~Mainly wheat, rice, and maize, wheat and rice make up 60% of calories consumed

~Fruits and veggies: have lots of vitamins, minerals, fiber, and complex carbs

Milk, Meat, & Seafood

~N. America, Japan, 7 Europe (20% world population) consume 80% of animal products
~Average American eats 260 lbs/meat/year (Bangladesh-6.5 lbs)
~90% of grain grown is used to feed animals (for slaughter)
~over harvesting, habitat destruction are endangering fisheries: 13/17 gone, with new technology, we can exhaust entire populations, 70% of fish are declining
1/4 animals are unwanted "by-catch", includes birds and mammals (by lines, drift nets)
~trawl nets can destroy habitats, spawning areas, impossible to rebuild populations

SOIL: A RENEWABLE RESOURCE

~mixture of weathered minerals from rocks, decaying organic material, and living organisms
~with good husbandry, soil can be replenished and renewed
~1/2 of cropland is being destroyed quicker than replaced

Soil Composition

~1/2 mineral (from bedrock/sediments), plant & animal residue, air, water, organisms
~sandy soil: light soil, good drainage, dries quickly vs. clay (tiny particles), heavy, impermeable, holds water longer
~Humus: a sticky, brown residue from decaying plants & animals, gives structure to soil and helps drainage

Soil Organisms

~Topsoil contains millions of organisms, most microscopic (bacteria, algae), worms insects, animals, plant roots draw up minerals and release acids that decompose particles
~leaf litter creates new organic material

Soil Profiles

~soil horizons: layers of soil, reveal the history, classified by color, texture, composition,
~Horizons make up soil profiles
~Topsoil: A horizon, covered by O horizon (newly deposited material), minerals mixed w/ organic matter, where most plants spread their roots to absorb nutrients
~subsoil: B horizon, dense with clay and nutrients (soluble)
~C horizon: parent material, weathered rock, weathering allows soil to extend downward

Soil Types

~classified into soil orders by their structure and composition

WAYS WE USE AND ABUSE SOIL

~11% of Earth is used for agriculture

Land Resources

~the average land area available to each individual is decreasing
~ways to improve usage of land: variety, better fertilizers, irrigation, pesticides, labor, water-95% of agricultural growth
~forests, plains being converted to farmland, will eventually have to increase output/acre
~some land shouldn't be farmed (more valuable in natural state)- nutrients in the plants, not soil, would result in loss of biodiversity

Land Degradation
~land destroyed by: 1) humans (buildings, etc) 2) desertification 3) erosion
~in some places, the degradation is so bad that no crops can be supported
~effects: less species, crops, biomass, diversity, vegetation, soil eroded, water runs off
~Causes: 1) water (55%) 2) wind (29%) 3) chemical (12%) 4) physical (4%)

Erosion: The Nature of the Problem
~Importance: redistributed sediments, part of soil formation and loss, sculpts landscapes, creates silt for farming
~However, erosion can destroy topsoil, (exposing the subsoil) reduce land fertility, load rivers with sediments, smother wetlands, clog water intakes, coat reservoirs with silt
~Erosion equals a 1% loss in cropland/year

Other Agricultural Resources:
water- 73% of all freshwater used for irrigation (15% crops are irrigated world wide)
-80% water irrigated never reach destination (because of evaporation and seepage)
water logging- water-saturated soil causing plants roots to die from lack of oxygen
salinization- when mineral salts accumulate in the soil (particularly occurs when soil in dry climates are irrigated with saline water)
-when water evaporates, leaves behind lethal salt accumulation for plants
-irrigation problems: 150 million acres worldwide crop land damaged by water logging and salinization.
Water Conservation: greatly reduced problems from excess water use
-makes water available for other uses
Fertilizer- inorganic nutrients
-plants need: nitrogen, potassium, phosphorus, calcium, magnesium and sulfur
-calcium and magnesium limited in areas w/ high rainfall: must be supplied in form of lime (fertilizer)
-lack of nitrogen, potassium and phosphorus also limits plants growth and these elements are added in fertilizers to enable plant growth
-crop production up since 1950: Nitrate levels in ground water have increased from fertilizers and young children are sensitive to this and it can be fatal
Alternatives for fertilizer:
-manure and green manure
-nitrogen-fixing bacteria in root nodules of legumes
-interplanting or rotating beans (or other leguminous crop) with other crops (corn, wheat)
Energy:
Direct- Fossil fuels supply almost all energy for farming
Indirect-energy synthetic fertilizers, pesticides (agricultural chemicals)- increase in this energy
-food system in U.S.: 16% of total energy use
-more energy put to produce, process and transport than actual farming
-present energy usages unsustainable (need alternatives for future because going to run out)!
New Crops and Genetic Engineering:
-3,000 species of plants have been used for food
-most food only comes from 16 widely grown crops!
-new varieties of crops valuable for humans and good for areas that are limited by climate, soil,

pests, etc (harsh environments)
-ex: winged beans, perennial plants (hot climates), tricale: drought resistant; grows in light, sandy, infertile soil
Green Revolution:
-50 years ago: agricultural research for tropical wheat and rice varieties (for developing countries)
-"miracle" variety- dwarf (Warmon Varlaug) in Mexico
-International Rice Institute in Philippines est. dwarf rice- dramatic increases with these varieties
-green rev. Breeds: "high responders": yield more than other varieties in optimal condition and produce less when under optimal conditions
Genetic Engineering-
-genetically modified organisms (GMO's) or Frankinsteinian foods!
-have DNA containing genes borrowed from unrelated species.
Ex: "golden rice": gene from daffodil- makes rice produce beta carotene (artificial nutrient in many poor countries).
-genetic engineering also creating new animals
-developed in 1980s
-2000 U.S. Dept of Agriculture reported more than 70 million acres of GM corn, soybeans and other crops planted.
-more than half of all soybeans and cotton and more than 1/4 of corn in the U.S. were GM varieties in the year of 2000
-most of these crops are in the U.S. - Canada and Argentina hold most of these crops outside the U.S.
Positives and Negatives: crops would require less chemicals, be nutrient rich and could withstand harsh conditions
-however, most are resistant to herbicides and can tolerate more chemical use
-some fear that traits will transfer to wild plants creating super, out-of-control weeds
-expensive
Pest Resistance:
-plants created with genes for insecticides
-Bacillus thuringiensis (Bt): bacterium makes toxins lethal to butterfly family and beetle family- when transformed to crops, protects against these pests
-reduces insecticide spraying
-most Bt crops in North America
-concerns: plants used to perfect conditions and not immune to pests (this natural pesticide is likely to be useless in the near future, so plants could be in danger in the future)
-effects on non-target species: can kill other species because susceptible and pesticides can travel long distances
-ex: can contaminate milkweeds that monarchs feed on
Weed Control- most popular transgenic crops: tolerates high doses of herbicides
-occupy 3/4 of all genetically engineered acreage
-2 main products: Monsanto's "Round up Ready" (resists glyphosate) and AgrEvo's "Liberty Link" crops (resists glufosinate).
-exterminates weeds but forces greater amounts of herbicides
-if widespread could create herbicide resistant "super weeds" (genes jump to wild relatives mostly in high biodiversity regions)

Public Opposition-
public shows concerns for safeness and making rich farmers richer and poor farmers bankrupt
-1999: protestors in India burnt crops suspected of genetic engineering
-objections strong in Europe (esp. Italy)
-2001 European Parliament passed rules requiring strict testing, monitoring and labeling of genetically engineered food products and seeds. Also banned genes for antibiotic resistance in plants: fear bacteria would become immune to it.
-potential risks to human health
-2000: StarLink corn only for livestock mixed into corn used in variety of human foods.
Sustainable Agriculture: (regenerative farming)
-aim to produce food and fiber on a sustainable basis and repair the damage caused by destructive practices.
Alternative Methods:
Soil conservation- soil is renewable resource
-most important elements in soil conservation: land management, ground cover, climate, soil type and tillage system
Managing Topography- water runoff downhill causes erosion: contour plowing- leave grass strips in waterways (plowing across hills, rather than up and down).
-like this is Strip Farming- planting of different kinds of crops in alternating strips along the land contours
-ridges created by cultivation make little dams that trap water to seep into the soil rather than runoff
terracing- shaping the land to create level shelves of earth to hold water and soil: edges of terraces planted with soil, anchoring plant species
-this is expensive and requires much hand labor (or expensive machines), but makes farming on steep hills possible
perennial species: plants that grow for more than two years- necessary for some crops to protect certain unstable soils on sloping gradients or watercourses (low areas w/ water runoff)
Ground Cover: protect soil
-cover crops (crop residues)
-interplanting of two different crops (or more) in same field (not only protects but produces double harvest) ex: beans or pumpkins planted in between corn rows- beans provide nitrogen for corn, pumpkin crowded out weeds and both crops provided balance of nutrients for corn
-Mulch: manure, wood chips, straw, seaweed, leaves, and other natural products
Reduced tillage: machines just cover seeds so do not disrupt ecosystem.

AIR

Weather is the day to day fluctuations in the atmosphere while Climate describes temperature and humidity changes over long periods of time. Climates are not static- they cycle through yearly, centurial (is that a word?) and millennial patterns.
Initially the climate on Earth was a deadly mixture of Hydrogen, Helium and Methane from the outgassing of molten rock. 3 billion years ago oxygen was added to our atmosphere with the evolution of photosynthetic organisms.
Air pressure at sea level 14.5 lbs per square inch known as one Atm. Air pressure decreases with altitude. The surface of the Earth also experiences low pressure when warm air masses rises due to low density.

Air composition of the Troposphere today:
Nitrogen- 78%
Oxygen- 21%
Traces of Water Vapor, Argon and Carbon dioxide

The Atmosphere has four distinct layers.
Troposphere (roughly 10 km up)
The layer closest to earth. Holds 75% air mass.
Gets colder with altitude
Weather happens here, also only layer with water
Stratosphere
The top of the stratosphere contains ozone- $O3$
Ozone absorbs high level UV radiation from the sun.
Temperature increases with altitude because of UV absorption
Ozone molecules are broken down by CFC (now outlawed ingredient in aerosol sprays, refrigerator coolants and electrical cleaning solvents)
Excessive UV light on the Earth causes skin cancer, cataracts and mutates and kills plankton (the ocean's bread basket).
Mesosphere
Temperature decreases with height
Thermosphere
Highly ionized gas interacts with magnetosphere to create Aurora borealis (Northern Lights)!

Global Energy Transfer.
Most of the energy from the sun is in the high energy wavelengths- UV and visible light.
50% of this energy is absorbed at the surface.
Energy reflected from the surface is infrared (longer wavelengths)

Convection- the transfer of energy of a warm fluid (like gas or water) upwards into a cooler zone. The cycle of air upwards around and down is called Convection Currents.

Why it rains in a rain forest: The sun's energy is concentrated near the Equator. Rising hot air expands and cools (called Adiabatic cooling). Colder air can't hold as much moisture so after a certain altitude, the air dumps out its water vapor in the form of water droplets- the stuff of clouds. Rising air creates low pressure and lots of nasty weather, unless you are a tropical plant in which case you are very happy. As the water vapor condenses it gives up latent heat energy- this helps large cloud formations rise higher, cool more and build energy to form large storm systems like hurricanes.

Why it is dry in a desert: At 30 degrees North and South latitude the air is cooling, becoming more dense and sinking. Sinking air creates high pressure. High pressure days are cloudless great tanning weather kind of days, unless you are thirsty.

Global winds are caused by the constant balancing act going on in our atmosphere as moist, warm air travels upward from the Equator and then cools and sinks at the 30 degree latitude belt. The air rises again at the 60 latitude and sinks at the poles. When the air moves laterally across the Earth's surface from belt to belt (High to Low pressure) it creates winds- we live in the Westerly wind belt which is why all of our weather comes from West to East. Below us are the trade winds which blow towards the Equator.

All wind belts are curved to the rotation of the Earth knows as the Coriolis Effect. In the Northern hemisphere the air curves to the right. In the south it curves to the left. These curving winds are also partially responsible for the direction of the major ocean currents of the world.

The Coriolis effect is also what spins tornadoes and cyclones. Cyclones are low pressure centers with winds that blow inwards in a counterclockwise direction. Weather conditions are very stormy.

Anticyclones are high pressure centers with cooler, sinking air that then spin clockwise outwards. Clear skies are created.

Jet Streams- 200 km/hr currents of air 10 km up. Responsible for guiding weather systems. Generated by temperature differences in upper atmosphere and the shear from Earth's rotation.

Types of Fronts
Cold Front
Cold air mass moves into warm. Sudden rise in air.
Creates large cumulonimbus rain clouds, lightening and hail
Powerful, but brief rainstorms
Warm Front
Warm air mass moves into cold
Creates cirrus clouds and later stratus clouds.
Sleet or long, light, cold rain created.
Occluded Front
Cold Fronts take over warm fronts by sandwiching and then pushing the warm air off the ground. The system begins to spin (cyclone) and rain like crazy.

Hurricanes (or Typhoon in the Pacific Ocean) are a hundred mile wide cyclones that last several weeks. Despite their relatively puny wind speeds (75- 200 mph) hurricanes are much more deadly than tornadoes. Between the heavy rain fall, mud slides and storm surges, people lose their lives by drowning.

Tornadoes- a mini cyclone that begin when the jet streams shear off the top of an especially large cumulonimbus cloud (cool, huh?). The cloud tightens as it sinks downward and spins faster due to angular momentum. The fastest tornado winds have been clocked at 318 mph. Most lives are lost in a tornado due to being struck by something that has no business flying.

Monsoons- seasonal rains and droughts caused by the differential temperatures of land and oceans. In the summer, the land heats up faster than the sea, so a low pressure center develops on land. Moist air from the ocean rush in to "fill" in the pressure void and monsoon rains last for four months or more. Then, during the winter, the ocean, which has a higher heat capacity, is now warmer than the land and winds tend to move towards the sea. A long term drought ensues.

Milankovitch cycles-
Periodic shifts in earth's orbit (100,000 year cycle), tilt (40,000 year cycle) and axis wobble (a 26,000 year cycle). The timing of all three of these phenomenon are such that every 100,000 years or so the Earth finds itself very far from the sun- enough to trigger an ice age.

La Nina
The "normal" state of affairs with relatively cool ocean temperatures on the Equatorial Pacific Ocean. Trade winds blow warm water in the South Pacific towards the Western Pacific Ocean. This causes a low pressure system off of Australia and Indonesia which leads to lots of rain. Nutrient rich water upwells off the coast of South America feeding a burgeoning anchovie population.
Back in the states we experience warm winters in the SE and cold winters in NE and the Middle Atlantic. Southern California is sunny (the brats!) and Washington is rainy (poor Kurt).

El Nino- occur every 3-5 years. Used to last 2 weeks to a month, now lasts one month to over a year!!!
Unusually warm ocean temperatures on Equator (made worse by global warming) cause the Trade winds to weaken. Warm water is sloshed back to South America
No upwelling of nutrient rich water occurs off of Peru and the anchovie population falls. Food chain disturbed
The jet stream splits over America causing lots of weird weather.
New Paltz gets mild winters while the South West US and Peru gets RAIN!!
Seattle goes dry as does the West Pacific causing large bush fires in Australia and Borneo-8 million acres burned just recently :(

Global Warming (now officially called Climate Change by our government)
The burning of fossil fuels creates greenhouse gases- especially carbon dioxide. Since 1800 we've gone from 280 ppm to 370 ppm of CO_2. Other gases implicated in global warming are water vapor, methane- mooo! (CH_4), N20 (laughing gas) and sulfur hexafluoride. The massive deforestation around the planet also adds to the greenhouse effect because our natural carbon dioxide sinks are compromised... ok, dead. Seasonal fluxations of CO_2 are natural due to the

increased photosynthesis in the summer which absorbs CO_2 and the dormant plant life in the winter.

These greenhouse gases trap infrared heat energy trying to exit the planet and the Earth is heated up- already we've noticed a 1.4 degree F (.8 degrees C) change. That doesn't sound like much but it only took 5 degrees F to trigger an ice age!

Effects of Global Warming include:
Glaciers melting and huge icebergs calving off ice sheets. The Arctic sea is now 40% thinner. Many alpine glaciers are shrinking quickly or melting altogether. Decreased snow pack on land also results in more sunlight energy being absorbed by the Earth's surface. Snow caused light to be reflected from the Earth's surface (albedo).
Creates sea level rise (6 inches projected in next 100 years). If all of the glaciers/ice sheets melted the sea would rise 300 feet. Sea level would also rise due to thermal expansion.
Drought/ fires due to changes in weather patterns. Already the seas have risen 15 cm in the last 100 years.
Crop failure- US bread basket is now moving to Canada- only problem is that the soil is thin and not particularly fertile.
More tropical disease will spread due to more tropical areas- malaria is coming- agghhh!
Extreme weather- contrary to popular misconception- winters get more ferocious and of course summers get hotter.
Coral reefs are being "bleached" by the hotter temperatures. That means that the algae that lives commensually on the coral is dying. It is projected that the reefs have 50 years left... poor Nemo!
Extinctions- animals and plants can't migrate fast enough to out pace environmental changes especially if you are trapped on a mountain or if you've reached the limit of your park land.

Kyoto Protocol
In 1997, 162 countries gathered together in Japan to figure out how to slow global warming. EVERY COUNTRY agreed to limit their carbon dioxide production and signed a treaty to that effect, except for the US and Australia. It really shocked and disturbed the world, especially when George Bush senior said, "We are going to put the interests of our own country first and foremost" and "The American lifestyle is not up for negotiation." We tried really hard to create a "CO_2 credit" in exchange for the fair amount of land we have still forested, but the countries won't go for it. The US produces 24% of the world CO_2, and yet have less than 5% of the world's population. Presently the government has responded to environmentalists' pressure by pledging lots of money to investigate the NATURAL causes of global warming (okay volcanoes do make CO_2...). Many people argue that historically we've seen massive fluctuations in temperature on the Earth, but the point is that the present RATE of temperature change is unprecedented, and inconveniently coincides with human-caused increases in CO_2 levels... The plot thickens.

AIR POLLUTION

-air pollution is the most widespread environmental damage.
-147 million metric tons of air pollution released each year by the US.
-the world releases about 2 billion metric tons a year.
-air quality has improved over the past 20 years in developed countries.
- developing countries however have higher air pollution sometimes ten times higher than the pollution levels considered safe for human health.

Natural Air pollution:
-natural fires-smoke
-Volcanoes- ash, acid mists, hydrogen sulfide and toxic gases.
-sea spray and decaying organics reactive sulfur compounds
-Trees and bushes- emit volatile organic compounds
-pollen, spores, viruses, bacteria also are air pollution
- the effects of natural contamination and human contamination can be the same

Human caused air pollution
-Primary pollutants- released directly from the source into the air in a harmful form.
-Secondary pollutants- changed into hazardous form after released into air by chemical reactions.
-Fugitive emissions- do not go through a smoke stack (most commonly dust from soil erosion, strip mining, rock crushing, and building construction)

-US clean Air Act of 1970- seven major pollutants for which maximum ambient air (air around us) levels are mandated - sulfur dioxide, carbon monoxide, particulates, hydrocarbons, nitrogen oxides, photochemical oxidants and lead.

PARTS
-Sulfur Compounds: about 114 million metric tons a year released from all sources. Humans release about 90% of the sulfur in the air in urban areas.
Natural sources: sea spray, erosion of sulfate containing dust, fumes from volcanoes.
Most sulfur released because of humans- burning fuel (coal and oil) containing sulfur China and US release the most sulfur because of their great amount of coal and oil burning
Sulfur dioxide- directly damaging to plants and animals. Once in the air it can turn into sulfur trioxide and react to water vapor contributing to acid rain.
Sulfate particles reduce visibility in US 80%. Reduction of SOX can be achieved with scrubbers and by burning coal low in sulfur.

Nitrogen compounds:
Nitrogen oxides- formed when nitrogen in fuel or combustion in air is heated to above 650 degrees C.
Total emissions about 230 million tons a year. About 60% is because of humans. Natural sources: lightening, fires and bacteria in soil. Anthropogenic sources: formed from auto exhaust and electrical power generation. NOX irritates the lungs, makes smog, is a potent greenhouse gas and makes acid rain. Reduction of NOX can be achieved with a catalytic converter.

Carbon Oxides:
Carbon Dioxide is causing global warming : about 3 billion tons accumulate in the atmosphere a year. The level of CO_2 is increasing .5%/year. 90% of C02 in air is consumed by photochemical reactions that produce ozone.
Carbon Monoxide: colorless, highly toxic gas. Produced by incomplete combustion of fuel. 1 billon metric tons released into atmosphere each year, half of that by humans (internal combustion engines). CO binds to hemoglobin reducing the oxygen in the blood. Can be deadly. It also is a respiratory irritant and strong oxidant. Reduction of CO can be achieved with a catalytic converter, emission testing/laws, oxygenated fuel and mass transit!

Metals and Halogens:
Lead emissions are about 2 million tons a year, 2/3 of all metallic air pollution. Most of the lead is from leaded gasoline. About 20% of inner city children suffer from some kind of mental retardation because of lead poisoning. Radon is a radioactive gas found naturally in the bedrock that contains radioactively decaying Uranium. It can cause lung cancer.

Mercury: sources: coal burning power plants and waste incinerators.
-Biomagnification in aquatic ecosystems and birds. It is dangerous to eat higher trophic level fish. Mercury is a neurotoxin. Reduction can be achieved with an electrostatic precipitator (a charge is given to the particulate as it tries to leave a smokestack. A charged plate inside the chimney attracts the pollutant.)
More toxic metals: nickel, beryllium, cadmium, thallium, uranium, cesium, plutonium, arsenic.
Particulate Matter:
Aerosol- any system of solid particles or liquid droplets suspended in a gaseous medium.
Particulate material: dust, ash, soot, pollen, leaf mildew.
Can be natural: dust, volcanic ash can also be suspended in the air. Anthropogenic sources are from burning fossil fuels, car exhaust, asbestos, and cigarettes. Particulates irritate the lungs, diffuse into the blood and react with tissues. Sometimes it can cause cancer.
These seem to be the most apparent pollution because they reduce visibility. Reduction can be achieved by filtering, electrostatic precipitators and alternative energy.

Volatile Organic Compounds: (VOC's)
-Organic chemicals that exist as gases in air. 2/3 of the air toxins regulated by the Clean Air Act are VOCs.
-Plants are the largest source
- Benzene, toluene, formaldehyde, vinyl chloride and other chemicals are released into the air by human activities through mainly unburned or partially burned hydrocarbons from transportation. They are also caused by power plants, chemical plants, oil refineries, oil based paint, cheap 70's carpets and furniture and dry cleaning solvents. They can cause asthma and respiratory disease also some are carcinogenic and neurotoxins.

Photochemical oxidants- from secondary atmospheric reactions driven by the sun. Creates smog and ozone which damages buildings, vegetation, eyes and lungs.

INDOOR AIR POLLUTION:
- It has been found that indoor concentration of toxic pollutants are often higher than outdoors.
- Smoking is the most severe air pollutant. 400,000 people die each year from Emphysema, heart attacks, lung cancer, strokes, and other diseases caused by smoking. (20% of all mortality in US)
- Leading cause of death for women because of advertising in the '50's
- These deaths cause us $100 billion a year; eliminating smoking would save more lives than any other pollution control.

Concentration of benzene, carbon tetrachloride, formaldehyde, and styrene has been found to be 70 times higher in indoor air than outdoor air. Yikes!
- Less developed countries burn for cooking and heat- because of poor ventilation and cooking fires there is a large amount of indoor air pollution especially particulates. women and children are most affected.
- Levels of carbon monoxide, particulates, aldehydes and toxic chemicals can be 100 times greater than the safe outdoor concentrations in US

Sick Building: a building in which a number of people adverse health effects related to the time spent in the building. These symptoms disappear when they go outside.

Climate:
Temperature inversions: occur when a stable layer of warmer air overlays cooler air, reversing the normal temperature decline with increasing height and preventing convection currents from dispersing pollutants. This is really bad if the pollutants then build up.
Can occur when:

-a cold air mass slides under an adjacent warmer air mass -or-
-Cool air subsides down a mountain slope to displace warmer air in the valley below.

Long range transport:
Many pollutants can be carried long distances by the wind currents.
-some of the most toxic and corrosive materials brought by long range transport are secondary pollutants.
-areas considered the cleanest in the world still have pollutants in the air.

Stratospheric Ozone:
- it was discovered in 1985 that the ozone levels in the stratosphere over the South Pole were dropping during September and October as the sun comes out after the polar winter has been happening since the 1960s.
- this hole was the largest ever found and is now spreading to other parts of the world. About 10% of ozone disappears during the spring.
- This is dangerous because ozone filters out UV light and without it organisms would be exposed to life threatening radiation. Skin cancers increase.
- CFC's (Chlorofluorocarbons) are suspected to be the major cause of ozone loss. known as Freon. When discovered they were regarded as nontoxic, nonflammable and cheaply produced. But because they are so stable they remain in atmosphere for decades. When they are diffused

into the stratosphere they release chlorine atoms which destroy the ozone.
- CFC's have been banned and minimized

Effects of air pollution:
-50,000 Americans die prematurely because of illnesses related to air pollution. (5-10 year decrease in life span)
Bronchitis: persistent inflammation of bronchi and bronchioles that causes mucus build up, painful cough, and involuntary muscle spasms that constrict airways.
- Bronchitis can lead to emphysema- an irreversible obstructive lung disease in which airways become permanently constricted and alveoli are damaged or even destroyed.
- Smoking is the leading cause of both these diseases.

Plants:
-Pollutants can be directly toxic damaging to the sensitive cell membranes of plants. Within a few days of exposure mottling can occur and plant eventually dies.
-damage because of pollutants can be hard to distinguish from insect damage.
-environmental factors can have synergistic effects: injury caused by exposure to each factor individually is less than together at the same together.

Acid Rain- normal pH of rain is about 5.6. Most acid rain in NPZ is due to coal- burning plants upwind. The pH scale is logarithmic.
Aquatic effects: acid in water effects fish- to protect their gills fish produce a mucus lining over their gills and eventually suffocate themselves. Acid shock is especially bad in the spring run off from melting snow.
Kills life in lakes and other aquatic ecosystems- usually the small fry and older fish die first.

Forest damage:- seedling production, tree density, and viability of spruce-fir trees at high elevations have declined about 50% because of air pollution. Plants waxing coating is destroyed, they have an increased vulnerability to insects, and they take up heavy metals in the soil that were previously inert at a higher pH.

Visibility has been reduced greatly. Even National Parks are effected by air pollution. Acid rain can be reduced by limiting fossil fuel use and alternative energy. Lime is added to acidic lakes but that is a temporary solution. Just increasing the size of smoke stacks is a bad idea!

BIODIVERSITY

Biodiversity preserves three ecological systems -Genetic Diversity: the measure of the variety of different versions of the same genes with individual species -Species diversity: the number of different kinds of organisms (richness) -Ecological diversity: the richness and complexity of a biological community

Only 1.4 million species are known- a fraction of the total. 70% known species are invertebrates, only 10-15% species live in North America and Europe Hot Spots of the World: The centers of greatest biodiversity tend to be in the tropics, especially tropical rain forests and coral reefs.

How do we benefit from Biodiversity?
-Food- 80,000 plants are edible to humans
-Drugs and Medicines- more than half of prescription drugs come from natural products. ex. Madagascar periwinkle inhibits cancer growth!
-Ecological Benefits-soil formation, waste disposal, air and water purification, nutrient cycling, etc. 95% of pests are controlled by other species that prey on them- better than chemicals!
-Aesthetic and Cultural Benefits- nature as "church". Provides psychological and emotional rejuvenation. Ecotourism is big.
Loss of Biodiversity: HIPPCO
-**Extinction**: the elimination of a species 99% of all species that have ever existed are now extinct!
-Natural Causes of Extinction: in an undisturbed ecosystem. Mass extinctions (that wiped out dinosaurs at the end of the Cretaceous period and two thirds of all marine life at the end of the Permian period) were caused by climate changes, perhaps triggered when large asteroids struck the earth. Now we are losing species at thousands of times the natural background rate of extinction. 1/3 to 2/3 of all current species could go extinct by the MIDDLE of this century. :(
-**Habitat Destruction:** The biggest reason for the current increase in extinction is habitat loss. Habitat Fragmentation: Habitat fragmentation divides populations into isolated groups that are vulnerable to catastrophic events.
-**Over harvesting** (hunting and fishing) is responsible for depletion or extinction of many species. Ex. Passenger pigeon: 3 to 5 BILLION birds lived 200 years ago. In addition to over harvesting wild species for food, we also obtain a variety of valuable commercial products from nature. ex. Rhino horns.
-Predator and Pest Control- some animals are killed off because they are deemed as dangerous. ex. coyotes
Exotic Species Introduction
-Exotic organisms are aliens introduced into habitats where they are not native and they are one of the greatest threats to native biodiversity. Exotics can be thought of as biological pollution. There are now more than 4,500 alien species in the United States. ex. Kudzu vine, purple loosestrife, asian longhorn beetles. They have no natural predators in their new home and can often out compete native plants for food and space. -Diseases- pathogens (disease organisms) can become predators when natural checks and balances are lost.
Endangered Species Management
-Hunting and Fishing Laws- 1890's most states authorized laws. ex. white tailed deer

-The Endangered Species Act- ESA of 1973 prohibits the killing of a endangered species. The act has now expired. Endangered: considered in imminent danger of extinction Threatened: those that are likely to become endangered **Vulnerable species**:
-naturally rare or have become so because of human activities. Problems arose with lawsuits. What about saving Mrs. Furbisher's lousewort??? Area in US with most endangered species is Southwest. Characteristics of endangered species: large body size, large or very small territory requirement, long-lived, specialist species, low reproduction rate.
Successful Comebacks: American alligator, Bald Eagle and California condor Some people want the economic cost of recovery to be included in the decision making process. ex. Snail darter and Northern Spotted Owl. 80% of the habitat for more than half of endangered species live on nonpublic property. Land owners are resistant. Over the past decade, growing numbers of scientists, land managers, policy makers, and developers have been making that case that it is time to focus on a rational, continent
-wide preservation of ecosystems that support maximum biological diversity rather than a species-by-species battle for the rarest or most popular organisms.
-**Minimum Viable Populations**: small numbers of surviving species are more vulnerable to extinction.
Island Biogeography. The smaller and farther away an "island" is from a continent, the faster the extinction rate. -International Wildlife Treaties Convention on International Trade in Endangered Species (CITES). Prohibits the trade of endangered species internationally. ex. Elephants -Captive Breeding and Species Survival Plans: zoo breeding can reintroduce endangered species back into the wild
Land Use: Forests and Range lands
Land Use Distribution of World:
-32% Forest and wetlands,
-31% Tundra, desert, wetlands, and urban areas,
-26% Range and pasture,
-11% Cropland Forests regulate climate, control water runoff, provide shelter and food and purify the air. Plus they are pretty to look at! 50 to 60% of the world depends upon wood or charcoal for heating and/or cooking. Forests in NE USA (Temperate) are rejuvenating! Tropical Forests are critically threatened. Jungles contain 2/3 of all plants and 1/2 of all animal life. There needs to be laws preventing deforestation in developing countries.
Forest management: Monoculture forestry is the most profitable but the most destructive to the health of the forest. -Temperate Forests: In the United States and Canada, the two main issues in timber management are (1) cutting the last remains of old-growth forest and (2) methods used in timber harvest. Clear cutting is when every tree in a given area is cut regardless of size. The concentration of nitrates in the runoff increases. Strip cutting entails harvesting all trees in a narrow corridor.
Sustainable Forestry: In both temperate and tropical regions, scores and certification programs are being developed to identify sustainably produced wood products. Selective cutting is when only a small percentage of the mature trees are taken in each 10- or 20- year rotation. Increasingly, non-timber forest products are seen as an alternative to timber production. Range lands: Pasture (generally enclosed domestic meadows or managed grasslands) and open range (unfenced, natural prairie and open woodlands) occupy about 26% of the world's land surface.
Overgrazing and Protection: About one-third of the world's range is severely degraded by overgrazing, making this the largest cause of soil degradation. The process of denuding and

degrading a once-fertile land initiates a desert-producing cycle that feeds on itself and is called desertification. Rotational grazing; confining animals to a small area for a short time (often only for a day or two) before shifting them to a new location; stimulates the effects of wild herds. This allows the animals to trample and fertilize the ground without damaging it.

BIOLOGICAL COMMUNITIES

Evolution

Tolerance Limits and Species Abundance

tolerance limits- the maximum and minimum levels beyond which a particular species cannot survive or is unable to reproduce, ex. temperatures, moisture levels, nutrient supply, soil and water chemistry, and living space.
-different for each species
-later discovered that rather than a single factor that limited growth, it was several factors working together, that determined biogeographical distribution
-for some species there may be a critical factor that determines their abundance and distribution in an area
-ex. saguaro cactus, sensitive to low temperatures, will begin to die in 12 hours of freezing temps. -young saguaros are more susceptible to cold than adults
-young animals also have more critical tolerance limits than the adults, ex. pupfish
-requirements and tolerances of species often are helpful in understanding the environmental characteristics of an area. the presence of a species can say something about the community and ecosystem
environmental indicators- species with specific tolerance limits that tell us something about the area where they are present ex. locoweeds grow in areas with a high soil concentration of selenium

Natural Selection and Adaptations
-term adapt used in two ways
1. limited range of physiological modifications, called acclimations, available to individual organisms. ex. house plants inside all winter
2. inheritance of specific genetic traits that allow a species to live in a particular environment
evolution- species change gradually through competition for scarce resources and natural selection
natural selection-a process in which those members of a population that are best suited for a particular set of environmental conditions will survive and produce offspring more successfully than their ill-suited competitors
-natural selection acts of preexisting genetic diversity created by small random mutations and occur spontaneously in every population
-mutations alight, but in the long run, create amazing diversity
-theory developed by Charles Darwin
Environmental factors that cause selective pressure and influence fertility or survivorship-
1. physiological stresses due to inappropriate levels of some critical environmental factor ex. moisture, light, temp. pH, specific nutrients
2. predation, including parasitism and disease
3. competition
4. luck, sometimes they're just lucky rather than better fir to survive
-selection affects individuals, but evolution and adaptation work at the population level, species evolve not individuals
-isolation can also drive evolution, and cause for variations in species

convergent evolution- when through time when unrelated organisms evolve to look and act very much alike

Niche Specialization
habitat- the place or set of environmental conditions in which a particular organism lives
ecological niche- description of either the role played by a species in a biological community or the total set or environmental factors that determine species distribution
-biophysical definition proposed by G.E. Hutchinson, he said every species has a range of physical and chemical conditions (temp. acidity, humidity etc) as well as biological interactions (predators, prey present, defenses, nutrition available) within which is can exist
-niches can evolve over time
-law of competitive exclusion states that no two species will occupy the same niche and compete for exactly the same resources in the same habitat for very long
resource partitioning- when competition forces one species to either migrate to a new area, become extinct, or change its behavior or physiology in ways that minimize competition
-niche specialization can cause subpopulations of a single species to diverge into separate species, but resources can only be partitioned so far

Species Interactions

Predation
-all organisms need food to live
predator- an organism that feeds directly upon another living organism
-in this broad sense parasites and pathogens may be considered predators
parasites- organisms that feed on a host organism or steal resources from it without killing it
pathogens-disease-causing organisms
-predation is a potent and complex influence on population balance of communities, it involves
1. all stages of the life cycles of predator prey species
2. specialized food obtaining mechanisms
3. specific prey-predator adaptations that either resist or encourage predation
-predation important factor in evolution because predators prey most successfully on the slowest, weakest, least fit members of their target population, causing the prey species to evolve with protective or defensive adaptations to avoid predation
coevolution- the process when predators evolve mechanisms to overcome the evolved defenses of their prey

Keystone Species
keystone species- a species of group of species whose impact on its community or ecosystem is much larger and more influential than would be expected from mere abundance
-many unexpected species can be a keystone species, ex. tropical figs, microorganisms

Competition
-organisms within a community much compete for all the survival necessities: energy and matter in usable forms, space, and specific sites for life activites

intraspecific competition- competition among members of the same species
interspecific competition- competition between members of different species
--competition more of a race than a fight, animals don't want to risk getting injured
-intraspecific competition intense because organisms are fighting directly for the exact same resources
territoriality- intense form of intraspecific competition in which organisms define an area surrounding their home site or nesting site and defend it, primarily against other members of their own species
-territorilaity helps to allocate resources by spacing members of a species

Symbiosis-intimate living together of members or two or more species

Mutualism- a type of symbiosis in which both members of the partnership benefit.
ex. lichens being a combination of fungus and a photosynthetic partner, alga or cyanobacterium
-mutualistic relationship may be important in evolution

Commensalism- a type of symbiosis in which one member clearly benefits and the other apparently is neither benefited nor harmed
ex. cattle and cattle egrets

Parasitism-a form of symbiosis in which one species benefits and the other is harmed.

Defensive Mechanisms-the way that different prey adapt to either hide from or discourage predators
ex. toxic chemicals, body armor
-some organisms produce noxious odors or poisonous secretions
-plants too produce chemical compounds that make them unpalapable or dangerous to disturb
ex. poison ivy, stinging nettles
Batesian mimicry- harmless species that evolve colors, patterns, or body shapes that mimic species that are unpalpable or poisonous
Mullerian Mimicry- when two dangerous species evolve to look alike
-others use camouflage

Community Properties
-productivity, diversity, complexity, resilience, stability, and structure

Productivity-
primary productivity- rate of biomass production
-higher productivity in areas of high temperature moisture and nutrient availability

Abundance and Diversity-
abundance-expression of the total number of organisms in a biological community
diversity- measure of the number of different species, ecological niches, or genetic variation present

-as you go from the equator towards the poles, generally diversity decreases but abundance increases
-productivity is related to abundance and diversity

Complexity and Connectedness
complexity-refers to the number of species at each trophic level and the number of trophic levels in a community
-you can have an abundant community that isn't very complex

Ecological Succession-
-the process by which organisms occupy a site and gradually change environmental conditions b creating soil, shade, shelter, or increasing humidity

Primary Succession-occurs when a community begins to develop on a site previously unoccupied by living organisms
ex. island, new volcanic flow
pioneer species- in primary succession, the species that fist colonizes the new area
-often microbes, mosses and lichens
ecological development- process or environmental modification by organisms

Secondary Succession-occurs when an existing community is disrupted and a new one subsequently develops at the site
-disruption may be caused by natural catastrophe, human activity
climax community- in either primary or secondary succession, when a community develops that resists further change
equilibrium communities/disclimax communities- when landscapes never reach a stable climax in the traditional sense because they are characterized by periodic disruption

Aquatic Succession-process or succession taking place in a body or water

BIOMES:

a broad, regional type of ecosystem characterized by distinctive climate and soil conditions and a distinctive kind of biological community adapted to those conditions.

~**Deserts**: characterized by low moisture levels and infrequent, unpredictable precipitation
-plant adaptations to conserve water and protect from predation
-seasonal leaf production, water storage tissues, thick epidermal layers
-spines and thorns
-warm, dry, descending air creates desert bands at 30 degrees N and S
-deserts at high latitudes are cool
-sand dunes are rare away from the coast
-2-2" of rain per year
-sparse but species-rich community dominated by shrubs and small trees
-animals- structural and behavioral adaptations
-hide in burrows or rocky shelters to escape daytime heat
-mice and rats obtain moisture from the seeds and grains they eat
-highly concentrated urine and dry feces to conserve water
-easily disturbed by humans
-slow to recover because of harsh climate
-EX. tracks still visible from army trucks in WWII, overgrazing, and use for farmland

~**Grasslands/Savannas**: rich biological communities of grasses, seasonal herbaceous flowering plants, and open savannas.
-seasonal cycles for temperature and precipitation">vegetative growth">enriches soil-> good farmland
-10-60" rain per year
-few trees b/c of inadequate rainfall, daily and seasonal temperature ranges, and frequent grass fires
-some are artificially created and maintained by native people using fire (balance ecosystem)
-large grazing animals EX. bison, deer, elk
-human disturbances
-fire suppression
-conversion into farmland
-overgrazing">soil erosion
-hunting, fencing, wetland drainage, introduction of alien species">diminished wildlife population

~**Tundra**: characterized by a short growing season, cold, harsh winters, and the potential for frost
at any time
-far N and S, and high elevations
-less than 10" rainfall per year
-no trees
-arctic-low productivity, low diversity, and low resilience
-long, dark winters
-in summer-only top few centimeters are unfrozen, the rest is permafrost
-surface soil waterlogged b/c of permafrost
-no deep root growth b/c of permafrost">not many plants
-alpine- thin mountain air">permits intense solar bombardment">plants w/dark pigment that shields inner cells
-hot daytime ground temps, freezing nighttime temps
-gravelly, rocky soil
-slope causes quick moisture drainage
-ALL this adds up to a drought problem
-dominant plants- dwarf shrubs, sedges, grasses, mosses, and lichens
-animals must be adapted to harsh climate and sparse food supply
-EX. arctic musk ox and caribou, alpine mountain goats and mountain sheep
-migration and hibernation
-birds nest in the tundra during the summer
-human disturbances
-slow to heal
-oil and natural gas wells in the arctic
-mineral excavation in mountain regions
-truck ruts and tracks

~**Conifer Forest**: regulated by fires
-20-40" of rain per year
-conifer trees can survive harsh winters or extended droughts
-boreal forest- northern coniferous forest
-mixture of coniferous and deciduous trees
-b/w 45 and 50 degrees N latitude
-dominant conifers- pine, hemlock, spruce, cedar, and fir
-dominant deciduous trees- birches, aspens, and maples
-many lakes, potholes, bogs, and fens
-mosquitoes and biting flies are abundant
-taiga- northernmost edge of the boreal forest.
-harsh climate">limited productivity and resilience of community
-cold temps, wet soil, and acids produced by fallen conifer needles"> full decay of organic matter">peat (semi-decayed organic material)
-peat mining could be severe and long-lasting
-southern pine forest-characterized by a warm, moist climate and sandy soil
-managed for timber, turpentine, and rosin
-temperate coniferous forests of the pacific coast- mild temps and abundant precipitation

-up to 100" of rain per year
-luxuriant plant growth and huge trees
-EX. California redwood- largest tree in the world, largest organism EVER
-in its wettest parts, the coniferous forest becomes a temperate rain forest

~**Broad-Leaved Deciduous Forest:** lush summer plant growth when rain is plentiful
-requires adaptations for the frozen season
-30-100" rain per year
-four seasons
-deciduous trees- produce summer leaves and then shed them at the end of the growing season
-EX. oak, maple, birch, beech, elm, ash
-form canopy over smaller shrubs, trees, and herbaceous plants
-human disturbances- most hard hit by man (NE cleared 100 years ago)
-trees harvested for timber
~**Tropical Rain Forest:** one of the most complex and biologically rich biomes
-ample rainfall
-uniform temperatures (about 80 degrees)
-cloud forests- high in the mountains
-fog and mist keep vegetation wet
-tropical rain forest- rainfall abundant (90-180" per year)
-warm to hot temps year round
-thin, acidic, and nutrient-poor soil
-1/2 to 2/3 of all species of terrestrial plants and insects live in tropical forests
-90% of nutrients in the nutrient cycle are in the bodies of living organisms
-growth depends on the decomposition and recycling of dead organic material
-human disturbance
-deforestation">loss of soil fertility b/c the thin soil cannot support crops or resist Erosion
-forest doesn't recover from clear cutting

AQUATIC ECOSYSTEMS

~**Estuaries-** bays of brackish water (mix of salt and fresh water) from where river enters ocean
-contain rich sediments carried downstream
-forming mud flats that nurture aquatic life
-sheltered from most ocean action other than tides
-high species diversity and productivity

~**Wetlands**: land surface is covered with standing water at least part of the year
-vegetation is adapted for growth under these conditions
-swamps- wetlands with trees

-marshes- wetlands w/out trees
-bogs and fens- wetlands w/ or w/out trees that have waterlogged soils that accumulate peat
-low productivity
-swamps and marshes- flowing water and high productivity
-fens- fed by ground water and surface runoff
-bogs- fed by precipitation
-5% of world's landmass and one of the most devastated
-high biomass production
40% net primary productivity interfered by humans.
Benthic- bottom-dwelling organisms
Abyssal plain- flat ocean bottom

RESTORATION ECOLOGY

Conservation	-"Controlled Use", "Scientific Management" of natural resources. "Greatest good for the greatest number of people.
Preservation	-Remaining wilderness areas on public lands should be left untouched
Restoration	-To bring back to former condition (Former Natural State/.Condition), active restoration seeks to reestablish a diverse, dynamic community at sited that have been degraded. -re-create species composition and ecosystem processes as close to the original state as possible
Rehabilitation	-Rebuild elements of structure or function in an ecosystem without achieving complete restoration to its original condition -bring an area back to a useful state for human purposes
Remediation	-Most often used with cleanup of chemical contaminants in a polluted area. -a first step toward protecting human and ecosystem health
Mitigation	-Repairing/Rehabilitating a damaged ecosystem or compensation for damage, Most often by providing a substitute or replacement area; frequently involves wetland ecosystems. The areas most severely underrepresented in protected areas are grasslands, aquatic ecosystems and islands. The least disturbed biomes are temperate conifer forests and arctic tundra.
Reclamation	-Typically used to describe chemical or physical manipulations carried out in severely degraded sites, such as open-pit mines or large-scale construction

Parks and Nature Preserves
History and Park Origins
- Most biologically productive land in private hands.
- Early parks were for higher classes to hunt and for royal recreation.
- Natural landscaping- (Lancelot Brown) A way of making nature look natural, rejecting strait lines, using rolling hills and all natural looking features.
- Used by modern zoos.

- Olmstead designed central park then left and became commissioner of Yosemite. (1864)
- Lincoln authorized Yosemite to save it from the exploitation of the settlers.
- Grant made first National parks, Yellowstone and Yosemite. After this, many other places designated National parks to save wild nature and places with scenic beauty and cultural importance.

North American Parks
- Mexico's Parks smaller than neighbors but encompass more diversity.
- US National Parks encompass 280000 + km2 w/ 376 different parks.
- Most visited parks are recreational; the best are the unspoiled ones.
- Alaska lands act double the area of the park system.
- Canada has 150000 km2 w/1471 parks
- Some Canadian parks allow hunting, logging, mining and environmental manipulation.
- Problems -
- Parks are being clear-cut right up to their boundaries.
- Mines contaminate water shed
- Tourist traps are at the entrances taking away from the beauty.
- Parks need money, traffic to parks increase by 1/3 in the last decade while funding went down _.
- Some have proposed to sponsor the parks, but most rejected.
- In Yosemite, people over crowd and destroy the valley floor, plans have been made to remove all buildings, and make inaccessible to cars to help preserve what is left.
- Other parks such as the ones in the Canadian Rockies, Jasper, California Desert, and the Everglades, are facing over commercialism and pollution.
- Smog is destroying beautiful vistas and reducing visibility.
- Conservation groups want to use federal money to buy private land in parks so that miners can’t go in parks to private land.
- Wildlife -
- Bad animals were killed in the beginning of the parks to increase the amount of good animals.
- Favoring species creates an unbalanced eco system. Good species take over and deplete food sources so smaller species have no food.
- IUNC (International Union for the Conservation of nature and natural resources.) divides protection into five levels.
- 1. Ecological reserves and wilderness areas- little human impact
- 2 .National Parks- Low to little impact
- 3. Natural Monuments and Archeological sites- low/medium
- 4. Habitat and wildlife management areas/ National Wildlife Refuge- medium. hunting okay.
- 5. Cultural or scenic landscapes, recreational areas, National Forests- medium/high.
- Parks need more than just a large boundary to protect an ecosystem, it needs to protect watershed, air shed. Unfortunately, most parks are designed based on political not ecological considerations. A biogeographical area refers to the entire ecosystem.
- Grand Staircase-Escalante National monument made by presidential decree, locals outraged because it stopped them from using rich resources.
- Lesson, it’s not easy to make a new park.
- Clinton made an 84,000,000 acre underwater preserve. This saved from tourism and fishing. He also made a combined 1.1 million ha of protection.

- Bush moved to revoke much of this once he took office.
- Canada's green plan called to double reserves, including an entire watershed.
- World parks and preserves -
- 530 million ha, reserves, nearly 4 % of Earth's surface.
- Most protected biomes, Tropical dry forests, Savannahs, Temperate deciduous forests, tundra. (many to small to protect ecosystem, excluding tundra.)
- Least protected areas: Islands, Lakes, Wetlands.
- IUNC Made the most significant areas of the world Biosphere Reserves.
- Best countries for reserves, Costa Rica, Tanzania, Rwanda.
- Protecting Natural Heritage -
- In many parks, there is political and economic priorities that come before preservation.
- IUNC made a world conservation strategy, maintain earth so humans can survive, preserve genetic biodiversity, and to ensure that any utilization of species and ecosystems is sustainable.

- SIZE AND DESIGN-

*Optimum size and shape for a preserve is large enough to support populations, keep ecosystems intact and isolate critical core areas from human disturbance
*Corridors between natural habitats allow for movement of animals between preserves and protect them from being wiped out in case of a calamity.
*Satisfy conflicting needs and desires of humans manage them this way:
(1) recreation areas- human entertainment
(2) historic areas- preserve a landscape from previous time
(3) conservation reserves- set aside to maintain ecological functions
(4) pristine research areas- baseline of nature for research
(5) inviolable preserves- for sensitive species human interference not allowed
*The smaller the reserve the faster species disappear. The exposed edge of the preserve is more vulnerable to destruction. The preserve with the least edge exposure make the best parks.
-Conservation and Economic Development-
*Tropics has a lot of threatened species and ecosystems
*Basic needs for humans take precedence over the environmental goals
*Tropics are suffering the greatest destruction and species loss in the world
*Ecotourism can benefit the environment more than logging or mining etc.
* Tourism can be utilized as a source of income for the people but also save the wildlife
-Indigenous Communities and Biosphere Reserves-
*UNESCO initiated Man and Biosphere (MAB) program that encourages division of protected areas into multi-use areas. The inner area, or core, is preserved while a buffer zone protects it. Multiple use areas make up the outside of the park.
*Passeo Pantera- a plan to create a thousand mile long series of preservations with corridors linking them along the coast of Central America

-Wilderness Areas-

*indigenous people were significantly hurt by the European diseases
*wilderness: "an area of undeveloped land affected primarily by the forces of nature, where man is a visitor who does not remain; it contains ecological, geological, or other features of scientific or historic value; it possesses outstanding opportunities for solitude or a primitive and unconfined type of recreation; and it is an area large enough so that continued use will not change its unspoiled natural conditions."
*Arguments pro-wilderness:

(1) refuge for endangered wildlife
(2) chance for solitude and recreation
(3) baseline for research
(4) area where it is simply in its natural state and left that way
*people in developing countries don't regard environmental problems as very important matters
*Saving culture, landscapes and history are good reasons to protect an area

-Wildlife Refuges-

*1901 Teddy Roosevelt established 51 wildlife refuges. There are now 511 in nearly 40 million hectares of land
*Franklin D. Roosevelt and Harold Ickes impacted refuges as did Jimmy Carter who signed the Alaska National Interest Land Act which added 22 million ha to the already existing land
-Refuge Management-
*intended to be sanctuaries but by passing of a compromise in 1948 allowed hunting for duck etc on the land.
*Refuges face threats from external activities such as water pollution
*biggest battle currently is about drilling in Alaska
-International Wildlife Preserves-
*The ecosystems in Kenya and Tanzania are very diverse and can hold many species from elephants to hyenas and vultures
*poachers are the major threat in Africa they pursue elephants and rhinos even in the park. Wildlife is worth more alive as an ecotourism lure than dead as a one time commodity.
*makes the supposedly peaceful areas like war zones and the rangers try to stop it, but the poachers have a lot of gun power

-Wetlands, Floodplains and Coastal Regions-

*extremely important sources of biodiversity and a key component of natural freshwater storage and purification systems

-Wetland Values-

*wetlands occupy less than 5 % of land in the US
*they improve water quality and act as a natural water purification system removing silt and absorb nutrients and toxins
*coastal and inland wetlands also provide recreational activities

-Wetland Destruction-

*US Swamp Lands Act of 1850 allowed individuals to buy swamps and marshes for as little as 10 cents per acre. Most wetlands have been converted to farmlands.
*66% of wetlands were destroyed as a result of such acts
*1972 Clean Water Act began protecting wetlands because they requested permits for discharging waste into the waters.

-Floods and Flood Control-

*floodplains: low lands along riverbanks, lakes, coastlines subjected to periodic inundation of water
*The fertile soil in areas prone to floods gives the land it is on a lot of value
*$25 billion elaborate Mississippi river flooding plan works well, except for the fact that it does not allow the water to go anywhere but forces it down the river quickly with no place to go and levees break
*Federal Emergency Management Agency has National Flood Insurance Program that aids people who can't buy insurance and allows them to collect on damage to their house by floods

only if they rebuild on the same sight
-Wetlands and Floodplain Conservation-
*Many different organizations work hard to preserve the floodplains and wetlands, such as Ducks Unlimited and The Department of Agriculture's Wetland Reserve Program
*Globally wetland losses are monitored by Ramsar Convention
-Beaches, Barrier Islands, and Estuaries-
*Estuaries- where salt water mixes with fresh water
*Construction directly on the beaches can cause a lot of damage to the ecosystem
*Damaging vegetation, breaching dune systems to create roads and sand dredging, building artificial barriers.
*Government policies tend to encourage building where there shouldn't be any
*Tactics employed such as "wise use" movement and dozens of "taking" bills, to repeal coastal and floodplain zoning and park and green belt establishment etc.

CONVENTIONAL ENERGY

History of Energy Use in United States- in order of supremacy.

Wood, slaves, coal, steam engine, and oil. Undeveloped countries still use biomass as 90% of their energy source. Amercians and Canadians (at 5% of the world population) use over one quarter of the WORLD's available energy. Hummer=Dummer. If we stopped driving gas hogs and living in sieves we could drastically reduce the amount of oil we use. Each person in the US uses an average of 60 barrels of oil/year- most of which is imported.

The 20 richest countries (1/5 the world's population) use 80% of the world's gas, 65% of the world's oil and 50% of the coal produced each year.

Calorically:

Hunter-gatherers required 2500 cal/day

World consumption is 31,000 cal/day

US consumption is 108,000 ca/day (including oil)

Fossil Fuels- provide 64% of the worlds electricity. Made from fossilized remains of once living organisms buried for years under intense heat and pressure.

Oil (liquid form of petroleum)- our primary source of energy.

Oil is formed when microorganisms accumulate at the bottom of the sea where oxygen is limited. There it is chemically transformed anaerobically into oil and gas by a process called maturation. The longer the hydrocarbon molecule, the more solid it is. Less than 5 carbon atoms is gas. Huge numbers of carbon atoms turn into crude oil. Geologists drill exploratory wells to find a "proven" reserve, a known large quantity of oil. Measured in barrels which are equal to 42 gallons of oil. We have a very vague idea of how much oil is left, but most estimates place our world reserves at 50 more years and US reserves at 25 years. The Hubbert peak theory predicts that the oil production will soon reach a peak and then decline rapidly. We reached peak world oil production in the mid-90's most likely. Iran and Saudi Arabia are a little touchy about informing us of EXACTLY how much oil they have. The US peaked in the 70's.

Petrochemicals are chemicals refined from oil. They include plastic, synthetic fibers, medicine, wax, synthetic rubber, insecticides, fertilizers, detergents, shampoos!!!

Extraction from a reserve is done by pumping (first 25%), then another 50-60% is done by pressure extraction- whereby steam, salt water is pumped into the oil field and pushes out the oil.

As oil prices rise it will be more cost effective to remove more of the oil from the field. Right now removing oil from tar sands and oil shale is cost prohibitive.

Oil prices in the US are heavily subsidized by the government. Europeans pay at least twice as much for oil. The US imports more than half of its oil.

Coal

Most coal originally formed from a dense swampy mat of decaying plants during the Carboniferous period- 300 million years ago. As plant material becomes buried it turns to peat (5% carbon). Further compaction and burial create lignite coal which is 60% carbon. Coal has various grades depending on purity and degree of metamorphism. The least favorable is lignite, then bituminous (sedimentary, 75% carbon) then anthracite (metamorphic, over 90% carbon).

We have roughly 200 years left of coal supplies. It is the most abundant fossil fuel and creates over one half of our electricity in US. Most of the coal supplies are in US, Russia and China.

Coal mining occurs through strip mining and underground mining. Underground mining requires shafts to be sunk to reach deposits. Networks of tunnels are created to reach the deposits and can be very unstable and dangerous. strip mining is horrible for the environment. The earth is removed all the way to the coal seam. Hazardous slag heaps are created containing sulfur which can leach out and damage the water table.

Coal fired electric plants are only 30% efficient AND they emit tons of sulfur and mercury into the air.. floating on the wind currents.... straight to NPZ! Scrubbers should be mandatory to remove S from coal's combustion gases.

Natural Gas

Its convenient, cheap and cleaner burning the previous two fossil fuels. It emits considerably less CO_2 when combusted. Only 10% of energy lost during conversion. (As opposed to 95% energy lost in a light bulb!) Difficult to transport as it has a tendency to blow up if hit. If transporting must keep under pressure to keep in liquid form or put into pipelines.

2/3 of natural gas is burned off when activating a oil well. Maybe they should rethink that.

Nuclear Fusion

2 isotopes of light elements are forced together at high temperatures till they fuse to form a heavier nucleus. 15 million degrees C to fuse H into He. Forgetaboutit. Too unstable. Cars running on nuclear fusion keep on blowing up. Very annoying trait. Takes

Nuclear Power

India and China create the most nuclear power

-Designs and Disasters

Nuclear reactors have fuel rods of uranium and some kind of control rod (cadmium, boron, graphite) to absorb neutrons and slow the chain reaction in the core inside a containment building, a heat exchanging material, steam generator, cooling system and a turbine. The greatest danger is a cooling system failure.

Types of reactors include- Boiling reactors, pressurized water reactors, heavy water reactors and graphite reactors.

After the Three Mile Island partial meltdown in Penn in 1979 and Chernobyl disaster in Russia in 1986 all new nuclear power plant construction projects in the US have been on hold.

-Radioactive Waste Management

-"Too cheap to meter?"
"Technology and engineering would tame the evil genie of atomic energy and use its enormous power to do useful work."
-nuclear power was supposed to be a cheap and safe solution for the projected natural oil and gas deposits being depleted.
-a lot of the future projections for the use of nuclear power were made under the assumption that future advancements in technology would figure out a way to get rid of the waste.
-1970-1974, 140 new reactors for power plants were ordered. Only forty of which were actually built.
-Nuclear energy supplies 20% of power in the US, 8% world wide.
-Nuclear power first developed in the 1950's after WWII, and the invention of the atomic bomb.
-Scientists thought this would be a safe and renewable energy source, but it was proven dangerous to work around, and even minor accidents could have long lasting, and long ranging affects.
-Technology did not catch up with the expectations of the scientists for disposing of the hazardous wastes.
-Another major problem is that because the reactor can not be allowed to melt down, all the systems had to be redundant, making an extremely complex and delicate system that causes more accidents than it prevents.
-Nuclear power plants need to be located next to an abundant source of water to provide the power plant with water. This harms the natural environment of the waterway, and poses great risk if the power plant were to leak nuclear waste. The Hudson river has thermal pollution from Indian Point.

"How does our misunderstood friend work"
-the thing that makes something radioactive is the fact that it is an unstable isotope. All isotopes long to be stable. That is their goal in life. Most plants use 97% U-238 and 3% U-235.

The way they attain this goal is by releasing charged particles. These particles can alter animal DNA
by mutating it in undesirable ways. Exposure to high levels of radiation creates bizarre types of cancer.
This very same process is what gives us power.
-when radioactive isotopes like U238 come in contact with neutrons, they break up into more stable
isotopes releasing massive amounts of energy such as heat and light. This is called nuclear fission. It also releases other neutrons, 2 or 3,making a chain reaction. The way this reaction is controlled is by the use of neutron absorbing materials like graphite. When the operators want to slow down the reaction, they put neutron absorbing material between the fuel rods. This material is removed if the reaction is to speed up. The way the energy is harnessed is
through the use of steam. The nuclear rods sit in a pool of water causing the water to become super heated. This heat is then transferred to another water pool that boils which then spins a turbine that spins a generator that creates electricity.
... And there is no harmful air pollution- no NOx or SOx. Environmentalists are pessimists. Air pollution will kill us slowly, nuclear power will kill us within a few short days! The half-life of uranium (the amount of time it takes for one half of uranium to decay is 4.5 billion years! It would take 10 half lives for uranium to decay to a safe level.

Waste disposal aka just put it where no one will find it.
- There are many ways to dispose of the waste that is generated by nuclear power.
-Waste is generated when the isotopes are first mined, and again when the isotopes are refined, and later when the isotopes are used. All the equipment that comes in contact with the isotopes also becomes waste.
-Countries that use nuclear power have devised many interesting ways to get rid of the waste. Some countries, ahh, like America, have chosen to store the waste on the nuclear reactor site for many years,
and then beginning in 2010 move it to Yucca Mountain, Nevada. This long term storage facility is between two active fault lines, above a major aquifer! Other countries, like Russia took the NIMBY approach, and decided to transport the waste to unprotected cites that are easily accessible by hostile peoples. They even dumped a bunch of nuclear waste on the bottom of the Arctic Ocean!

ECONOMICS

Ecological Economics

Natural Resource
-anything with potential use in creating wealth or giving satisfaction.

Renewable vs. Nonrenewable Resources

Nonrenewable resource
-resources that cannot be replaced (in a human time scale) because they take long periods of time to generate by earth's geological development or they are finite: the minerals, fossil fuels and metals.

-present supplies are becoming exhausted by human standards and will be gone.. soon. Yikes!

Renewable Resources
-things that can be replenished or replaced (usually refers to energy resources) such as sunlight, biological organisms, fresh water, fresh air, wind, and used cooking oil!!!

-but if we rip apart habitats we disrupt self renewing biological cycles. Yikes!

Tragedy of the Commons

-Article written in 1968 by biologist Garret Hardin.

-resources are being destroyed or degraded because people care more about the interest of themselves than they do about public interests. People who use or destroy more than their fair share
of common property.

-Hardin described an open access system- no rules to manage resource use. (ex. Native American management of rice beds and hunting grounds, Maine lobster fisheries)

-communal resource management systems- resources managed by a community for long-term sustainability- can work IF collectively enforced and community anticipates continually living on the land which will be then be passed onto their children.

Classical Economics

The theory is built on the idea that a free capitalistic market is the best method to govern our financial well-being... maybe.

Law of Supply and Demand. As supply (how much product is available) increases its demand (the amount of product the consumers will buy) decreases and the price of the good also decreases. As supply decreases, the demand increases and its price increases. Kind of like a school dance when too many students of the same sex show up.

Market equilibrium is when the demand for a good equals its supply. Supply and demand are inversely proportionate.

GNP- Gross National Product. A nations' wealth is measured by the sum total of all the goods and services it provides.

GDP- Gross Domestic Product. The amount of goods and services produced only within its national boundaries within a year.

Natural Resource Management

Cost Benefit Analysis (CBA)

-This concept is used to evaluate the pollution prevention with the costs and social benefits of a project. It assigns values to resources and evaluates whether the pollution cost of a project is "worth" the social benefits. Legislators use this process to determine whether a given undertaking is a "good idea"
by how cost efficient it is and what benefits it will create as well as how much pollution there will be. This can be looked at as a way for businesses to assign values to natural resources and hopefully a way to mitigate the extent of environmental damage done by any project before it is undertaken.

Often the true cost of using environmental resources are "externalized" meaning the price of permanently distroying nature and polluting our air, water and soils are not taken into consideration when goods are valued on the market. Note with neither of the above calculations are the natural resources (biodiversity, fresh air), human capital (fair wages) or social capital (indigenous societies) taken into consideration.

Marginal Costs

Fixed costs- the costs paid to make a product or provide a service that does not change as production increases. For instance, the mortgage on a property.

Variable costs- costs that increase as the number of products produced increases, such as for raw materials to manufacture a product.

Marginal costs- the cost of making one additional unit of product or service. The total cost per item when one more item is produced. The marginal cost increases as more units are produced, but as more products are made the cost goes down for the consumer.

Margin of diminishing returns- additional benefits gained by the buyer by procuring one more unit of product or service. ex. eating TWO bowls of ice cream or having two oil changes back to back. What is the added value of having that second helping or service?

Internal Costs- immediate costs that are experienced to manufacture a product.

External Costs- costs to people or society that are not experienced by the company and are NOT passed down on to the consumer directly. External costs are felt by someone but NOT those that turn the resources into a profit or those that establish the price of the product. litigation is one way to INTERNALIZE the external costs. ex. Erin Brockovich. So are laws and taxes. ex. Surface mining control and reclamation act (SMCRA) and cigarette taxes.

To internalize external costs means that the consumer is paying for the full cost of the product or the TRUE Cost. Also called the full-cost analysis or true-cost pricing.

Technological Developments

Pollution Tax
-This is used to ensure more environmental protection concerns in national or local economies. Taxes
are paid per unit of effluent.
Businesses are taxed which creates an incentive for these industries to find more ecological ways to
deal with their pollution.

Green Business
-businesses are starting to realize that businesses cannot be sustainable over a long time period.

-new approach to business to how we can achieve both environmental protection and social welfare.

-promotes eco-efficiency, clean production pollution prevention, industrial ecology, natural capitalism, restorative technology, and environmentally preferable products.

Green Consumers
-includes: the Body Shop, Patagonia, Aveda, Malden Mills, Johnson and Johnson and Interface, Inc.

ENVIRONMENTAL GEOLOGY

- Forces inside the earth cause continents to drift, split and crash into each other (very slowly).

A Layered Sphere
-**core**: interior of the earth, composed of hot metal (mostly iron), solid center, semi fluid outer, 2,900-5,000 km in diameter.
-Mantel: surrounds core, much less dense, high concentration of light elements (O2, Si, and Mg), 2,900 km in depth.
-**Crust**: cool, lightweight brittle rock that floats on the mantle (oceanic crust is like the mantle but has more Si while the continents are thicker, lighter regions of crust rich in Ca, Na, K, and Al).
Tectonic Processes and Shifting Continents
-**Tectonic Plates**: large pieces of land broken and moved by huge convection currents on the upper layer of the mantle.
-**Magma**: molten rock that gets pushed up from the mantle through cracks in the oceanic crust and piles underwater to create ocean ridges. Huge mountains and trenches are formed, greater than anything on the continents.
-Earthquakes are caused by grinding and jerking as plates slide past each other.
-When plates collide mountain ranges are pushed up.
-When an oceanic plate collides with a continental landmass, the ocean plate will be subducted and move into the magma where it is melted and the continent will be pushed up (deep ocean trenches form where the ocean plates submerge and volcanoes form where magma erupts though vents and fissures in the crust usually due to this process).
-"**Ring of Fire**" is the place where oceanic plates are subducted under the continental plates. More earthquakes and volcanoes occur here than any other place on the planet.
-The continents are known to have been connected at least once (**Pangaea**). The moving plates and changing climates may have something to do with the mass extinctions that have occurred.

ROCKS AND MINERALS:

-**Mineral**: a naturally occurring, inorganic solid element or compound with a defiant chemical composition and a regular internal crystal structure (must be solid therefore ice is a mineral but liquid water is not) (when an element is purified and in a solid noncrystaline structure, it is no longer a mineral but the ore it was extracted from is).
-**Rock**: a solid, cohesive, aggregate of one or more minerals.
-Each rock is made of grains of different minerals and the size of the grains will depend on how the rock was formed.
Rock Types and How They Were Formed
-**Rock Cycle**: creation, distraction and metamorphosis of rocks. Knowing this cycle can explain the origin and characteristics of rocks and how they are shaped, worn away, transported, deposited, and altered by geologic forces.
-**Igneous Rocks**: solidified from magma from the earth's interior. Magma that reaches the earth's surface cools quickly into basalt, rhyolite, andesite. These rocks have fine grains. Magma that is cooled in subsurface chambers has coarser grains and forms granite, gabbro etc.
-**Weathering**: exposure to air, changing temps and chemical reactions cause the breakdown of

even durable rocks. (Mechanical weathering -physical breakup of rocks into smaller particles w/o a change in chemical composition. Chemical weathering- selective removal or alteration of specific components that leads to the weakening and disintegration of rocks ex. oxidation and hydrolysis. The products of chemical weathering are very susceptible to mechanical weathering and dissolving in water).

-**Sedimentation**: deposition of particles of weathered rock

-**Sedimentary Rock**: when deposited material remains in one place long enough or covered with enough material to compact it will become this type of rock. These rocks usually have layers.

-Relatively soft sedimentary rocks can be formed into unique shapes by the wind.

-**Geomorphology-** study of the processes that shape the earth's surface and the structures they create.

-**Metamorphic rocks**: preexisting rocks that have been modified by heat, pressure (sediments pile on top and tectonic buckling) and chemical agents. These rocks often hold the most economically important minerals such as talc, graphite and gemstones.

ECONOMIC GEOLOGY AND MINERALOGY:

-**Economic Mineralogy**: the study of minerals that are valuable for manufacturing and are important parts of domestic and international commerce. Metal bearing ores are the most economic minerals.

-The most valuable crystal resources are everywhere but concentrated and in places of easy access is what is needed.

Metals

-The metals consumed in greatest quantity by world industry include iron, aluminum, manganese, copper, chromium and nickel.

Nonmetal Mineral Resources

-Include gemstones, mica, talc, asbestos, sand, gravel, salts, limestone, and soils.

-Sand and gravel have the highest economic value of nonmetals and metals.

-**Evaporites**: are materials deposited by evaporation of chemical solutions. They are mined for halite, gypsum, and potash. Often found at 97% purity. Halite is used for water softeners and as road salt and refined as table salt.

Strategic Metals and Minerals

-World industry depends on about 80 minerals and metals, some of which exist in plentiful supplies

others do not like gold, silver and lead.

-Strategic metals and minerals: resources a country uses but cannot produce itself. A government usually will consider these materials as capable of crippling its economy or military strength if unstable global economics or politics were cut off to supplies.

-Usually less developed countries sacrifice the environment to mine and become producers of resources other countries need. This emphasis on a single export is not a stable foundation for an entire economy to be built since steady international markets are not a reality.

Environmental Effect on Research Extraction:

-Physical processes of mining and physical or chemical properties of separating minerals, metals, and other geological resources from ores or other materials.

-**Ore**: A rock in which valuable or useful metal occurs at a concentration high enough to make mining it economically attractive.

-**Copper**: concentration is close to 1 percent.

-Gold and other precious metals: concentration is close to 0.0001 percent.

Methods of Mining:

-Placer Mining: process in which native metals deposited in the gravel of streambeds are washed out hydraulically. Streambeds and aquatic life are destroyed.

-Strip mining and open-pit mining: Materials are removed from large, deep ores by big equipment.

-nearly a million acres of US land have been destroyed by strip mining

-50 percent of US coal is strip mined

-Underground tunnels- used to reach the deepest deposits.

-Mountaintop removal mining: mountain is removed from coal which devastates ecosystems.

Mining Hazards:

-tunnels collapse

-natural gas in coal mines can cause explosion

-fires produce smoke and gases

-acidic and toxic waste runoff is caused by surface waste deposits called tailings

-tailings from uranium can caused wind scattering of radioactive dust

-water dissolves metals and toxic materials which causes pollution

- Long ridges called spoil banks are susceptible to erosion and chemical weathering.

-19,000 km or rivers and streams in US are contaminated by mine drainage

-soil is destroyed which prevents vegetation

Controlling Mining:

-**1977** federal Surface Mining Control and Reclamation Act requires better restoration of strip-mined lands, especially farmlands

-expense of reclamation is high, approximately $1,000 per acre

Processing:

-Metals are released from ores by heating or treatment with chemical solvents

-**Smelting**: roasting ore to release metals is a major source of air pollution

-**Ducktown Tennessee:** mid-1800s mining companies extracted copper with huge open-air wood fires which acidified soil and poisoned vegetation

-**1907**: sulfur emissions from Ducktown were reduced when Supreme Court ruled to stop interstate transport of air pollution

-**1930s**: Tennessee Valley Authority began treating soil and replanting trees

- two-thirds are areas is now considered adequately covered

-heap-leach extraction: technique used to separate gold from low-grade ores. It has a high potential for water pollution.

-Cyanide spills have occurred in Summitville mine near Almosa, Colorado and in a gold operating mind near Baia Mare in Romania.

Conserving Geological Resources:

Recycling:

-advantages of recycling: less waste, less land lost to mining, less consumption of money, energy and water resources

-recycling aluminum consumes one-twentieth of the energy of extracting new aluminum

-1/2 of aluminum cans will be made into another can in 1 to 2 months

-platinum is recycled for used cars
commonly recycled metals are gold, silver, copper, lead, iron, and steel.
-recycled metals are used for copper pipes, lead batteries, and steel and iron auto parts.
Steel and Iron Recycling:Minimills:
-Minimills: remelt and reshape scrap iron and steel
-produce half of US steel production
-use less energy than integrated mills
-Minimills produce steel at between $225 and $480 per metric tons
-Integrated mills produce steel at $1,425 to $2250 per metric tons
Substituting New Materials for Old:
-plastic pipes have decreased our consumption of copper, lead and steel pipes
-in automobile industry, steel is being replaced by polymers (long-chain organic molecules similar to plastics) , aluminum, ceramics, and high-technology alloys
-new materials reduce vehicle weight and cost, and increase fuel efficiency
-Electronics and communication technology use glass cables to transmit light pulses instead of copper and aluminum wires

Geological Hazards:
Earthquakes:
-sudden movements in the earth's crust that occur along faults where one rock mass slides under another.
-Kobe, Japan and Mexico cities are built on soft landfills and they suffer the greatest damage from earthquakes
-contractors plan to build heavily reinforced structures, strategically placed on weak spots in buildings, to absorb vibrations from earthquakes.
-tsunami: giant seismic sea swells that can move at 1,000 km/hr or faster from the center of an earthquake
-1883 Indonesian volcano Krakatoa created a tsunami that killed 30,000 people.
Volcanoes:
-source of most of the earth's crust
-fertile soils are weathered volcanic materials
Nuees ardentes (glowing clouds) are denser-than-air mixtures of hot gases that move faster than 100 km/hour and destroys towns such as St. Pierre on the Caribbean island of Martinique
-Mudslide associated with volcanoes have devastated Armero and Chinchina in Columbia
-volcanic eruptions release large volumes of ash and dust into air which blocks sunlight
-1991:Mt Pinatubo in Philippines emitted 20 million tons of sulfur dioxide producing sulfuric acid **Landslides:**
-rapid downslope movement of soil or rock
-In US, $ 1 billion in property damage is done every year by landslides and related mass wasting
-threats: road construction, forest clearing, agricultural cultivation, and building on steep slopes

ENVIRONMENTAL HEALTH & TOXICOLOGY

Disease

Pathogens- Disease causing organisms, such as bacteria, viruses and parasites
Morbidity- illness
Mortality- death

* Illness Factors include diet and nutrition, infectious agents, toxic chemicals, physical factors and psychological stress.

* Antibodies are introduced to prevent disease, by introducing a foreign particle

*** The Top Three Leading killers**

1. Cardiovascular Disease
2. Cancers and Tumors
3. Acute Respiratory Disease

* Higher Death Rates occur in less fortunate counties where conditions are not ideal for human health and survival

* **Pesticides**- used to eliminate insect vectors. Problem: Insects tend to become very resistant to the pesticides being used to destroy them, therefore allowing the insect population to come back and infect others

- Currently, death rate is decreasing and life expectancy is increasing

****AIDS****- the largest cause of deaths in the world...killing 3 MILLION people in YEAR 2000!!!

* Over 36 million people are currently living with HIV.

* Largest occurrence in Africa

* Drug Addictions and Unprotected Sex are the two main causes, Heterosexuality

* Places such as Botswana, Zimbabwe and Zambia tend to have survival only of the very young and very old, as the middle ages of those living in these communities have died due to AIDS

****Other Diseases****

Viruses

- Ebola- 90% Mortality
- AIDS- 40 Million People now affected

Bacteria

- Tuberculosis- 256 cases resistant to drugs
- Anthrax-
- Botulism- most recognized in Botox injections (beauty purposes)

Malaria- One million die a year

- More people are being able to afford vaccines, as they are being made faster and cheaper
- U.S. spends $75 Million a year on infectious disease research

*DALY or The Disability-Adjusted Life Years measure the total burden of disease on productivity and quality of life.

*DALY measures are very high in poor countries such as Africa due to lack of sanitation, bad water and polluted drinking water

- Malnutrition creates many diseases

*Approximately 2 billion people suffer from worms, flukes, protozoa and other internal

parasites...affects the immune system greatly!
* 30 new diseases have been introduced in the past two decades
*Emergent diseases are those never known before or that has been absent for at least 20 years
* Flu Epidemic of 1918 was LARGEST loss of life from an individual disease in a single year...(between 30 and 40 million)
*Most flu strains are transmitted by air, or by pigs, birds, monkeys and rodents
- As population grows, the faster a disease will spread
* Outbreaks can occur among livestock as well
* Strep is the most common form of hospital-acquired conditions

Toxicology (Toxic and Hazardous Materials)
- Hazardous = dangerous, including flammables, explosives, irritants, sensitizers, acids and caustics
- Toxins = poisons so they react with cellular components that kill cells
- Allergens = substances that activate the immune system, can act directly as antigens
  * Antigens *- foreign white blood cells

******Four Main Categories of TOXINS******
1. Neurotoxins- kill neurons in the nervous system...example/ Mercury and Lead
2. Mutagens- cause mutations by altering DNA
3. Carcinogens- cause cancer
- The Delaney Clause to the US Food and Drug Act states that no known carcinogen causing "reasonable harm" may be added to food and drugs.
4. Teratogens- toxins that cause abnormal embryonic cell division and result in birth defects...example/ Alcohol and Thalidomide

* **LD50**- measures toxicity of a chemical, LD50 is the dose lethal to 50% of a test population; the lower the LD50, the more toxic the chemical
- The established dose curve will determine the dose below which none of the test subjects were harmed...creating the threshold level, or guide for setting human tolerance levels
- The Dose/Response Curves are not always symmetrical, making it difficult to compare toxicity of unlike chemicals

****Bioaccumulation** of a toxin occurs when an organism absorbs and stores the toxin in its tissues
****Biomagnification**, and the best-known example is with the insecticide DDT

1. Effects of DDT were explained in Rachel Carson's book "Silent Spring"

*****Famous Cases*****
- "**Silent Spring**" mentioned the persistence of pesticides in the environment, Bioaccumulation and biomagnification and effect on non-target species
- **Love Canal**- Mentions Social Justice, Persistence of toxic wastes and Superfund Site. Canal was dug beginning in 1892. When canal failed to be completed, it was used as an industrial dump for several toxic chemicals. The property was sold in order to build several homes and a community school. Many people became ill and when tests were conducted high toxic levels of chemicals were found and the company who originally sold the property was forced to pay for

the removal of the waste found. Today, the people are allowed to move back to their old homes, the site is clean.

- Other cases include the Bhopal Crisis, Ebola and the Hot Zone, Agent Orange and the Vietnam Conflict and the Flu Vaccine

*Acute Toxicity occurs when a large dose inflicts immediate harm on an organism
*Chronic Toxicity occurs when a smaller dose is expressed over a long period of time, harder to detect because it may not be seen for years
*Chemical Synergism- when two toxins together have a greater effect than the SUM of the effects of the two toxins separately...example/ small amount of alcohol with small amount of barbiturates can have a severe effect on the central nervous system...or smoking and asbestos can expose a person to cancer ten times greater than if they were exposed to just one of the factors.
*Best way to destroy these chemicals and toxins-through neutralization or oxidation... Incineration, Air Stripping, Carbon Absorption or Flocculation
* Waste Disposal...Landfills and Dumps, Incineration or a huge problem creator, Selling the Waste to Poor Counties, by doing this the people of the country absorb these toxic wastes into their bodies, all so they get more money.

*HAZMAT Alternatives- You can replace your everyday cleaner with the right combination of harmless substances...things such as Lemon Juice, Vinegar, Water, Club Soda and so much more can replace more hazardous chemicals to make the result safer
*How to Help- Conserve, Recycle and Reduce!

ENVIRONMENTAL PHILOSOPHIES

Understanding our Environment and Environmental Ethics and Philosophy

"The more clearly we can focus our attention on the wonders and realities of the universe about us,
the less taste we shall have for destruction."
-- Rachel Carson

Environmental History of the World
1 BIBLE-nature: dark + evil (viewed by Western Civilization)
2.UTILITARIAN CONSERVATION- Nature is for man's use.
~**Gifford Pinchot**- 1st head of Forest Service
~anthropocentric- what's in it for man?
3. BIOCENTRIC PRESERVATION- nature for nature's sake.
~ **John Muir** -started Sierra Club. ex. Mineral King Valley court case
4. MODERN ENVIRONMENTAL MOVEMENT-
~**Rachel Carson**- wrote Silent Spring (DDT softens egg shells)
~ **David Brower-**saved the Grand Canyon

***Population Explosion**
-6.4 billion & averaging 85 million more each year. Most populated countries: China and India
-Most growth & occurring in poor countries
- Theories vary on long-term population standing (up or down?)
Are there enough resources to provide for this population let alone an increase (drinkable water, food?

***Deforestation**= "destruction of tropical forest, wetland, coral reefs"
-extreme lose of species abundance and diversity
If continued, how will this impact the earth's future?

***Pollution**
-50% toxic waste produced by U.S.
-26% toxic air emissions by U.S.
-Growing problem in industrialized nations
- Hundreds of millions of toxic waste is produced annually
-"No one wants it in their backyard"= exporting to other countries
When there is no room left, where will waste go and at what cost?
~Combination of toxic waste & other environmental ills cause more destruction than infectious diseases

***Global Warming**
- Fossil Fuels (FF)=80% of energy used in industrialized nations (non-renewable....yikes!)
-Burning Fossil Fuels creates CO_2 & heat absorbing gases= *GLOBAL WARMING!!!!!!!!
- effects: sea level rises, drastic climate changes, & massive extinctions

Signs of Hope:
-some cities are cleaner and less polluted than in the past
-population stabilized in industrialized countries
-# of children/women decreased from 6.1 to 3.4
-Infectious diseases have been reduced, life expectancy nearly doubled

-the relative gap between the rich and poor has increased but the percentage of those living in poverty has decreased slightly.

Still Need to have:
-Clean renewable energy sources
- Process of safely disposing toxic waste
-Control birth rate & minimizing poverty

Interrelationship of society and the environment
- North/South Division of haves and have nots
--income ratio of poor to wealthy in 2000 =100 to 1

Economic Classification:
First World-industrialized, democratic, market economies.
Second World- previous socialist countries.
Third World- developing, non-industrialized.

Acute Poverty-1/5% world making less than $1/day.
How can we work within the boundaries of nature and continue to improve economic status of all humanity? (Sustainable Development)

Perspectives
-Neo-Malthusian: world full of too many people fighting over to few resources (pessimistic)
-Technological optimists: human innovations and advancements will solve the earth's problems (critics refer to as Cornucopian Fallacy)

Environmental Ethics and Philosophy

morals: distinction between right and wrong
values: the ultimate worth of actions or things

Environmental Ethics~~> moral relationships between humans + the world around them

A. Other Ethics:
1) Universalists~~> the principles of ethics are universal, unchanging, and eternal
2) Relativists~~> moral rules always apply to a particular person, society, or situation
"There are no facts, only interpretations"-Nietzsche
3) Nihilists~~>there are no truths, life is hard, and dark. The world makes no sense at all!
4) Utilitarians~~>an action is right when it produces the greatest good for the greatest number of people. Pleasures on the intellect are superior to pleasures on the body.

Modern Environmentalism- Silent Spring, written by Rachel Carson, is often viewed as initiating the environmental movement. Her book documented the tragic effects of DDT on birds.

B. World views and Ethical Perspectives
"What people do about their ecology depends on what they think about themselves in relation to the things around them" - Lynn White Jr.

1.) Anthropocentric~~> "human-centered" Environmental responsibility and duties are derived from human interest.
2.) Stewardship~~> a strong sense of responsibility to manage and care for a particular place.
3.)Biocentric~~> "life-centered" All forms of life have the right to exist! Everything in this world is important.
4.) Ecocentric~~> "Earth-centered" the environment deserves moral consideration on its own, not associated with human interest.
5.) Ecofeminism~~> a philosophy that suggests how humans could reconceived themselves and their relationship to nature in non-demanding ways.

C. Environmental Justice~~> combines civil rights with environmental protection to demand a safe, healthy, beautiful environment for everyone.
ex: 3 out of 5 African-Americans and Hispanics, and nearly half of all NATIVE AMERICANS, ASIANS AND PACIFIC islanders live in communities with one or more toxic waste sites or major landfills. (LULU's Locally Unwanted Land Uses)

D. Environmental Racism~~> inequitable distribution of environmental hazards based on race.
Ex: the people who have the highest lead content in their bodies are Latino, Native American, African American, and Asian children.

>>>Dumping Across Borders:
Paying a poorer country/community to allow the dumping of toxic wastes in their land.
Ex: nearly every tribe in America has been approached with proposals for some dangerous Industry or waste facility

Toxic Colonialism~~> targeting poor communities of color in the 3rd or 4th world countries for waste disposal and/or experimentation with risky technologies.
This has gotten worse over the years. Millions of tons of hazardous materials have been moved (legally or illegally) from richer to poorer countries every year.

1992 - The Environmental Justice Act introduced in US.
identify areas threatened by toxic chemicals, assess health effects, ensure residents chance for public discussion concerning cleanup of industrial facilities.

>>>"Green" Organizations.

Most Environmental Activist groups seem to only care about wildlife preservation, instead of inner-city problems (which are much more pressing to people who are struggling for survival)

NIMBY**-** Not In My Back Yard- protests the dumping of pollution in one's own neighborhood. The protests too often end with dumping in someone ELSE's backyard.

National People of Color Environmental Leadership Summit (1991) decided to combine civil rights with Environmental justice.

HUMAN POPULATION

Population Growth rate
History of Human Population

-Human populations were kept in check by diseases, famines and wars until the middle ages ex: Infanticide, Bubonic Plagues
-Populations began to increase rapidly after A.D. 1600 (Increased sailing and navigating skills, agricultural developments, better sources of power, better health care and hygiene)
-We are now in a J-curve, population is increasing at an exponential rate. Our present population is 6.6 billion people and growing by 100 million people per year.

Demographics-vital statistics about people (births, deaths, where people live, total population size)
1) **Crude Birth rate**-the number of births in a year per thousand persons
2) **Crude Death rate**-the number of deaths per thousand persons in any given year
3) **Life Expectancy**-the average age that a newborn infant can expect to attain in any given society
To calculate the annual rate of population growth subtract the crude death rate from the crude birth rate and divide by 10.

The **replacement fertility rate** is the number of children a couple must have to keep the population stable. In the third world it is 2.7, in the US it is 2.1.
-Developing countries have seen the greatest progress
-Discrepancies in how benefits are distributed within a country are shown by varying life expectancies at different areas in a country
-Annual income has a strong correlation to life expectancy
Developing Countries-residents live for about twice as long as they used to
Developed Countries-increase not as great because it was higher to begin with

Impact on Resources-The more people there are, the more resources are used. Especially in developed countries like the U.S. where the amount of resources used per person is greater than in less developed countries.

Carrying Capacity-local, regional and global
-The number of individuals who can be supported in a given area within natural resource limits, and without degrading the natural social, cultural and/or economic environment for present and future generations. As the environment is degraded, carrying capacity gets smaller. The maximum carrying capacity for humans on the Earth is 13-15 billion. The average ecological footprint an American makes is approximately 12 acres/person. Our footprint is the number of acres required to meet the resource needs of an individual.

Population Projections and Solutions
-There could be a population overshoot past the carrying capacity and then a die-off or we could adjust our population growth to an S-curve

-Estimated Demographic Transitions-from high birth and death rates to lower birth and death rates due to improved living conditions and economic development

-Cairo Conference-179 countries met in 1994 to develop an action plan to deal with population growth and included issues such as poverty and health care

-5 Basic Components

1) Provides family-planning services
2) Promotes free trade, private investment, and assistance to countries that need help.
3) Addresses issues of gender equity.
4) Addresses issues of equal access to educational opportunity.
5) Educates men.

*Female Education and Economic Status-If females are educated about birth control, and made aware that they do not need to have many children to replace them, they will not have as many babies. Also, if their economic status is improved, many women will get jobs instead of having children

-Family Planning

-Fertility Decline in Rich Countries

-Abortion-RU486, methotrexate, misprostol, surgical abortion

-Avoidance-Body temp. technique, celibacy/abstinence

-Barrier-Condom, diaphragm, cervical cap, vaginal sponge, spermicide, IUD

-Chemical-"The Pill"

-Surgical-Tubal litigation, vasectomy

LAWS

-Federal Insecticide, Fungicide, Rodenticide Act of 1947 (FIFRA): regulates the manufacture and use of pesticides
-**Wilderness Act of 1964**: established the national wilderness preservation system
-Water Quality Act of 1965: attempt to reduce non-point source pollution by creating government watch dog under Dept of Heath, Ed and Welfare.
-National Environmental Policy Act of 1969: Environmental Impact statements must be done before any project effecting federal lands is started. Created a council on environmental quality.
-Clean Air Act of 1970: established national primary and secondary air quality standards. Set emission standards for cars, and limits for release of air pollutants.
-**Clean Water Act of 1972**: set maximum permissible amounts of water pollutants that can be discharged into waterways and created pollutant discharge permits. Goal: To make all water swimmable and fishable.
-**Endangered Species Act of 1973**: protects threatened and endangered animals in the US, and puts their protection over economic considerations.
-Safe Drinking Water Act (SDWA) of 1974: set maximum contaminant levels for pollutants that may have adverse effects on human health.
-**Superfund Amendments and Reauthorization Act (SARA)**: increased superfund to $8.5 Billion. Shares responsibility for cleanup among potentially responsible parties.
-**Toxic Substance Control Act of 1976**: EPA- ban or regulate chemicals deemed a risk to health to the environment.
-Resource Conservation & Recovery Act (RCRA) of 1976: Controls hazardous waste with a cradle to grave system from storage, treatment, transportation to disposal.
-**Surface Mining Control & Reclamation Act of 1977 (SMCRA)**: requires coal strip mines to reclaim the land
-Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980: Created $1.6 billion superfund designed to identify and clean up abandoned hazardous waste dump sites. Established liability for clean up costs if source could be identified.
-**Ocean Dumping Ban Act of 1988**: Bans dumping of sewage, sludge and industrial waste into oceans.
-**Food Quality Protection Act of 1996 (FQPA0**: Set pesticide limits in food, and all active and inactive ingredients must be screened for estrogenic/endocrine effects.
-**Low Level Radioactive Policy Act**: all states must have facilities to handle low level radioactive wastes.
-Nuclear Waste Policy Act: US government must develop a high level nuclear waste site by 2015
-**Coastal Zone Management Act (CZMA)-** A 1972 Federal law that provides guidance and federal assistance to voluntary state and local coastal management programs. Goals are for the protection of natural resources and management of land development along coasts.
-**Federal Land Policy and Management Act (FLPMA)-** A 1976 Federal law that outlines procedures concerning the use and preservation of public US lands.
-**Food Drug and Cosmetic Act-** A federal law passed in 1906 that regulates the sanitary condition and safety of food, drugs and cosmetics. It includes food additives.

International Treaties, Laws and Conventions

-Convention on International Trade in Endangered Species (CITES): lists species that cannot be commercially traded as live specimens or wildlife products.
-Madrid protocol: Moratorium on mineral exploration for 50 years in Antarctica
-Kyoto Protocol of 1997: Controlling global warming by setting greenhouse gas emissions targets for developed countries. Not signed by the U.S.
-Montreal Protocol of 1987: A plan to limit and eventually phase out ozone depleting substances (CFC's)
-Earth Summit: held in 1970's, discussed clean water and air. Held in South Africa. The last summit tried to pass a world law by the year 2010 that 15% of our power was to be created by air and solar power. But the Summit was shut down.
-The World Trade Organization (WTO): designed to make international trade more fair and encourage development.
It has been used to subvert national environmental laws. Has the effect of hurting small, local farmers and businesses.
-North American Free Trade Agreement (NAFTA): Trade alliance between U.S., Canada and Mexico

Environmental Legislation/Agreements (Short Version)

Name	Abbr.	Description
Atomic Energy Act	AEA	Provides for the development and regulation of the uses of nuclear materials and facilities in the US.
Clean Air Act	CAA	Established primary and secondary air quality standards. Required states to develop implementation plans. Sets limits and goals to reduce mobile source air pollution and ambient air quality standards.
Clean Water Acts	CWA	Regulates and enforces all discharge into water sources and wetland destruction/construction.
Comprehensive Environmental Response, Compensation Liability Act	CERCLA Superfund	Established federal authority for emergency response and clean-up of hazardous substances that have been spilled, improperly disposed, or released into the environment
Consumer Product Safety Act	CPSA	Purpose is to protect the public against unreasonable risks of injury associated with consumer products.
Convention on International Trade in Endangered Species	CITIES	Controls the exploitation of endangered species through international legislation. Bans hunting, capturing and selling of threatened species and bans the import of ivory.
Emergency Planning & Community Right-To-Know Act	EPCRA	Requires reporting of toxic releases: the Toxic Release Inventory (TRI); Encourages response for

		chemical releases
Endangered Species Act	ESA	Protects species that are considered to be threatened or endangered. Includes migratory birds and their habitats.
Energy Policy Act	EPA	The Act originally publicizes radiation protection standards for the Yucca Mountain repository.
Energy Policy and Conservation Act	EPCA	Authorizes the president to draw from the petroleum reserve as well as established a permanent home-heating oil reserve in the Northeast. Clarifies when the president can draw from these resources.
Federal Food, Drug, and Cosmetic Act	FDA	Assures the safety, wholesomeness, efficacy, and truthful packaging and labeling of food, drugs, cosmetics, and medical devices.
Federal Insecticide, Fungicide and Rodenticide Act	FIFRA	Requires that all pesticides are registered and approved by the FDA and creates a pesticide registry.
Federal Water Pollution Control Act	FWPCA	Authorized the surgeon general of the Public Health Service, with others, to prepare comprehensive programs for eliminating or reducing the pollution of interstate waters and tributaries and improving the sanitary condition of surface and underground waters.
Food Quality Protection Act	FQPA	Set pesticide limits in food, & all active and inactive ingredients must be screened for estrogenic/endocrine effects
Hardrock Mining and Reclamation	HMA	The bill provides that the secretary of the interior will establish a royalty rate of from 2% to 5% of the value of locatable mineral production from any new mines on federal mineral lands.
Hazardous Material Transportation Act	HAZMAT	Governs the transportation of hazardous materials and wastes.
International Environmental Protection Act	IEPA	Authorized the president to assist countries in protecting and maintaining wildlife habitat and provides an active role in conservation by the Agency for International Development.
Kyoto Protocol	KP	Agreement among 150 nations requiring greenhouse gas emission reduction.
Lacey Act	LA	A conservation law prohibiting the transportation of illegally captured or prohibited animals across state lines. It was the first federal law protecting wildlife, and is still in effect, though it has been revised several times. Today the law is primarily

		used to prevent the importation or spread of potentially dangerous non-native species.
Law of the Sea Convention	LOSC	International agreement that sets rules for the use of the world's oceans, which cover 70 percent of the Earth's surface.
Low Level Radioactive Policy Act	LLRPA	All states must have facilities to handle low level radioactive wastes
Madrid Protocol		Moratorium on mineral exploration for 50 years in Antarctica
Marine Plastic Pollution Research and Control Act	MPPRCA	Regulates the dumping of wastes into oceans and coastal waters
Migratory Bird Hunting Stamp Act	MBHSA	Requires purchase of a stamp by waterfowl hunters. Revenue generated is used to acquire wetlands. Since its inception, the program has resulted in the protection of approximately 4.5 million acres (18,000 km^2) of waterfowl habitat.
Mining Act of 1872	MA	United States federal law that authorizes and governs prospecting and mining for economic minerals, such as gold, platinum, and silver, on federal public lands.
Montreal Protocol	MP	Banned the production of aerosols and initiated the phase out of all CFC's.
National Appliance Energy Act	NAEA	Set minimum efficiency standards for numerous categories of appliances.
National Environmental Policy Act	NEPA	Authorized the Council on Environmental Quality as the oversight board for general conditions; directs federal agencies to take environmental consequences into account in decision making; requires EIP statement be prepared for every major federal project having environmental impact.
National Park Act	NPA	Created Yosemite and Yellowstone National Parks.
Noise Control Act	NCA	Promotes a national environment free from noise that jeopardizes health and welfare. Establishes research, noise standards, and information dissemination.
Nuclear Waste Policy Act	NWPA	Established a site to identify for, and construct, an underground repository for spent nuclear reactor fuel and high-level radioactive waste from federal defense programs.
Occupational Safety and Health Act	OSHA	Created to protect worker and health. Its main aim was to ensure that employers provide their

		workers with an environment free from dangers to their safety and health, such as exposure to toxic chemicals, excessive noise levels, mechanical dangers, heat or cold stress, or unsanitary conditions.
Ocean Dumping Act	ODA	Makes it unlawful for any person to dump or transport for the purpose of dumping sewage, sludge, or industrial waste into ocean waters.
Oil Pollution Act	OPA	It states "A company cannot ship oil into the United States until it presents a plan to prevent spills that may occur. It must also have a detailed containment and cleanup plan in case of an oil spill emergency."
Pollution Prevention Act	PPA	Requires facilities to reduce pollution at its source. Reduction can be in volume or toxicity.
Quiet Communities Act	QCA	Provides for the coordination of federal research and activities in noise control. Authorized FAA funds for development of noise abatement plans around airports.
Resource Conservation and Recovery Act	RCRA	Management of non-hazardous and hazardous solid waste including landfills and storage tanks. Set minimal standards for all waste disposal facilities and for hazardous wastes.
Safe Drinking Water Act	SDWA	The Environmental Protection Agency (EPA) is allowed to set the standards for drinking water quality and oversees all of the states, localities, and water suppliers who implement these standards
Soil and Water Conservation Act	SWCA	Provides for a continuing appraisal of US soil, water, and related resources, including fish and wildlife habitats, and a soil and water conservation program to assist landowners.
Soil Conservation Act	SCA	Established the soil conservation service, which deals with soil erosion problems, carries out soil surveys, and does research on soil salinity.
Solid Waste Disposal Act	SWDA	To find better and more efficient ways to dispose of solid waste; promotes shredding and separation of waste and burning of remaining materials to produce stream or generate electricity; promotes recycling.
Stockholm Declaration	SD	United Nations Conference on Human Environment having considered the need for a common outlook and principles to inspire and guide the peoples of the world in the preservation

		and enhancement of the human environment.
Surface Mining Control and Reclamation Act	SMCRA	Requires restoration of abandoned mines.
Taylor Grazing Act	TGA	A United States federal law that regulates grazing on federal public land. The Secretary of the Interior has the authority to handle all of the regulations, and he became responsible for establishing grazing districts. Before these districts are created there must be a hearing held by the state.
Toxic Substances Control Act	TSCA	EPA is given the ability to track the 75,000 industrial chemicals currently produced or imported into the United States. EPA repeatedly screens these chemicals and can require reporting or testing of those that may pose an environmental or human-health hazard. EPA can ban the manufacture and import of those chemicals that pose an unreasonable risk.
Water Resources Planning Act	WRPA	Provides for a plan to formulate and evaluate water and related land resources.
Wild and Scenic Rivers Act	WSRA	Selected rivers in the United States are preserved for possessing outstandingly, remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values.
Wilderness Act	WA	Allowed congress to set aside federally owned land for preservation.

Major Environmental Laws (Long Version)

Clean Air Act

42 U.S.C. s/s 7401 et seq. (1970)

The Clean Air Act is the comprehensive Federal law that regulates air emissions from area, stationary, and mobile sources. This law authorizes the U.S. Environmental Protection Agency to establish National Ambient Air Quality Standards (NAAQS) to protect public health and the environment.

The goal of the Act was to set and achieve NAAQS in every state by 1975. The setting of maximum pollutant standards was coupled with directing the states to develop state implementation plans (SIP's) applicable to appropriate industrial sources in the state.

The Act was amended in 1977 primarily to set new goals (dates) for achieving attainment of NAAQS since many areas of the country had failed to meet the deadlines. The 1990 amendments to the Clean Air Act in large part were intended to meet unaddressed or insufficiently addressed problems such as acid rain, ground-level ozone, stratospheric ozone depletion, and air toxics.

Clean Water Act

Growing public awareness and concern for controlling water pollution led to enactment of the Federal Water Pollution Control Act Amendments of 1972. As amended in 1977, this law became commonly known as the Clean Water Act. The Act established the basic structure for regulating discharges of pollutants into the waters of the United States. It gave EPA the authority to implement pollution control programs such as setting wastewater standards for industry. The Clean Water Act also continued requirements to set water quality standards for all contaminants in surface waters. The Act made it unlawful for any person to discharge any pollutant from a point source into navigable waters, unless a permit was obtained under its provisions. It also funded the construction of sewage treatment plants under the construction grants program and recognized the need for planning to address the critical problems posed by non-point source pollution.

Subsequent enactments modified some of the earlier Clean Water Act provisions. Revisions in 1981 streamlined the municipal construction grants process, improving the capabilities of treatment plants built under the program. Changes in 1987 phased out the construction grants program, replacing it with the State Water Pollution Control Revolving Fund, more commonly known as the Clean Water State Revolving Fund. This new funding strategy addressed water quality needs by building on EPA-State partnerships.

Over the years, many other laws have changed parts of the Clean Water Act. Title I of the Great Lakes Critical Programs Act of 1990, for example, put into place parts of the Great Lakes Water Quality Agreement of 1978, signed by the U.S. and Canada, where the two nations agreed to reduce certain toxic pollutants in the Great Lakes. That law required EPA to establish water quality criteria for the Great Lakes addressing 29 toxic pollutants with maximum levels that are safe for humans, wildlife, and aquatic life. It also required EPA to help the States implement the criteria on a specific schedule.

The electronic version of the Clean Water Act (available below) is a thirtieth anniversary snapshot of the law, as amended through the enactment of the Great Lakes Legacy Act of 2002 (Public Law 107-303, November 27, 2002). Provided by the Congressional Great Lakes Task Force, it is the amended law as of that particular point in time. This electronic version annotates the sections of the Act with the corresponding sections of the U.S. Code and footnote commentary on the effect of other laws on the current form of the Clean Water Act.

Introduction to the Clean Water Act

The Clean Water Act (CWA) is the cornerstone of surface water quality protection in the United States. (The Act does not deal directly with ground water nor with water quantity issues.) The statute employs a variety of regulatory and non-regulatory tools to sharply reduce direct pollutant discharges into waterways, finance municipal wastewater treatment facilities, and manage polluted runoff. These tools are employed to achieve the broader goal of restoring and maintaining the chemical, physical, and biological integrity of the nation's waters so that they can support "the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water."

For many years following the passage of CWA in 1972, EPA, states, and Indian tribes focused mainly on the chemical aspects of the "integrity" goal. During the last decade, however, more attention has been given to physical and biological integrity. Also, in the early decades of the Act's implementation, efforts focused on regulating discharges from traditional "point source" facilities, such as municipal sewage plants and industrial facilities, with little attention paid to runoff from streets, construction sites, farms, and other "wet-weather" sources.

Starting in the late 1980s, efforts to address polluted runoff have increased significantly. For "non-point" runoff, voluntary programs, including cost-sharing with landowners are the key tool. For "wet weather point sources" like urban storm sewer systems and construction sites, a regulatory approach is being employed.

Evolution of CWA programs over the last decade has also included something of a shift from a program-by-program, source-by-source, pollutant-by-pollutant approach to more holistic watershed-based strategies. Under the watershed approach equal emphasis is placed on protecting healthy waters and restoring impaired ones. A full array of issues are addressed, not just those subject to CWA regulatory authority. Involvement of stakeholder groups in the development and implementation of strategies for achieving and maintaining state water quality and other environmental goals is another hallmark of this approach.

Take the "Fact or Fiction" Clean Water Act Quiz: http://www.epa.gov/watertrain/cwa/

Endangered Species Act

7 U.S.C. 136; 16 U.S.C. 460 et seq. (1973)

The Endangered Species Act provides a program for the conservation of threatened and endangered plants and animals and the habitats in which they are found. The U.S. Fish and Wildlife Service of the Department of the Interior maintains the list of 632 endangered species (326 are plants) and 190 threatened species (78 are plants).

Species include birds, insects, fish, reptiles, mammals, crustaceans, flowers, grasses, and trees. Anyone can petition FWS to include a species on this list. The law prohibits any action, administrative or real, that results in a "taking" of a listed species, or adversely affects habitat. Likewise, import, export, interstate, and foreign commerce of listed species are all prohibited.

EPA's decision to register a pesticide is based in part on the risk of adverse effects on endangered species as well as environmental fate (how a pesticide will affect habitat). Under FIFRA, EPA can issue emergency suspensions of certain pesticides to cancel or restrict their use if an endangered species will be adversely affected. Under a new program, EPA, FWS, and USDA are distributing hundreds of county bulletins that include habitat maps, pesticide use eliminations, and other actions required to protect listed species.

Emergency Planning & Community Right to Know Act (EPCRA)

42 U.S.C. 11001 et seq. (1986)

Also known as Title III of SARA, EPCRA was enacted by Congress as the national legislation on community safety. This law was designated to help local communities protect public health, safety, and the environment from chemical hazards.

To implement EPCRA, Congress required each state to appoint a State Emergency Response Commission (SERC). The SERC's were required to divide their states into Emergency Planning Districts and to name a Local Emergency Planning Committee (LEPC) for each district.

Broad representation by fire fighters, health officials, government and media representatives, community groups, industrial facilities, and emergency managers ensures that all necessary elements of the planning process are represented.

Federal Insecticide, Fungicide, and Rodenticide Act

7 U.S.C. s/s 136 et seq. (1996)

The primary focus of FIFRA was to provide federal control of pesticide distribution, sale, and use. EPA was given authority under FIFRA not only to study the consequences of pesticide usage but also to require users (farmers, utility companies, and others) to register when purchasing pesticides.

Through later amendments to the law, users also must take exams for certification as applicators of pesticides. All pesticides used in the U.S. must be registered (licensed) by EPA. Registration assures that pesticides will be properly labeled and that if in accordance with specifications, will not cause unreasonable harm to the environment.

National Environmental Protection Act

42 U.S.C. s/s 4321 et seq. (1969)

The National Environmental Policy Act was one of the first laws ever written that establishes the broad national framework for protecting our environment. NEPA's basic policy is to assure that all branches of government give proper consideration to the environment prior to undertaking any major federal action that significantly affects the environment.

NEPA requirements are invoked when airports, buildings, military complexes, highways, parkland purchases, and other federal activities are proposed. Environmental Assessments (EAs) and Environmental Impact Statements (EISs), which are assessments of the likelihood of impacts from alternative courses of action, are required from all Federal agencies and are the most visible NEPA requirements.

Oil Pollution Act of 1990

33 U.S.C. 2702 to 2761

The Oil Pollution Act (OPA) of 1990 streamlined and strengthened EPA’s ability to prevent and respond to catastrophic oil spills. A trust fund financed by a tax on oil is available to clean up spills when the responsible party is incapable or unwilling to do so. The OPA requires oil storage facilities and vessels to submit to the Federal government plans detailing how they will respond to large discharges. EPA has published regulations for aboveground storage facilities; the Coast Guard has done so for oil tankers. The OPA also requires the development of Area Contingency Plans to prepare and plan for oil spill response on a regional scale.

Pollution Prevention Act

42 U.S.C. 13101 and 13102, s/s et seq. (1990)

The Pollution Prevention Act focused industry, government, and public attention on reducing the amount of pollution through cost-effective changes in production, operation, and raw materials use. Opportunities for source reduction are often not realized because of existing regulations, and the industrial resources required for compliance, focus on treatment and disposal. Source reduction is fundamentally different and more desirable than waste management or pollution control.

Pollution prevention also includes other practices that increase efficiency in the use of energy, water, or other natural resources, and protect our resource base through conservation. Practices include recycling, source reduction, and sustainable agriculture.

Resource Conservation and Recovery Act

42 U.S.C. s/s 6901 et seq. (1976)

RCRA (pronounced "rick-rah") gave EPA the authority to control hazardous waste from the "cradle-to-grave." This includes the generation, transportation, treatment, storage, and disposal of hazardous waste. RCRA also set forth a framework for the management of non-hazardous wastes.

The 1986 amendments to RCRA enabled EPA to address environmental problems that could result from underground tanks storing petroleum and other hazardous substances. RCRA focuses only on active and future facilities and does not address abandoned or historical sites (see CERCLA).

HSWA (pronounced "hiss-wa")—The Federal Hazardous and Solid Waste Amendments are the 1984 amendments to RCRA that required phasing out land disposal of hazardous waste. Some of the other mandates of this strict law include increased enforcement authority for EPA, more stringent hazardous waste management standards, and a comprehensive underground storage tank program.

Safe Drinking Water Act

42 U.S.C. s/s 300f et seq. (1974)

The Safe Drinking Water Act was established to protect the quality of drinking water in the U.S. This law focuses on all waters actually or potentially designed for drinking use, whether from above ground or underground sources.

The Act authorized EPA to establish safe standards of purity and required all owners or operators of public water systems to comply with primary (health-related) standards. State governments, which assume this power from EPA, also encourage attainment of secondary standards (nuisance-related).

Comprehensive Environmental Response, Compensation, and Liability Act (Superfund) (CERCLA)

42 U.S.C. s/s 9601 et seq. (1980)

CERCLA (pronounced SIR-cla) provides a Federal “Superfund” to clean up uncontrolled or abandoned hazardous-waste sites as well as accidents, spills, and other emergency releases of pollutants and contaminants into the environment. Through the Act, EPA was given power to seek out those parties responsible for any release and assure their cooperation in the cleanup.

EPA cleans up orphan sites when potentially responsible parties cannot be identified or located, or when they fail to act. Through various enforcement tools, EPA obtains private party cleanup through orders, consent decrees, and other small party settlements. EPA also recovers costs from financially viable individuals and companies once a response action has been completed.

EPA is authorized to implement the Act in all 50 states and U.S. territories. Superfund site identification, monitoring, and response activities in states are coordinated through the state environmental protection or waste management agencies. In Region 5, CERCLA is administered by the Superfund Division.

CERCLA Overview The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), commonly known as Superfund, was enacted by Congress on December 11, 1980. This law created a tax on the chemical and petroleum industries and provided broad Federal authority to respond directly to releases or threatened releases of hazardous substances that may endanger public health or the environment. Over five years, $1.6 billion was collected and the tax went to a trust fund for cleaning up abandoned or uncontrolled hazardous waste sites. CERCLA:

• established prohibitions and requirements concerning closed and abandoned hazardous waste sites;

• provided for liability of persons responsible for releases of hazardous waste at these sites; and

• established a trust fund to provide for cleanup when no responsible party could be identified.

The law authorizes two kinds of response actions:

• Short-term removals, where actions may be taken to address releases or threatened releases requiring prompt response.

• Long-term remedial response actions, that permanently and significantly reduce the dangers associated with releases or threats of releases of hazardous substances that are serious, but not immediately life threatening. These actions can be conducted only at sites listed on EPA's National Priorities List (NPL).

CERCLA also enabled the revision of the National Contingency Plan (NCP). The NCP provided the guidelines and procedures needed to respond to releases and threatened releases of hazardous substances, pollutants, or contaminants. The NCP also established the NPL.

CERCLA was amended by the Superfund Amendments and Reauthorization Act (SARA) on October 17, 1986

Role of Government in Environmental Affairs

History

In 1639 Rhode Island Colony established a closed season on deer hunting

1. Colonies and later states established similar regulations
2. Enforcement of regulations not really dealt with until warden systems developed in the 1850's

Lacey Act - 1900

1. Prohibited the transportation of illegally killed game across state lines, curbed trafficking of plumage and other wildlife products and initiated permit requirements and controls for the introduction of mongooses, starlings and other exotic species
2. Established federal control over wildlife, broadened the areas of interest, strong deterrent to the unwarranted exploitation of wildlife

Migratory Bird Treaty Act (1918)

1. International treaty for the protection of whooping cranes, swans, most shorebirds and wood ducks, bird nests and eggs and establishment of closed seasons for waterfowl, and authorization for the states to adopt and enforce regulations that were not inconsistent with federal provisions
2. Beginnings of an expanded wildlife refuge system, endangered species management and federal law enforcement

Pittman-Robertson Act (1937)

1. Levied a 10% tax on the sales of sporting arms and ammunition, money returned to the state based on a formula
2. Through matching program ($1 from state: $3 P-R) state projects approved at the federal level; research, land acquisition and construction

Dingell - Johnson Act (1950)

1. Levied a 10% excise tax on fishing tackle
2. Similar matching program as P-R and supported research projects, fish hatcheries, land acquisition

Fish and Wildlife Coordination Act (1934)

1. Ensured that fish and wildlife receive equal consideration with other features of water-development programs at the federal level
2. Massive dislocations of water must consider fish and wildlife values
3. If project jeopardizes existing wildlife habitat, land acquisition may be required part of the project

Wetland Loan Act (1961) - Money loaned to the U.S. Fish and Wildlife Service for wetland acquisition in the face of rapid loss of wetlands

Wilderness Act (1964)

1. Maintain the pristine nature of land where man is a visitor who does not remain
2. Established the value of pristine wilderness, protected areas from any development, habitat preservation, use for research

Current Federal legislation

Freedom of Information Act (1966)

National Environmental Policy Act (1969)

Clean Air Act (1970)
Occupational safety and Health Act (1970)
Federal Insecticide, Fungicide and Rodenticide Act (1972)
Endangered Species Act (1973)
Safe Drinking Water Act (1974)
Resource Conservation and Recovery Act (1976)
Toxic Substances Control Act (1976)
Clean Water Act (1977)
Comprehensive Environmental Response, Compensation and Liability Act
Emergency Planning and Community Right to Know Act (1986)
Superfund Amendments and Reauthorization Act (1986)
Oil Pollution Act of 1990
Pollution Prevention Act (1990)

Pertinent Legislation
Where to find the Environmental Conservation Laws

1. Seasons, bag limits, regulations etc.
2. Recycling laws
3. Air pollution standards
4. Endangered species related laws

Interpretation of the fundamental principles of ecology to further the understanding of why these laws have been instituted

Key Agencies
U.S. Environmental Protection Agency
U.S. Department of the Interior - Fish and Wildlife Service
U.S. Agencies whose work impacts on the environment

1. Department of Justice
2. Department of Transportation
3. Federal Emergency Management Agency
4. U.S. Geological Survey
5. Department of Health and Human Services
6. Department of Labor

MATTER

Energy Flow

-**First Law of Thermodynamics-** Energy is conserved, not created or destroyed. It can only change in form.
-**Second Law of Thermodynamics-** Energy transfers lead to the energy being in a less "useful", lower form.
Matter recycles itself, unlike energy. Energy always degrades to a less concentrated level.

High Quality Energy: Very concentrated, rich, intense, has high temperatures.
Low Quality Energy: dispersed, diffused, sporadic, low temperature

-**Photosynthesis**: Plants convert energy from sun along with carbon dioxide and water into sugars ($C6H12O6$) and oxygen within the chlorophyll. Only 1-2% of the sunlight ever makes it into the plant's tissue!
-**Aerobic Respiration**: Oxygen consuming producers, consumers and decomposers break down complex organic compounds (glucose, etc) and convert carbon back into carbon dioxide. The energy stored in the glucose bonds is transformed into chemical and heat energy- it is not lost! The formulas for photosynthesis and respiration are the same but reversed!

Biotic- living components of the ecosystem
Abiotic-nonliving components of the ecosystem

Trophic Levels:
1. Tertiary Consumers- eats secondary consumers
2. Secondary Consumers- eats primary consumers
3. Primary Consumers/Herbivores -eats plants
4. Producers/Autotroph- Photosynthesize energy

The biomass of each level is 90% greater than the one below it! Only 10% of useable energy is transferred up to the next trophic level because so much is lost.
-Some of the food source many be inedible or indigestible.
-Energy may be expended catching the prey
-Energy is degraded through normal metabolic processes (Second law of thermodynamics).

-**Food Chain**- A linear list of who eats who. The arrow points to who is doing the consuming.
-**Food Web**- A more complex interwoven diagram of which organisms prefers to eat each other.

Scavenger- Feeds on dead animals. ex. coyote
Detritivore- Eats leaf litter, dung. ex. ants
Decomposers- organsims that break down or feeds on dead organic matter. ex. Fungus or bacteria

NUTRIENT CYCLES

Carbon Cycle

The building blocks of life.
Short cycle: Photosynthesis and Respiration. Carbon is incorporated into a sugar during photosynthesis and then released during respiration. Plants, animals and microbes all respire which send the CO_2 back into the air.

Long term cycle:
Carbon can stay in one form for years to thousands of years before changing.
Carbon sinks: plants, animals, ocean life (especially in plankton, coral and fish skeletons), coal, oil, atmosphere, and limestone ($CaCO_3$).

Largest storage reservoirs of carbon are in carbonate rocks.

Man is upsetting this cycle by burning fossil fuels and tearing down the jungles and woodlands of the world.

Nitrogen Cycle

Nitrogen is a critical limiting factor for plant growth. A majority of nitrogen exists as an inert gas (N_2) the in air (78%), yet plants can't take it up. How can a plant access it?
1. Nitrogen Fixing: Atmospheric nitrogen is "fixed" or transformed by bacteria living symbiotically on plant roots of legumes or in blue green algae (cynobacteria). The bacteria change the N_2 into ammonia. (This form of nitrogen is toxic to most plants). Examples of legumes are peas, beans, soy, clover and alfalfa.
2. Nitrification- A different set of bacteria break down the ammonia by combining it with oxygen to create nitrites and then finally nitrates. Plants can absorb nitrates nicely.
3. Assimilation- The plants then incorporate the nitrogen into organic molecules (DNA, amino acids, proteins, etc!). Animals might then chow on the plants incorporating the nitrogen into their bodies.
4. Ammonification- Dead plants and organic waste (like cow dung) convert their stored nitrogen back into ammonia with the help of decomposers.
5. Denitrification- Some of the nitrates can be converted back into atmospheric N_2 through the help of (you guessed it)- bacteria!

Man is upsetting the natural balance of nitrogen by fixing nitrogen artificially to make fertilizers. These fertilizers as well as excess sewage rich in nitrogen (from large animal farms or crappy municipal waste systems for humans) is added to aquatic ecosystems by rain runoff or sewage overflows. This in turn destroys the health of our fresh water streams and ponds by promoting rampant algae growth, which eventually renders the aquatic environment lifeless!!!

Phosphorus Cycle

A very very veeerrryy slllloooow cycle.
Soils contain very little phosphorous naturally, so it is also major limiting factor for growth.
Phosphorous does not circulate as easily as nitrogen because it does not exist as a gas, but is released by weathering of phosphate rocks. The phosphorous (PO_4) is then dissolved in water and absorbed by plants. Animals that eat plants then pass the phosphorous along to the decomposers through their waste products, or when they die and decay. The decomposers then break down the phosphorous to the soil.

The largest storage reservoir of phosphorous is in rocks.

Man is creating an imbalance in phosphorous levels by mining Guano (bird poop rich in phosphates) for fertilizers and detergents. These products then make their way to our fresh waterways causing massive algae blooms and wide zones devoid of life.

Sulfur Cycle

Another slow cycle upset by mans influence. Most sulfur is bound up inside rocks (like pyrite and gypsum). On a good day sulfur can become mobile through volcanic eruptions or deep-sea vents. Unfortunately, burning coal and other fossil fuels adds massive amounts of sulfur into the air, which causes the rain to be damagingly acidic.

PESTS

Persistence and Mobility in the Environment

-Because DDT and other chlorinated hydrocarbons are so stable, have high solubility, and high toxicity, it makes them effective pesticides, as well as environmental nightmares.
-Often bio-accumulate in animal fat, leading to bio-magnification in predators like falcons.
-Grasshopper Effect: substances evaporate from warm regions and precipitate in colder regions, accumulating in great concentrations in top predators up north.
-DDT byproduct has been found to be able to enter a woman's amniotic fluid, which can be dangerous to the developing baby even in small amounts.
-POPs (persistent organic pollutants) like Atrazine and alochlor are so dangerous and long-lasting, 127 countries agreed to ban them. The 12 most dangerous (dirty dozen) have been banned
-Pesticide can either have short term effects on human health or long term effects. Short term effects include poisoning and illness from high exposure doses. Long term effects include cancer, birth defects, Parkinsons, and other degenerative diseases.
-3.5- 5 million people suffer acute pesticide poisoning each year. 20,000 die from it.
-farmers who use pesticides are 8 times more likely to develop non-Hodgkin's lymphoma.
-long-term exposure and consumption of contaminated foods can cause learning disorders in the generations that were developing with the pesticides.

Alternatives

Behavioral changes

-crop rotations, flooding fields, burning crop residues, restoring windbreaks, hedge rows, and groundcover allows bird and other predators perches from which to eat insects. Adjusting planting times could avoid pest concentration, growing where pests are not prevalent, and tilling and diversifying species can prevent losses from pests.
-Biological controls- predator insects (mantises, wasps, ladybugs), pathogens, as well as ducks and geese, which eat insects and weeds, and are harmless to crops. Often times they will continually provide protection year after year. Herbivorous insects also control populations of hardy weeds.
-bio-engineered sterile males can fight against pests or plants that are engineered to be resistant to insects or weeds.
-development of upsetting hormones and sex lure traps have been used to stop the spread of pest insects.

Integrated Pest Management

-a flexible, ecologically based pest control strategy that carefully applies techniques at specific times, intervals, and aimed at specific pests. It determines economic threshold at which pesticides need to be applied to justify returns.
-trap crops are grown a week before other crops, mature early, attract the insects, and are sprayed with pesticides. Thus, they detract pests away from the real crop.
-many countries and states like Massachusetts, Brazil, Cuba, and Costa Rica have had remarkable success transforming their agriculture with IPM.

-in Indonesia, pests that once ran rampant were controlled by the education of poor farmers in the benefits of IPM. Because the staple crop is rice, it could be important for other countries.

Reducing Pesticide Exposure
Regulating pesticides
-many of the thousands of tons of pesticides in the U.S. contain suspected carcinogens and pose human health hazards.
-EPA regulates through scientific studies which pesticides pose health risks.
-FDA & USDA- enforce EPA rulings, have authority to destroy food shipments that do not conform.
- Delaney Clause- added in 1958 to the U.S. FFDCA that states that any cancer causing agent cannot be added to processed food, drugs, or cosmetics.
-has been revamped, now law has been restated, saying that if the risk is so slight that it has "little" effect (it just kills you slowly), the additive can be used.
-now, pesticides like methyl parathion and other harmful ones have been banned for use on fruit because of human health concerns. These pesticides can damage human internal organs.
-however, many people agree that carcinogens from food are relatively unimportant as opposed to the natural carcinogens all around us.

A Personal Plan
-don't use chemicals on your yard and garden. Clean up spilled food to eliminate insects. Wash houseplants to get rid of pests. Drown slugs in stale beer in a saucer. Drain stagnant water to discourage mosquito breeding. Use toxic chemicals in only the smallest possible amounts. Read magazines on being organic and healthy.

HISTORY:
-5,000 yrs, ago. Sumerians: sulfur
-2,5000 yrs ago: China: mercury, arsenic. Greek/Roman: oil sprays, ash, sulfur, lime.
Also: burn fields, rotate crops, spices and alcohol for spoilage
-1,200 yrs ago: predatory ants in China used for caterpillar control
-1934 DDT discovered by Paul Muller controls insects
-1943 first DDT produced on large scale, used on fields, forests, and cities.
-1960's discovery that predatory birds had softened egg shells from DDT- passed through food webs
-1970s DDT use banned

PESTICIDE USE:
US uses the most pesticides in the world :(
Monoculture growing practices causes need for more insecticide use

PESTICIDE TYPES
-Inorganic pesticides- arsenic, copper, lead and mercury compounds. Highly toxic, indestructible, neurotoxin, harmful to humans.
-Natural organic pesticides (botanicals)- extracted from plants, nicotine, rotenone (from roots of debris plants- kills fish), pyrethrum (Chrysanthemum extractions), coniferous oils.
-Fumigants- easily dispersed gasses to sterilize soil, prevent decay/rodents/insects harmful to

humans- banned [ex: carbon disulfide]
-Chlorinated hydrocarbons (organochlorines)- synthetic organic insecticides, toxic and long lasting, banned, blocks nerve signals, [ex: DDT, aldrin]
-Organophosphates- lethal, but only for short time period, quickly dissipate, damages nervous system not persistent, low bioaccumulation [ex: DDVP]
-Carbamates (urethanes)- not persistent, low bioaccumulation, damages nervous system, kills bees esp. [ex: Sevin, Temik, Baygon]
-Microbial agents & Biological controls- pest control using living organisms [ex: ladybugs eat aphids, parasitic wasps lay eggs in caterpillars]

PESTICIDE BENEFITS:
-Disease control- insects that carry diseases are killed, thus decreasing human suffering [ex: malaria via mosquitoes]
-crop production- crop loss is decreased by eliminating pest, farmers save $3-5 for every $1 spent on pesticides

PESTICIDE PROBLEMS:
-other species- sometimes wipe out area of all living organisms [ex: bees die, thus bee keeper profit goes down, and crops not well pollinated. Sacramento River herbicide dumped and river ecosystem decimated]
-pest and pesticide resurgence. Resistant genes are being communicated between species problem is having used pesticides so abundantly, no longer as useful and effective
-pest creation- predators are reduced by pesticides, predator controls are gone, thus lower trophic levels explode [ex: Canete Valley, Peru]

DEFINITIONS:
Biological pest- organism that inhibits use of resources
Pest control- any method of killing pests
Pesticide- chemical that kills pests
Biocide- kills many kinds of organisms
Herbicide- kills plants
Insecticide- kills insects
Fungicides- GUESS. (kills fungi)
Pest resurgence (rebound)- quick reproduction cycle causes pests to re-populate with pesticide-resistant individuals
Pesticide treadmill- using increasing dosages of pesticides to catch up with higher resistance in pests

STATS:
90% of pesticides world wide used in agriculture or food storage/transport
34 pesticides used in US are in agriculture
59% herbicides
22% insecticides
11% fungicides
8% other
90% pesticides never get to organism intended!!!!

POPULATION

Population Ecology

- Exponential growth and doubling time:
- Exponential growth: growth at a constant rate of increase per unit of time. The sequence follows a geometric rate of increase (ex. 2,4,8,16)
- Doubling time: Amount of time necessary for the population to double. 70 / annual % growth (ex. Populations growing at 35% will double every 2 years.)

- **Population Oscillations:**
- Population exceeds carrying capacity or limiting factors come into effect, death rates surpass birth rates = crash or dieback
- Extent to which a population exceeds the carrying capacity = overshoot
- Population explosion followed by a population crash = irruptive/ Malthusian growth
- Sometimes populations go through cycles of exponential growth and catastrophic crashes, usually they are quite regular if they depend on certain factors like seasonal light, temperature. May be irregular if they depend on complex environmental and biotic relationships.

- **Carrying Capacity:**
- Carrying Capacity: the maximum number of individuals of any species that can be supported by a particular ecosystem on a long-term basis.

- **Catastrophic Population Decline:**
- Catastrophic System: when the population jumps from one seemingly steady state to another without any intermediate stages.

Factors that Increase/Decrease Populations

- **Natality, Fecundity and Fertility:**
- Natality: production of new individuals, main source of adding to populations, sensitive to environmental conditions (nutritional levels, climate, soil and water conditions, social interaction between species),
- Fecundity: physical ability to reproduce
- Fertility: measure of the actual number of offspring produced.
- Immigration: Seeds, spores, and small animals may be introduced by wind, water (major source of organisms to islands), carried inside other animals, walking, swimming, flying,
- **Mortality and Survivorship:**
- Mortality: death rate, death rate is found by dividing the number of organisms that die in a certain time period by the number alive at the beginning of the period.
- Survivorship: the percentage of a certain organism that lives to be a certain age.
- Life Expectancy: probable number of years of survival of an individual of a given age.
- Life Span: longest period of life reached by a given type of organism.

Survivorship Curves gives us the predicted life expectancy at each age interval. Humans in the first world have a high survivorship when young and most likely live to old age. Most marine organisms have a low survivorship- they are cast out into the waters, but once they survive that trauma they are likely to live out their full age. Hyrdas and sea gulls randomly die throughout their lives.

-**Age Structure Diagrams/Histograms:**

- An outcome of the interaction between mortality and natality.
- Bigger towards the bottom- rapidly expanding population
- Pretty equal throughout- stable population
- Bigger at the middle/top- diminishing population
  - Emigration: movement of members out of the population

Factors that Regulate Population Growth

- Density dependent and independent factors and Biotic/Abiotic:
- Mostly these things affect natality and mortality, therefore changing the population.
- Intrinsic: operating within individual organisms or between organisms of the same species.
- Extrinsic: imposed from outside the population
- Biotic: caused by living organisms
- Abiotic: caused by non-living components of the environment
- Density dependent: effects are stronger or a higher percentage of the population is affected as the population density increases (food shortage)
- Density independent: the effect is the same or a constant proportion of the population is affected regardless of the population density (fire, climate conditions, volcano)
- In general, biotic factors are density- dependent while abiotic factors are density-independent

SOLID, TOXIC, AND HAZARDOUS WASTE

Most common = least desirable
USA makes 33% world's waste

The three R's: reduce reuse recycle

Ocean Dumps
illegal in US
55 million lbs/yr of packaging are dumped into ocean
330 million lbs/yr of fishing gear lost or discarded
deadly to marine life (ex. seals)

Landfills
fate of most municipal solid waste
Paper is most common in landfill
trash buried within impermeable lining (clay, plastic) to prevent leaching
controls pollution of aquifer (oil, chemical compounds, toxic metals, contaminated rainwater)
methane gas burned for energy
Once very effective, landfills are now expensive land hogs- $1 billion/hectare
many aquifers already toxic from leaks
Natural Hydrogeologic Setting-
New landfills must now be set on stable, impermeable bedrock, away from streams rivers lakes etc.
Must include Leachate Collection System - contaminated fluids seep to bottom of landfill where they are collected by complex drainage pipes

Exporting
Often sent to poor, un-educated communities or countries ex. American Indians
Bet Trang plastics calamity- $3 million bribe for dumping toxic waste in Cambodia
"garbage imperialism" and NIMBY

Incineration
volume of waste reduced 90%
45,000 tons/day burned in US
energy production as by product- stream or electricity
expensive to build and operate
high levels of toxins in smoke & ash
ex. dioxins, mercury, lead, cadmium, PVC
Need to remove batteries and plastics first for cleaner burn but expensive
Mass burn- throw everything in smaller than Volkswagen. Dirty air

Reduction and Reuse
- reduce- is minimizing the amount of waste to begin with. Don’t buy it!
- reuse is simply reusing an item (Tupperware and cloth shopping bags)
- recycling is reprocessing discarded materials (glass, aluminum)

Recycling
glasses to glasses, rust to rust
bottles may be reforged as bottles
tires may be turned into roadways or sandals!
benefits include more efficient use of non-renewable resources
- cheaper method of waste disposal
- less air and water pollution
- cuts waste volume in landfill

Alternatives to Household Chemicals
Use garlic and ginger for an insecticide
Vinegar or citrus oil make solvent for cleaning counters, etc. (but not both at the same time!)

Long Term Storage
It has to go somewhere
non bio-degradables
- permanent retrievable storage vs. non-retrievable storage

EPA ranks best strategy for Municipal Solid Waste
1. Source reduction (including reuse)
2. Recycling and composting
3. Incineration
4. Landfilling

Hazardous and Toxic Waste
Hazardous waste if any waste that poses a danger to human health. It could be corrosive, ignitable, reactive or toxic.
The fate of hazardous waste

1. Recycled
2. Converted to less hazardous form
3. Bioremediated ex. Brassica (broccoli family) absorbs Fe
4. Placed in permanent storage- deep well injection-agh! or surface impoundment- the creation of shallow pools from which the hazardous liquid evaporates.

Hazardous/toxic wastes could be "temporarily" located in

1. Brownfields- polluted properties that have been abandoned because of real or suspected contamination
2. Superfund Sites- highly polluted waste site that is (hopefully) undergoing rapid containment, cleanup and remediation. Money for clean up comes from a Superfund which is funded by the federal government (our taxes) and a tax on the producers of toxic or hazardous waste. IF responsible parties can be identified they will be held responsible for the cleaning up cost.

Long-term storage of nuclear waste at Yucca Mountain is a controversial topic because of NIMBY and that fact that the mountain has two active fault lines and is above a huge aquifer. So the short-term storage of the nuclear waste is at the nuclear power plants in huge pools or giant land “coffins”. High-level nuclear waste is the high level of ionizing radiation that is created at uranium mines, manufacture of nuclear weapons, and the waste from spent nuclear fuel. Low-level waste is waste from industrial or research industries like clothing, needles, animal carcasses and etc.

SUSTAINABLE CITIES

Urbanization- an increasing concentration of the population in cities and the transformation of land use and society to a metropolitan pattern of organization
-Nearly half the people in the world now live in urban areas
-By the end of the 21st Century 80-90% will live in urbanized areas
-Rural area- most residents depend on agriculture or other ways of harvesting and natural resources
for their livelihood
-Urban area- a majority of the people are not directly dependent on natural resource based occupations
-Village- a collection of rural households linked by culture, custom, family ties and an association
with the land, sense of community and connection, can be stifling
-City- a differentiated community with a population and resource base large enough to specialize in arts, crafts, services rather than natural resource based occupations, freedom to experiment, be upwardly mobile and break from restrictions, can be harsh and impersonal
-Mega-city- beyond about 10 million inhabitants

World Urbanization
-19th and early 20th centuries-US undergoes major shift
-Many developing countries are experiencing similar demographic movement
-In 1850 only 2% of the world's population lived in cities
-2000-47% live in cities
-Only Africa and South Asia remain predominantly rural
Some urbanologists believe that the whole world will be urbanized to the level of developed countries by 2100
-90% of pop. Growth in next 25 years is expected to occur is less developed countries- mostly in already overcrowded cities of poor countries such as India, China and Brazil
-in 1900- 13 cities had a population over 1 million- all in NA or Europe by 1995 there were 1300 metropolitan areas with over 1 million people only 3 in developing countries

Causes of Urban Growth
-2 ways that urban populations can grow-natural increase-more births than deaths, immigration
-Natural increase is fueled by improved food supplies, better sanitation, and advances
in medical care-reduced death rates can cause populations to grow both in cities and rural areas around them
-Immigration to cities can be caused by push factors (force people out of the country) pull factors (draw them into the city)
-Push factors- people migrate to cities for many reasons
-Countryside can not support massive populations
-"Surplus" population is forced to migrate to cities in search of jobs, housing in some places economic forces or political, religious or racial conflicts drive people out of their homes
-UN estimated that in 1992 at least 10 million fled their native country and that another 30-40 million were internal refugees within their own countries, displaced by political, economic or social instability

-Land tenure patterns and changes in agriculture also play a role in pushing people into cities
-Pull factors- jobs, excitement, vitality and desire to meet people who are similar
-Jobs, housing, entertainment and freedom of constraints of village traditions
-Possibilities exist in the city for upward social mobility, prestige of power not ordinarily available in the countryside
-City supports specialization in arts, crafts, and markets, which do not exist elsewhere
-Modern communication
-90% of the people in Egypt have access to a television set
-Government policies often favor urban over rural areas in ways that both push and pull people into
the cities
-Developing countries spend most of their budgets on improving urban areas even though only a small
percentage of the population lives there or benefits from the industry
-Governments often manipulate exchange rates for the benefit of more politically powerful urban populations but at the expense of rural people

Current Urban Problems in the developing world
-90% of human pop growth in next century is expected to occur in the developing world in Asia, Africa and South America
-Problems will occur especially in largest cities, which already have trouble supplying food, jobs and basic services for their residents
Traffic and congestion- in less developed countries there is an overwhelmingly amount of pedestrians and vehicles that clog the streets
-Noise, congestion and confusion of traffic make it seem suicidal to venture into the street
-Air pollution- dense traffic, smoky factories and use of wood/coal fires create a thick pall of air pollution in the world's super cities
-Lenient pollution laws corrupt officials, inadequate testing equipment, ignorance about the sources and lack of funds to correct the situations cause the problem
Sewer systems and water pollution-
-Modern waste treatment systems are too expensive to build for rapidly growing populations
-35% of urban residents in developing countries have sanitary systems
-400 million people (one third) of the population in developing cities have safe drinking water
-Many rivers and streams, little more than open sewers, used for washing clothes, cooking, bathing, and drinking
-Diarrhea, dysentery, typhoid, cholera are widespread diseases
-Infant mortality high
-Housing-
Slums- legal but inadequate multifamily tenements rooming houses
Shantytowns- settlements created when people move onto undeveloped lands and build their own houses
Shacks- built of corrugated metal, discarded packing crates, plastic sheets, or whatever building materials people can scavenge
Squatter towns- people occupy land without owners permission
-Three quarters of residents of Addis Ababa, Ethiopia, Luwanda live in refugee camps
Current problems in the developed world:

-Urban Sprawl- pattern of urban growth where cities spread out and consume open space and waste
resources
-In a study of 213 American urban areas, David Russ found that between 1960 and 1990 total population grew 47% while land use increased by 107%
-Atlanta, Georgia (1990-2000) 32% growth
-In some metropolitan areas, 1/3 of land is used for automobiles
-Traffic congestion costs the U.S. 78 billion dollars in wasted time and fuel.
-To solve this, people want to buy more freeways, but this will cause people to drive even further than before.
-Sprawl causes the city to be unable to maintain its infrastructure (schools, parks, streets and other buildings fall into disrepair)

Sustainable Community Design:
-Smart Growth- proposed by many urban planners, makes effective and efficient use of land resources and existing infrastructure, aims to provide a mix of land uses to create a variety of affordable housing choices and opportunities. Goal: not to block growth, but to channel it to areas
where it can be sustainable in the long term. Protects environmental quality by conserving farmland, wetlands and open space. Portland, Oregon has a boundary on outward expansion and is
considered one of the best cities in America because of its urban amenities. Between 1970-1990, the population grew 50%, land use only grew by 2%.
-Garden Cities- neighborhoods separate from the central city by a green belt of forests and fields. Done in the early 1900s in London by Ebeneezer Howard who wrote a book called Garden
Cities of Tomorrow
-Planned Communities are built in the United States as well.

New Urbanist Movement:
-Redesign metropolitan areas to make them more efficient, appealing and livable.
-Examples: Stockholm, Sweden, Helinski, Finland and Leicester, England
-Urban Ecology Research- LTER (Long Term Ecological Research) in Phoenix and Baltimore, funded by national science foundation, researches every aspect of urban ecology, advocate for environmental justice (toxic materials and how they affect the health of the population)
Examples: Detroit has many children with elevated levels of lead in their blood, linked to low-income, old housing
-Design for Open Space-
-Conservation Development- cluster housing or open space zoning preserves at least half of the subdivision is natural spaces, farmland etc.
-Ian McHarg, Frederic Steiner and Randall Arendt have led these movements in places such as Farmview, PA, Hawksnest, WI

Sustainable Development in the Third World-
-Immediate needs are housing, clean water, sanitation, food, education, health care and basic

transportation for the residents
-Redistribute unproductive land
-Some people believe that social justice and sustainable economic development are the answers, because if people have the opportunity and money to buy better housing, adequate food, clean water,
sanitation and other things they need for a decent life, they will do so.
- Social Welfare system ensures that old people will not be alone and abandoned.

Sustainable Development
Environmental Literacy
- every citizen is fluent in the principles of ecology and has a "working
knowledge of the basic grammar and underlying syntax of environmental wisdom"- according to EPA
administrator William K. Reilly
- An important part of environmental education
- Creates a stewardship ethic-care for environment and its resources for the long run
- Helps prepare for life in the next century
- Hope for students to continue learning about the environment:
Books to read to help with this:
- My First Summer in the Sierra by John Muir
- Silent Spring by Rachel Carson
- Walden by Henry David Thoreau

Environmental Movement
1. Student Environmental Groups
- Projects to teach ecology and environmental ethics to students as well as to get them involved in active projects to clean up their local community.
- Kids Saving the Earth
- Eco-Kids Corps.
- Student Environmental Action Coalition (SEAC)-work on activities like promoting recycling and lobby against industrial projects
2. Mainline Environmental Organizations
- Influential and powerful forces in environmental protection
- Help pass legislation like the Clean Air Act
- National Wildlife Federation
- Sierra Club
- Ducks Unlimited
3. Radical Environmental Groups
- Direct action groups
- Often associated with the deep ecology philosophy and bioregional ecological perspective
- Main tactics: civil disobedience, attention-grabbing actions like guerrilla street
theater and picketing. (rar!)
- Earth First!
- Sea Shepard
- Earth Liberation Front
4. Wise Use Movement

- Advocate conservation rather than preservation of natural resources
- National Cattlemen's Association
- National Farm Bureau (these organizations have great names, don't they?)

Personal Choices and Personal Action
- Write to elected officials and urge them to support environmental causes.
- Petition
- Email them political folks
- Run for a local office
- Participate in practical environmental projects-i.e. litter cleanup- Clean Sweep!, restoration projects

SUSTAINABLE ENERGY

***Solar*:**

.1% of the electricity in US produced through solar panels.

Constant, free energy supply
-Amount of solar energy reaching the earth's surface is 10,000 times all the commercial energy used each year.
-Until this century it was too diffuse and low in intensity to use except for environmental heating and photosynthesis.

-*Passive Solar Heat*

Much of passive solar heat is simply orientating your home toward the sun and absorbing the heat- naturally.

- Indirect gain: Absorption-using natural materials or absorptive structures with no moving parts to simply gather and hold heat.
-Old Method: Thick-walled stone and adobe dwellings that slowly collect heat during the day and gradually release heat during the night. After cooling at night, they maintain a comfortable daytime temperatures while still absorbing external warmth.
-New Method: glass-walled "sunspace" or greenhouse on the south side of a building. Uses massive energy-storing materials such as brick walls, stone floors, or barrels of heat-absorbing water to collect heat to be released at night.

-Direct gain: Use a roof overhang that blocks the direct sunlight in the summer, but lets the sun in when its at a lower angle in the winter.

-*Active Solar Heat*

-Solar panels-Photovoltaic Cells-capture solar energy and convert it directly to electrical current by separating electrons from their parent atoms and accelerating them across a one-way electrostatic barrier formed by the junction between two different types of semiconductor material. This is known as the photovoltaic effect.

-They used to be too expensive for practical use but prices are falling.
-In 2001 prices were approaching $5 per watt.
-By 2020 it will be down to about $1 per watt and nuclear energy will cost twice as much.
-World market for solar energy is expected to grow rapidly in the near future, especially in remote places where conventional power isn't available.
-Already used in watches, solar-powered calculators and toys
-Solar energy could mean being able to build a house anywhere and have a cheap, reliable, clean, quiet source of energy with no moving parts to wear out, no fuel to purchase, and little equipment to maintain.

Pro:

No pollution, unlimited resource, can store energy during the day and release it at night, cost going down- decreased by a factor of ten in 2 years!

Con:

Needs a storage system like deep cell batteries, not efficient if climate too cloudy, high costs for purchasing solar panels and have limited life span, Visual pollution, efficiency between 10 and 25%.

-Solar water heaters- generally pump a heat-absorbing, fluid medium through a relatively small collector instead of passively collecting heat.
-Can be located next to or on top of buildings.
-Flat, black surface sealed with a double layer of glass makes a good solar collector.
-A fan circulates air over the hot surface and into the house through ductwork, like standard forced-air heating.
-A simple flat panel of 5 square meters can provide enough hot water for an average family of four.
-What about when it's not sunny?
    1) For climates where sunless days are rare- small, insulated water tank makes a good solar energy storage system.
    2) For winter months-A large, insulated bin containing a heat-storing mass, such as stone, water, clay provides solar energy storage.

Fuel Cells:

- Devices that use an ongoing electrochemical reaction to produce an electric current.
- Discovered by William Grove in 1839 during his study of electrolysis.
- Fuel cells consist of a cathode (positive electrode) and an anode (negative electrode) and are separated by an electrolyte.
- an electrolyte is a material that allows ions (positively charged atoms) to pass through but not electrons.

How a fuel cell works: hydrogen passes over the anode and a catalyst on the anode takes an electron from each hydrogen atom, creating a positive hydrogen ion. The ion can pass through the electrolyte to the cathode, but not the electron. The electron then passes through an external circuit going into the cathode creating an electrical current. Then, at the cathode the electrons and positive ions rejoin and combine with oxygen creating water.

Pro:

-Emits water as waste! no pollution, minimal environmental impact, easily transported, not explosive when stored in compounds

Con:

- takes energy to produce hydrogen, changing from fossil fuels to hydrogen would take a lot of money to build the infrastructure, hydrogen gas is explosive which is inconvenient- how could we store it in a car?

Biofuels:

-Biofuels produce 15% of the world's energy, 4% of that energy is used by the U.S (.1% electricity).

-Types of biofuels include switchgrass, woodchips, sawdust, wood residue, any kind of wood or plant material. Maybe we should use all the paper we throw into the dumps... if I were queen...-Biomass (plants, wood, etc.) converted into a liquid form making storage and transportation easier.

Pro:
-It is a renewable resource if used in moderation; biofuel could produce 1/2 of the world's electrical needs if managed properly; many marginal areas of the world could support biomass plantations with plants like cottonwoods, poplars, sycamores and shrubs; its inexpensive, and the burning of biofuels produce less SOx and NOx then coal.

Con:
-Deforestation and soil erosion occur, requires fertilization and water. It is expensive to transport and can cause the loss of wildlife and habitats. Some methods of burning biomass causes air pollution such as CO2 emission. Also the use of corn to produce ethanol takes more energy than it creates and is driving the price of corn up for the poor who depend on it for food (ex. Mexicans).
-When biofuels are converted to electricity, 70% of the energy is lost!

Hydroelectric Power:

-Dams trap water which is then released and channeled through turbines which generate electricity.
- 9% of USA's electricity, 3% worldwide. There are 2000 dams in the US.

Pro:

- Good because there's no pollution, low operation costs and they control flooding. They also have a high to moderate energy yield and a long life span.

Con:

Dams create large floods, which uproot people, destroy habitats, and disrupt natural soil fertilization of agricultural land downstream. Sediments eventually need to be dredged from the reservoir. Also dams upset fish migration patterns (salmon!) and the natural beauty of rivers. Also dams are extremely expensive to build.

Tidal and Wave energy:

The natural movement of tides spin turbines which generate electricity. Very few plants exist- only in US, France and Scotland.

Pro:

No pollution, moderate energy yield, minimal environmental impact, cheap to maintain.

Con:

Costs a lot to construct, few suitable sites. Plants get hurt by corrosion from salt and storms.

Wind Power:

Large blades of wind mills spin create electricity. Now make less than .1% of electricity in US but growing!

Pro:
-Fastest growing renewable energy resource today- no pollution
-Very promising
-Unlimited source (quick fact: all electrical needs of the US could be met by wind in North Dakota, South Dakota and Texas!)
-Wind farms can be built quickly
-Maintenance is low and automated
-Moderate to high net-energy yield
-Production of wind turbines would be a boost to economy
-Land underneath turbines can be used for agriculture

Con:
-Steady wind is required to make it economical. Back up systems needed when wind is not blowing
-Visual Pollution- ugly
-Noise pollution
-May interfere with communications (radio, TV, Microwave)

- may kill some birds if on migrational pattern

Geothermal Power:

-Two kinds: Heat contained in underground rocks and fluids from magma are used or just the stable subsurface ground temperature is used to heat air in winter and cool it in summer.

-Geothermal energy supplies less than 1% of energy needs in the U.S.
-It is being utilized in Hawaii, Iceland, Japan, Mexico, New Zealand, Russia and California

Pro:
-Moderate net-energy yield
-Limitless and reliable source if managed
-Little air pollution
-Competitive cost

Con:
-Reservoir sites for hot geothermal power are scarce
-Source can be depleted if not managed
-Non-renewable
-Noisy
-Odor
-Local climate changes
-Land damage involved for pipes and roads- can cause land sinks.
-Can degrade ecosystems due to hot water wastes and corrosive or saline water

WATER

~Water- essential for all living processes: dissolves nutrients and distributes them to cells, regulates body temperature, supports structures, and removes waste products; 60% of our body is water and 70% of the world's surface is covered in it.
~The hydrologic cycle- the circulation of water as it evaporates from land, water, and organisms, enters the atmosphere, condenses and precipitates to the earth's surfaces, and moves underground by infiltration or overland by runoff into rivers lakes and seas: Allows for a fresh supply of water, maintains a habitable climate and moderates world temperatures. Plants help add water vapor to the air through transpiration.
Evaporation= process through which liquid is turned into a gas way below its boiling point
*Sublimation= when water moves from the solid to the gaseous form with out ever being liquid (occurs on bright, dry cold winter days)
*Saturation point= when a volume of air contains the most water vapor that it can at a given temperature
*Relative humidity= the amount of water vapor in the air expressed as a percentage in terms of the saturation point
*Condensation= when saturation point is exceeded and water molecules begin to aggregate
*Dew point= the temperature at which condensation occurs
*Condensation nuclei= tiny particles that help facilitate the condensation process (smoke, dust, sea salts, spores, etc)
*Cloud= accumulation of condensed water vapor in droplets or ice crystals
~Mountains have two different climates: the windward side is cool wet and cloudy; the leeward side is warm dry and sunny, ex. Himalayans (dry spot on mtn= rain shadow)
~Deserts lack moisture and have much evaporation due to the descending air masses. The air will condense under the higher pressure and warms through adiabatic heating. This typically occurs at 30 degree latitudes North and South of the equator. Typical deserts include the Sahara, Gobi, and Death Valley.
~Tropical rainforests receive much rain
~Oceans make up 86% of evaporation, 90% returns directly to the ocean: the other ten percent is carried onto the continents- once there some is incorporated into plants and animals, the rest seeps into the underground but all eventually returns to the ocean. 40,000 km2 of surface runoff and underground flow represents the renewable supply for us and freshwater-deep ecosystems.
~Evaporation and condensation help regulate the climate, as winds redistribute the heat and moisture
~Oceans= contain 90% of all bio mass and 97% of all the liquid in the world. They moderate the global temperature- warm water flow from tropics to poles and vice versa,
*Residence time= that length of time an individual molecule spends circulating in the ocean before evaporation, on average its 3,000 years
~Glaciers hold almost 90% of the earths freshwater. These frozen rivers slowly move downhill. Antarctic glaciers contain 85 % of all the ice in the world.

GROUNDWATER:
-Second largest freshwater reservoir
~Ground water= holds next largest amount of fresh water
*Infiltration= precipitation that doesn't evaporate and runs through fractures of the rocks in the

soil
*Zone of aeration= upper soil layers that hold both air and water, moisture for plant growth comes from here. The depth varies.
*Zone of saturation= lower levels where all soil air spaces are filled with water. The top of the zone is called the water table and it is neither flat nor stationary. Aquifers: porous layers of sand etc. below water table
-Artesian well: water gushes out without being pumped

Should We Remove Dams?

YES!
*Storage reservoirs drown free-flowing rivers
*They can submerge towns, farms, and cemeteries and important historic sites
*Block fish migration- salmon migration routes impeded
*Can change aquatic habitats that were important to species
*Siltation of reservoir behind dam builds up requiring dredging.
*Nutrients carried within the silt and clay are lost to down stream farmlands that would normally be deposited during floods.
*Dam breakage could devastate communities living downstream.

NO!
*Stores water, and generates electricity
*Create jobs for workers
*Help economic development
*Allows arid and unfarmable lands to grow crops through irrigation of water

Main problem with dams are their inefficiency!!! Dams lose water through evaporation, and seepage through porous rocks~~~> wasting more water than they make available.
* Accumulating sediments can clog reservoirs and make dams completely useless~~~> lose a lot of valuable nutrients. Silts can be replaced with commercial fertilizers costing more than 100 million bucks a year!

LOSS OF FREE-FLOWING RIVERS

Hetch Hetchy Valley in Yosemite National Park: San Francisco wanted to dam the Tuolumne River in the park to produce hydroelectric power and provide water for the city. Some people liked it because it supported clean water and power. John Muir opposed the dam project (He founded the Sierra Club and Yosemite Park!! Wahoo!) He said that Hetch Hetchy valley's beauty should be protected. The people fought a hard fight but the dam builders won.

WATER MANAGEMENT AND CONSERVATION
*Goal: prevent flood damage and store water for future use instead of building dams and reservoirs.
Watershed-> also known as a "catchment" is all the land drained by a stream or river. Retaining vegetation and ground cover in watersheds help hold back rainwater and decrease downstream floods.

*More environmentally sound farming and forestry techniques can help reduce runoff.
*Retaining crop residue on fields can reduce flooding
*Minimizing plowing and forest cutting on steep slopes protect watersheds
*Conserving wetlands helps preserve natural water storage capacities and aquifer recharge zones.

Small dams can be just as useful as big dams:
Small dams on tributary streams have the ability to hold back water before it turns into a big flood. These dams can form ponds, and they provide useful wildlife habitats! Small dams can be built with simple equipment and local labor.
More than 60 million people in 33 states obtain their drinking water from national forest lands

DOMESTIC CONSERVATION
How can we help stop water shortages?
Take shorter showers!! Stop leaks!! Efficiently wash your cars, dishes, and clothes!!! What about appliances? Use low-volume showerheads, and efficient dishwashers and washing machines!!
If you plant native ground cover in a "natural lawn" or make a rock garden, landscape in harmony with the surrounding environment- xeriscaping (choosing plants that require little moisture) can be great instead of constantly watering and feeding a dry, arid garden.*
:0) Our biggest domestic water use is toilet flushing!! eeeew. We use about 13,000 gallons of drinking quality water annually to flush toilets. People are now creating low-volume and waterless toilets.

RECYCLING AND WATER CONSERVATION
*In 3rd world countries 70% of all the agricultural water used is lost to leaks in irrigation canals, application to areas where plants don't grow, runoff, and evaporation. People have been trying to turn to new farming techniques such as leaving crop residue on fields and ground cover on drainage ways, using mulches, and low-volume irrigation in order to reduce water losses. And its been working!
*Cooling electric power plants = bad water usage
*Installing dry cooling systems= better water usage

PRICE MECHANISMS AND WATER POLICY
In the past, water policies were been against conservation. Some parts of the US were based on riparian use rights= people who lived near a river could use as much as they wanted as long as they didn't taint its quality or the limit others who wanted to access to the water down stream. In many places, like NYC, water used to be very cheap. People didn't have any incentive to repair leaks, or restrict usage. The drought of 1988 changed all of these practices...
*The US is currently saving 38 million gallons a day compared to per capita rates 20 yrs ago. However, we have 10% less water because of the growing population!
*Drip irrigation= AWESOME! It applies water directly to plant roots, but its very expensive. Used on only 1% of farmland worldwide.
*Charging higher proportion of costs to users of public water projects~~~> encourages conservation!

WATER POLLUTION

A Flood of Pigs

- Hurricane Floyd flooded Cape Fear in North Carolina on September 16, 1999
- The flooding created a lake that was 300 km (200 miles) across covering towns, farms, factories and forests
- The worst of this flood was the open manure lagoons submerged by the water
- North Carolina was the leading turkey-producing state and the second largest pork producing state which contained ponds of 40,000 cubic meters of liquid waste that isn't protected against floods
- It is believed that the waste found in wells is from the waste and bacteria that leaked into areas that the flood got into
- Dead animals were buried in the ground where they continue to contaminate groundwater

What is Water Pollution?

- Point sources-factories, power plants, underground coal mines and oil wells that discharge pollution from specific locations such as drain pipes, ditches or sewer outfalls
- Nonpoint sources-scattered or diffuse so that they have no specific location where they discharge into a particular body of water
- Nonpoint sources include runoff from farm fields and feedlots as well as golf courses, lawns and gardens
- Atmospheric deposition of contaminants carried by air currents and precipitated into watersheds or directly onto surface waters as rain, snow or dry particles
- Sources of some nonpoint chemicals can be thousands of kilometers away
- It is estimated that there is 600,000 kilograms of herbicide atrazine in the Great Lakes
- Studies have shown that health problems are occurring among those who eat fish regularly from the Great Lakes

Infectious Agents

- Serious water pollutants in terms of human health world-wide are pathogenic organisms
- Some of these diseases like malaria, yellow fever and filariasis are transmitted by insects that have aquatic larvae
- The main source for these pathogens is from untreated or improperly treated human wastes as well as inadequately treated animal waste from feedlots
- If everyone had pure water and satisfactory sanitation, the World Bank estimates that 200 million fewer episodes of diarrheal illness would occur each year and 2 million and 2 million childhood deaths would be avoided
- 450 million people would be spared debilitating roundworm or fluke infections
- Coliform bacteria-any type of bacteria that lives in the colon or intestines of humans and other animals
- To test for coliform bacteria, a water sample is placed in a dish containing a nutrient medium that supports bacterial growth

- The EPA recommended maximum coliform count for swimming water is 200 colonies per 100 ml, but some cities and states allow higher levels

Oxygen-Demanding Wastes

- The amount of oxygen in water can help to determine the quality of the water
- Game fish and other desirable forms of aquatic life exist above 6 parts per million (ppm) while worms, bacteria and fungi exist below 2 ppm of oxygen
- Oxygen is added to the water through diffusion with the air and removed through respiration and chemical processes that consume oxygen
- The affects of materials on water quality is expressed in terms of biochemical oxygen demand (BOD) which is a standard test of the amount of dissolved oxygen consumed by aquatic microorganisms over a five-day period
- The chemical oxygen demand (COD) uses a strong oxidizing agent (dichromate ion in 50% sulfuric acid) that completely breaks down all organic matter in a water sample
- Dissolved oxygen (DO) content measured directly using an oxygen electrode also measures the affects of organic materials on water quality
- Oxygen sag-the decline in oxygen downstream of a pollutant source
- Rough fish such as carp, bullheads and gar can survive oxygen-poor environments

Plant Nutrients and Cultural Eutrophication

- Rivers and lakes hat have clear water and low biological productivity are said to be oligotrophic (oligo = little + trophic = nutrition)
- Eutrophic (eu + trophic = truly nourished) waters are rich in organisms and organic materials
- Eutrophication, an increase in nutrient levels and biological productivity is a normal part of successional changes in most lakes
- An increase in biological productivity and ecosystem succession caused by human activities is called cultural eutrophication
- “Dead zones” often form where rivers dump nutrients into estuaries and shallow seas

Inorganic Pollutants

- Some toxic inorganic chemicals are released from rocks by weathering and are carried by runoff into lakes or rivers
- Other inorganic materials such as acids, salts, nitrates and chlorine that are normally not toxic at low concentrations may become concentrated enough to lower water quality or adversely affect biological communities
- Metals such as mercury, lead cadmium and nickel are highly toxic
- Levels in the parts per million that are so little that you can’t see them or taste them and they can be fatal
- Miners in the Amazon River who look for gold use mercury to trap the gold and separate it from sediments
- The mercury is boiled off with a blow torch which is believed to be why miners and their families suffer nerve damage from breathing the toxic fumes

- Lead poisoning has been known since Roman times to be dangerous to human health
- In 1990 the EPA lowered the maximum limit for lead in public drinking water from 50 parts per billion to 20 parts per billion
- Desert soils often contain high concentrations of soluble salts including toxic selenium and arsenic
- Sodium chloride (table salt) is nontoxic at low concentrations and can become toxic to plants when mobilized by irrigation and concentrated by evaporation
- Acids are by-products of industrial processes such as leather tanning, metal smelting and plating, petroleum distillation, and organic chemical synthesis coal mining is an especially important source of acid water pollution because of the sulfur compounds in coal react with oxygen and water to make sulfuric acid
- 200 lakes in the Adirondack Mountains of New York State have been reported having aquatic damage due to acid precipitation

Surface Waters in the United States and Canada

- The 1972 Clean Water Act established a National Pollution Discharge Elimination System (NPDES) which requires an easily revoked permit for any industry, municipality or other entity dumping wastes in surface waters
- Since the Clean Water Act was passed, the US has spent more than $180 billion in public funds and perhaps ten times as much in private investments on water pollution control
- The goal of the Clean Water Act to make all US surface waters “fishable and swimmable” has not been fully met, but in 1999 the EPA reported that 91.4% of all monitored river miles and 87.5% of all assessed lake acres are suitable for their designated uses
- States are required to identify waters not meeting water quality goals and to develop total maximum daily loads (TMDL) for each pollutant and each listed water body
- The 1970 Water Act in Canada has produced comparable results
- 70% of all Canadians in towns over 1,000 population are now served by some form of municipal sewage treatment
- In the USA as much as 25% of the 46,800,000 metric tons of (52 million tons) of fertilizer spread on farmland each year is carried away by runoff
- Nitrates and phosphates in surface water have decreased from point sources but have increased about four-fold since 1972 from nonpoint sources
- Fossil fuel combustion has become a major source of nitrates, sulfates, arsenic, cadmium, mercury and other toxic pollutants that end up in water

Surface Waters in Other Countries

- The fall of the “iron curtain” in 1989 revealed appalling environmental conditions in much of the former Soviet Union and its satellite states in eastern and central Europe
- Parts of Russia itself and some other former socialist states in the Balkans and Central Asia remain some of the most polluted places on earth
- In Russia, only half of the tap water is fit to drink
- Life expectancies for Russian men have plummeted from about 72 years in 1980 to 59 years in 1999 and deaths now exceed births by about 1 million per year

- There are also some encouraging pollution control stories such as in 1997 Minamata Bay in Japan, long synonymous with mercury poisoning was declared officially clean again
- Less-developed countries such as South America, Africa and Asia have even worse water quality than do the poorer countries of Europe
- The coliform count in the Yamuna River in New Delhi has 7,500 coliform bacteria per 100 ml that increases to 24 million cells per 100 ml as the river leaves the city

Groundwater and Drinking Water Supplies

- Half the people in the United States including 95% of those in rural areas depend on underground aquifers for their drinking water
- One of the serious sources of groundwater pollution throughout the US is MTBE (methyl tertiary butyl ether) a suspected carcinogen and is added to gasoline
- In one US Geological Survey (USGS) study, 27% of shallow urban wells tested contained MTBE
- The US EPA estimates that every day some 4.5 trillion liters of contaminated water sep into the ground in the United States from septic tanks, cesspools municipal an industrial landfills and waste disposal sites, surface impoundments, agricultural fields, forests and wells
- Although most of the leaky, single-walled underground storage tanks once common at filling stations and factories have now been removed and replaced by more modern ones, a great deal of soil in American cities remains contaminated by previous careless storage and disposal of petroleum products
- A 1996 survey concluded that nearly 20,000 public drinking water systems in the US expose consumers to contaminants such as lead, pesticides and pathogens at levels that violate EPA rules

Human Waste Disposal

- In poorer countries of the world, most rural people simply go out into the fields and forests to relieve themselves as they have always done
- Major cities of many less-developed countries are often littered with human waste which has been left for rains to wash away or for pigs, dogs, flies, beetles or other scavengers to consume
- Studies have shown that a significant portion of the airborne dust in Mexico City is actually dried, pulverized human feces
- Grease and oils rise to the top of a septic tank while solids settle to the bottom where they are subject to bacterial decomposition
- Primary treatment is the first step in municipal waste treatment, it physically separates large solids from the waste stream
- Secondary treatment is the biological degradation of the dissolved organic compounds
- Tertiary treatment removes plant nutrients such as nitrates and phosphates from the secondary effluent
- Effluent sewerage is a hybrid between traditional septic tanks and a full sewer system in which the effluents are pumped into a central treatment plant instead of a drainfield

The Clean Water Act

- The Clean Water Act of 1972 along with the endangered Species Act and the Clean Air Act are the most significant and effective pieces of environmental legislation ever passed by the US Congress
- To fulfill the main goal of the act make all surface waters "fishable and swimmable" they used a best practicable control technology (BPT) which sets national goals of best available, economically achievable technology (BAT) for toxic substances and zero discharge for 126 priority toxic pollutants
- Industries, state and local governments, farmers, land developers and others who have been forced to change their operations or spend money on water protection aren't happy with the Clean Water Act
- These people who aren't happy often times feel imposed upon
- Another flaw with the act is when state or local governments spend money that is not repaid by Congress
- Small cities that couldn't afford or chose not to participate in earlier programs in which the federal government paid up to 90% of water quality programs are especially hard hit by requirements that they upgrade municipal sewer and water systems

HOW IT HAPPENS

Acid Rain

The pH of rainwater is normally slightly acidic, at about 5.6, due mainly to reaction of carbon dioxide with water to form carbonic acid.

Other natural events can contribute to the acidity of precipitation. Volcanic eruptions, forest fires, and lightning bolts produce sulfur dioxide, sulfur trioxide, and nitrogen dioxide. These gases can react with atmospheric water in much the same way that carbon dioxide does to produce sulfurous acid, sulfuric acid, nitric acid and nitrous acid.

Air Pollution Control and Prevention

: Formula that represents the process of “scrubbing” products of industrial combustion processes. Sulfur dioxide gas is removes by using an aqueous solution of calcium hydroxide, also called limewater. The sulfur dioxide reacts with the limewater to form solid calcium sulfite. Scrubbers that utilize this “wet” scrubbing method can remove up to 95% of sulfur oxides.

Another process for scrubbing that utilizes magnesium hydroxide instead of limewater. The sulfur dioxide dissolves in the water and reacts with the magnesium hydroxide to form a salt. The magnesium sulfite that is formed can be isolated and heated to regenerate sulfur dioxide. The recovered sulfur dioxide can be collected and used as a raw material in other commercial processes.

Air Pollution

Impurities such as pyrite or iron pyrite are found in coal, when we burn coal it interacts with atmospheric oxygen to form iron oxide and sulfur dioxide (a primary air pollutant).

The primary air pollutant, sulfur dioxide, is oxidized, once in the atmosphere, to sulfur trioxide.

Sulfur trioxide dissolves it atmospheric water droplets to form sulfuric acid. Sulfuric acid is a major component of acid rain. Sulfuric acid is considered a secondary air pollutant:

The generalized representation of sulfur oxides, whether it be sulfur dioxide or sulfur trioxide. The Sulfur oxides are considered primary air pollutants.:

Molecules of nitrogen and atmospheric oxygen combine AT VERY HIGH TEMPERATURES to form nitric oxide, a colorless gas. The high temperatures of natural processes like lightening or those of the combustion chambers of an engine are effective in causing this conversion. Nitric oxide is a primary air pollutant:

Once in the atmosphere, nitric acid reacts with additional oxygen to form nitrogen dioxide, a red-brown toxic gas that causes irritation to the eyes and respiratory system:

Further reaction of nitrogen dioxide with water can produce nitric acid, another component of acid rain

Ozone Formation and Destruction

As sunlight penetrates into the stratosphere, high-energy UV photons react with oxygen gas molecules, splitting them into individual oxygen atoms. These highly reactive oxygen atoms are examples of free radicals; they quickly enter into chemical reactions that allow them to attain stable arrangements of electrons. In the stratosphere free radicals can combine with oxygen molecules to form ozone. A third molecule, typically nitrogen gas or atmospheric oxygen (represented by M in the equation), carries away excess energy from the reaction but remains unchanged.

Each ozone molecule formed in the stratosphere can absorb a UV photon with a wavelength of less than 320nm. This energy absorption prevents potentially harmful UV rays from reaching the earth's surface. The energy also causes the ozone to decomposed, producing an oxygen molecule and an oxygen free radical. These products can then carry on the cycle by replacing ozone in the protective stratospheric layer.

CFC's (chlorofluorocarbons) are highly stable molecules in the troposphere, however, high energy UV photons in the stratosphere split chlorine radicals from CFC's by breaking their C-Cl bond. The freed chlorine radicals are very reactive and can participate in a series of reaction that destroy ozone by converting it to diatomic oxygen. Every chlorine radical that participates in the first reaction can later be regenerated . Thus each chlorine radical acts as a catalyst participating in not just one, but an average of 100,000 ozone –destroying reactions. In doing so, it speeds up ozone destruction but remains unchanged itself.

Photochemical Smog

Nitrogen oxide is an essential ingredient of photochemical smog that is produced during the high temperatures associated with combustion of vehicle's engines.

Initial reaction of nitrogen dioxide with sunlight:

The oxygen atom generated from the initial reaction reacts with atmospheric, diatomic oxygen, to form ozone. This is not the good, protective ozone of the stratosphere, this is the polluting ozone of the lithosphere, which traps heat and contributes to thermal inversion.

This simplified equation represents the key ingredients and products of photochemical smog. Hydrocarbons (including VOC's), carbon monoxide, and nitrogen oxides from vehicle exhausts are irradiated by sunlight in the presence of oxygen gas. The resulting reactions produce a potentially dangerous mixture that include other nitrogen oxides, ozone, and irritating organic compounds, as well as carbon dioxide and water vapor.

The Carbon Cycle

The different forms and compounds in which carbon atoms are found are considered chemical reservoirs of carbon. These reservoirs include atmospheric carbon dioxide, calcium carbonate (in limestone), natural gas, and organic molecules, to name a few.

Plants use carbon dioxide and energy from the sun to form carbohydrates in photosynthesis. The carbohydrates are consumed by other organisms, and are eventually broken down, or "oxidized".

The process of respiration. The chemical representation of how carbohydrates are broken down, or oxidized, thereby releasing energy for use by the consuming organisms. The carbon used and circulated in photosynthesis represents only a tiny portion of the available global carbon.

Atmospheric carbon dioxide levels have increased by 30% since the 1800's (industrial revolution).This increase can be explained, primarily, but several human activities. The most significant of these activities is the burning of fossil fuels.

The Nitrogen Cycle

Atmospheric nitrogen is converted to ammonia or ammonium ion by nitrogen-fixing bacteria that live in legume root nodules or in soil, or atmospheric nitrogen is converted to nitrogen oxides by lightening.

Ammonia and Ammonium are oxidized by soil bacteria first to nitrite ions and then to nitrate ions

After plants have taken up nitrogen from the soil in the form of nitrate ions, the nitrogen is passed along the food chain. When those plants and animals dies, bacteria and fungi take up and use some of the nitrogen from the plant/animal protein and other nitrogen containing molecules. The remaining nitrogen is released as ammonium ions or ammonia gas. Denitrifying bacteria convert some ammonia, nitrite, and nitrate back to nitrogen gas, which returns to the atmosphere.

Haber-Bosch Process: A technique for making ammonia from hydrogen and nitrogen, according to the first equation. To get the reactants, nitrogen gas is liquefied form air and hydrogen gas is obtained chemically from methane (natural gas). First natural gas is treated to remove sulfur-containing compounds; then the present methane is allowed to react with steam. Carbon monoxide, a product of methane reacting with steam, is converted to carbon dioxide which allows for the additional production of nitrogen gas.

TOPIC SUMMARIES

Science, Systems, Matter, and Energy

Summary

1. Science is an attempt to discover the natural world's order and use that in describing what is likely to happen in nature. Scientists ask a question or identify a problem to investigate. Then, they collect scientific data through observation and measurement. Experiments may be used to study specific phenomena.

2. The major components of complex systems are environmental inputs, flows within the system, and outputs to the environment.

3. The basic forms of matter are elements and compounds. Matter is useful to us as a resource because it makes up every material substance.

4. The major forms of energy are kinetic energy and potential energy. Energy is useful to us as a resource because it moves matter.

5. The Law of Conservation of Matter states that matter is neither created nor destroyed when a physical or chemical change occurs.

6. Matter can undergo three types of nuclear changes: natural radioactive decay, nuclear fission, and nuclear fusion.

7. The First Law of Thermodynamics states that in all physical and chemical changes, energy may be converted from one form to another but it is neither created nor destroyed. The Second Law of Thermodynamics states that when energy is changed from one form to another, there is always less usable energy left.

8. These laws, then, show that energy goes from a more useful to a less useful form and that high-quality energy cannot be recycled. So, the quality as well as the quantity of our resources and our environment will be reduced.

Ecosystems: What Are They and How Do They Work

Summary

1. Ecology is the study of connections in nature.

2. Life on earth is sustained by the one-way flow of high-quality energy from the sun, by the cycling of matter, and by gravity.

3. Matter, energy, and life are the major components of an ecosystem.

4. Energy in an ecosystem decreases in amount to each succeeding organism in a food chair or web.

5. Soil is a complex mixture of eroded rock, mineral nutrients, water, air, decaying organic matter, and billions of living organisms. It covers most of the earth and provides nutrients for plant growth. Soils are formed by a breaking down of rock, decomposing surface litter and organic matter. Bacteria and other decomposer microorganisms break down some of soil's organic compounds into simpler inorganic compounds.

6. Matter is recycled through the earth's ecosystem of air, land, water, and living organisms. This vast global recycling system is composed of nutrient cycles.

7. Scientists study ecosystems through the use of aquarium tanks, greenhouses, and controlled indoor and outdoor chambers. Specific variables are carefully controlled, like temperature, light, carbon dioxide, and humidity.

8. Two principles of sustainability found from learning how nature works are the law of conservation of matter and the two laws of thermodynamics.

Evolution and Biodiversity

Summary

1. Life emerged on the earth through two phases of development: a chemical evolution of the organic molecules, biopolymers, and systems of chemical reactions to form the first cells and the biological evolution from single-celled prokaryotic bacteria to single-celled eukaryotic creatures, and then to multicellular organisms.

2. Evolution is the change in a population's genetic makeup over time. Evolution forces adaptations to changes in environmental conditions in a population. The diversity of life on earth reflects the wide variety of adaptations necessary and suggests that environmental conditions have varied widely over the life of the earth.

3. An ecological niche is a species' way of life or its functional role in a community. Everything that affects its survival and reproduction (temperature tolerance, water needs, space needs, interactions with other organisms, etc.) is a part of that niche. The ecological niche helps a population survive by the adaptive traits that its organisms have acquired.

4. Extinction of species and formation of new species constantly change the biodiversity of the earth.

5. In the future, evolution will continue to influence our environment. Man's use of artificial selection and genetic engineering to evolve species may have unintended consequences because evolution is a long, slow process and is unpredictable.

Biodiversity, Species Interactions, and Population Control

Summary

1. Two major factors affect the number of species in a community: the latitude in terrestrial communities and pollution in aquatic systems.

2. Species play different roles in a community. Native species sustain the ecosystem in which they are a part. Some nonnative species will crowd out native species. Indicator species alert us to harmful changes in the community. Keystone species play ecological roles in the specific community: they may assist in pollination help regulate populations. Foundation species affect the community's habitat to benefit other species.

3. Species interact with each other in these different ways: interspecific competition, predation, parasitism, mutualism, and commensalism.

4. As environmental conditions change, one species may be replaced by other groups of species. This gradual change in the composition of species in a given area is called ecological succession.

5. A community has three aspects of sustaining itself: its persistence, the ability to resist being altered, its constant population, and its resilience in repairing damage. High biodiversity may give a community some edge in surviving, but we do not know this for certain.

The Human Population and Its Impact

Summary

1. Birth, death, fertility, and migration rates are the factors that determine population size. As birth rates have declined in developed countries, population has increased due to people's migrating into these countries. Women's fertility rates have dropped but are still above the replacement-level fertility around the world.

2. Population size is profoundly affected by age structure. If women are past their primary child-bearing ages, population increase will be limited. If, however, the population has a large percentage of young women entering their childbearing years, the potential for large population increases is present. In general, the closer a country's young women are to 15–40 years of age, the more potential for a rapidly increasing population.

3. We can influence population size by encouraging smaller families, by encouraging adoption of children already born and discouraging new births. Population size is, also, affected by health care or its lack; by epidemics (such as AIDS); by losses through war, etc. Lack of prenatal care for expectant mothers, failure to protect children from communicable diseases (like measles) or wide-spread diseases (like malaria), can contribute to a smaller population. In the past economic development, family planning, and economic opportunities for women have reduced birth rates.

4. India and China have both made efforts to control their population growth. China has been more successful because, as a dictatorship, it has imposed restrictions on family size with rewards and punishments for those who support or defy the government's direction. India, without a policy of coercion, has reduced its birth rate; but the wish for male children and several children for the care of old parents has helped to maintain a growing population.

5. Effective methods for slowing the growth of world population include investing in family planning, reducing poverty, and elevating the status of women.

Climate and Terrestrial Biodiversity

Summary

1. Key factors that determine the earth's weather are short-term atmospheric conditions such as temperature, pressure, moisture content, sunshine, cloud cover, precipitation, wind direction, and wind speed.

2. Climate is a region's long-term atmospheric conditions over decades. The two main factors in determining climate are average temperature and average precipitation.

3. The average climate—annual precipitation and temperature—determines terrestrial regions with characteristic types of natural ecological communities. According to these two factors, biomes form.

4. The major types of desert biomes are hot, medium, and cold. Human activities have created large desert cities, destroyed soil through urban development and off-road vehicles, salinized the soil through irrigation, depleted underground water supplies, disturbed land and polluted, stored toxic and radioactive wastes, and located arrays of solar cells and solar collectors.

5. The three major types of grasslands are tropical or savannas, temperate grasslands, and polar grassland/tundra. The savannas have been destroyed by grazing cattle, which destroy vegetation and kills grass through fecal droppings. The temperate grasslands have been used to grow crops and graze animals. As a result, the grasslands have disappeared. The arctic tundra has been compromised by oil drilling, mines, and military bases.

6. The three main types of forest biomes are tropical, temperate, and polar/boreal. Human activities have destroyed much of the native trees; grazing has compromised the vegetation and eliminated food sources for native animals. And the deforestation has changed the tropical forest's ecosystem, leading to death of plants and animals. The temperate forest has a fewer number of broadleaf trees and rich forest soil; but fires, logging, and hunting have undermined this type of forest. The evergreen firs of the polar forest support a variety of wildlife. But oil drilling and oil spills have compromised the water, the wildlife, and the vegetation in the arctic.

7. Mountain and arctic biomes play important ecological roles; they help regulate climate and effect sea levels. Mountain biome degradation arises from timber and mining extraction, from hydroelectric dams and reservoirs, from air pollution, increased tourism, and radiation from ozone depletion.

Aquatic Biodiversity

Summary

1. The basic types of aquatic life zones are the surface, middle, and bottom layers. The life in aquatic life zones is influenced by temperature, access to sunlight for photosynthesis, dissolved oxygen content, and availability of nutrients.

2. The major types of saltwater life zones are the coastal zone and the open sea. Coastal ecosystems contain estuaries, wetlands, and mangrove swamps. Because of their close proximity to man's activities, they are under constant strain from water pollution, industrial run-off, construction and soil erosion, agricultural pesticides flowing into rivers and streams, and aquaculture farming. The open sea contains the euphotic zone, which is the lighted upper zone of the ocean. The bathyal zone is in the middle and is dimly lit. The lowest zone, the abyssal zone, is dark and very cold. But all are being affected by human activities: over-harvesting, oil spills, filling-in of wetland areas, agricultural and industrial development and pollution, rising sea levels, and careless fishing/trawling techniques.

3. The major types of freshwater life zones are lakes, wetlands, and rivers. Human activities, such as dams or canals; flood control levees and dikes; and industrial, urban, agricultural pollutants all affect the flow and health of freshwater zones. Much of U.S. wetlands have been drained and filled to farm and/or to construct homes and businesses. These actions increase flood potential and encourage droughts. People overfish the waters; pollute the streams, rivers, and lakes; and dump excessive nutrients from pesticides and waste lots into the fresh water sources.

4. We must protect aquatic life zones from the pollutants, water controls, and deterioration that we press upon them every day.

Sustaining Biodiversity: The Species Approach

Summary

1. Biologists estimate extinction rates in one of three levels. Local extinction occurs when a species in a specific area is lost but the species is still found in other places. Ecological extinction describes a species that is so small it cannot play out its ecological role where it is found. Biological extinction means that the species is gone from the earth. Scientists use measurement and models to estimate extinction rates: studying past records, identifying species-area relationships, examining lists of threatened species. Extinction rates are increasing because of human activities. Our growing population, degrading and eliminating biological environments and biological hot spots all contribute to growing extinction rates.

2. Biodiversity and species extinction are important because species provide enormous economic and ecological services we need to survive. In 100 years, mankind will destroy species that it would take five million years to rebuild. These species may provide genetic information, medicines, and information about natural processes we need to discover. These wild plants and animals are economic, recreational, and health resources.

3. Many human activities endanger wildlife, such as degradation/loss of habitat; capture of wild animals, which prevents their breeding; overfishing, oil spills, and exposure to pesticides; and extinction from nonnative species, which we introduce.

4. To prevent premature extinction of species, we must reduce threats from nonnative species; end illegal poaching and hunting; provide means for people to survive economically without killing native animals for food; maintain predator species, not destroy them; reduce greenhouse emissions and deforestation throughout the world; develop governmental policies to support biodiversity; and protect wild species in sanctuaries.

Sustaining Terrestrial Biodiversity: The Ecosystem Approach

Summary

1. Conservation biology attempts to slow down the rate at which we are destroying and degrading the earth's biodiversity through the use of rapid response strategies. Hot spots, the most endangered and species-rich ecosystems, receive emergency action to slow down/stop the loss of biodiversity in these systems. Bioinformatics manages, analyzes, and communicates basic biological and ecological information to help sustain biodiversity.

2. Forests provide important ecological and economic services, are storehouses of biodiversity, and affect weather and climate throughout the world. Forest resource management varies according to the type of forests. In diverse forests, the age and size of trees are preserved to foster natural regeneration. Government policies will primarily determine the future of forests, including old-growth forests.

3. Forests in the United States should be managed so as to retain as much of the forests as possible. Clear-cutting and seed-tree cutting methods of harvesting are scourges on the forest; selective cutting is the most reasonable way to harvest trees.

4. Deforestation is one of the most serious ecological problems of this century. The earth's forests have been reduced by 20–50% and the destruction continues to this day. Deforestation has many harmful environmental effects: reduces ecological services of forests, releases large amounts of carbon dioxide in the air, produces a drier and hotter climate; reduces the control of water movements, and increases soil erosion.

5. Tropical deforestation is one of the biggest threats to world economic health and climate. To help sustain tropical forests, nations of the world must unite to discourage deforestation and degradation.

6. Problems affecting parks run from little/no protection from their governments or being too small to sustain large animal species, to being too popular and, therefore, overused by people. Some methods for managing parks include: limiting the number of visitors, raising entry fees to provide funds for maintenance and management, managing parks in reference to nearby federal lands, discouraging development around already established parks, and providing more volunteers and better paid employees to maintain the parks.

7. Only about 7% of the world's terrestrial areas are protected from potentially harmful human activities; these areas need to be expanded throughout the world. In order to adequately conserve biodiversity, at least 20% of the earth's land area should be protected in a global network of reserves.

8. Wilderness is an amount of land legally set aside to prevent/minimize harm from human activities. This is land where human beings may visit but not remain. Wilderness areas are important for: (1) their natural beauty, (2) their natural biological diversity, (3) their enhancement of mental and physical health of visitors, and (4) their contributions to

biodiversity and to evolutionary possibilities.

9. Ecological restoration is the process of repairing damage caused by humans to the biodiversity and dynamics of natural ecosystems.

10. Initiatives that would help to sustain the earth's biodiversity include:
    – Immediately preserving the world's biological *hot spots*
    – Protecting the remaining old-growth forests
    – Mapping the world's terrestrial and aquatic biodiversity
    – Identifying and taking action for the world's marine hot spots, just as for the terrestrial hot spots
    – Protecting and restoring the world's lakes and river systems
    – Developing a global conservation strategy that protects the earth's terrestrial and aquatic ecosystems
    – Making conservation profitable
    – Initiating ecological restoration projects worldwide

Sustaining Aquatic Biodiversity

Summary

1. Aquatic biodiversity refers to the composition of plants and animals in the fresh and salt waters of the planet. The economic importance of aquatic diversity lies in the conservative estimate of the value of their ecological services, which is $21 trillion a year. Additionally, at least 3.5 billion people depend on the seas for their primary source of food and this number could double to 7 billion in 2025. Many medicines have been developed from sea organisms: sponges, anemones, puffer fish, porcupine fish, seaweeds, etc. The waters are used for extensive recreational activities, not to mention commercial transportation.

2. Human activities are undermining aquatic biodiversity by destroying and degrading coastal wetlands, coral reefs, seagrass beds, kelp beds, mangroves, and the ocean bottom.

3. We can protect and sustain marine biodiversity by using laws, international treaties, and education. We must identify and protect species that are endangered and/or threatened. This entails cleaning up aquatic environments, as well as inventing fishing methods that do not destroy animals and birds inadvertently caught in fishing nets. Poaching and illegal harvesting of marine creatures must also be eliminated. Public aquariums can also educate the public about protecting marine animals and birds. Marine sanctuaries and coastal management can protect aquatic environments as well as their creatures.

4. The world's marine fisheries can be managed by setting catch limits below the maximum sustained yield limits, by reducing/eliminating fishing subsidies, and by charging fees for fishing in publicly owned offshore waters. Some areas can be protected from any kind of fishing; there should be more marine protected areas and more integration of coastal management practices. Develop net-escape devices for fishing boats. Restriction of coastal locations for fish farms, control of pollution, and decreasing the pollution of ship ballast water into the sea will all protect marine fisheries. Multispecies management of large marine systems offers hope for conserving marine resources and for renewing those resources.

5. Wetlands can be protected, sustained, and restored by government regulations that prevent wetland loss. Destroyed wetlands can also be restored and adequately monitored for their protection. Development can be kept away from wetland areas and control of nonnative species needs to be instituted to prevent invasion into wetlands.

6. Freshwater fisheries, lakes, and rivers can be protected, sustained, and even restored by building and protecting populations of desirable species, by prevention of overfishing, and by decreasing populations of less desirable species. Laws can be enacted, and enforcers of these laws must be funded to protect scenic rivers; they should be protected from development and dam construction projects.

Food, Soil, and Pest Management

Summary

1. Even though food production has leveled off in the last 25 years, the world still produces enough food to meet the basic nutritional needs of people. However, the food cannot be evenly distributed throughout the world, leading to malnutrition and starvation. Many of these deaths come from malnutrition, which leads to a lack of resistance to diseases. Modern agricultural techniques create significant environmental harm, but the green revolution is also responsible for large increases in agricultural productivity.

2. Three systems produce foods for human consumption. Croplands produce mostly grains, about 77% of the world's food. Rangelands provide meat, about 16% of the world's food. Ocean fisheries supply about 7% of the world's food.

3. Soils are degraded and eroded by water, wind, and people. Soil erosion is primarily caused by flowing water and wind. Human activities, such as farming, logging, construction, off-road vehicles, etc., also disturb soil and hasten erosion. In much soil there is also salt buildup and waterlogging. Crops can be planted today with less soil disturbance through conservation-tillage, tillage, contour farming, and strip farming. Farmers may also use cover crops to help hold the soil in place. Several crops planted between trees and shrubs, alley cropping, help preserve soil and its productivity. And windbreaks are used to prevent soil from being blown away. Conservation and fertilization can be used to restore soil fertility, but fertilizing with commercial pesticides brings its own set of problems.

4. The green revolution uses particular methods to raise crops. Monocultures are developed and planted, bred selectively, or genetically engineered to produce high yields of particular crops. Large amounts of fertilizer, pesticides, and water are added to the crops. Yields of crops are increased through multiple cropping throughout the year. The second green revolution since 1967 involved using fast-growing dwarf varieties of wheat and rice in countries with tropical and subtropical climates. Traditional agriculture: uses interplanting, several crops grown together on the same area of land; uses agroforestry, which grows crops and trees together; and applies polyculture, where various plants are planted together but mature at different times.

5. Food production can be increased by using crossbreeding techniques on similar organisms and using genetic engineering on different organisms. Genetic engineering, including using advanced tissue culture techniques, is growing in use; but many people are concerned about the potential harm such crops may cause. Irrigating more land and cultivating more land are additional solutions but they may not prove sustainable. Rangelands can be managed more efficiently, with the land area better protected; but a meat-based diet requires substantially more resources than a plant-based diet. Overfishing and habitat degradation dominate the marine environment; better management of this food source and protection of the marine environment would ensure continued availability of fish worldwide.

6. More sustainable agricultural systems can be created by reducing resource throughput and working with nature. Technologies based on ecological knowledge are used to increase crop

production, to control pests, and to build soil fertility. Such low-input organic farming is often more friendly to the environment by using less energy than conventional farming demands, and by improving soil fertility. Low-input organic farming is also more profitable for farmers.

7. Pesticides are chemicals that kill or control populations of organisms we consider undesirable. Types include insecticides, herbicides, fungicides, and rodenticides. The advantages of using pesticides include the fact that they save lives, increase food supplies, lower food cost, increase profit for farmers, and work fast. The disadvantages include the acceleration of pest resistance to pesticides and pesticides dispersing widely, harming wildlife, and threatening human lives. The Federal Insecticide, Fungicide, and Rodenticide Act established in 1947 and amended in 1972, as well as the 1996 Food Quality Protection Act regulate pesticide use in the United States. Alternatives to pesticides include integrated pest management, cultivation practices, food irradiation, genetic engineering, biological control, hot water, and pheromones. These all reduce pesticide use but may prove timely, costly, and not as reliable.

Water

Summary

1. Approximately 0.024% of the earth's water supply is available as liquid freshwater. Management of the world's water supply is a huge 21^{st} century challenge.

2. Freshwater shortages are caused by dry climate, droughts, desiccation, and water stress. Solutions for this problem include building dams and reservoirs, transporting freshwater between locations, withdrawing groundwater, and desalination.

3. Advantages of dams and reservoirs include cheap electricity, reduction of downstream flooding, and year-round water for irrigation. Disadvantages include displacement of people and disruption of aquatic systems, and the hydrological cycle.

4. Transferring large amounts of water from one area to another can give stream runoff from water-rich areas to water-poor areas and aid in irrigation of farmland. It can also cause ecological, economical, and health disasters.

5. The advantages of withdrawing groundwater include water for drinking and irrigation; availability and locality; low cost, no evaporation losses; and it is renewable. Disadvantages include aquifer depletion from over pumping, subsidence, pollution, saltwater intrusion, and reduced water flow. Desalination increases the supply of fresh water but is expensive and produces large quantities of wastewater.

6. We can waste less water by lining canals, leveling fields, irrigating at night or using new irrigation techniques, polyculture or organic farming, seasonal farming, irrigating with treated waste water, and importing water-intensive crops and meat.

7. Flooding is caused by heavy rain or melting of snow within a short time. To reduce flood damage or the risk of flooding we can avoid building on floodplains, removing water-absorbing vegetation, or draining wetlands.

8. Methods for achieving more sustainable use of the earth's water include not depleting aquifers, preserving aquatic systems and water quality, integrated watershed management, agreements among regions and countries sharing surface water resources, outside party mediation of water dispute nations, marketing of water rights, raising water prices, wasting less water, decreasing government subsidies for reducing water waste, and slowing population growth.

Geology and Nonrenewable Mineral Resources

Summary

1. Tectonic plates have rearranged the earth's continents and ocean basins over millions of years like pieces of a gigantic jigsaw puzzle. The plates have three types of boundaries. Natural hazards such as earthquakes and volcanoes are likely to be found at plate boundaries.

2. Rocks are large, natural, continuous parts of the earth's crust. There are three major types of rocks: igneous, sedimentary, and metamorphic. Rocks are affected by changes of physical and chemical conditions that change them over time from one type to another through the rock cycle.

3. Mineral resources include all naturally occurring materials that are used for human purposes. These resources include metals and fossil fuels, and the distribution of these materials across the earth's surface is highly variable leading to concentrated deposits in certain areas (e.g., diamonds in Angola or oil in Saudi Arabia). This unequal distribution can lead to conflicts and has implications for national security and international relations.

4. Mineral resource extraction methods include surface and subsurface mining. Surface mining types are open-pit, strip, contour strip mining, and mountain removal. Resource extraction technologies are constantly changing but always create some environmental disturbance. In some cases, the environmental impacts of mineral extraction can be severe.

5. All mineral resources are finite but the lifetime of materials varies with the rate of use and the size of the resource. Recycling of mineral resources leads to a longer depletion time compared to those that cannot be reused or recycled.

6. Scientists are developing new types of materials as substitutes for many metals. Mineral conservation and more sustainable manufacturing processes are helping to decrease our use and waste of such resources. Recent, dramatic increases in the cost of minerals are driving aggressive recycling of many resources and particularly metals (e.g., copper).

Nonrenewable Energy

Summary

1. Nonrenewable energy sources are obtained from the earth's crust and primarily from carbon-containing fossil fuels. They are non-renewable because they have finite lifetimes, but the different forms of non-renewable fuels (e.g., oil, coal, uranium) have highly variable lifetimes.

2. The advantages of oil include low cost, high net energy yield, easy transportation, low land use, well-developed technology, and efficient system of distribution. Disadvantages include need for a substitute discovery; low price encourages waste, air pollution, and water pollution. Oil supplies are estimated to be approximately 80% depleted between 2050 and 2100.

3. The advantages of natural gas include plentiful supplies, high net energy yield, low cost, less air pollution than oil, moderate environment impact, and easy transport. Disadvantages include the fact that it is a nonrenewable resource, comparative high cost, release of carbon dioxide when burned (although lower than other fossil fuels such as coal), leaks, and requirement for pipeline infrastructure for transport.

4. The advantages of coal include plentiful supplies, high net energy yield, low cost, well-developed technology, and air pollution can be partially managed with appropriate technology. Disadvantages include very high environmental impact, land disturbance, air and water pollution, threat to human health, high carbon dioxide emissions, and release of radioactive particles and mercury.

5. The advantages of nuclear power include large fuel supply, low environmental impact, low carbon dioxide emissions (none from energy generation), moderate land disruption and use, and low risk of accidents. Disadvantages include high cost, low net energy yield, high environmental impact in case of accident, catastrophic accidents, long-term storage of radioactive waste, and potential for nuclear proliferation.

Energy Efficiency and Renewable Energy

Summary

1. The advantages of improving energy efficiency include benefits to the environment, people, and the economy through prolonged fossil fuel supplies, reduced oil imports, very high net energy yield, low cost reduction of pollution, and improved local economies.

2. The advantages of solar energy include reduction of air pollution, reduction of dependence on oil, and low land use. Disadvantages include production of photocells results in release of toxic chemicals, life of systems is short, need backup systems, and high cost.

3. The advantages of hydropower include high net energy yield, low cost electricity, long life span, no carbon dioxide emissions during operation, flood control below dam, water for irrigation, and reservoir development. Disadvantages include high construction cost, high environmental impact, high carbon dioxide emissions from biomass decay, flooding of natural areas, conversion of land habitats to lake habitats, danger of dam collapsing, people relocation, limits fish populations below dam, and decrease flow of silt.

4. The advantages of wind power include high net energy yield and efficiency, low cost and environmental impact, no carbon dioxide emissions, and quick construction. Disadvantages include need for winds and backup systems, high land use, visual and noise pollution, interfering with bird migrations.

5. The advantages of biomass include large potential supplies, moderate costs, no net carbon increase, and use of agricultural, timber, and urban wastes. Disadvantages include nonrenewable resource if not harvested sustainably, moderate to high environmental impact, low photosynthetic efficiency, soil erosion, water pollution, and loss of wildlife.

6. The advantages of geothermal energy include very high efficiency, low carbon dioxide emissions, low cost and land use, low land disturbance, and moderate environmental impact. Disadvantages include scarcity of suitable sites, potential depletion, moderate to high air pollution, noise and odor, and high cost.

7. The advantages of hydrogen gas include the fact that it can be produced from water, the low environmental impact, no carbon dioxide emission, competitive price, ease of storage, safety, and high efficiency. Disadvantages include energy needed to produce the fuel, negative energy yield, nonrenewable, high cost, and no fuel distribution system exists.

8. The advantages of using smaller, decentralized micropower sources include size, fast production and installation, high energy efficiency, low or no CO_2 emissions, low air pollution, easy repair, reliable, increased national security, and easily financed.

9. We can improve energy efficiency by increasing fuel efficiency standards, large tax credits for purchasing energy efficient cars, houses, and appliances, encouraging independent energy production, and increasing research and development.

Environmental Hazards and Human Health

Summary

1. Major types of hazards faced by humans include cultural, physical, chemical, and biological hazards.

2. Toxicology is the scientific field that measures the degree of harm a hazardous agent can cause. Scientists measure toxicity based on dosage, solubility, persistence, bioaccumulation, biomagnification, and chemical interactions.

3. Chemical hazards include agents that are flammable or explosive, damage or irritate lungs or skin, interrupt oxygen uptake, and cause allergies. Chemical hazards are defined by their toxicity, the person's acute and chronic reactions to it, and its pervasiveness in the environment.

4. The types of disease threatening people in developing countries are primarily infectious diseases of childhood, while those threatening people in developed countries tend to be chronic diseases of adults, such as heart disease, stroke, cancer, and respiratory conditions.

5. Risks can be estimated, managed, and reduced by identifying hazards, evaluating related risks (risk assessment), ranking risks (comparative risk analysis), determining alternative solutions, making decisions about reducing risks (risk management), and informing decision-makers about risk (risk communication).

Air Pollution

Summary

1. The layers of the atmosphere are the troposphere, stratosphere, mesosphere, and thermosphere.

2. Major classes of air pollutants include carbon, sulfur, and nitrogen oxides, volatile organic compounds, suspended particulate matter, photochemical oxidants, radioactive substances, and hazardous chemicals that can cause health problems. Primary sources of these pollutants include cars, industry, and natural phenomena such as volcanic eruptions.

3. The two types of smog are the photochemical and the industrial, or gray-air, smog.

4. Acid deposition includes wet deposition of acidic rain, snow, fog, and cloud vapor with pH less than 5.6, and dry deposition of acidic particles. Major sources of acid deposition are nitrogen oxides produced during fossil fuel combustion and sulfur oxides produced primarily from coal-fired power plants.

5. Harmful effects of air pollution include various respiratory diseases, premature deaths, damage to plants, and materials such as buildings, cars, statues, etc.

6. We can reduce air pollution by reducing emission through the use of low-sulfur coal, shifting to less polluting fuels (e.g., coal to natural gas), removal of pollutants after combustion or lower emissions through the use of mass transit or alternative transportation, improving fuel efficiency, and tax incentives.

Climate Change and Ozone Depletion

Summary

1. The earth's average surface temperature and climate has changed in the past. The changes include prolonged periods of global cooling and global warming.

2. There is a natural greenhouse effect in the earth's atmosphere caused by the presence of gases that trap long-wave radiation (water, CO_2, and others). Human emissions of carbon dioxide, methane, and nitrogen oxide increase the concentrations of greenhouse gases and cause additional warming of the earth's surface.

3. Factor's influencing changes of earth's average surface temperature include changes in the solar output, the earth's reflectivity, the ability of oceans and land ecosystems to store carbon dioxide, the ocean currents, the average sea level, cloud cover, and air pollution.

4. Possible effects from a warmer earth include shifts in plant-growing areas, crop yields and pests, extinction of some species, loss of habitats, prolonged heat waves and droughts, increased flooding, changes in water supplies, decreased water quality, changes in forest composition, increased fires, rising sea levels, beach erosion, contamination of aquifers, spread of tropical diseases into temperate zones, increased respiratory diseases and allergies, increased deaths, and migration.

5. To prevent or slow global warming we can limit fossil fuel use, shift from coal to natural gas use, place energy efficient technologies in developed and developing countries, improve energy efficiency, shift to renewable resources, reduce deforestation, use sustainable agriculture, limit urban sprawl, reduce poverty, and slow population growth.

6. Human activities that cause ozone depletion include emissions of chlorofluorocarbons, methyl bromide, hydrogen chloride, carbon tetrachloride, methyl chloroform, and others. The stratosphere contains high concentrations of ozone that absorbs UV radiation as it enters the atmosphere. Ozone depletion can lead to sunburns, cataracts, skin cancers, immune suppression, and reduced crop yields, particularly in the Southern Hemisphere. Note that students often confuse tropospheric ozone (air pollution) and stratospheric ozone (UV absorption), and confuse ozone depletion with global warming.

Chapter 20
Water Pollution

Summary

1. Water pollutants include infectious agents from human or animal wastes; oxygen-demanding wastes from sewage, paper mills, and food processing; inorganic chemicals from surface runoff, industrial effluents, and household cleaners; organic chemicals from oil, plastics, pesticides, and detergents; sediment from erosion; and thermal pollution from power plant cooling.

2. Water pollution problems in streams and lakes relate to chemical and biological pollutants, with the greater problems being cultural eutrophication.

3. Groundwater pollution is caused by leaks from waste ponds and underground storage tanks, chemical dumping or spilling, surface runoff, and fertilizers. It can be prevented by finding substitutes for toxic chemicals, installing monitoring wells near landfills and underground tanks, requiring leak detectors on underground tanks, banning hazardous waste disposal in landfills and injection wells, and storing harmful liquids in aboveground tanks.

4. Water pollution of oceans relates to nitrogen oxide from industry and cars, heavy metals from effluents, toxic sediment, sewage, runoff of pesticides, manure, fertilizers, and red tides from excess nitrogen.

5. Reduction or prevention of water pollution can be achieved through reduction of use of toxic pollutants, banning of ocean dumping of sludge, protection of sensitive areas from oil drilling and oil transport, regulation of coastal development, and regulation of sewage treatment.

6. The U.S. Safe Drinking Water Act of 1974 requires that drinking water contain less than the maximum contaminant levels for any pollutants that may have adverse effects on human health. Restructuring of water treatment systems, enforcing current regulations, banning the use of lead in new structures, and chemical tests and biological indicators can be used to make drinking water safer.

Solid and Hazardous Waste

Summary

1. Solid waste is any unwanted or discarded material that is not a liquid or a gas. Thirty-three percent of the world's solid wasted is produced by one country—the United States—which represents 4.6% of the world's population.

2. Waste management, waste reduction, reduced usage, and pollution prevention can all be used to reduce, reuse, or recycle solid waste.

3. The advantages of burning waste include reducing trash volume, minimizing the need for landfills, and lowering water pollution. The disadvantages include high cost, air pollution, producing toxic ash, and encouraging waste production. The advantages of burying wastes include safety, wastes can be retrieved, ease of application, and low cost. Disadvantages include leaks and spills, existing fractures or earthquakes can cause waste escape, and encouraging waste production.

4. Hazardous waste is any discarded solid or liquid material that is toxic, ignitable, corrosive, or reactive enough to explode or release toxic fumes. We can use a pollution prevention or waste reduction approach to reduce production and manage existing hazardous waste mostly by burning or burying it.

5. Physical methods such as filtering and distilling, chemical reactions, bioremediation, phytoremediation, and plasma torches can all be used to detoxify hazardous waste.

6. Advantages of burning hazardous waste include reducting waste volume, minimizing the need for storage space, and lowering water pollution. The disadvantages include air pollutants such as toxic dioxins and production of toxic ash that must be stored. Advantages of burying hazardous waste include safety, wastes can be retrieved, ease of application, and low cost. Disadvantages include leaks and spills, existing fractures or earthquakes can cause waste escape, and encouraging waste production.

7. The United States regulates hazardous waste through the 1976 Resource Conservation and Recovery Act, which was amended in 1984.

Sustainable Cities

Summary

1. Almost half of the world's population lives in urban areas and half in rural areas. Government policies, poverty, lack of land to grow food, declining agricultural jobs, famine, and war that force people out of rural areas are all factors that determine how urban areas develop.

2. Urban areas are rarely self-sustaining, threaten biodiversity, destroy and damage ecosystems, lack trees, grow little of their own food, concentrate pollutants and noise, spread infectious disease, and are centers of poverty, crimes, and terrorism.

3. Urban areas relying on mass transportation spread vertically and urban areas relying on automobiles spread horizontally. Advantages of automobiles include convenience, personal benefits, and boosted economies, Disadvantages include air pollution, promotion of urban sprawl, increase in death rate, and time- and gas-wasting traffic jams. Advantages of bicycles and motor scooters include low cost, little to no air or noise pollution, require little space, and are energy efficient. Disadvantages include little accident protection, impractical for long distances, can be tiring, little parking, and gas scooter engines emit high air pollution. Mass transit rail systems are more energy efficient than cars, produce lower air pollution, require less land, cause fewer injuries and deaths, and reduce car congestion. Disadvantages include high cost to build and maintain, rigid schedules, noise pollution, and they are cost effective only in densely populated areas. Buses are more flexible than rail systems, can easily be rerouted, cost less to develop, and can reduce car use. Disadvantages include rigid schedules, noise pollution, and they are not always cost efficient. Rapid rail systems can reduce car and plane travel, are ideal for long trips, and are more efficient than cars and planes. Disadvantages include high operation and maintenance cost, noise pollution, and they are not always cost efficient.

4. Land-use planning, zoning, and smart growth can be used for planning and controlling urban growth.

5. Cities can be made more sustainable and more desirable places to live by creating parks, greenbelts, urban growth boundaries, cluster developments, mixed-use villages, greenways, and ecocities.

Economics, Environment, and Sustainability

Summary

1. Economic systems are the social institutions through which goods and services are produced, distributed, and consumed to satisfy people's wants in the most efficient possible way. Natural capital, human capital, financial capital, and manufactured capital all comprise economic resources, which must be managed to sustain the world's environmental health.

2. Neoclassical economists see natural resources as a part of the economic system and assume that economic growth potential is essentially unlimited. Ecological economists see economic systems as a component of nature's economy and would have higher optimum levels of pollution control and lower optimum levels of resource use than would neoclassical economists.

3. Economic and environmental progress is monitored through the gross national income (GNI), gross domestic product (GDP), and per capita GNI and GDP indicators.

4. Full-cost pricing includes the internal and external costs in the market price of any good or service.

5. Some components of an environmental economics perspective include phasing out environmentally harmful subsidies, levying taxes on environmentally harmful goods and services, passing laws to regulate pollution and resource depletion, and using tradable permits for pollution or resource use.

6. Poverty can be reduced by forgiving dept to developing countries, through increase of nonmilitary government and private aid, and by stabilizing populations.

7. Shifting to more environmentally sustainable economies includes rewarding sustainable activities and penalizing non-sustainable resource use, use of full-cost pricing, and reduction of poverty.

Politics, Environment, and Sustainability

Summary

1. In this century, we have increased concern about human activities and the harmful effects on biodiversity, shifted from local to regional and global concerns, focused on climate change, become aware of pollution in developing countries, increased concern about trace amounts of some chemicals, and are starting to rely more on our international community to deal with environmental problems.

2. Democracies are governments in which people elect officials and representatives who pass laws, develop budgets, and formulate regulations. Democracies are designed to deal mostly with short-term, isolated problems and are not always efficient when dealing with environmental problems.

3. Environmental policy in the United States is made through: persuasion of lawmakers that an environmental problem exists, influence on how the laws are written, finding funds to implement and enforce each law, drawing up regulations for implementing each law by the appropriate government department, and the enforcement of these regulations.

4. Environmental groups range from small grassroots groups to major global organizations. Their roles include monitoring environmental activities, working to pass and strengthen environmental law, and working with corporations to find solutions to problems. Opponents of these groups include some corporate leaders, some corporations, and some citizens.

5. There are currently environmental protection agencies in 115 countries, over 500 international environmental treaties and agreements, UNEP to negotiate and monitor international environmental treaties, Rio Earth Summit, and Johannesburg Earth Summit. These can be improved by monitoring and evaluating effectiveness.

Environmental Worldviews, Ethics, and Sustainability

<u>Summary</u>

1. The planetary management worldview is the human-centered environmental worldview that guides most industrial societies. This worldview has as a key component the idea that humans are the most important species and that the earth should be managed for our benefit. Variations include the no-problems school, the free-market school, the responsible planetary management school, the spaceship school, and the stewardship school.

2. Life-centered and earth-centered worldviews include environmental wisdom worldview, species centered, biosphere centered, and ecosystem centered. All of these worldviews have far less emphasis on management for human benefit alone and all are far less human-centered.

3. Education is an important component of living sustainably. Education includes understanding ecosystems, developing environmental literacy, and viewing the earth as a complex, interconnected system.

4. We can live sustainably through pollution prevention, waste prevention, species protection, and environmental restoration.

IN-DEPTH TOPIC NOTES

Living Sustainably

Environment - all external conditions and factors that affect living organisms

Ecology - the study of relationships between living organisms and their environment

Environmental Science - the interdisciplinary study that examines the role of humans on earth - includes the disciplines of chemistry, economics, politics, ethics, etc.

Solar Capital - energy from the sun - provides 99% of the Earth's energy

Earth Capital - the planet's air, water, soil, wildlife, minerals, natural purification, recycling and pest control processes

Sustainability - the ability of a specified system to survive and function over a specified time

Carrying Capacity - the maximum number of organisms a local, regional or global environment can support over a specified time period - is dependent on the available resources and the ability of the environment to clean itself of the waste products produced

- Varies with:

    Location

    Time

    Types of technology

Growth and the Wealth Gap

Linear Growth - a quantity increases by a constant amount per unit of time - yields a straight line sloping upwards

Exponential Growth - a quantity is increased by a fixed percentage of the whole in a given time as each increase is applied to the base for further growth - Creates a J-shaped curve - e.g., the human population

Doubling Time - the amount of time it takes to double resource use, population size, or money in a savings account that is growing exponentially

Rule of 70: 70/percentage growth rate = doubling time (in years)

e.g., growth rate = 3%; doubling time = 70/3% = 23.3 yrs

- at the current rates of exponential growth, the world's human population will reach 8 billion by 2025

Economic growth - an increase in (a country's, state's, world's) capacity to provide goods and services for people's final use

GNP - Gross National Product - the market value in current dollars of all goods and services produced within and outside of a country by the country's businesses for final use during a year

GDP - Gross Domestic Product - the market value in current dollars of all goods and services produced within a country for final use during a year

Per Capita GNP - the GNP divided by the total population - used to show an individual's slice of the economic pie -

The United Nations broadly classifies the world's countries as:

Developed countries

- highly industrialized

- usually have per capita GNPs above $4,000

- United States, Japan and Germany together account for over half the world's economic output

Developing countries

- low to moderate industrialization and per capita GNPs

- most are in Africa, Asia, and Latin America (they account for 80% of the population but only have 15% of the wealth and income)

What is sustainable development?

Economic Development - using economic systems to improve the quality of people's lives and the environment

Sustainable Development - meeting present needs without preventing future generations of humans and other species from meeting their needs

Resources

Ecological Resource- anything required by an organism for normal maintenance growth and reproduction, e.g., food, water, shelter, habitat

Economic resource- anything obtained from the environment to meet human needs and wants, e.g., food, water, shelter, transportation, communication, and recreation

Renewable resources - (perpetual resources) on a human time scale these resources are essentially inexhaustible -e.g., direct solar energy, winds, tides, and flowing water

Potentially Renewable resources - resources that can be replaced rapidly through natural processes - e.g., fresh air, fresh water, fertile soil, plants and animals (biodiversity)

Biodiversity

1. genetic diversity - varies in the genetic make-up among individuals within a single species

2. species diversity - variety among the species or distinct types of living organisms found in different habitats of the planet

3. ecological diversity - variety of forests, deserts, grasslands, streams, lakes, oceans, wetlands, and other biological communities

Sustainable yield - the highest rate at which a potentially renewable resource can be used indefinitely without reducing its available supply

Environmental degradation - when the rate at which you are using a resource exceeds the rate at which it can be replaced

Non-renewable Resources - resources that exist in a fixed quantity in the earth's crust can be completely used up on the human time scale (fossil fuels, minerals)

Economically depleted resource - a resource becomes economically depleted when the cost of exploiting what is left exceeds the economic value

- reuse, recycle, waste less, use less, develop a substitute or do without recycling

- collecting and reprocessing resource into a new products reuse

- using a resource over and over in the same form reserves

- known deposits from which a useable mineral can be profitably extracted at current prices

Pollution - any addition to air, water, soil, or food that threatens the health, survival or activities of humans or other living organisms Enter the environment through natural (volcanic eruption) or human activities (burning coal)

Point sources - pollutants that come from single identifiable sources

Nonpoint sources - pollutants that come from dispersed, difficult to identify, sources

What types of harm are caused by pollutants?

Three factors determine how severe the harmful effects of pollution are:

1. Chemical Nature - how active and harmful it is to living organisms

2. Concentration - the amount per unit of volume

3. Persistence - how long it stays in the air, water, soil or body

What can we do about pollution?

Two basic approaches to dealing with pollution:

1. Prevention
2. Clean up

Three major problems with clean-up:

1. Temporary
2. Usually transfers a pollutant another location
3. Too costly - currently 99% of government spending goes to clean-up and only 1% to prevention

Environmental And Resource Problems: Causes and Concentrations

Causes of Environmental Problems:

- rapid population growth

- rapid and wasteful use of resources

- simplification and degradation of the earth's life-support systems

- poverty causes people to use potentially renewable resources unsustainable for short-term survival

- economic and political systems fail to encourage "earth friendly" forms of development

- economic and political systems fail to have market prices of goods reflect overall environmental costs

- our urge to dominate nature and manage it for our own use before knowing about how nature works

Environmental Impact (I) - depends on three factors:

1. The number of people (population size, P)

2. The average number of units of resource each person uses (per capita consumption or affluence, A)

3. The amount of environmental degradation and pollution produced for each unit of resource used (destructiveness of the technologies used to provide and consume resources, T)

P x A x T = I (environmental impact)

Cultural Changes and Sustainability

What major Human Cultural Changes have taken place?

Age of our solar system - 4.6 billion years

Humans have been on Earth for 60,000 years

The Evolution of People:

Hunters and Gatherers

- until about 12,000 years ago we moved as needed to find food for survival

- survived through expert knowledge of their natural surroundings

- had only three energy sources:

  1. the sun
  2. fire
  3. their own muscle power

- advanced hunter-gatherers had a greater impact on their environment than the earlier hunter-gatherers who were much more Earth friendly

- attempted to live sustainably through low resource use per person and working with nature in small groups

The Agricultural Revolution (Neolithic Revolution):

- began 10,000 to 12,000 years ago

- involved a gradual transition from nomadic hunting lifestyle to a lifestyle based on a centered community where people domesticated wild animals and plants

- initially involved subsistence farming (growing only enough to feed your individual family)

- impact on the environment included:

- use of domesticated animals to have increased energy

- more reliable food source led to increase in birth rates

- large areas were cleared and irrigation systems were built

- people began accumulating material goods

- farmers could grow more then just enough for their families

- urbanization became practical and prevalent

- the survival of plants and animals once vital to humanity became less important

- human population began working to tame and manage nature rather then working with nature to survive

The Industrial Revolution

- began 275 years ago (~1870s)- production, commerce, trade, and distribution of goods expanded rapidly

- shifted dependence from renewable resources to non-renewable resources

- new machines were then created and large-scale production became prevalent

- more food and supplies became available so the population began to grow rapidly

Information Revolution

- current cultural shift

- new technologies are enabling people to deal with more information more rapidly

- the impact of this on the environment is not yet clear

- positively: we are finding out new information on how to respond to environmental problems more effectively

- negatively: there is so much information that we are being faced with that the small useful amount may be overlooked

Is our present course sustainable?

Two opposing views:

1. The world is not overpopulated. People are the most valuable resource. Technological advances will allow us to clean up pollution, find substitutes

for resources and continue to expand the Earth's ability to support more humans as it has done in the past.

2. Environmentalists feel we are depleting and degrading Earth's natural capital at an accelerating rate, faster rates and over larger areas than ever before in the history of our existence, and we are causing Earth great harm that is not fixable on a human time scale.

Environmental Worldviews and Sustainability

Environmental worldviews - how people think the world works, what they think their role in the world should be, and what they see as right and wrong environmental behavior

The basic planetary management beliefs of the world:

1. We are Earth's most important species, and we are in charge of the rest of nature

2. There is always more

3. All economic growth is good, more economic growth is better, and the potential for economic growth is essentially limitless.

4. Our success depends on how well we can understand, control, and manage the earth's life-support systems for our benefit

The basic earth-wisdom worldview beliefs of the world:

1. Nature exists for all of Earth's species, not just for people

2. There is not always more

3. Some forms of economic growth are environmentally beneficial and should be encouraged, but some are environmentally harmful and should be discouraged

4. Our success depends on learning to cooperate with one another and with the rest of nature to learn how to work with the earth

The key to creating a sustainable society:

Earth Wisdom - learning as much as we can about how Earth sustains itself and adapts to ever-changing environmental conditions and integrating such lessons from nature into the ways we think and act

Critical Thinking: Science, Models and Systems

Science, Technology, and Environmental Science

Science is a pursuit of knowledge about how the world works, an attempt to discover order in nature and use that knowledge to make predictions.

Scientific data (or facts) are used to make observations and solve problems.

Experiment - a procedure a scientist uses (in lab or in nature) to study some phenomenon.

Reproducibility is important in science to detect errors in experimentation.

Scientific Hypothesis (a testable statement) is a possible explanation for a particular observation

A **model** is an approximate representation or simulation of a system being studied and may be used to test a hypothesis.

> Mental - perceive the world, control their bodies and think about things
>
> Conceptual - describe the general relationships among components of a system
>
> Graphic - compile and display data in meaningful patterns (map)
>
> Physical - try out designs and ideas (scale models of airplanes, buildings)
>
> Mathematical - consist of one or more mathematical equations to describe the behavior of a system (rule of 70).

Data is subject to review by other scientists and usually falls into this pattern:

observe---> hypothesize---> argue---> test---> hypothesize---> argue---> test

A **scientific theory** is an idea, principle, or model that usually ties together and explains many facts that previously appeared to be unrelated and is supported by a great deal of evidence. (Big Bang Theory, John Dalton-Atomic Theory of Matter- all matter is made up of small particles called atoms that cannot be destroyed, created, or subdivided by physical and chemical changes.)

A **scientific law** is a description of what we find happening in nature over and over in the same way, without known exception. (Law of Gravity, the Law of Conservation of Matter states that we can change matter from one physical or chemical form to another, but no matter is created or destroyed by such processes).

Accuracy is the extent to which a measurement agrees with the accepted or correct value for that quantity.

Precision is a measure of reproducibility, or how closely a series of measurements of the same quantity agree with one another.

Controlled experiment - to test a hypothesis.

An experiment consists of two groups:

experimental group, in which the variable is changed in a known way

control group, in which the variable is not changed

Double blind experiment in which a group of patients is given a placebo, and a new drug is tested on another group.

Scientists cannot prove a hypothesis to be true in all cases. They can only prove it to be false under specific conditions.

Types of reasoning

Inductive - uses observations and facts to arrive at generalizations or hypotheses.

Deductive - uses logic to arrive at a specific conclusion based on a generalization or premise. From general to specific.

Frontier Science is controversial because it has not been widely tested and accepted.

Consensus Science consists of data, theories, and laws that are widely accepted by scientists considered experts in the field involved.

Technology is the creation of new products and processes intended to improve our efficiency, chances for survival, comfort level, and quality of life.

Environmental Science is the study of how we and other species interact with one another and with the nonliving environment (matter and energy).

Physical and social science

A study of connections and interactions

Often involves arguments over the validity of data

Limitations: most environmental problems involve so many variables and such complex interactions that we don't have enough information or sufficiently sophisticated models to aid in understanding them very well.

Systems and System Models

System - is a set of components that function and interact in some regular and theoretically predictable manner. A system has

structure - consists of components or parts that fit together to make a whole, and

function - what the system does. (e.g., circulatory system)

Models are used as approximate representations or simulations of real systems to find out which ideas or hypotheses work.

Mathematical models require three steps:

Make a guess and write down some equations,

Compute the predictions implied by the equations, and

Compare the predictions with observations, the predictions of mental models, existing experimental data, and scientific hypotheses, laws, and theories.

Mathematical models are important because they can give us improved perceptions and predictions, especially concerning matters for which our mental models are weak.

Some Basic Components and Behaviors of System Models

Any system being studied has one or more inputs (such as matter, energy or information). Inputs accumulate in the environment, such as population. Inputs flow through a system at a certain rate. Such flows or throughputs of matter, energy, or information through a system are represented using arrows. Anything flowing out of a system is called an output.

A **feedback loop** occurs when one change produces some other change, which reinforces or slows the original change. They occur when an output of matter, energy or information is fed back into the system as input.

Positive feedback loop is a runaway cycle in which a change in a certain direction provides information that causes a system to change further in the same direction.

Negative feedback loop occurs when one change leads to a lessening of that change.

Homeostasis - the maintenance of favorable internal conditions despite fluctuations in external conditions. Homeostatic systems consist of one or more negative feedback loops that help maintain constant internal conditions when changes occur.

Most systems contain one or a series of coupled positive and negative feedback loops. The idea that life on earth helps sustain its own environment is a modified version of the Gaia hypothesis, proposed in the early 1970s by James Lovelock and Lynn Margulis.

Some Behaviors of Complex Systems

Complex systems often show time delays between the input of a stimulus and the response to it. A long delay can mean that the corrective action comes too late. (e.g., smoker who quits but already has lung cancer)

Synergistic reactions occur when two or more processes interact so that the combined effect is greater than the sum of their separate effects. Synergy amplifies the action of positive feedback loops and thus can amplify a change we believe is favorable. Can also bring about harmful changes.

Some systems are now appearing to be random, chaotic, and unpredictable. This behavior of systems comes from within the system itself, and is said to be generating chaos.

Matter and Energy Resources: Types and Concepts

Matter: Forms, Structure, and Quality

Matter- anything that has mass and takes up space

2 chemical forms:

1. elements - distinctive building blocks of matter that make up every substance

2. compounds - two or more different elements held together in fixed proportions by attractive forces (chemical bonds)

mixtures - various elements, compounds, or both

atoms - smallest unit of matter that's unique to a particular element "ultimate building blocks for matter"

ions - electrically charged atoms or combinations of atoms [monatomic (Na^+, Mg^{+2}) or polyatomic (CO_3^{-2}, PO_4^{-3})]

molecules - combinations of two or more atoms of the same of different elements held together by covalent bonds (O_2, CO_2, CH_4). Neutral charge.

Three physical states of matter:

solid
liquid
gas

Atoms are made of subatomic particles:

protons - positively charged; located in the nucleus

neutrons - neutral/no charge; located in the nucleus

electrons - negatively charged, found in electron clouds

atomic number - number of protons in the nucleus (tells the number of electrons as well) mass number - total number of neutrons and protons in the nucleus

isotopes - various forms of an element with the same atomic number but different mass numbers

periodic table - classification of elements according to chemical behavior

period - horizontal row

group/family - vertical column

metals - usually conduct heat and electricity, strong

nonmetals - don't conduct heat and electricity very well, and usually aren't shiny

metalloids - mixture of metallic and nonmetallic properties

nutrients - required for all or some forms of life chemical formula- shorthand way to show the number of atoms (or ions) in the basic structural unit of a compound. e.g., H_2O, NaCl, $C_6H_{12}O_6$

ionic compounds- compounds made of oppositely charged ions (ionic bonds- strong forces of attraction between opposite charges)

covalent (molecular) compounds- compounds of molecules of uncharged atoms

e.g., H_2O (covalent bonds-atoms share 1 or more pairs of electrons) usually gases or liquids

hydrogen bonds - forces of attraction between molecules

organic compounds - contain carbon atoms combined with each other and with atoms of 1 or more other elements, such as: H, O, N, S, P, Cl, F

-molecular compounds held together by covalent bonds (almost all)

-polymers - larger and more complex organic compounds, consist of a number of basic structural or molecular units (monomers), linked by chemical bonds

1. **complex carbs** - made by linking a number of simple carb. Molecules

e.g., Complex starches in rice and potatoes

2. **proteins** - produced in living cells by linking different sequences of about 20 different monomers (amino-acids) whose number and sequence in each protein are specified by genetic code found in DNA molecules in an organism's cells.

essential amino acids - the 10 amino acids that must be obtained from food can act as enzymes to control the rate at which chemical reactions take place in a cell.

3. nucleic acids made by linking hundreds to thousands of five different types of monomers (nucleotides- have 1 phosphate group, 1 sugar molecule, 5 carbon atoms [deoxyribose in DNA and ribose in RNA], and 1 of 4 nucleotide bases [A, G, C, T])

DNA -instructions for new cells and proteins for each cell

RNA - instructions for proteins within cells

Genes - specific sequences of nucleotides in DNA molecules; approx. 75,000 in each cell -carries codes required to make various proteins

-gene mutations - changes of the nucleotide bases in a gene sequence

-chromosomes - combinations of genes that make up a single DNA molecule together with a number of proteins; human cell- 46 chromosomes

lipids - biologically important molecules, not polymers, include molecules of fat, oils, waxes phospholipids, and various substances

-serve as energy storage molecules, regulators of certain cellular functions, nutrients, and water proof coverings around cells

inorganic compounds - all other compounds; ex. ionic and covalent

Earth’s crust - outermost layer, made of inorganic materials and rocks

-mineral - element or inorganic compound that occurs naturally, is solid; usually has crystalline internal structure made of 3-d arrangement of atoms or ions.

-rock - any material that makes up a large, natural, continuous part of the earth's crust; must contain at least 2 minerals

matter quality - measurement of how useful a matter resource is; availability and concentration

high-quality matter-organized, concentrated, and usually found near the earth's surface; has great potential for use as a matter resource

low-quality matter- disorganized, dilute, and often deep underground or dispersed in the ocean or atmosphere; has little potential as a matter resource

entropy - measurement of disorder or randomness of a system.

high disorder = high entropy

3-2 Energy: Forms and Quality

energy- capacity to do work and transfer heat

-many forms: light, heat, electricity; chemical, mechanical, nuclear energy

-**kinetic** - energy that matter has b/c of its mass and speed (velocity)

~ energy in action or motion

~ wind, flowing water, falling rocks, electricity

~ electromagnetic radiation- consists of wide band (spectrum) of electromagnetic waves that differ in wavelength and energy content

e.g., radio waves, TV waves

~ heat - total kinetic energy of all moving atoms, ions, molecules with a given substance; excluding the motion of the whole object

~ temperature - measurement of the average speed of motion of an atom, ion, molecule in a sample of matter at a given moment

-**potential energy** - stored energy that's potentially available for use

~ rock, dynamite, still water behind dam

~ can be changed to kinetic energy

energy quality - measurement of energy source's ability to do useful work:

high energy quality - organized or concentrated and can perform much useful work

e.g., electricity, coal, gas

low energy quality - disorganized, dispersed and has little ability to do useful work

e.g., heat in atoms

3-3 Physical and Chemical Changes and the Law of Conservation of Matter

physical change- involves no change in chemical composition - ex. cutting, changing states

chemical change (reaction)- chemical compositions are altered -chemical equation: reactants ------> products

$$C + O_2 \text{------>} CO_2 + \text{energy}$$

Law of Conservation of Matter

- we may change elements and compounds from one physical of chemical form to another, but we cannot create or destroy the atoms involved

- nothing is "consumed" or "thrown away"

3-4 Nuclear Changes

Law of Conservation of Matter and Energy- In any nuclear change, the total amount of matter and energy involved remains the same nuclear changes- nuclei of certain isotopes spontaneously change or are made to change into one or more different isotopes; 3 types:

1. **natural radioactive decay**- nuclear change in which unstable isotopes (radioisotopes) spontaneously emit fast-moving particles, high-energy radiation, or both at a fixed rate, continues until isotopes are stable and not radioactive

-**gamma rays**- most common; form of high energy radiation

-2 types of high speed ionic particles:

1. **alpha** - fast-moving, positively charged chunks of matter with 2 protons and 2 neutrons (helium nuclei)

2. **beta** - high-speed electrons

half-life - time needed for half of the nuclei in radioisotopes to decay and emit their radiation to form different isotopes

radiocarbon dating - using carbon-14 to estimate ages of fossils, etc.

tracers - used in pollution detection, agriculture, industry

nuclear medicine - uses radioisotopes for diagnosis and treatment

2. **nuclear fission** - nuclear change in which the nuclei of certain isotopes with large mass numbers are split into lighter nuclei when struck by neutrons

-each fission releases 2 or 3 neutrons and energy

-4 multiple fissions, enough critical mass must be present

-forms chain reaction - releases huge amounts of energy

3. **nuclear fusion** - nuclear change in which 2 isotopes of light elements are forced together at extremely high temperatures until the fuse to form a heavier nucleus and release energy

- uncontrolled nuclear fusion - used to develop extremely powerful thermonuclear weapons

3-5 The Two Ironclad Laws of Energy

1st Law of Thermodynamics

In all physical and chemical changes, energy is neither created nor destroyed, but may be converted from one form to another.

Energy input = energy output

2nd Law of Thermodynamics

When energy is changed from one form to another, some of the useful energy is always degraded to low quality, more dispersed, less useful energy

-can never recycle or reuse high quality energy to perform useful work

-all forms of life are tiny pockets of order (low entropy) maintained by creating a sea of disorder (high entropy) in their environment.

3-6 Connections: Matter and Energy Laws and Environmental Problems

high-waste or high-throughput societies - attempt to sustain ever-increasing economic growth by increasing throughput of matter and energy resources in the economic system; will eventually become unsustainable

matter recycling society - allow economic growth to continue without depleting matter resources or producing excess pollution and environmental degradation; will but some time

low-waste society - recycling and reusing discarded matter, preventing pollution, conserving matter and energy resources; reducing

Ecology, Ecosystems and Food Webs

What is Ecology? Is the study of relationships between organisms and their environment

Organism – any form of life

Species – groups of organisms that resemble one another in appearance, behavior, chemistry and genetic endowment.

Wild and domesticate species

Population – a group of interacting individuals of the same species that occupy a specific area at the same time

Community – populations of different species occupying a particular place at the same time

Ecosystem – a community of different species interacting with one another and with the nonliving environment of matter and energy

Earth's Life-Support systems

Major parts of the Earth – Core, mantle, crust

Lithosphere – Earth's crust and upper mantle

Atmosphere – troposphere, stratosphere, mesosphere, thermosphere

Hydrosphere – Earth's liquid water, ice and water vapor

Geosphere –

Biosphere – all living organisms (plant and animal)

What sustains life on Earth?

The one-way flow of high-quality (usable) energy from the Sun

The cycling of matter and nutrients through parts of the ecosphere

Gravity – allows Earth to hold onto its atmosphere and causes the downward movement of chemicals in the matter cycles.

Open and closed systems:

Open: flow of energy and matter in and out of the system

Closed: only flow of energy into and out of the system. No flow of matter

Sun: Nuclear fusion

How the Sun helps sustain life on Earth

Supplies energy for photosynthesis

How the Nutrient Cycles Sustain Life

Nutrient – any atom, ion or molecule an organism needs to live, grow or reproduce

Macronutrients – nutrients needed in large amounts

Micronutrients – nutrients needed in small or trace amounts.

Natural Greenhouse Effect: greenhouse gases are water, carbon dioxide, methane, nitrous oxide and ozone.

4-3 Ecosystems:

land: Biomes (determined largely by the climate) - see Video: BIOMES

water: Aquatic Life Zones

ECOTONES - Boundaries of an ecosystem

Components of an Ecosystem:

Abiotic - nonliving (water, air, nutrients, solar energy)

Biotic - living - (plants and animals)

Range of Tolerance (Tolerance limits) The Law of tolerance: The existence, abundance and distribution of a species in an ecosystem are determined by whether the levels of one or more physical or chemical fact ors fall within the range of tolerance by that species.

Limiting Factor principle. Too much or too little of any abiotic factor can limit or prevent growth of a population, even if all other factors are at or near the optimum of tolerance.

Major Living components of an ecosystem

Producers (autotrophs)

photosynthesis

chemosynthesis

Consumers

Herbivores - plant eaters, primarily feed on producers

Carnivores – meat eaters -

secondary - feed only on primary consumers (herbivores)

tertiary - feed only on other carnivores

Omnivores - eat plants and animals

Other consumers:

scavengers:

Detritivores

Decomposers

Respiration

Aerobic

Anaerobic

Food Webs and Energy Flow in Ecosystems

Food Chain: high quality energy (sunlight) is converted to nutrients by photosynthesis. This energy is passed on to consumers and eventually decomposers. Low quality heat is emitted into the environment

Trophic Level: feeding level
- producers
- 1st trophic level - primary consumers
- 2nd trophic level - secondary consumers
- 3rd trophic level - etc.

Food Web is interconnected food chains (v. complex)
1. grazing food webs
2. detrital food webs

Biomass

Ecological Efficiency - the percentage of energy transferred from one trophic level to another.

a 10% efficiency means that 90% of the energy is lost.

Pyramids of Energy Flow - illustrate energy loss in a food chain help explain how the Earth can support more people if people would eat more grains, vegetables, etc., and not eat consumers of those grains (steer, deer, etc.)

Top level carnivores (eagles, hawks, tigers, sharks) are few in number and are the first to suffer when the ecosystems are disrupted. - making them especially vulnerable to extinction.

Storage of biomass at various trophic levels can be represented by a pyramid of biomass.

Pyramid of Numbers -

Gross Primary Productivity (GPP) - the rate at which an ecosystem's producers convert solar energy into chemical energy as biomass

Net Primary Productivity (NPP) - biomass that is left after producers use some for their own use.

How do Ecologists learn about Ecosystems?

Field Research
Lab Research
Systems Analysis
Systems Measurement -
Data Analysis -
Systems Modeling -
Systems Simulation -
Systems Optimization -

Ecosystem Services and Sustainability

Why is Biodiversity such an important ecosystem service?

Biodiversity the many forms of life the conditions

Genetic diversity – variability in the genetic makeup among individuals in a single species

Ecological diversity – the variety of biological communities that interact with one another and with their abiotic environment

The two Basic Principles of Ecosystem Sustainability

1. By using renewable solar energy as their energy source
2. by recycling reasonably efficiently the nutrients its organisms need for survival, growth and reproduction

These two processes are common to all ecosystems

Nutrient Cycles and Soils

Matter Cycling in Ecosystems

What are Nutrient (biogeochemical) Cycles?

Processes by which nutrients are recycled between living organisms and the nonliving environment.

The three general types of nutrient cycles:

Hydrologic Cycle – the Water Cycle; Water is recycled through nature driven by the Sun's energy and gravity. The major steps include evaporation, precipitation, condensation, runoff, permeation, infiltration, transpiration.

Atmospheric Cycle – A large portion of the element exists in a gaseous form (N_2, CO_2); These cycles operate, locally, regionally and globally.

Sedimentary Cycle – The element does not have a gaseous form or gaseous compounds making up a significant portion of its supply.

The Water Cycle

Role of Water - terrestrial: major factor that determines types of organisms that can live there: rain forests and deserts.

Aquatic ecosystems: water flow influences temperature, salinity, and availability of nutrients.

How is water cycled in the Ecosphere?

Driven by the Sun's energy and gravity

evaporation – conversion of water into water vapor

transpiration – evaporation from leaves of plants

condensation – conversion of water vapor into liquid water droplets

precipitation – rain, sleet, hail, snow

infiltration – movement of water into the soil

percolation – downward flow of water through the soil and permeable rock formations to groundwater storage areas call aquifers.

Runoff – downslope surface movement of water back to the sea.

Humidity - the amount of water in the air - depends on the temperature of the air.

Absolute humidity (g/kg) – amount of water vapor in a certain mass of air.

Relative humidity (%) – amount of water vapor in a certain mass of air expressed as a percentage of the maximum amount it can hold.

Precipitation - requires the presence of condensation nuclei (volcanic ash, smoke, sea salts, any particulate matter)

Dew Point - the temperature at which condensation will occur; i.e., the temperature at which the air would be saturated.

Aquifer – water-laden rock (porous)

Aquitard – impermeable rock

Water Table – upper layer of the zone of saturation

Zone of Aeration – soil that is not saturated with water.

Circulation rate - underground water (300-4600 yrs), lakes (13 years), streams (13 days), atmosphere (9 days), ocean (37,000 yrs) and glaciers (16,000 yrs).

Many natural processes act to purify the water (a natural distillation/filtration processes).

How people affect the water cycle:

We withdraw large quantities of fresh water from lakes, rivers, groundwater, …

We clear vegetation from land for agriculture and other uses (increasing runoff and reducing infiltration)

We modify water quality by adding nutrients (phosphates) and other pollutants

The Carbon Cycle

Carbon - the currency of energy exchange (energy is stored in chemical bonds); it is the basic building block of all organic chemicals including carbohydrates, fats, proteins, nucleic acids (DNA and RNA)

The flow of energy follows the flow of carbon (temp. is proportional to the conc. of CO_2)

See pp.114-115 (Miller, 11th edition; R&B, p. 106) for conceptual model of the carbon cycle.

Average residence time: atmosphere (3 yrs), soils (25-30 yrs), oceans (1500 yrs).

How people affect the carbon cycle:

forest and brush removal - less vegetation to remove CO2 through photosynthesis

burning fossil fuels

The Nitrogen Cycle

Role of nitrogen: used by organisms to make vital organic compounds: amino acids, proteins, DNA and RNA.

Nitrogen is usually in short supply and limits the rate of primary production.

Nitrogen (N_2) cannot be absorbed and used directly by plants or animals.

most complex of the nutrient cycles.

Nitrogen fixation - bacteria convert N_2 into NH_3 [$N_2 + 3\ H_2 \longrightarrow 2\ NH_3$]; cyanobacteria in soil and water and by the Rhizobium bacteria living in small nodules on the roots of legumes (soybeans, alfalfa, and clover).

Nitrification - NH_3 is converted to NO_2^- (nitrite, toxic to plants) and then to NO_3^- (nitrate, readily used by plants).

Assimilation - roots absorb NH_3, NH_4^+ and nitrate to make the nitrogen containing compounds.

Ammonification - specialized decomposed bacteria convert the nitrogen rich organic compounds (waste, etc.) into simpler nitrogen containing inorganic compounds (NH_3 and NH_4^+).

Denitrification - bacteria convert NH_3 and NH_4^+ back into nitrite and nitrate and then into N_2 and nitrous oxide (N_2O). The N_2O is released into the atmosphere and the process starts all over again.

See p. 117, Miller (11^{th}) or R&B p.107 for a schematic diagram of the nitrogen cycle.

How people affect the Nitrogen Cycle:

We react nitrogen with hydrogen to make ammonia (the Haber Process)-revolutionizing agriculture.

We emit large quantities of NO when we burn fuel. The NO is produced when nitrogen and oxygen molecules combine at high temperatures:
$N2 + O2 \longrightarrow 2\ NO$ The NO produces HNO_3 (acid rain) and creates ozone (O_3) and photochemical smog.

We emit heat-trapping nitrous oxide (N_2O) into the atmosphere through the action of anaerobic bacteria on livestock waste

We remove nitrogen from the earth's crust when we mine nitrogen-containing mineral deposits for fertilizers.

We remove nitrogen from topsoil when we burn grasslands and clear forests.

We add excess nitrogen compounds to aquatic systems in agricultural runoff, discharge of municipal sewage and deposition of nitrogen compounds from the atmosphere.

We add excess nitrogen compounds to terrestrial ecosystems through atmospheric deposition involving HNO_3 and NO_2.

The Phosphorus Cycle

Phosphorus is an essential nutrient for plants and animals (as PO_4^{3-} and HPO_4^{2-})

How is Phosphorus Cycled in the Ecosphere?

Water, crust and in living organisms.

In Sedimentary Cycle: phosphate deposits on land and forms shallow ocean deposits to living organisms and then back to the land and ocean. Phosphorus is found as phosphate salts in rock and is released by weathering of the rock, is dissolved in soil water and taken up by plant roots.

Phosphorus and its compounds are not gaseous, so P is not circulated in the atmosphere.

Phosphorus cycle is very slow.

Most soils are low in phosphorus, so P is the limiting factor for plant growth (so fertilizer is needed).

How people affect the Phosphorus Cycle (3):

we mine large quantities of phosphate rock for fertilizers and detergents

cutting down the rain forests reduces available Phosphate. In rain forests, all phosphate is found in the plants and animals, not the soil. P is washed away when forests are cut and burned.

we add excessive phosphate to aquatic ecosystems in runoff of animal wastes from livestock feedlots, runoff of commercial fertilizers

The Sulfur Cycle

Sulfur is a component of most proteins and some vitamins.

Sulfur enters the atmosphere from several natural sources. H_2S from active volcanoes and breakdown of organic matter in swamps, bogs, tidal flats.

SO_2 (from volcanoes)

SO_4^{2-} (sulfate) salts from sea spray.

How people affect the Sulfur Cycle:

burning sulfur-containing coal and oil to produce electricity

refining petroleum

using smelting to convert sulfur compounds of metallic minerals into free metals (Cu, Pb, Zn),

other industrial processes.

Rock Cycle - How rocks change over time

Slowest of all Earth's cycles

Three types of rocks:

- Igneous
- Sedimentary
- Metamorphic

Soil - mixture of eroded rock, minerals, organic matter, water, air, living organisms (decomposers) - very slow to renew

Soil Horizons

O – organic matter; leaf litter

A - topsoil

B - subsoil

C - parent material

Soil Profiles

Soil Texture

Clay = silt = sand = gravel --- Relative amounts determine texture of the soil; Soil triangle

porosity - volume of the pores

permeability - determined by the average size of the pores in the soil

See soil triangle in text (Miller, p.128)

Soil texture, porosity and permeability determine a soil's 1) water-holding capacity, 2) aeration or oxygen content, and 3) workability. (ease of cultivation)

Soil acidity (pH) - influences the uptake of nutrients

Nutrient Cycling

Rainfall - can erode soil, dissolve soil nutrients

Wind - can blow away topsoil and deposits nutrients elsewhere

Nutrients lost from one ecosystem must enter another ecosystem

Evolution and Biodiversity: Origins, Niches and Adaptation

Why should we care about the alligators?

The alligator:

is North America's largest reptile

has no natural predators (except man)

Ecological role of the alligator

digs depressions that collect fresh water (serving as refuges for aquatic life and supplies fresh water and food for many animals).

Alligator nesting mounds provide nesting and feeding sites for species of herons and egrets.

Keystone species: its important ecological roles in helping to maintain the structure function and sustainability of its natural ecosystem.

The subject of this chapter is understanding evolution, the evolutionary origins of biodiversity, and the ecological roles of species.

Major Types of Life on Earth:

The Earth's biodiversity: the many types of life on this planet.

All forms of life consist of one or more cells. Each cell consists of two types of components:

genes - containing DNA - determines the form the cell will take and its functions

other parts which protect the cell and carry out instructions encoded in the cell's DNA.

Based on cell structure cells are classified as either:

eukaryotic - cells surrounded by a membrane and have a nucleus and other internal parts

prokaryotic - surrounded by a membrane - no distinct nucleus or other internal parts enclosed by membranes. Bacteria are a good example of this.

Taxonomic Classification (classification of organisms based on common characteristics)

Kingdom

Monera - microorganisms; (bacteria and cyanobacteria) single-celled, prokaryotic; decomposers; a few bacteria cause disease in humans (Streptococcus; Salmonella); billions of beneficial bacteria in the human body (aid in digestion; crowd out disease-causing bacteria)

Protists (protista) - microorganisms; single-celled, eukaryotic; (diatoms; dinoflagellates, amoebas, golden brown and yellow-green algae, and protozoans); some protists cause human disease (malaria, sleeping sickness, Chagas' disease).

Fungi- microorganisms; many-celled, eukaryotic; (mushrooms, molds, mildews, yeasts); many are decomposers; some fungi kill plants and cause huge losses of crops and valuable trees.

Plants (plantae) - many-celled, eukaryotic; (red, brown and green algae; mosses, ferns, conifers, and flowering plants). Annuals: complete life cycles in one growing season. Perennials: can live for more than two years (roses, grapes, elms, magnolias).

Animals (animalia) - many celled eukaryotic;

Invertebrates - no backbones (sponges, jellyfish, worms, arthropods (insects), shrimp, spiders), mollusks (snails, clams, octopuses) and echinoderms (sea urchins and sea stars).

Vertebrates - animals with backbones and a brain protected by skull bones. fishes (sharks and tuna), amphibians (frogs and salamanders), reptiles (crocodiles and snakes), birds (eagles and robins) and mammals (bats, elephants, whales and humans).

Nomenclature (how species are named):

Each kingdom is subdivided into subcategories based on anatomical, physiological and behavioral characteristics:

Kingdom

Phylum

Subphylum

Class

Order

Family

Genus (pl. genera)

Species

Species

Scientific nomenclature: consists of two words (italicized):

Word 1: genus, capitalized: Word 2: species

e.g., robin: Turdus migratorius

grizzly bear: Ursus horribilis

Species - a distinct type of organism

If members of two populations that reproduce sexually have the potential to interbreed with one another and produce live fertile offspring, they belong to the same species. i.e., each sexually reproducing species is reproductively isolated from every other species in nature.

Species that do not fit this definition (because of limitations) must be identified by their appearance, biochemical traits and DNA sequences.

ORIGINS OF LIFE

Life on earth evolved in two (2) phases:

1. chemical evolution of the organic molecules, biopolymers, and systems of chemical reactions needed to form the first protocells (lasted approx. 1 billion years).

2. biological evolution of single-celled organisms (first prokaryotes and then eukaryotes) and then multi-cellular organisms (approx. 3.7-3.8 billion years).

Chemical Evolution (p.139)

4.6-4.7 billion years ago: cosmic dust cloud condensed to form Earth (heated from meteorite impact and radioactive decay (interior)). As the Earth cooled, a hardened crust formed (no atmosphere and no water).

4.4 billion years ago - atmosphere was formed (initially CO_2, N_2, H_2O, with trace amounts of CH_4, NH_3, H_2S and HCl. No oxygen (O_2) since it is very reactive chemically.

Energy from lightning, heat from volcanoes and UV light and other solar radiation was available. Russian biochemist Alexander Oparin proposed that the inorganic chemicals in the primitive atmosphere along with these energy sources lead to the formation of the first organic molecules. Such compounds have been formed in the laboratory.

Other hypotheses include organic molecules coming from meteors/comets, or forming near hydrothermal vents (black smokers).

Organic molecules then accumulated and underwent countless reactions in warm shallow waters. Different combinations of molecules may have formed membrane-bound protocells.

Biological Evolution (p.140)

Protocells evolved into single-celled prokaryotes having the properties we describe as life.

These single celled bacteria multiplied and underwent mutations resulting in new prokaryotic cells. Since there was no ozone layer, life could not have existed on land (intense UV from Sun).

2.3-2.5 billion years ago, evolution of photosynthetic prokaryotes: cyanobacteria removed CO_2 from water and combined it with water to form carbohydrates - releasing oxygen into the atmosphere. O_2 began increasing in the atmosphere about 2.0-2.1 billion years ago.

The Oxygen Revolution lasted about 500 million years. More complex organisms formed.

1.2 billion years ago: the first eukaryotic cells formed. Since they reproduce sexually, they produced offspring with different genetic characteristics. These changes eventually produced an amazing variety of protists, fungi, and plants and animals.

As oxygen accumulated in the atmosphere, it reacted with solar radiation to form ozone (lower stratosphere)

400-500 million years ago: first plants on land. Then mammals, then man.

How do we know what organisms lived in the past?

Fossils - however, only about 1% of species have been found.

Chemical and radioactive dating of fossils.

EVOLUTION AND ADAPTATION

Evolution: the change in a population's genetic makeup through successive generations. Individuals do not evolve, only populations.

Microevolution - describes the small genetic changes that occur in a population

Macroevolution - describes the long-term, large-scale evolutionary changes among groups of species: new species are formed from ancestral species; other species are lost through extinction.

How Microevolution Works

Driven by genetic variability

Gene pool - the sum total of all genes possessed by the individuals of the population

microevolution - a change in a population's gene pool over time.

alleles - two or more forms of a particular gene

Microevolution works through a combination of four processes:

1. Mutation - only changes in reproductive cells are passed on to offspring

    random and unpredictable
    the only source of totally new genetic material
    very rare events

2. Natural Selection - three conditions necessary for evolution by natural selection to occur

    natural variability

    heritable trait

    differential reproduction

Adaptive trait

Selective pressure

Three types of natural selection (3):

    directional natural selection
    stabilizing natural selection
    diversifying natural selection

3. Gene Flow

4. Genetic Drift

Coevolution - interaction between species can result in microevolution in each of their populations

Ecological Niche - the species' way of life or functional role in an ecosystem; involves everything that affects its survival and reproduction and includes:

the range of tolerance

the types of resources it uses

how it interacts with other living and nonliving components of the ecosystem

the role it plays in the flow of energy and cycling matter

Habitat - the physical location where a species lives.

Speciation, Extinction and Biodiversity

Macroevolution - concerned with how evolution takes place above the level of species and over a much longer period of time.

Macroevolutionary patterns include:

genetic persistence

genetic divergence

genetic losses (background extinction or mass extinction)

Speciation - formation of a new species (two species arise form one)

Geographic isolation - separation -

Reproductive isolation

How do species become extinct?

When environmental conditions change, a species may cease to exist if it cannot adapt.

Several major factors affecting speciation:

large-scale movements of the continents

gradual climate changes

rapid climate changes (catastrophic events)

Background extinction - disappearance of a species at a low gradual rate.

Mass extinction - abrupt rise in extinction rate above the background level

catastrophic and worldwide where large numbers of species are eliminated.

Adaptive radiation - period of recovery following mass extinctions

There are two theories about how rapidly macroevolution occurs:

gradualist model of evolution

punctuated equilibrium hypothesis

The actual rate of evolution is probably a wide spectrum of time frames from one extreme to the other.

Speciation - Extinction = Biodiversity

People are a major force in the premature extinction of species

We have had five major extinctions with the last being 65 million years ago (at the end of the mesozoic era). The sixth mass extinction is caused by humans.

Can the Earth be Healed?

Prevention is the best approach

Description Time to Recover
Ecosystems damaged by air and water pollution decades
Desertification century
Tropical Rain Forest loss 1,000 years
loss of plant / animal species millions of years

Geographical Ecology, Climate & Biomes

Weather - the short term properties of the troposphere at a given place and time - is very changeable:

Climate - the average long-term weather of an area.

averaged over a long time - at least 30 years.

determined by two main factors: temperature and precipitation

masses of air are constantly moving

Weather Front: the boundary between two fronts

warm front - boundary between an advancing warm air mass and the cool air mass it replaces

high wispy clouds; release moisture as rainfall.

days of cloudy skies and drizzle

cold front - boundary between an advancing cold air mass and the warm air mass it replaces.

the advancing cold air stays close to the ground (more dense)

produces rapidly moving towering clouds (thunderheads)

high surface winds and thunderstorms

after the front, cooler temperatures and clear skies

Weather Extremes:

tornadoes - form over land
tropical cyclones - form over ocean waters
hurricanes - in the Atlantic
typhoons - in the Pacific

Computer models predicts the weather for several days by calculating the probabilities that air masses, winds and other factors will move and change in certain ways.

How does Global Circulation of Air Affect Regional Climates?

The two most important factors determining a region's climate: average temperature and average precipitation

Factors that determine global air circulation patterns

1. Uneven heating of the earth's surface

    air is hot at the equator and cold at the poles, and temperate in between

2. Seasonal changes occur because the axis is tilted

    This tilt causes the seasonal changes as the earth revolves around the sun

    creates opposite seasons in the northern and southern hemispheres

3. The earth rotates on its axis

    prevents air currents from moving due north and south from the equator

    forces caused by this rotation cause winds to be deflected to the right (northern hemisphere) or the left (southern hemisphere)

    Coriolis Effect - results in the formation of six huge convection cells

4. Long-term variations in the amount of solar energy striking the earth

    these variations are the result of occasional changes in solar output, slight planetary shifts: earth wobble (22,000-year cycle) and tilt (44,000-year cycle) and minute changes in the shape of the Earth's orbit (100,000-year cycle)

5. Properties of air and water

    ocean water heated by the sun evaporates, removing heat from the oceans.

moist hot air rises, expands, becomes less dense (area of low pressure)

rising hot air cools and releases moisture as condensation (cold air hold less water than hot air)

when vapor condenses (precipitation), heat is released (radiating into space)

cooler denser air sinks (area of high pressure)

air mass flows across the surface picking up heat and moisture

How do Ocean Currents Affect Regional Climates?

In addition to the factors we just mentioned concerning global circulation, other factors include warm and cold ocean currents. Ocean currents are driven by the wind and the earth's rotation redistributes heat received from the sun.

Ocean currents redistribute heat - therefore, influence climate and vegetation (esp. near coastal areas)

Gulf Stream

Upwelling of cold, nutrient rich bottom water

> bring nutrients from the deeper parts of the ocean to the surface to support phytoplankton, zooplankton, fish and fish-eating birds

El Nino - Southern Oscillation (ENSO)

> can trigger extreme weather changes over 2/3 of the globe (esp. along the Pacific and Indian Oceans)

How Does the Chemical Makeup of the Atmosphere Lead to the Greenhouse Effect?

Greenhouse gases: carbon dioxide, water vapor, ozone, methane, nitrous oxide and chlorofluorocarbons

Visible light, infrared and some UV from sun pass through the troposphere

Earth's surface absorbs this energy and degrades it to longer wavelength infrared.

Some of this IR escapes into space; some is absorbed by molecules of the greenhouse (warming the air)

Some radiates back to the earth's surface.

Amount of heat trapped depends primarily on the concentration of the greenhouse gases and the length of time they stay in the atmosphere.

Water vapor - 1-5%
Carbon dioxide: 0.036%

How Does the Chemical Makeup of the Atmosphere Lead to the Ozone Layer?

In stratosphere 17-26 km (11-16 miles): $3\ O_2 + UV = 2\ O_3$

Ozone concentration is 10 ppm

Ozone layer blocks out almost all UV-A (highest energy UV); one-half of UV-B and only a small part of UV-C

Ozone layer prevents at least 95% of sun's harmful rays, creates warm layers of air (thermal cap) that prevents the churning air masses of the troposphere from entering the stratosphere and determines the earth's average temperature and the earth's current climates.

How Do Topography and Other Features of the Earth's Surface Modify Climate to Form Microclimates?

Microclimates - differ from the general climate of the region

Mountains - interrupt the flow of air masses

Rain shadow effect

Vegetation- takes up and releases water, affects wind near the ground and casts shadows.

Cities - bricks, concrete, asphalt etc. absorb heat and buildings block wind flow.

Motor vehicles generate heat and pollutants; haze, smog, higher temperatures

Biomes, Climate and Life on Land

Why Are There Different Organisms in Different Places?

Climate determines the nature of the land surface - determined by average temperature and precipitation

Biome - a terrestrial region with characteristic types of natural, undisturbed ecological communities adapted to the climate of the region.

For plants, precipitation is generally the limiting factor that determines whether a land area is desert, grassland or forest.

Biomes blend into one another - ecotones - transitional zones; are not uniform

Climate and biomes vary with latitude and altitude

Why Do Plant Sizes, Forms, and Survival Strategies Differ?

Plant communities in different biomes have distinct physical appearances depending on the types, sizes and forms of their plant species - determined largely by climate and soil type. Size and form of a plant species tend to represent adaptations for gathering sunlight for photosynthesis and for maintaining the optimum temperature in a particular environment.

e.g., Plants exposed to cold air year round or during winter have traits that keep them from losing too much heat and water. Desert plants must be able to lose heat so they don't overheat and die. They must also conserve water (ability to store water, and synthesize food)

Trees of wet tropical rain forests tend to be broadleaf evergreen plants

In cold dry winters, broadleaf deciduous trees shed leaves and go dormant to conserve heat and water.

Coniferous evergreen plants: leaf shape slow down heat loss and evaporation. leaves that are kept in winter enable photosynthesis to occur during brief summer periods.

Desert Biomes

Evaporation exceeds precipitation (less than 25 cm/year)

30% or earth's land surface

situated mainly between tropical and subtropical regions north and south of the equator (± 30^o)

Different average temperatures create tropical, temperate and cold deserts

Tropical Deserts – Sahara Desert

Temperate Deserts

Cold Deserts – Gobi Desert

Semidesert

How do Plants and Animals Survive?

"Beat the Heat" and "Every drop of water counts"

What Impacts Do Humans Have on Desert Ecosystems?

Grassland, Tundra and Chaparral Biomes

Forest Biomes

Mountain Biomes

New Perspectives on Geological Ecology

Rather than concentrating on the minute details of each biome, learn the trends as one progresses from one biome to the next. Refer to the diagrams handed out in class:

Aquatic Ecology

Coral Reefs: the aquatic equivalent of the tropical rain forests

The two major aquatic life zones are determined by salinity:

saltwater or marine (estuaries, coastlines, coral reefs, coastal marshes, mangrove swamps, ocean over the continental shelf, deep ocean)

freshwater (lakes, ponds, streams, rivers, inland wetlands)

Aquatic Life Zone Organisms

plankton - weak swimming, free-floating

phytoplankton - photosynthetic cyanobacteria, algae; producers

nanoplankton - recently discovered

zooplankton - nonphotosynthetic primary consumers (herbivores); feed on phytoplankton or secondary consumers that feed on other zooplankton.

nekton - strong swimming consumers (fish, turtles, whales)

benthos - bottom dwelling creatures (barnacles, oysters, worms, lobsters)

decomposers (bacteria) - break down organic compounds into simple nutrients.

Unique Properties of Water - How they affect aquatic life.

buoyancy - provides physical support

limited fluctuation in temperature - reduces risk of freezing or overheating

nutrients - are soluble and readily available

potentially toxic material - is diluted and dispersed

Factors that limit aquatic life at different depths (surface, middle and bottom layers)

temperature - little fluctuation; organisms have limited ability to withstand temperature fluctions.

access to sunlight - can penetrate onto to a depth of 100 feet; confined to upper layer - euphotic zone

dissolved oxygen content - enters from the atmosphere & photosynthesis; removed by aerobic respiration; can vary widely; [O_2] and [CO_2] vary with depth due to differences in rates of photosynthesis and respiration.

availability of nutrients (CO_2, NO_3^- and PO_4^{3-}) - NO_3^- (nitrate) and PO_4^{3-} (phosphate) are sufficient in shallow waters; but in short supply in open ocean;

PO_4^{3-} is most limiting nutrient in freshwater ecosystems.

NO_3^- is the most limiting nutrient in saltwater ecosystems

Saltwater Life Zones

Oceans

- 71% of earth's surface
- currents distribute solar heat
- regulate the earth's climate
- participate in nutrient cycles
- reservoir for carbon dioxide - thus help regulate temperature of the troposphere
- 250,000 known species of marine plants and animals
- disperse and dilute human produced wastes

two major life zones in the oceans:

coastal zone - 10% of ocean area; 90% of all marine species; warm nutrient rich shallow water extending from high tide mark to edge of continental shelf

open sea - 90% of ocean area

Estuaries and Tidal Ecosystems

Estuary - partially enclosed area of coastal water; seawater mixes with freshwater from rivers, streams and runoff from land; an ecotone; constant water movement stirs up nutrients in silt; highly variable salinity and temperature;

Coastal Wetlands

Areas of coastal land covered all or part of the year by salt water.

breeding grounds and habitats for waterfowl and other wildlife

popular recreational areas (boating, hunting, fishing

maintain quality of coastal waters by diluting, filtering and settling out sediments, excess nutrients and pollutants.

protect lives and property during floods

buffer against damage and erosion during storms

constitute only 3% of wetland area in the US. (97% is inland wetlands)

In temperate area (US): bays, lagoons, salt flats, salt marshes

grasses - dominant vegetation

serve as nurseries and habitats for shrimp and other animals

Mangrove Swamps

along tropical coasts where there is too much silt for coral reefs to grow

dominated by salt-tolerant trees or shrubs (mangroves) protect coastline from erosion and reduce damage from typhoons and hurricanes

trap sediment washed off the land

provide breeding, nursery and feeding grounds for 2000 species of fish, invertebrates and plants

Rocky and Sandy Shores

Intertidal Zone - shoreline area between high and low tides

stressful area for organisms; must cope with waves, being left high and dry; changing levels of salinity (high and low)

most organisms hold on to something, dig in or hide in protective shells

Rocky Shores

Barrier Beaches/Sandy Shores

organisms burrow into the sand

sand dunes on barrier beaches - first line of defense against the ravages of the sea

Barrier Islands

long, thin, low offshore islands of sediment running parallel to the shore

protect the mainland by dispersing the energy of approaching storm waves

constantly shifting beaches: built up by gentle waves; flattened and eroded by storms

longshore currents (run parallel to the shore)

Coral Reefs

form in clear, warm coastal waters of the tropics and subtropics

among the most biologically diverse life zones

ecologically complex interactions among the organisms that live there.

Human Impacts on Coastal Zones

Coastal development - two-thirds of world's population lives within 100 miles of a coast

55% of estuaries and wetlands in US destroyed by dredging, filling and waste contamination

Coastal ecosystems are vulnerable to toxic contamination because they trap pesticides, heavy metals and other pollutants (concentrating them to high levels).

37% of coastal shellfish beds are closed to fishing due to contamination from sewage treatment plants, septic tank systems and urban runoff

10% of coral reefs are dead; 30% in critical condition; 30% are threatened; 30% are stable.

Beach Erosion

most methods intended to reduce beach erosion have failed

solutions are temporary at best - see p.197)

solutions usually cause more damage than they prevent

Open Sea

Divided into three zones based on sunlight penetration:

Euphotic - where photosynthesis occurs; low nutrient levels; high DO levels; 90% of ocean surface; 10% of world's commercial fishing

Bathyal - dimly lit; no photosynthesis

Abyssal - dark; very cold; v. little DO; high nutrient level on ocean floor

deposit feeders - take mud into their gut and extract nutrients

filter feeders - pass water over their bodies and extract nutrients

primary and net productivity is low in the open sea - except for the occasional equatorial upwelling

Freshwater Life Zones

Dissolved salt concentration is <1% by volume; about 1% of Earth's surface water; 41 % of world's known fish species

Lentic - standing bodies of water - lakes, ponds and inland wetlands

Lotic - flowing bodies of water - streams and rivers

Aquatic Life Zones in Freshwater Lakes

Lakes - depression caused by glaciation, crustal displacement and volcanic activity

ZONES - defined by 1) depth and 2) distance from shore

Littoral Zone - shallow area near shore to a depth at which rooted plants stop growing

abundant sunlight and nutrients

most productive zone in a lake

high biodiversity

large numbers of decomposers

Limnetic Zone - the open sunlit water surface layer away from the shore

extends to depth penetrated by sun

contains varying amounts of phytoplankton, zooplankton and fish; depending on available nutrients

Profundal Zone - deep open water; too dark for photosynthesis

cooler darker water

Benthic Zone - bottom of the lake; inhabited mostly by decomposers, detritus feeding clams, wormlike insect larvae, catfish

How Plant Nutrients Affect Lakes

Lakes are classified according to their nutrient content and primary productivity

Oligotrophic Lake - poorly nourished

newly formed lakes

small supply of nutrients

low productivity

crystal clear blue or green; small populations of phytoplankton and fish (small mouth bass and trout)

Eutrophic Lake - well nourished

older lakes; shallow

sediment for plants to grow;

large or excessive supply of nutrients (nitrates and phophates)

murky brown/green with poor visibility

high primary productivity

contain large populations of phytoplankton, many zooplankton and diverse populations of fish (bass, sunfish and perch)

Mesotrophic Lakes - most lakes fall somewhere between the two extremes of oligotrophic and eutrophic

Seasonal Changes in Temperate Lakes

When ice freezes, it floats on liquid water (which is more dense)

If lakes froze from the bottom up, fish and other organisms would be pushed up and die in winter.

Thermal stratification of deep lakes in northern climates. - resist mixing because (in summer) warmer less dense water is on top.

Epiliminon - upper layer of warm water with high levels of DO

Hypoliminon - lower layer of colder, denser water with low level of DO (not exposed to atmosphere)

Thermocline - middle layer where water temperature changes rapidly with increased depth;

- acts as a barrier to the transfer of nutrients and DO

Fall overturn -

Spring overturn -

Freshwater Streams and Rivers

Surface Water - Precipitation that doesn't sink into the ground or evaporate -

Runoff - when surface water flows into streams and eventually the ocean

Watershed / drainage basin - the land area which delivers water, sediment and dissolved substances via streams to a larger stream or river and ultimately to the sea

Flow of surface water occurs in three zones:

Source Zone - headwater or mountain highland streams of cold clear water; waterfalls and rapids

high DO; coldwater fish (trout) which need lots of DO

Transition Zone - wider deeper streams flowing down gentler slopes with fewer obstacles

warmer water; supports more producers with slightly lower oxygen requirements

Flood Plain Zone - wider and deeper rivers that meander across broad

Freshwater Inland Wetlands

Lands covered with fresh water all or part of the time and located away from coastal areas

> include marshes, prairie potholes, swamps, mud flats, floodplains, bogs, wet meadows, wet arctic tundra

Seasonal wetlands - covered only part of the year

> provide food and habitats for fish, migratory waterfowl, and other wildlife
>
> improve water quality by filtering, diluting and degrading toxic wastes, excess nutrients, sediments and other pollutants.
>
> floodplain wetlands near rivers reduce flooding and erosion by absorbing stormwater and releasing it slowly; absorb overflows from streams and lakes.

help replenish groundwater supplies

play significant roles in the global carbon, nitrogen, sulfur and water cycles

provide recreation (waterfowl hunting)

grow crops (blueberries, cranberries and rice)

Human Impacts on Inland Wetlands

They are drained, dredged, filled in or covered over.

As a result of agriculture, mining, forestry, oil and gas extraction, highways, urban development

Only 8% of remaining inland wetlands are under federal protection

Mitigation Banking - wetlands can be destroyed if equal areas of the same type of wetland are created or restored; Most attempts are ineffective.

Sustainability of Aquatic Ecosystems

Seasonal stratification of temperate freshwater lakes demonstrates how different resources are limiting in different places

Corals Reefs - most biologically diverse of the aquatic zones (tropical rain forests)

Estuaries - most productive aquatic zones

Open ocean - most expansive and least productive (the desert)

Aquatic ecosystems are connected to everything upstream; and accumulate both direct abuses and indirect abuses from human activities.

Each stream, river and lake reflects the sum of all that occurs in the watersheds above.

Aquatic ecosystems are constantly being renewed and water is purified by natural hydrologic processes.

Community Processes: Species Interactions and Succession

The Ecological Niche

Each species has an ecological niche - the role it plays in an ecosystem; its lifestyle or way of life.

The Niche is the range of conditions and resources within which the organism can live.

Habitat - the actual physical location where a species lives.

Conditions - physical or chemical attributes of the environment.

Resources - substances that can be consumed by an organism.

n-dimensional hypervolume - many conditions and resources influence the maintenance, growth and reproduction of an organism. we can't describe all the conditions and resources that influence an organism, but we can determine the most important ones.

Fundamental Niche - the full potential range of conditions and resources it could theoretically use if there were no competition from other species. A niche of a species overlaps with those of other species.

Realized Niche - that part of a fundamental niche that an organism occupies.

Why is it important to understand the niches of species?

scientific curiosity

so we can work to prevent it from becoming prematurely extinct

assessing the human impact on changes in terrestrial and aquatic systems.

Generalist vs. Specialist (classification according to their niches)

Generalists: have broad niches. They can live in many different places, eat a variety of foods, and tolerate a wide range of environmental conditions. (humans, mice, rats, raccoons, etc.)

Specialists: have narrow niches. Live in one type of habitat, a narrow range of climatic and other environmental conditions, and eat only one or two types of food. (This makes them more prone to becoming endangered or extinct.

Specialists have an advantage when environmental conditions are fairly constant. When environmental conditions change, generalists are better off.

Some General Types of Species

Native species - species that normally live and thrive in a particular ecosystem

Non-native, exotic or alien species - species that migrate into an ecosystem or are deliberately or accidentally introduced into an ecosystem by humans. - Wild African bees,

Indicator species - species that serve as early warnings that a community or an ecosystem is being damaged. Birds are excellent biological indicators because they are found almost everywhere and respond very quickly to environmental change.. The presence or absence of trout species in water at temperatures within their range of tolerance is an indicator of water quality because trout require clean water and high levels of dissolved oxygen (DO).

Keystone species - species whose roles in an ecosystem are much more important than their abundance or biomass would suggest. They play pivotal roles in the structure, function, and integrity of an ecosystem because they are critically linked to a large number of other species. The dung beetle, sea otters, gopher tortoises, American alligator, elephants and rhinoceroses, beavers, wolves, leopards, lions, giant anteaters, great white shark, giant armadillo.

Species Interactions: Competition and Predation

Members of species may be harmed by, benefit from, or be unaffected by the interaction.

Interspecific competition - (competition between species) - occurs when two or more species compete for food, space or other limited resource. this competition can harm the competing species to varying degrees

Predation - one species (predator) feeds directly on all or part of a living organism or another species (the prey). The predator benefits; the prey is clearly harmed. The prey may or may not die from the interaction.

Symbiosis - a long-lasting relationship in which species live together in an intimate association. There are three types of symbiosis:

Parasitism - One species (the parasite) feeds on part of another organism (the host). The parasite benefits; the host is harmed.

Mutualism - two species interact; both benefit from the relationship.

Commensalism - one species benefits; the other species is neither harmed or benefits.

Symbiotic relationships help regulate the populations of species and can help them survive changes in environmental conditions.

How do species compete with one another?

Interspecific competition results when parts of the fundamental niches of different species overlap. The more the niches overlap, the more they compete with one another.

One of the species must:

migrate to another area

shift its feeding habits

suffer a sharp population decline

become extinct in that area

Species compete in two ways:

Interference competition - one species limits another's access to some resource, regardless of its abundance. Members establish a territory and defend it against other invading species

Exploitation competition - competing species have equal access to a specific resource but differ in how fast or how efficiently they exploit it.

What is the Principle of Competitive Exclusion?

Two species that require the same resource cannot coexist indefinitely in an ecosystem in which there is not enough of that resource to meet the needs of both species. "one-niche, one-species, one-place principle" - e.g., the paramecium study.

How have some species reduced or avoided competition?

1. Resource Partitioning - the dividing up of available resources (hawks feed during day, owls at night.).

2. Character displacement - species develop physical or behavioral characteristics or adaptations that allow them to use different resources.

How Do Predator and Prey Species Interact?

Predators feed on prey, but they do not live in or on the prey.

This is a positive feedback system for the predator limited by the negative feedback when the prey population falls below a certain minimum level.

Prey organisms may or may not be killed by their predators. Predation can benefit the prey by eliminating the sick, weak and aged members.

How do predators increase their chances of getting a meal?

1. pursuit - run fast to catch their prey; have keen eyesight; hunt in packs; humans have invented tools (weapons and traps).

2. ambush - camouflage helps conceal them while they lay in hiding waiting for their prey.

How do prey defend themselves against predators?

1. run, swim or fly fast; keen sight or sense of smell to alert them to the presence of predators; protective shells; thick bark; spines; thorns; camouflage to hide from predators

2. Chemical warfare - chemicals that are poisonous, irritating, foul smelling, bad tasting

3. Warning coloration so predators know that this animal is bad tasting

4. Mimicry - species take on the appearance or another animal that may be very poisonous.

Symbiotic Species Interactions: Parasitism, Mutualism and Commensalism.

Parasitism - a form of predation; the parasite is usually smaller than its host prey; remains closely associated with its host and rarely kills its host.

Parasitoids - parasites that routinely kill their hosts as part of their life cycle (used by farmers to control pest species.

endoparasites - live inside their hosts

ectoparasites - live outside their hosts (often move from one host to another)

Parasites play important ecological roles.

Mutualism - both species benefit from the relationship; each species benefits by exploiting the other.

e.g., pollination relationship between flowering plants and insects

Nutritional mutualism - lichens: photosynthetic algae and chlorophyll-lacking fungi. The fungi and algae cannot live apart. This is called obligatory mutualism.

Nutritional and protection mutualism -

Mutualism is more common when resources are scarce.

Commensalism - one species benefits; the other species is neither helped nor harmed significantly.

Redwood sorrel benefits from growing in the shade of tall redwood trees

relationship between some trees and plants called epiphytes

Ecosystem Structure and Ecological Succession

Ecosystem structure is described in terms of four characteristics

1. physical appearance

2. niche structure

3. species diversity or richness

4. species abundance

How do Ecosystems Respond to Change?

Structures of ecosystems change in response to changing environmental conditions.

Ecological Succession - the gradual and fairly predictable change in species composition of a given area. Some species colonize and flourish, while others decline and even disappear.

Primary Succession - the gradual establishment of biotic communities in an area that has not been occupied by life before.

Secondary Succession - the reestablishment of a biotic community in an area where a biotic community was previously present.

Primary Succession - starts with a lifeless area (no soil)

Pioneer species - lichens and mosses

Early successional plant species - grow close to the ground; help break up rock and make more soil.

Midsuccessional plant species - herbs, grasses and low shrubs;

Late successional plant species. - trees;

Secondary Succession begins in an area where the natural community has been disturbed, removed or destroyed, but the soil or sediment remains. (abandoned farmlands, burned or cut forests, heavily polluted streams, etc.)

How do species replace one another in ecological succession?

facilitation - species behave in such a way that facilitates the growing/survival of other species - e.g., legumes convert nitrogen to nitrates thus making the soil more suitable for other plants.

inhibition - early species hinder the establishment and growth of other species

tolerance - late successional plants are largely unaffected by plants at earlier stages of succession.

What is the role of Disturbance in Ecological Succession?

A disturbance is a discrete event in time the disrupts an ecosystem or community

Natural disturbance - fires, hurricanes, earthquakes, droughts, floods, ...; play an important role in ecosystems. The immediate effect is to change conditions and release resources.

Intermediate disturbance hypothesis - communities that experience fairly frequent, moderate disturbances have the greatest diversity of species.

The Role of Fire in Succession.

How do Agriculture and Plantation Forestry Relate to Succession?

How Predictable is Succession?

Ecological Stability and Sustainability

What is Stability?

Stability of an ecosystem is maintained only by constant dynamic change in response to changing environmental conditions.

Inertia (or persistence) - the ability of a living system to resist being disturbed or altered.

Constancy - the ability of a living system to maintain a certain size or keep its numbers within the limits imposed by available resources.

Resilience - the ability of a living system to bounce back after an external disturbance that is not too drastic.

The signs of ill health in a stressed ecosystem include

a drop in primary productivity

increased nutrient losses

decline or extinction of indicator species

Increased populations of insect pests or disease organisms

decline in species diversity

the present of contaminants

Does Species Diversity Increase Ecosystem Stability?

An ecosystem with a diversity of species and feeding paths has more ways to respond to most environmental stresses; but there may be many exceptions to this rule.

Ecosystems with more species tend to have higher net primary productivities than simpler ecosystems.

Grasslands: much less diverse than forests and they have low inertia; have high resilience and recover quickly.

What determines the Number of Species in an Ecosystem?

Two main factors are: size and degree of isolation

Species Equilibrium Model or Theory of Island Biogeography (MacArthur and Wilson)

the number of species found on an island is determined by a balance between two factors: the immigration rate of species to the island from other inhabited areas, and the extinction rate of species established on the island. At some point these two rates should be equal and a stable ecosystem should result.

Immigration and extinction rates are affected by two important variables: the size of the island and the distance from a mainland source of immigrant species (see figures on p.232)

Human-caused disturbances - deforestation, overgrazing, plowing

Population Dynamics,
Carrying Capacity, and Conservation Biology

Major Characteristics of a Population

Population Dynamics: Populations are dynamic: changing in size, density dispersion and age distribution - in response to environmental conditions.

Population Size - the number of individuals in a population at a given time.

Population Density - the number of individuals of a population in a certain space at a given time.

Population Dispersion - the spatial pattern in which the members of a population are found in their habitat.

Dispersion Patterns for individuals in a population

Clumping

Uniformly dispersed

Randomly dispersed

Age Structure - the proportion of individuals in each age group in a population.

prereproductive

reproductive

postreproductive

A population with a large percentage of its individuals in the prereproductive and reproductive categories has a high potential for growth.

Population Dynamics and Carrying Capacity

Four variables that govern population size :

births

deaths

immigration

emigration

Population change = [births + immigrations] - [deaths + emigration]

or

Population change = [births - deaths] + [immigrations - emigration]

ZPG = zero population growth: when number of individuals added to a population from births and immigrations equals the number of individuals lost due to deaths and emigration.

Population size is determined by the interplay between it biotic potential and environmental resistance.

Biotic Potential - capacity of a population for growth

Intrinsic rate of growth (r) - the rate at which a population could growth it had unlimited resources

High r - reproduce early in life, have short generation times, can reproduce many times and produce many offspring each time the reproduce

critical size - a minimum size a population should have to support a breeding population

There are always limits to population growth in nature.

Environmental Resistance - all the factors acting jointly to limit the growth of a population.

Carrying Capacity (K) - the number of individuals of a given species that can be sustained indefinitely in a given space; determined by biotic potential and environmental resistance.

Exponential Growth and Logistic Growth

Exponential Growth - a population that does not have resource limitations;

J-shaped exponential growth curve

Logistic Growth - involves exponential growth when a population is small and a steady decrease in growth in time as the population approaches the carrying capacity

S-shaped growth curve

When a population exceeds the Carrying Capacity.

Overshoot the carrying capacity due to a reproductive time lag - the time it takes for the birth rate to fall and the death rate to rise in response to resource overconsumption)

the population will dieback or crash (deer on the Aleutian Island, Alaska)

Carrying Capacity is determined by many factors:

competition

immigration

emigration

catastrophic events

seasonal fluctuations in food, water, hiding places, and nesting sites

How Does Population Density Affect Population Growth?

Density-independent population controls affect a pop. size regardless of its density. (floods, hurricanes, earthquakes, landslides, drought, fire, habitat destruction, pesticide spraying)

Density-dependent population controls have a greater effect on a pop. as the pop. size increases (competition for resources, predation, parasitism, disease). Dense populations have lower birth rates, higher death rates.

Infectious disease (bubonic plague).

Overcrowding causes hormonal changes that inhibit sexual activity, lower sexual activity, reduced milk production. Stress from overcrowding reduces the number of offspring produced (spontaneous abortion). May also lead to cannibalism and killing of the young.

Population Change Curves (Population Cycles)

Stable - pop. fluctuates slightly above and below its carrying capacity

Irruptive - pop. occasionally explodes (irrupts) to a high peak and then crashes to a v. low level. Caused by some factor that temporarily increases the carrying capacity.

Cyclic - boom-bust cycles; poorly understood and involve a number of factors.

Reproductive Strategies and Survival

r-Strategist Species - species with a high intrinsic rate of increase (r) - Many small and unprotected young

K-Strategist Species - reproduce late, have few offspring with long generation times;

have big bodies, live for a long time, spend little of their energy on reproduction

tend to do well in competitive conditions when pop. is near carrying capacity

prone to extinction

Survivorship Curves show the number of survivors of each age group for a particular species.

late loss

early loss

constant loss

Life table - a table showing the number of individuals at each age (used by insurance companies)

Conservation Biology

Deals with problems in maintaining the earth's biodiversity: its goals are to investigate human impacts on biodiversity and to develop practical approaches to maintaining biodiversity

Three Underlying Principles of Conservation Biology

1. Biodiversity and ecological integrity are useful and necessary to all life on earth and should not be reduced by human activity

2. Humans should not cause or hasten the premature extinction of populations and species

3. The best way to preserve biodiversity is to protect intact ecosystems that provide sufficient habitat for sustaining natural populations of species

Conservation Integrity - the conditions and natural processes (energy flow and matter cycling in ecosystems) that generate and maintain biodiversity and allow evolutionary change as a key mechanism for adapting to changes in environmental conditions.

It is better to maintain existing ecosystems than to have to rebuild ecosystems that have been damaged.

Conservation Biology seeks answers to the following:

1. What is the status of natural populations and which species are in danger of extinction?

2. What is the status of the integrity of ecosystems?

3. What measures can we take to ensure that we maintain habitat of the quality and size needed viable populations of wild species?

Habitat Fragmentation

The process by which human activity breaks natural ecosystems into small and smaller pieces of land called habitat fragments.

Corridors - Long areas of land that connect habitat that would otherwise become fragmented.

permit movement of migratory animals

ensure a diverse gene pool

one of the best solutions to the problem of habitat fragmentation.

Bioinformatics - useful information concerning biodiversity (computer databases)

HUMAN IMPACT ON ECOSYSTEMS

How Have Humans Modified Natural Ecosystems?

Fragmenting and degrading habitat

Simplifying natural ecosystems

Strengthening some populations of pest species and disease-causing bacteria by speeding up natural selection

Eliminating some predators

Deliberately or accidentally introducing new species

Overharvesting potentially renewable resources

Interfering with the normal chemical cycling and energy flows (throughputs) in ecosystems

What can we learn from nature about living sustainably

Most ecosystems use sunlight as their primary source of energy

Ecosystems replenish nutrients and dispose of wastes by recycling chemicals

Soil, water, air, plants and animals are renewed through natural processes

Energy is always required to produce or maintain an energy flow to recycle chemicals

Biodiversity takes various forms in different parts of the world.

Complex networks fo positive and negative feedback loops give organisms and populations information and control mechanisms of adapting to changing conditions

The population size and growth rate of all species are controlled by their interactions with other species and with their nonliving environment. There are always limits to population growth.

Organisms generally only use what they need to survive, stay healthy and reproduce.

Important Principles to guide us toward a more sustainable lifestyle:

We are part of the earth's dynamic web of life.

Our lives, lifestyles and economies are totally dependent on the sun and the earth

We can never do merely one thing (the first law of human ecology)

Everything is connected to everything else; we are all in it together.

Global CPR: conservation, preservation and restoration

SOLUTIONS: how can we rehabilitate and restore damaged ecosystems?

Prevention strategy - reduce and minimize the damage we do to nature

Restoration ecology - renew, repair or reconstruct damaged ecosystems

Natural restoration - an abandoned damaged ecosystem will eventually partially recover through secondary ecological succession

Rehabilitation - human intervention to make degraded land productive again through stopping soil erosion, etc.

Active Restoration - take a degraded site and reestablish a diverse, dynamic community of organisms consistent with the climate and soil of an area.

Human Population:
Growth, Demography, and Carrying Capacity

Factors Affecting Human Population Size

Pop. size is affected by birth rates, death rates, emigration and immigration

Population change = [births + immigrations] - [deaths + emigration]

Zero Population Growth (ZPG) - when births plus immigration equal deaths plus emigration

Crude Birth Rate (CBR) - number of live births per 1000 people in a pop. in a given year

Crude Death Rate (CDR) - number of deaths per 1000 people in a population in a given year

Rate of World's Population Change (%) =

= (Birth Rate - Death Rate)/1000 people x 100

= (Birth Rate - Death Rate)/10

China and India constitute 38% of world's population. U.S. - 4.6% of world's population.

Developing countries will constitute >95% of pop. growth between 1998 and 2025

Global Fertility Rates

There are two types of fertility rates

1. Replacement Level Fertility

This is the number of children a couple must bear to replace themselves.(2.1 in developed countries and 2.5 in developing countries). These numbers are greater than 2 because some female children die before reaching their reproductive years.

Population Momentum - The pop. increase resulting from a large number of people entering their childbearing years. Will continue even though future parents only have an average of 2.1 children.

2. Total Fertility Rate (TFR)

The most useful measure of fertility for projecting future population change. TFR is an estimate of the average number of children a woman will have during here childbearing years under current age-specific birth rates. In 1998, TFR was 2.9;(1.6 in developed countries; 3.3 in developing countries).

Highest TFR: Africa = 5.6 children per woman.

If the world's TFR remained at 2.9, the human pop. would reach 694 billion by the year 2150.

TFR = 2.3; World pop. = 8 billion (2025)

(See charts on p.257)

U.S. Fertility Rates

U.S. pop.: 76 million (1900); 270 million (1998)

TFR (US) has oscillated wildly (see p. 257)

US has highest fertility rate and highest immigration rate of any industrialized country. The rate of pop. growth has declined, but pop. is still growing faster than most developed countries. Pop. growth in 1998 was 1.17% (double the rate of other industrialized countries).

Growth added 3.1 million people; 1.8 million more births than deaths; 935,000 legal immigrants; 400,000 illegal immigrants.

Moderate Projection: US pop. of 383 million by 2050 (41% increase).

Less Conservative Projection: pop. = 507 million

***Because of the high per capita rate of resource use in the US, each addition to the US pop. has an enormous environmental impact.

In Pacific Northwest population growth is higher than that of India.

Reasons for Projected Growth:

1. Large number of baby-boom women still in child-bearing years

2. Increase in number of unmarried mothers (incl. teenagers)

3. Continued higher fertility rates for women in some racial and ethnic groups than for Caucasian women.

4. High levels of legal and illegal immigrants (43% of US pop. growth).

5. Inadequate family-planning services.

Case Study: Increasing Fertility Rates and Environmental Problems in California

What Factors Affect Birth and Fertility Rates?

1. Average level of education and affluence

2. Importance of children as part of the labor force

3. Urbanization

4. Cost of raising and educating children

5. Educational and employment opportunities for women

6. Infant mortality rate

7. Average age at marriage

8. Availability of private and public pension systems

9. Availability of legal abortions

10. Availability of reliable methods of birth control

11. Religious beliefs, traditions and cultural norms

What Factors Affect Death Rates?

Decline in the CDR (crude death rate) has led to the rapid incr. in world's pop. People started living longer:

"It's not that people stopped breeding like rabbits; it's just that they stopped dying like flies" (UN)

Two useful indicators of overall health in a country:

1. Life expectancy (the avg. number of years a newborn infant can expect to live)

    Life Expectancy: 75 years (developed countries); 63 years (developing countries)

    Globally, life expectancy = 48 years (1955), 66 years (1998), 73 years (2025, proj.)

2. Infant mortality rate (the number of babies out of every 1000 born each year that die within 1 year)

    Infant mortality is the single most important measure of a society's quality of life - because it reflects the general level of nutrition and health care.

    U.S. infant mortality rate = 7.0/1000 (1998); 32 other countries had lower rates;

    These rates are high because inadequate health care (poor women), drug addiction (among pregnant women) and high birth rate among teenage women.

    Babies born to teenage women are more likely to have low birth weights - the most important factor in infant deaths.

How is Migration Related to Environmental Degradation?

People voluntarily move from less affluent areas to more affluent areas both within countries and between countries.

1995 - 27 million international environmental refugees moved from one country to another because of drought, desertification, deforestation, soil erosion, and resource shortages. (23 million traditional refugees in 1995)

1988-1998: 50 million people left homeless by natural disasters (earthquakes, hurricanes, floods and landslides)

Most countries restrict immigration. Only a few accept large numbers of immigrants or refugees (U.S., Canada and Australia).

Population Age Structure

Age Structure Diagrams - show the proportion of the population at each age level. (see p. 260-1)

Three main age categories:

- prereproductive (ages 0-14)
- reproductive (15-44)
- postreproductive (45+)

How Does Age Structure Affect Population Growth?

A wide base (0-14 years) has a strong built-in momentum to increase pop.

1998: Half of world's women were in the reproductive age group;

World: 32% of people <15 years.

In developing countries: 35% <15 years;

Africa: 44% <15 years

How can Age Structure Diagrams be used to make population and economic projections?

Baby-Boom vs. Baby-Bust Generations (see fig. 11-15, p.263)

Any boom or bust in the age structure of a population can create social and economic changes that ripple through a society for decades. Competition for jobs; political clout; retirement benefits and needs.

What are some of the effects of population decline?

Gradual population decline: negative effects are manageable. Rapid pop. decline can lead to severe economic and social problems. A sharp rise in proportion of elderly will lead to a large share of medical care, social security and other costly social services. Labor shortages (unless you can utilize increase automation, immigration of foreign workers or both).

Case Study: The Graying of Japan.

1949: TFR = 4.5
1998: TFR = 1.4 (one of the world's lowest)

Declining workforce: encourage automation and women working outside the home.

Japan resists increasing immigration - fearing a breakdown in its social cohesiveness.

Solutions: Influencing Population Size.

U.S. Immigration - 1998 - 935,000 legal immigrants and refugees; 400,000 illegal immigrants (constituting 43% of pop. growth). 75% of legal immigrants live in CA, FL, IL, NY, NJ and TX.

Immigrants provide labor for jobs many Americans refuse to do.

Immigrants pay taxes

Immigrants increase the need for goods and services

Immigrants increase the need for social services (incl. schools)

Immigrants have children who are automatically US citizens (?)

What are the Pros and Cons about Reducing Births?

Can we provide enough food, energy, water, sanitation, education, health care, and housing for twice as many people if the world pop. continues to grow? Can we provide adequate standard of living for twice as many people without causing massive environmental damage? Some say the Earth is already overpopulated. Others say the Earth could support 20-48 million people if everyone existed at a minimal survival level (grain diet only, cultivate all arable land, mine the Earth's crust to a depth of 1 mile.

Computer Models

System dynamics computer modeling mimics the behavior of complex systems and makes projections. Use mathematical equations to represent interactions of key variables: feedback loops, time delays, synergistic interactions and other properties of complex systems.

Models are no better than the assumptions built into them and the accuracy of the data used.

They are very useful for evaluating possible implications of current trends and proposed changes in environmental and economic policies.

The Limits of Growth (1972) by Forrester et al.: projected economic and ecological collapse if pop. trends and resource use continued unchanged from 1970s.

Beyond the Limits: Confronting Global Collapse, Envisioning a Sustainable Future. Forrester et al.: updated their projections saying the world already overshot some limits. We face global economic and environmental collapse during the 21st century.

See Questions 1 and 2 on pp.269-70 as examples of the types of questions that can be addressed by computer modeling.

How Can Economic Development Help Reduce Births?

Demographic Transition (a hypothesis of population change): As countries become more industrialized, first their death rates and then their birth rates decline.

This Transition takes place in four stages:

1. pre-industrial stage - harsh living conditions, high infant mortality rates, high death rate; need a high birth rate .. pop. growth is small (or zero)

2. transitional stage - industrialization begins, rise in food production, improved health care, reduction in death rate, birth rate remains high .. pop. grows rapidly (2.5-3%/year)

3. industrial stage - industrialization is widespread. Birth rate drops and approaches the death rate. Better access to birth control, reduced infant mortality, incr. job opportunities for women, high cost of raising children, HS and college educations. Pop. grows but at a slower rate.

4. postindustrial stage - Birth rate declines further, equals death rate ==> ZPG. 37 countries (mostly western Europe, 12% of world's pop.) are in this stage.

Developing countries are still in the transitional stage. Pop. growth in many developing countries will still outstrip economic growth leading to a demographic trap (this is happening esp. in Africa).

A poor country with a pop. growth rate of 2.5% /year needs an economic growth rate of 5%/year to achieve the 2.5% per capita economic growth regarded as the minimum req'd t make the demographic transition. Developing countries do not have enough skilled workers to produce high-tech products. Many low- to middle-income countries lack the capital and resources for rapid economic development. The amount of economic assistance from developed countries has been on the decrease since 1980.

Family Planning

Family planning provides educational and clinical services to help couples choose how many children to have and when to have them.

600,000 women die from pregnancy-related causes each year

Modern contraception: 49% worldwide (1998) where China is 81%. 61% in developed countries.

Responsible for 40% of the drop in TFR in developing countries from 6 (1960) to 3.3 (1998).

Two major factors for this reduced TFR:

1. a six-fold increase in contraceptive use by married women in past 20 years.

2. couples seeking fewer benefits of large families

Moderate to poor results in the more populous developing countries of India, Egypt, Pakistan and Nigeria (and in 79 less populous developing countries - Africa, Latin America).

How can Economic Rewards and Penalties be used to Help Reduce Births?

Family planning alone cannot curb pop. growth enough in developing countries. Economic Rewards and Penalties are needed.

Penalties (China): higher taxes, other fees, elimination of tax deductions for a third child, lose health care benefits, food allotments and job options.

Economic rewards and penalties designed to lower birth rates work best if they encourage (rather than mandate) people to have fewer children, reinforce existing customs and trends toward smaller families, or increase a poor family's economic status.

A population out of control may be forced to use coercive methods to prevent mass starvation and hardship.

Empowering Women to Help Reduce Births

Education
Jobs outside the home
Societies where individual rights are not suppressed

Case Studies: India and China

Cutting Global Population Growth and Sustainability

We are exceeding the carrying capacity for humans in parts of the world and eventually for the entire world. Our goals should be to reduce the current rate of population growth in all countries and stabilize it.

Replacement-level fertility can be reached in 15-30 years. And the best way to achieve that goal is through family planning, reducing poverty and elevating the status of women. Devise government policies to minimize environmental impact of population growth in efforts to achieve sustainability.

How are Governments Planning to Reduce Population Growth?

1. Provide universal access to family planning services and reproductive health care.

2. Improve health care for infants, children and pregnant women

3. Encourage pop. policies as part of social and economic development policies

4. More equitable relationships between men and women.

5. Increase access to education, esp. for girls

6. Increase involvement of men in child-rearing responsibilities and family planning

7. Take steps to eradicate poverty

8. Reduce or eliminate unsustainable patterns of production and consumption

Food Resources

How is Food Produced?

What Plants and Animals Feed the World?

15 plant and 8 animal species supply 90% of our food

wheat, rice and corn provide ~50% of the calories people consume; all three are annuals

2/3 of the world's people live primarily on grains (rice, wheat and corn)

The Two Major Types of Food Production

1. Industrialized agriculture (high-input agriculture)

uses large amts. of fuel energy, water, commercial fertilizers & pesticides

Plantation agriculture (cash crops)

2. Traditional subsistence agriculture

Traditional intensive agriculture

The Green Revolution (1950-1970)

Increased yields per unit of area of cropland

Involves three steps

developing and planting monocultures of key crops

lavishing fertilizer, pesticides and water on crops to produce high yields

increasing the intensity and frequency of cropping

A second green revolution (1967+)

began when fast-growing dwarf varieties of rice and wheat were introduced into developing countries

Case Study: Food Production in the U.S.

Production doubled since 1940

Agribusiness -

Each US farmer feeds about 140 people

How Are Livestock Produced?

10% of the world's land is suitable for producing crops

20% is used for grazing cattle and sheep

Developed countries consume >50% of the world's grain

Poor developing countries eat mostly grain and live low on the food chain

Traditional Agriculture

Interplanting - simultaneously grow several crops on the same plot of land

Common interplanting strategies:

1. Polyvarietal cultivation
2. Intercropping
3. Agroforestry (alley cropping)
4. Polyculture

World Food Problems

1950-1990: amount of food traded in the world market quadrupled

population growth is outstripping food production

Factors leading to the slowdown in the growth of per capita grain production:

population growth

increasing affluence (incr. demand for food, esp. meat products)

degradation and loss of cropland

little growth in irrigation since 1980

10% decline in global fertilizer use between 1989-1997

How many people can the world support?

Earth's carrying capacity depend on:

quality of life (cultural carrying capacity)

whether future food production can be increased

the length of the food chain (grain eaters vs. meat eaters)

Undernutrition, Malnutrition and Overnutrition

1. Undernutrition

Chronically undernourished -

Seriously undernourished -

2. Malnutrition

Marasmus – a diet low in calories and protein

Kwashiorkor – severe protein deficiency

The number of chronically undernourished fell from 36% to 14% (1970-1995)

The number of chronically malnourished fell from 940 million to 840 million (1970-1995)

Vitamin and mineral deficiencies (iron and iodine)

3. Overnutrition

obesity, coronary heart disease, cancer, stroke, diabetes

Healthy Diet: largely vegetarian, 10% of calories from fat,

Can we produce enough food to feed the world's people?

goods news -

bad news -

The principal cause of hunger and malnutrition is poverty

Environmental Effects of Producing Food:

Soil erosion

desertification

salinization

waterlogging

water deficits

droughts

loss of wild species

Environmental constraints that limit food production:

Increased UV radiation form ozone-layer depletion

Projected global warming

Increasing World Food Production

The gene revolution - bioengineering

Food production: from exponential growth to logistic growth

monoculture vs. polyculture

Can we cultivate more land to increase crop production?

36% of the world's land is devoted to raising crops.

Clearing Rain Forests (?)

Desert areas (?)

A major economically profitable and environmentally sustainable expansion of cropland is unlikely over the next few decades.

Catching and Raising More Fish

Fisheries

Overfishing

Sustainable Yield

Commercial Extinction

Habitat Degradation

Destruction of wetlands, estuaries, coral reefs, salt marshes and mangroves; pollution of coastal areas

Aquaculture - "The Blue Revolution" - Two basic types:

Fish Farming

Fish Ranching

Advantages - efficient and high yields in a small volume of water

Problems: require large inputs of land, feed, water and energy; produce large outputs of wastes

Pesticide runoff

Agricultural Policy, Food Aid and Land Reform

1. Keep food prices artificially low

2. Give farmers subsidies to keep them in business, and encourage food production

3. Eliminate most or all price controls and subsidies

Sustainable Agriculture (low-input agriculture)

Guidelines for sustainable agriculture (p.305)

Water

Supply, Renewal and Use of Water Resources

Water -

97% by volume is found in the ocean (salt water)

3% is fresh water with 2.997% locked up in ice caps and glaciers

0.003% easily available as soil moisture, usable groundwater, water vapor, lakes and streams

Hydrologic Cycle

Canada - 20% of world's fresh water

China - 7% of world's fresh water

Surface Water

Surface Runoff - water that flows into streams, lakes, wetlands and reservoirs

Watershed (drainage basin) -a region from which water drains into a stream, lake, reservoir, or other body of water.

Groundwater

Zone of Saturation - below the surface where voids are filled with water

Water Table - the surface of the zone of saturation

Aquifer - porous sand, gravel or bedrock through which groundwater flows

Aquitard – nonporous rock

Recharge area - an area of land through which water passes downward or laterally into an aquifer

Natural recharge or lateral recharge

Water mining - removal of water from an aquifer that exceeds its replenishment

How do we use the world's fresh water?

65% - irrigate farm land (agriculture)

25% - energy production

10% - domestic and municipal use

Too Little Water
Causes of Freshwater Shortages

Dry climate

Drought

Desiccation

Water Stress

How Can Water Supplies be Increased?

Build dams and reservoirs

Bring in surface water from another area

Withdraw groundwater

Desalination

Improve the efficiency of water use

Dams

Capture and store water from rain and melting snow; then released as desired to produce elec. power, irrigate land, control flooding below the reservoir and provide water to towns

can reduce downstream flow to a trickle (Colorado River)

reduce biodiversity

Danube's Iron Gate dam

China's Three Gorges project (Yangtze River)

Malaysia's Bakun dam - would be the world's highest

Transferring water from one place to another

James Bay Watershed

Aral Sea Watershed

Salt Rain - salty dust picked up by rain

How they are dealing with this problem of the Aral Sea

1. charging farmers more for irrigation water
2. decreasing irrigation water quotas
3. introducing water-saving technology
4. dev. a regional integrated water management plan
5. planting protective forest belts
6. using underground water
7. improving health services
8. slowing the area's rapid population growth

Tapping groundwater and converting salt water to fresh water

Overuse of groundwater can cause:

aquifer depletion

aquifer subsidence

intrusion of salt water into aquifers

Ways to slow groundwater depletion include controlling population growth, not planting water-thirsty plants in dry areas and wasting less irrigation water

Desalination:

Distillation

Reverse Osmosis

Uses vast amount of electricity. Distribution of desalinated water is also costly

Process produces large quantities of brine (contains high levels of salt and minerals)

Cloud Seeding

Add chemicals to clouds to promote rain

Legal issues over the ownership of water in clouds
Tow massive icebergs to arid coastal areas.

Using Water More Efficiently

65-70% of water used throughout the world is wasted: evaporation, leaks, etc.

In U.S., artificially low water prices - government subsidies

Multiple water resource management responsibility

How can we waste less water in irrigation?

Line irrigation ditches (50-60% efficiency)

Use high efficiency center-pivot sprinkler system (70-80% efficiency)

LEPA - low energy precision application sprinklers (75-85% efficiency)

High-efficiency trickle or drip irrigation systems (80-90% efficiency)

Computer-controlled systems to monitor soil moisture and irrigate as needed.

Organic Farming - requires ~1/4 water of conventional farming.

How can we waste less water in industry, homes and businesses?

Recycle aluminum (97% less water)

Xeriscaping (use of dry climate vegetation) and drip irrigation for gardens and other vegetation

Eliminate leaks

Eliminate single rate billing systems (apartments and 1/5 of US public water systems)

Rebates for installing water-saving devices (showerheads, toilets)

"Negaliters" or "Negagallons" are savings in water used.

Salmon - anadromous (living in both fresh and salt water environments)

salmon ranching

To build up the salmon runs

build hatcheries upstream

transport young salmon around dams

makes streams off limits for hydropower

obliterate old logging roads to reduce runoff of silt

Too Much Water

Natural flooding

Floodplain

Humans contribute to flood deaths and damage by removing vegetation, living in the floodplains, through urbanization (highways, parking lots, etc.).

How can we reduce flooding risks?

1. Channelization (straightening and deepening streams)

    reduces upstream flooding, increases upstream bank erosion and downstream flooding and deposition of sediment

2. Building levees and dams

    increases water's capacity for doing damage downstream

    destruction happens downstream from each levee

    the levee race

    Flood control dam - the reservoir gradually fills up with sediment

    gives a false sense of security

3. Restoring wetlands

4. Instituting floodplain management

    The best approach from an environment viewpoint

"Sooner or later the river (or ocean) always wins"

A Sustainable Water Future

preserve the ecological integrity of water supply systems

waste less water

allow fair access to water

give people a say in how water resources are developed and used.

Three underlying forces that can lead humans to use water in an unsustainable way:

depletion or degradation of a shared resource

population growth

unequal distribution or access

A key to reducing water waste is for governments to phase out subsidies

Minerals and Soil Resources

Geologic Processes

Earth's Structure - three concentric zones

Core - solid inner core of iron and liquid outer core (iron) which gives the Earth its magnetic poles

Mantle – thick, solid zone consisting of iron, silicon, oxygen and magnesium. The outermost layer of the mantle is a thin plastic layer of partially molten rock - the asthenosphere

Crust - outermost and thinnest zone of the Earth

continental crust - 29%

oceanic crust - 71%

soil and mineral resources

Three types of rock (The Rock Cycle)

igneous

sedimentary

metamorphic

The source of virtually all nonrenewable resources:

fossil fuels

metallic minerals

nonmetallic minerals

The source of soil and the elements that make up all living organisms

Chemical makeup of the crust (%)

Element	Percent
Oxygen	46.65
Silicon	27.7
Aluminum	8.1
Iron	5.0
Calcium	3.6
Sodium	2.8
Potassium	2.6
Magnesium	2.1
All others	1.5

Plate Tectonics

Plates - major areas of the Earth's crust whose boundaries are determined by lines of earthquakes and volcanoes

Lithosphere - crust and the rigid outermost part of the mantle above the asthenosphere

The plates move constantly floating on the constantly-moving asthenosphere

Plate Tectonics is the theory that explains the movement of the plates and the processes that occur at their boundaries (developed from the continental drift concept).

Plate movement produces mountains, volcanoes, the oceanic ridge system, trenches and other earth features.

Helps explain how certain patterns of biological evolution occurred.

Three types of boundaries

Divergent Plate Boundary - plates move apart in opposite directions

Convergent Plate Boundary - plates are pushed together (subduction zone) forming a trench and causes earthquakes and volcanoes

Transform Fault - plates move in opposite but parallel directions (slide past each other)

Geologic Processes on the Earth's Surface

External processes - those geologic changes based directly or indirectly on energy from the sun and on gravity (rather than heat from the Earth's interior)

Internal Processes generally build up the Earth's surface, external processes tend to wear it down

Erosion - major external process: loosened material is dissolved, or worn away from one part of the Earth's surface and deposited in another

Weathering - mechanical or chemical

Streams - the most important agent of erosion

produce ordinary valleys and canyons; may form deltas when they flow into lakes and oceans

Wind Erosion -

Human activities can accelerate erosion:

activities that destroy vegetation (deforestation, ...)

Finding and Removing Nonrenewable Mineral Resources

Mineral Resources

A concentration of naturally occurring solid, liquid or gaseous material in or on the earth's crust that can be extracted and processed into useful materials at an affordable cost.

Energy resources - coal, oil, natural gas, uranium, geothermal energy

Metallic mineral resources - iron, copper, aluminum

Nonmetallic mineral resources - salt, gypsum, clay, sand, phosphates, water, soil

Ore - a metal-yielding material that can be economically extracted at a given time

Identified Resources - deposits that have known location, quantity and quality (or estimated from direct geological evidence)

Undiscovered Resources - potential supplies of a particular mineral resource that are assumed to exist on the basis of geologic knowledge and theory

Reserves - identified resources that can be extracted economically at current prices using current mining technology

Other Resources - identified and undiscovered resources not classified as reserves

Finding Mineral Resources

Aerial photos

Satellite images

Effect on the Earth's magnetic and gravitational fields

Types of Mining

Subsurface mining - removal of deep deposits of minerals

Surface mining - used to retrieve shallow mineral deposits

Overburden - soil and rock which lies over shallow mineral deposits

Spoil - waste material

Surface Mining -

Open-Pit Mining - dig holes and remove ores

Dredging - chain buckets and draglines scrape up underwater mineral deposits

Strip Mining - overburden is removed in strips - coal, phosphate rock

Area Strip Mining - terrain is flat; overburden is stripped away and mineral deposit is removed by power shovels then trench is filled with overburden; Spoil Banks are left - wavy series of hills

Contour Strip Mining - terrain is hilly / mountainous; terraces are cut into the side of the hill; overburden is removed and mineral is extracted. Overburden from each new terrace is dumped onto the one below. Highwall - a wall of dirt left in front of the highly erodible bank of soil and rock.

Mountaintop Removal - mountain tops are completely removed. Debris is dumped into the valleys.

Restoration is difficult and usually incomplete. Most surface mining in the U.S. is in arid and semiarid regions where soil and climate prevent full restoration. Remember, damage to desert biomes is almost always permanent.

Subsurface Mining
- use to remove ores too deep to be extracted by surface mining techniques.

Room-and-pillar Method

Longwall Method

More dangerous and more expensive than surface mining

Damages much less of the surface land

Mines collapse, trapping and killing miners

Dust Explosions and natural gas

Prolonged inhalation of mining dust causes lung diseases.

Estimating Supplies of Nonrenewable Mineral Resources

Two factors determine our future supply of nonrenewable resources:

Actual or potential supply

Rate at which the supply is used

Economically Depleted - when cost of finding, extracting, transporting and processing the remaining deposits exceed the returns. Then our choice becomes one of recycling, reusing, wasting less, using less, finding a substitute or doing without

Depletion Time - the time it takes to use up a certain proportion of the reserves of a mineral at a given rate of use.

Reserve-to-Production Ratio - the number of years that proven reserves of a particular resource will last at current annual production rates.

Prices of most metals have changed little in constant dollars over the past 150 years - due mostly to government subsidies and failure to include the harmful environmental effects of metal mining and processing in their market prices.

Who has the World's Mineral Resources?

Mineral resources are not distributed evenly

Of the world's 20 most important non-fuel resources, supplied by U.S., Canada, Australia, South Africa and former Soviet Union.

Japan has virtually no mineral resources.

Europe depends heavily on minerals from Africa.

Increasing Mineral Resource Supplies

Most mineral prices are low because governments subsidize development of their domestic mineral resources to help promote economic growth and national security.

The cost of non-fuel resources is only a small part of the final cost of goods. Industries and consumers have no incentive to reduce demand for products in time to avoid economic depletion of minerals.

Harmful environmental costs are not included in their pricing.

Exploration is financially risky

takes a lot of investment capital

lack of capital limits production of nonfuel minerals

Can We Mine More Lower-Grade Ores?

The average ore mined today is lower than it was 100 years ago.

Factors that limit the mining of low grade ore:

1. costs to mine the ore exceed the expected return

2. large amount of water are needed (mineral-rich areas lack fresh water)

3. the environmental impact of waste material (cost of land restoration and pollution control exceed current value of the minerals)

Mining the Oceans

Most minerals in seawater occur at very low concentrations - not economically practical to recover them. Only minerals that can be profitably extracted are magnesium, bromine and sodium chloride.

Continental Shelf - sand, gravel, phosphates, sulfur, tin, copper, iron, tungsten, silver, titanium, platinum, and diamonds.

Deep ocean floor - future site for sources of manganese and other metals; uncertainty who own the mineral rights in international waters.

Hot volcanic springs - sources of sulfide deposits of gold, silver, zinc and copper

Environmental effects of deep-sea mining are unclear and debatable

Substitutes for Scarce Nonrenewable Mineral Resources

Some substitutes are possible - e.g., we are currently using ceramics and plastics as replacements for metals

Substitutes may be found, but the search is costly and it takes time to phase in new materials and processes. Some substitutes are inferior. Finding some substitutes may be very difficult or impossible.

Environmental Effects of Using Mineral Resources

Mining and use of resources requires enormous amounts of energy and often cause land disturbance, erosion, and air and water pollution

Land Surface:

scarring and disruption

fires in coal mines

land subsidence causing houses to tilt, cracked sewer lines, broken gas mains and disrupted groundwater systems.

erosion of spoil heaps and tailings by water and wind

air and water pollution

Rainwater seeping through a mine or mine waste can carry sulfuric acid to nearby streams

Other mining wastes: radioactive uranium compounds, compounds of lead, mercury, arsenic and cadmium

Beneficiation - separation of ore material from the gangue (waste mineral material); tailings - waste material

Smelting

separates the metals from other metals in the mineral

emits enormous amounts of air pollutants damaging vegetation and soil

SO_2, soot, tiny particles of arsenic, cadmium, lead and other heavy metals.

Pollution control is expensive, but can save millions of dollars of clean-up costs later.

The grade of an ore largely determines the environmental impact of mining it. Lower grade ores require more money, energy, water and other materials.

Soil Erosion and Degradation

Soil Erosion - movement of soil components from one place to another; caused by wind and water

In vegetated areas, soil is not lost faster than it forms

Soil becomes vulnerable to erosion as a result of:

farming

logging

construction

overgrazing

off-road vehicles

deliberate burning of vegetation

other activities that destroy plant cover leaving soil exposed

Most soil erosion is caused by moving water (3 types):

Sheet erosion - wide flow

Rill erosion - fast flowing little rivulets

Gully erosion - rivulets joining together cutting deeper and wider channels (gullies)

Losing topsoil makes a soil less fertile and less able to hold water. The sediment clogs ditches, boat channels, reservoirs, and lakes. Sediment laden water is cloudy, tastes bad, fish die and flood risk increases.

Soil can be renewed: in tropical and temperate areas: 200 - 1000 years depending on climate for 1 inch of new topsoil to form

Global Soil Erosion

World is losing 7-21% of its topsoil from actual or potential cropland each decade.

In developing countries, poverty and erosion interact in a destructive positive feedback cycle.

Soil Erosion in the U.S.

About 1/3 of nation's original prime topsoil has been washed or blown into streams, lakes and oceans - mostly as the result of overcultivation, overgrazing and deforestation.

Soil on cultivated land is eroding 16 times faster than it can form. erosion rate is even faster in heavily farmed areas (Great Plains)

Desertification - process whereby productive potential or arid or semiarid land falls by 10% or more - and results primarily from human activities.

Moderate desertification - 10-25% drop in productivity

Severe desertification - 25-50% drop in productivity

Very severe desertification - >50% drop in productivity (creates huge gullies and sand dunes)

Practices that leave topsoil vulnerable to desertification:

- overgrazing
- deforestation without reforestation
- surface mining without land reclamation
- irrigation techniques that lead to increased erosion
- salt buildup and waterlogged soil
- farming on land that has unsuitable terrain or soil
- soil compaction by farm machinery and cattle hooves

Consequences of desertification include worsening drought, famine, declining living standards, increasing numbers of environmental refugees

How Can We Slow Desertification?

Reduce overgrazing, deforestation, destructive forms of planting, irrigation and mining

Plant trees, grasses to anchor soil and hold water

How Do Excess Salts and Water Degrade Soils?

Irrigation is needed to produce increased yields of crops

Irrigation leaves behind a thin crust of dissolved salts in the topsoil

Salinization - Accumulation of salts

stunts crop growth

lowers yields

eventually kills plants

ruins the land

Severe salinization has reduced yields on 20% of the world's irrigated cropland

Cure for heavily salinized soil

take land out of production for 2-5 years

install underground network of perforated drainage pipe

flush soil with large amount of low-salt water

Flushing water increases the salinity of downstream water unless this water is drained into evaporation ponds

Waterlogging

Huge amount of irrigation water used to wash salts out of the topsoil accumulate underground - gradually raising the water table. This saline water envelops the roots lowering their productivity and killing them after prolonged exposure

Approximately 1/10 of all irrigated land worldwide suffers from waterlogging, and the problem is getting worse.

Solutions: Soil Conservation

Soil Conservation - involves reducing soil erosion and restoring soil fertility

keep the soil covered with vegetation

Conventional-tillage farming

land is plowed and the soil broken up and smoothed to make a planting surface.

land is usually plowed in the fall, left bare during the winter and early spring

Conservation-tillage farming (minimum-tillage or no-till farming)

special tillers break up and loosen the subsurface soil without turning over the topsoil, previous crop residues and any cover vegetation

special planting machines inject seeds, fertilizers and weed killers into slits made in the unplowed soil.

saves fuel, cuts costs, holds more water in the soil, keeps the soil from getting packed down, and allows more crops to be grown during a season (multiple cropping).

How Can Terracing, Contour Farming, Strip Cropping and Alley Cropping Reduce Soil Erosion?

Terracing - reduces erosion on steep slopes (converted into a series of broad nearly-level terraces that run across the land contour

Retains water and reduces erosion by controlling runoff

Good choice for mountainous areas

Contour Farming - on gently sloping land plowing and planting crops in rows across rather than up and down the sloped contour of the land.

Strip Cropping - A row crop (corn) alternates with another crop (a grass or grass-legume mixture). The cover crop traps soil that erodes from the row crop. They catch and reduce water runoff and help prevent the spread of pests and plant diseases. Soybeans and alfalfa help restore soil fertility.

Alley Cropping (agroforestry) - is a form of intercropping

several crops are planted together in strips or alleys between trees or shrubs that provide fruit or fuelwood.

The trees provide shade (helps to retain moisture).

Trimmings from the trees and shrubs provide mulch (green manure) for the crops.

Gully Reclamation, Windbreaks, Land Classification and PAM Reduce Soil Erosion

Gully Reclamation - restore sloping bare land on which water runoff quickly creates gullies

plant fast growing plants, shrubs, vines and trees to stabilize soil

Windbreaks (shelterbelts) - reduce wind erosion - long rows of trees

Land Classification (voluntary system)

classified as marginal (easily erodible) and should not be planted with crops or cleared of vegetation.

PAM - Polyacrylamide - used to sharply reduce erosion of some irrigated fields

can reduce erosion by 70-99%

increases cohesiveness of surface soil particles

How Can We Maintain and Restore Soil Fertility?

Fertilizers - partially restore plant nutrients lost by erosion, crop harvesting and leaching.

1. organic fertilizer - from plant and animal materials

2. commercial inorganic fertilizer -produced from various minerals

Three basic types of organic fertilizer:

1. Animal Manure

Dung and urine of cattle, horses, poultry and other farm animals

improves soil texture, adds organic nitrogen, stimulates beneficial soil bacteria and fungi

2. Green Manure

fresh or growing green vegetation plowed into the soil to increase organic matter and humus available to the next crop

weeds, grasses, clover, legumes, alfalfa, soybeans

3. Compost

rich natural fertilizer and soil conditioner

aerates soil

improves its ability to retain water and nutrients

helps prevent erosion

prevents nutrients from being wasted in landfills

Crop Rotation

Plant corn, tobacco or cotton one year. The following year plant legumes to add nitrogen to the soil (soybeans, oats, rye, barley, sorghum). Also helps reduce crop losses to insects by presenting them with a changing target.

Will Inorganic Fertilizers Save the Soil?

These fertilizers have plenty of advantages

Easy to transport, store, apply

Disadvantages

Do not add humus to the soil (so organic content of soil will decrease) and soil will become compacted.

Decreased soil porosity leads to reduced oxygen content and prevent added fertilizer from being taken up efficiently.

Usually supply only two or three of the needed 20 or so nutrients

Cause water pollution especially on sloped land near streams. The resulting plant-nutrient enrichment causes algae blooms that use up oxygen dissolved in the water - this kills the fish.

Rainwater leaches nitrates into the groundwater.

Nonrenewable Energy Resources

Evaluating Energy Resources

What Types of Energy Do We Use?

99% of energy we use to heat the earth and all our buildings comes directly form the sun.

1% of energy used is commercial energy sold in the marketplace (oil, gas, coal)

How Should We Evaluate Energy Resources?

Types of energy used and how we use them determines our quality of life and our harmful environmental effects.

Dependency on fossil fuels is primary cause of air and water pollution, land disruption, and global warming

Affordable oil - expected to be depleted in 40-80 years

Goals:

> #1 - eliminate unnecessary waste by improving energy efficiency
>
> #2 - (disagreement) - either start relying more on renewable energy sources, or burn more coal and synthetic liquid and gaseous fuels made from coal.

Energy alternatives take 50^{+} years to phase in

Net Energy

def'n: the total useful energy available from the resource over its lifetime minus the amount of energy used (1st law of energy), automatically wasted (2nd law of energy) and unnecessarily wasted in finding, processing, concentrating and transporting it to others.

Oil - Crude Oil and how it is processed

Petroleum (crude oil) is a fossil fuel produced by the decomposition of deeply buried dead organic matter from plants and animals under high temperatures and pressures over millions of years.

- consists mostly of hydrocarbons, with small amount of sulfur, oxygen and nitrogen.

Prime oil recovery - pumping out oil that flows into the bottom of the well by gravity

Secondary oil recovery - water is injected into nearby wells to force oil to the surface.

Primary and secondary oil recovery - only 35% of oil can be recovered.

Enhanced or tertiary oil recovery - recover about 10-25% of remaining heavy oil (inject steam or CO_2 into the well cavity).

Crude oil is transferred to a refinery where it is fractionated by distillation to produce naphtha, diesel oil, home heating oil, fuels (gasoline) and various solid fractions (waxes, asphalt, greases, etc.)

Petrochemicals - refinery products that are use as raw materials in the production of organic chemicals, pesticides, cosmetics, synthetic fibers (nylon, acrylates, etc.), medicines, etc.

World's Oil Supplies

Oil reserves - identified deposits from which oil can be extracted profitably at current prices with current technology.

OPEC controls 67% of world oil supplies

Saudi Arabia - 26%
Iraq - 10%
United States - 2.3%

Reserves are expected to be depleted in 35-80 years - depending on consumption. At the current rate of consumption, reserves will last 44 years. But global oil consumption is expected to increase 25% by 2010.

Pros and Cons of Conventional Oil

Advantages:

Oil is cheap, easily transported (pipelines, trucks, ocean tankers), has a high net energy yield

Low prices encourage waste and discourage improvements in energy efficiency of switching to another source of energy

Disadvantages:

Reserves are running low

Demand may exceed production in 10-20 years

Can cause pollution and environmental degradation throughout its life cycle

Drilling causes land disturbance - accelerating erosion, producing waste material, polluting soil and water when spilled.

Groundwater contamination

Burning produces CO_2, a greenhouse gas, sulfur dioxide and nitrogen oxides

Pros and Cons of Shale Oil

Oil shale - fine grained rock containing a solid, waxy mixture of hydrocarbons called kerogen

Shale oil is extracted from the rock by crushing, heating to vaporize the kerogen, condensing to form heavy, slow flowing dark-brown shale oil. Must be heated to reduce viscosity for pumping. Sulfur, nitrogen and other impurities must be removed.

Global supplies are potentially 200 times larger than estimated supplies of conventional oil

Disadvantages:

Lower net energy yield - take about 1/2 barrel oil to process shale oil

Requires large amounts of water (scarce where shale deposits are located)

Greatly disturbs the land leaving mountains of shale rock (expands when heated)

Can contaminate water supplies with salts, toxic metals and cancer-causing substances

Underground processing of shale oil is too expensive and produces more sulfur dioxide than surface processing.

Pros and Cons of Oil from Tar Sands

Tar Sand - mixture of clay, sand, water and bitumen (gooey black high-sulfur heavy oil)

Removed by surface mining, heated with pressurized steam to soften the bitumen and float it to the top. Bitumen is then purified and chemically upgraded into a synthetic crude oil suitable for refining.

World's largest deposit - Athabasca Tar Sands - northern Alberta, Canada. (33 years supply for Canada alone)

Also found in Venezuela, Colombia and parts of former Soviet Union

Disadvantages:

Net energy yield is low (1/2 half barrel to extract and process)

Requires large quantities of water to process

Upgrading bitumen releases large quantities of air pollutants

Creates huge waste disposal ponds

Natural Gas - What is it?

Mixture of 50-90% methane (CH_4) by volume; contains smaller amounts of ethane, propane, butane and hydrogen sulfide.

Deposits normally occur near hot spots where high temperatures and pressures or catalytically active metals break down long chain hydrocarbons in petroleum to the smaller molecules.

Conventional natural gas - lies above most reservoirs of crude oil

Unconventional deposits - include coal beds, shale rock, deep deposits of tight sands and deep zones that contain natural gas dissolved in hot water.

Gas Hydrates - an ice-like material that occurs in underground deposits (globally)

Liquefied Petroleum Gas (LPG) - propane and butane are liquefied and removed from natural gas fields. Stored in pressurized tanks.

Removal of natural gas from remote locations costs more than it is worth.

Liquefied Natural Gas (LNG) - natural gas is converted at a very low temperature (-184^{o}C)

World's Natural Gas Supplies.

Russia and Kazakhstan - 40%
Iran - 15%
Qatar - 5%
Saudi Arabia - 4%
Algeria - 4%
United States - 3%
Nigeria – 3%
Venezuela - 3%

Most natural gas reserves are located in the same places as crude oil

Pros and Cons of Natural Gas

Advantages:

Cheaper than Oil

Known US reserves 65-80 years

World reserves - >125 years

Easily transported over land (pipeline)

High net energy yield

Produces less air pollution than other fossil fuels

Produces less CO_2 than coal or oil

Extracting natural gas damages the environment much less that either coal or uranium ore

Easier to process than oil

Can be used to transport vehicles

Can be used in highly efficient fuel cells

Disadvantages:

When processed, H_2S and SO_2 are released into the atmosphere

Must be converted to LNG before it can be shipped (expensive and dangerous)

Conversion to LNG reduces net energy yield by one-fourth

Can leak into the atmosphere; methane is a greenhouse gas that is more potent than CO_2.

Coal - What is it?

Coal is a solid, rocklike fossil fuel; formed in several stages as the buried remains of ancient swamp plants that died during the Carboniferous Period (ended 286 million years ago); subjected to intense pressure and heat over millions of years.

Coal is mostly carbon (40-98%); small amount of water, sulfur and other materials

Three types of coal

lignite (brown coal)

bituminous coal (soft coal)

anthracite (hard coal)

Carbon content increases as coal ages; heat content increases with carbon content.

Subsurface Mining - labor intensive; world's most dangerous occupation (accidents and black lung disease)

Surface Mining - three types

Area strip mining

contour strip mining

open-pit mining

How is coal used?

Coal provides 25% of world's commercial energy (22% in US).

Used to make 75% of world's steel

Generates 64% of world's electricity

Remainder of world's electricity is produced by:
hydroelectric dams - 18%
nuclear energy - 17%
other - 1% (solar, wind, etc.)

In US electricity is produced by coal (57%), nuclear energy (19%), natural gas (11%), hydroelectric power (9%), oil (3%) and renewable resources (1%)

Coal-Fired Electric Power Plant

Coal is pulverized to a fine dust and burned at a high temperature in a huge boiler. Purified water in the heat exchanger is converted to high-pressure steam that spins the shaft of the turbine. The shaft turns the rotor of the generator (a large electromagnet) to produce electricity.

Air pollutants are removed using electrostatic precipitators (particulate matter) and scrubbers (gases). Ash is disposed of in landfills. Sulfur dioxide emissions can be reduced by using low-sulfur coal.

World's Coal Supplies

US - 66% of world's proven reserves

Identified reserves should last 220 years at current usage rates. Unidentified reserves could last about 900 years

Pros and Cons of Solid Coal

World's most abundant and dirtiest fossil fuel

High net energy yield

Disadvantages:

harmful environmental effects

mining is dangerous (accidents and black lung disease)

harms the land and causes water pollution

causes land subsidence

surface mining causes severe land disturbance and soil erosion

surface mined land can be restored - involves burying toxic materials, returning land to its original contour, and planting vegetation (expensive and not often done)

Acids and toxic metals drain from piles of water materials

Coal is expensive to transport

Cannot be used in solid form in cars (must be converted to liquid or gaseous form)

Dirtiest fossil fuel to burn releases CO, CO_2, SO_2, NO, NO_2, particulate matter (fly ash), toxic metals and some radioactive elements.

Burning coal releases thousands of times more radioactive particles into the atmosphere per unit of energy than does a nuclear power plant

Produces more CO_2 per unit of energy than other fossil fuels and accelerates global warming.

A severe threat to human health (respiratory disease)

Fluidized-bed combustion - developed to burn coal more cleanly and efficiently.

Use of low sulfur coal - reduces SO_2 emissions

Pros and Cons of Converting Solid Coal into Gaseous and Liquid Fuels

Coal gasification - synthetic natural gas (SNG)

Produce hydrogen gas

Coal liquefaction - produce a liquid fuel - methanol or synthetic gasoline

Synfuels can be transported by pipeline inexpensively; burned to produce electricity; burned to heat houses and water; used to propel vehicles.

Coal gasification and coal liquefaction - low net energy yield; 30-40% of energy content would be lost in the energy conversion

Synfuels requires huge amount of water, release more CO_2 than coal.

Nuclear Energy

Three reasons why nuclear power plants were developed in the late 1950s:

Atomic Energy Commission promised electricity at a much lower cost than coal

US Gov't paid ~1/4 the cost of building the first reactors

Price Anderson Act protected nuclear industry from liability in case of accidents

Globally, nuclear energy produces only 17% of world's electricity (6% of commercial energy)

Why is nuclear power on the decline?

huge construction overruns

high operating costs

frequent malfunctions

false assurances

cover-ups by government and industry

inflated estimates of electricity use

poor management

Chernobyl

Three Mile Island

public concerns about safety, cost and disposal of radioactive wastes

How a Nuclear Reactor Works

Nuclear fission of Uranium-235 and Plutonium-239 releases energy that is converted into high-temperature heat. This rate of conversion is controlled. The heat generated can produce high-pressure steam that spins turbines that generate electricity.

Light-water reactors (LWR)

Core containing 35,000-40,000 fuel rods containing pellets of uranium oxide fuel. Pellet is 97% uranium-238 (nonfissionable isotope) and 3% uranium-235 (fissionable).

Control rods move in and out of the reactor to regulate the rate of fission

Moderator - slows down the neutrons so the chain reaction can be kept going [liquid water in pressurized water reactors; solid graphite or heavy water (D2O)].

Coolant - water to remove heat from the reactor core and produce steam

1/3 of fuel rod assemblies must be replaced every 3-4 years. They are placed in concrete-lined pools of water (radiation shield and coolant).

Nuclear wastes must be stored for 10,000 years

After 15-40 years of operation, the plant must be decommissioned by

dismantling it

putting up a physical barrier, or

enclosing the entire plant in a tomb (to last several thousand years)

Advantages of Nuclear Power:

Doesn't emit air pollutants (i.e., no CO_2)

Water pollution and land disruption are low

Nuclear Power Plant Safety

Very low risk of exposure to radioactivity

Three Mile Island - March 29, 1979; No. 2 reactor lost coolant water due to a series of mechanical failures and human error. Core was partially uncovered

Nuclear Regulatory Commission estimates there is a 15-45% chance of a complete core meltdown at a US reactor during the next 20 years.

US National Academy of Sciences estimates that US nuclear power plants cause 6000 premature deaths and 3700 serious genetic defects each year.

Low-Level Radioactive Waste

Low-level waste gives off small amounts of ionizing radiation; must be stored for 100-500 years before decaying to levels that don't pose an unacceptable risk to public health and safety

1940-1970: low-level waste was put into drums and dumped into the oceans. This is still done by UK and Pakistan

Since 1970, waste is buried in commercial, government-run landfills.

Above-ground storage is proposed by a number of environmentalists.

1990: the NRC proposed redefining low-level radioactive waste as essentially nonradioactive. That policy was never implemented (as of early 1999).

High-Level Radioactive Waste

Emit large amounts of ionizing radiation for a short time and small amounts for a long time. Must be stored for about 240,000 years if plutonium-239 is not removed by reprocessing.

Spent fuel rods; wastes from plants that produce plutonium and tritium for nuclear weapons.

Possible Methods of Disposal and their Drawbacks

Bury it deep in the ground

Shoot it into space or into the sun

Bury it under the Antarctic ice sheet or the Greenland ice cap

Dump it into descending subduction zones in the deep ocean

Bury it in thick deposits of muck on the deep ocean floor

Change it into harmless (or less harmful) isotopes

Currently high-level waste is stored in the DOE $2 billion Waste Isolation Pilot Plant (WIPP) near Carlsbad, NM. (supposed to be put into operation in 1999)

Worn-Out Nuclear Plants

Walls of the reactor's pressure vessel become brittle and, thus, are more likely to crack.

Corrosion of pipes and valves

Decommissioning a power plant (3 methods have been proposed)

immediate dismantling

mothballing for 30-100 years

entombment (several thousand years)

Each method involves shutting down the plant, removing the spent fuel, draining all liquids, flushing all pipes, sending all radioactive materials to an approved waste storage site yet to be built.

Connection between Nuclear Reactors and the Spread of Nuclear Weapons

Components, materials and information to build and operate reactors can be used to produce fissionable isotopes for use in nuclear weapons.

Can We Afford Nuclear Power?

Main reason utilities, the government and investors are shying away from nuclear power is the extremely high cost of making it a safe technology.

All methods of producing electricity have average costs well below the costs of nuclear power plants.

Breeder Reactors

Convert nonfissionable uranium-238 into fissionable plutonium-239

Safety: liquid sodium coolant could cause a runaway fission chain reaction and a nuclear explosion powerful enough to blast open the containment building.

Breeders produce plutonium fuel too slowly; it would take 100-200 years to produce enough plutonium to fuel a significant number of other breeder reactors.

Nuclear Fusion

D-T nuclear fusion reaction; Deuterium and Tritium fuse at about 100 million degrees Celsius

Uses more energy than it produces

Energy Efficiency and Renewable Energy Resources

The Importance of Improving Energy Efficiency

What is Energy Efficiency?

Energy efficiency - the percentage of total energy input that does useful work

84% of all commercial energy in used in the US is wasted

Life cycle cost - the initial cost plus lifetime operating costs

The net efficiency of the entire energy delivery process is determined by the efficiency of each step in the energy conversion process.

The three least energy efficient using devices are incandescent light bulbs, vehicles with internal combustion engines, and nuclear power plants producing electricity for space heating.

Why it is important to reduce energy waste?

1. make nonrenewable fossil fuels last longer

2. gives us more time to phase in renewable energy resources

3. decreases dependence on oil imports

4. lessens the need for military intervention in the oil-rich and politically-unstable Middle East

5. Reduces local and global environmental damage

6. Is the cheapest and quickest way to slow projected global warming

7. Saves more money, provides more jobs, improves productivity and promotes more economic growth per unit of energy than other alternatives.

8. Improves competitiveness in the international marketplace.

The reasons there is not more emphasis on improving energy efficiency is the glut of low-cost underpriced fossil fuels and huge government subsidies

Ways to Improve Energy Efficiency

How can we use waste heat?

Energy cannot be recycled

For a house: insulate it, eliminate air leaks and equip it with an air-to-air heat exchanger

How can we save energy in industry?

Cogeneration - production of two useful forms of energy from the same fuel source.

Efficiency can be increased to approx. 90%

Replacing energy-wasting electric motors; use adjustable-speed drives

How can we save energy in producing electricity? The Negawatt Revolution

The Negawatt Revolution is known as demand-side management - reducing demand for electricity

How can we save energy in Transportation?

Increase the fuel efficiency of motor vehicles

There is little interest in fuel-efficient vehicles when gasoline is so cheap

Electric cars - pollution to recharge batteries is produced elsewhere

Electric cars are not very efficient

Shift to more energy efficient way to move people and freight

How can we save energy in buildings?

Superinsulated houses; air-to-air heat exchangers

Use the most energy-efficient ways to heat houses: passive solar heating and high-efficiency natural gas furnaces. [electric resistance heating is the most wasteful]

Heat pumps work in warm climates

For existing homes add insulation, plug leaks and install energy saving windows

Use the most energy-efficient ways to heat water (using electricity is the least efficient)

Use the most energy-efficient appliances and lights

Rebates or tax credits for building energy-efficient buildings, etc.

Direct use of solar energy for heat and electricity -

The Renewable Energy Age

Using Solar Energy to Heat Houses and Water

Passive Solar Heating - captures sunlight directly within a structure and converts it into low-temperature heat for space heating

Thermal mass stores collected energy as heat and releases it day and night

Active Solar Heating - special collectors absorb solar energy; a fan or pump is used to circulate the hot water

Net energy yield is moderate; CO_2 not emitted; land disturbance is minimal

Owners need solar legal rights

How Can Solar Energy Be Used to Generate High-Temperature Heat and Electricity?

1. Central Receiver System (Power Tower)

    Heliostats - computer controlled mirrors

2. Solar Thermal Plant (distributed receiver system)

3. Parabolic dish collectors

4. Nonimaging optical solar concentrator

5. Solar cookers

Producing Electricity from Solar Cells - The PV Revolution

Photovoltaic Cells (Solar Cells) - Sunlight falling on a wafer thin silicon sheet releases a flow of electrons creating an electric current.

High net energy yield; works in cloudy weather.

Cost of PVs is high;

Storage of electricity produced is a problem

Batteries are expensive

Flywheels are promising

Producing Electricity from Moving Water and from Heat in Stored Water

Hydroelectric Power

Large-scale hydroelectric project (large dam)

Small-scale hydroelectric project - a low dam with no reservoir

Pumped storage hydropower systems - water reservoirs at two different levels

Moderate to high net energy yield

Flood vast areas, destroy wildlife habitat, uproots people, ...

Producing electricity from Tides and Waves

Few suitable sites and construction costs are high

Producing electricity from heat stored in water

OTEC (Ocean Thermal Energy Conversion)

Saline solar ponds

Freshwater solar ponds

Producing electricity from Wind

Unlimited source at favorable sites

Land underneath turbines can be used for grazing cattle or farming

Need steady winds

Producing Energy from Biomass

Organic matter can be burned directly as a solid fuel, or converted into gaseous or liquid biofuels.

Potentially renewable if managed properly.

Biogas (60% methane, 40% CO2); liquid methanol; liquid ethanol

Biomass Plantations of Btu Bushes: burned directly or converted to alternative fuels

Requires large areas of land

Burning Wood - contains pollutants known to cause cancer, bronchitis, emphysema

Need efficient wood-burning stoves

Burning agricultural or urban wastes

Bagasse - residue left after harvesting and processing sugar cane.

Solar Hydrogen Revolution

Water can be split by electricity into H_2 and O_2.

Geothermal Energy

Sustainable Energy Strategy

improved energy efficiency

chose projects carefully

we cannot continue to depend on a single nonrenewable energy source.

What the government can do

increase fuel efficiency standards for motor vehicles

establish energy-efficiency standards for buildings and appliances

increase government sponsored R&D to improve energy efficiency

give tax credits and exemptions for purchases of energy efficient vehicles, houses, buildings and appliances

phase in full-cost pricing to include the environmental impact

Risk, Toxicology and Human Health

The Big Killer

There are about 1.1 billion smokers in the world.

The World Health Organization estimates that each year tobacco contributes to the premature death of at least 3 million people.

A 1998 report estimated that more than 500,000 people in Europe and 750,000 people in China die from smoking-related disease every year.

The overwhelming consensus in the scientific community is that nicotine inhaled in tobacco smoke is highly addictive.

Only 1 in 10 people who try to quit smoking succeed.

U.S. Government agencies and independent economists estimate that the country's 48 million smokers cost the United States up to 100 billion a year in medical bills, increased insurance costs, disability, and lost earnings and productivity because of illness. A $2-4 tax on tobacco products would help pay a much greater share of the health, economic, and social costs associated with their smoking: a user-pays approach.

Reducing the death toll from cigarettes

1) Banning all cigarette advertising
2) Forbidding the sale of cigarettes to anyone under 21
3) Banning all cigarette vending machines
4) Classifying nicotine as an addictive and dangerous drug
5) Eliminating all federal subsidies and tax breaks to U.S. tobacco farmers and companies
6) Using cigarette tax income to finance a massive anti-tobacco campaign

Risks and Hazards

Risk is the possibility of suffering harm from a hazard that can cause injury, disease, economic loss, or environmental damage.

Risk is expressed in terms of probability: a mathematical statement about how likely it is that some event or effect will occur.

The probability of a risk is expressed as a fraction ranging from 0 to 1.0.

Risk assessment involves using data, hypotheses, and models to estimate the probability of harm to human health, to society, or to the environment that may result from exposure to specific hazards.

Major types of Hazards

Cultural hazards such as unsafe working conditions.

Chemical hazards from harmful chemicals (such as, in the air).

Physical hazards (such as, noise, fire, and tornadoes).

Biological hazards from pathogens, bacteria, and pollen.

Toxicology

The study of the adverse effects of chemicals on health is called toxicology.

Toxicity is a measure of how harmful a substance is.

The amount of potentially harmful a substance that a person had ingested, inhaled, or absorbed through the skin is called the **dose** and the amount of the resulting type and amount of damage to the health is called the **response**. (Dose-Response Curves)

An **acute effec**t is an immediate or rapid harmful reaction to an exposure: it can range from a rash to death.

A **chronic effect** is a permanent or long-lasting consequence of exposure to a harmful substance.

Bioaccumulation is an increase in the concentration of a chemical in specific organs or tissues at a level higher than would normally be expected.

The levels of some toxins in the environment can also be magnified as they pass through food chains and webs by a process called **biomagnification**.

Dose and especially response can also depend on whether and how a chemical interacts with other chemicals (e.g., asbestos and cigarette smoking).

What is a Poison?

Legal definition: a poison is a chemical that has an LD_{50} of 50 milligrams or less per kilogram of body weight.

An LD_{50} is the median lethal dose, or amount of a chemical received in one dose that kills exactly 50% of the animals in a test population within a 14-day period.

How do Scientists Determine Toxicity?

Three methods used to determine the level at which a substance poses a threat:

1) case reports - about people suffering from some adverse health effect or death after exposure to a chemical

2) laboratory investigations - usually on test animals, to determine toxicity, residence time, what parts of the body are affected, and how the harm takes place.

3) epidemiology - which involves studies of populations of humans exposed to certain chemicals or diseases.

Dose-response curve - which shows the effects of various doses on a group of test organisms. (see Miller, p.440)

linear dose-response model - any dose of a toxic chemical or ionizing radiation has a certain risk of causing harm (no threshold).

threshold dose-response model - there is a threshold dose below which no detectable harmful effects occur, presumably because the body can repair the damage caused by low doses of some substances.

Some scientists challenge the validity of extrapolating data from test animals to humans because human physiology and metabolism are often different from those of test animals.

Another approach to testing toxicity and identifying the agents causing diseases is epidemiology. Epidemiology is the study of the patterns of disease or toxicity to find out why some people get sick and other do not.

Chemical Hazards

Toxic chemicals are generally defined as substances that are fatal to over 50% of test animals at given concentrations (LD_{50}).

Hazardous chemicals cause harm by

1) being flammable or explosive
2) irritating or damaging the skin or lungs
3) interfering with or preventing oxygen uptake and distribution
4) inducing allergic reactions of the immune system

Mutagens - are agents, such as chemicals and radiation, that cause mutations, or changes in the DNA molecules found in the cells.

Teratogens - are chemicals, radiation, or viruses that cause birth defects while the human embryo is growing and developing during pregnancy, especially during the first 3 months (first trimester).

Carcinogens - are chemicals, radiation, or viruses that cause or promote the growth of malignant tumor, in which certain cells multiply uncontrollably.

In the U.S. the incidence of all new cancers increased by 54% between 1950 and 1992, and the death rate for all cancers increased by 9.6%.

According to the World Health Organization, environmental and lifestyle factors play a key role in causing or promoting 80% of all cancers.

How Can Chemicals Harm the Immune, Nervous, and Endocrine Systems?

The immune system consists of:

1) antibodies- which identify alien invaders in your blood stream and mark them for other immune cells to attack.

2) Cellular defenses- such as killer T-cells, which seek out and kill cells that have been invaded.

The human nervous system is also being threatened by synthetic chemicals in the environment.

Do Hormone Disrupters Threaten the Health of Wildlife and Humans?

Hormone mimics - are estrogen-like chemicals that disrupt the endocrine system by being able to attach to estrogen receptor molecules.

Hormone blockers - disrupt the endocrine system by preventing natural hormones (such as androgens) from attaching to their receptors.

Pollutants can now act as thyroid disruptors and cause growth, weight, brain, and behavioral disorders.

So far, 51 chemicals, many of them widely used, have been shown to act at extremely low levels as hormone disruptors in wildlife, laboratory animals, and some populations of humans.

Why Do We Know So Little About Harmful Effects of Chemicals?

The U.S. National Academy of Sciences estimates that only about 10% of the nearly 100,000 chemicals in commercial use have been thoroughly screened for toxicity and only 2% have been adequately tested to determine whether they are carcinogens, teratogens, or mutagens.

Each year we introduce into the marketplace about 1,000 new chemicals about whose potentially harmful effects we have little knowledge.

The difficulty and expense of getting information about the harmful effects of chemicals is one reason an increasing number of environmentalists and health officials are pushing for much greater emphasis on pollution prevention.

Physical Hazards: Earthquakes, Volcanic Eruptions, and Ionizing Radiation.

Earthquakes.

Volcanoes.

Ionizing radiation, a form of electromagnetic radiation, has enough energy to damage body tissues.

> Ionizing radiation can cause harm by penetrating a human cell, knocking loose one or more electrons from a cellular chemical, and thus altering molecules needed for normal cellular functioning.

Ionizing radiation can damage cells in two ways: 1) genetic damage or 2) somatic damage.

Is Nonionizing Electromagnetic Radiation Harmful?

Electromagnetic fields are low-energy, nonionizing forms of electromagnetic radiation given off when an electric current passes through a wire or a motor.

Since the 1960s there has been growing public concern and controversy over the possibility that EMFs could have harmful effects on humans (e.g., cell phones).

Numerous epidemiological studies have suggested that prolonged exposure to EMFs could lead to increased risk from some cancers, miscarriages, birth defects, and Alzheimer's disease.

Biological Hazards

What are Nontransmissible Diseases?

Diseases not caused by living organisms and that do not spread from one person to another.

What Are Transmissible Diseases?

A transmissible disease is caused by a living organism and can spread from one person to another.

In developing countries, infectious diseases accounted for about 44% of the deaths, compared to only 5% in developed countries (in 1997).

About 80% of all illnesses in developing countries are caused by waterborne diseases , mainly from unsafe drinking water.

However, ebola, HIV and other new emerging diseases, which have been rising for at least two decades and are likely to increase in the near future, should not be ignored.

What Factors Can Affect the Spread of Transmissible Diseases?

Outbreaks of infectious diseases often occur because of a change in the physical, social, or biological environment of disease reservoirs, carrier vectors, or hosts.

In 1998, scientists warned that increased outbreaks of many tropical infectious diseases in developing countries are related to **reducing biodiversity** by destroying forests and wiping out other species that help control disease vectors.

Climate can also affect the spread of infectious diseases.

Natural disasters such as floods, landslides, and hurricanes can also spread disease-causing organisms.

Are We Losing the War Against Infectious Bacteria?

There is growing and alarming evidence that we may be losing our war against infectious bacterial diseases because bacteria are among Earth's ultimate survivors. Microbes that cause disease are constantly and rapidly mutating and evolving in ways that allow them to escape human control.

Through natural selection, a single mutant can pass such traits on to most of its offspring, which can amount to 16,777,216 in only 24 hours.

Bacteria can become genetically resistant to antibiotics that they have been exposed to.

How Rapidly are Viral Diseases Spreading?

Health officials worry about the emergence of new viral diseases, they recognize that the greatest viral health threat to humans is the emergence of new, very virulent strains of influenza.

Flu viruses move through the air and are highly contagious.

In 1918-19, a flu epidemic infected more than half the world's population and killed 20-30 million people. These massive epidemics are called pandemics. Case Study: Malaria, a Protozoal disease

According to a 1993 World Bank report, among infectious diseases malaria is a serious global health problem second only to tuberculosis.

Currently, an estimated 300-500 million people are infected with malaria parasites worldwide, and at least 110 million new cases occur each year.

Malaria is caused by four species of protozoa of the **genus Plasmodium**.

The malaria cycle repeats itself until immunity develops, treatment is given, or the victim dies.

What are the major diseases in developed countries?

A country makes an epidemiological transition:

> **First phase** - characterized by extremely high death rates.
>
> **Second phase** - epidemic peaks become less frequent and the crude death rate from infectious diseases drops.
>
> **Third phase** - in which the death rate levels off and the leading causes of death are from nontransmissible diseases associated with aging.
>
> **Fourth phase** - degenerative diseases associated with aging continue to cause more deaths.
>
> **Fifth phase** - might be the emergence of new infectious diseases which will cause death rates to rise.

How can we reduce infectious and other diseases

Increasing research on tropical diseases

Mounting a global campaign to reduce overcrowding, unsafe drinking water, poor sanitation, inadequate health care system, and poverty.

Increase funding for monitoring, diagnosing and responding to disease outbreaks

Using extreme caution in instituting strategies to battle disease causing organisms.

Not using as many antibiotics.

Educating the public, establishing and enforcing much more rigorous anti-infection programs.

Not selling antibiotics without a presecription

Reducing the use of pesticides

Increase funding for development of vaccines to prevent infections by bacteria and viruses

Emphasizing preventative health care

Risk Analysis?

Risk analysis involves identifying hazards and evaluating their associated risks, ranking risks, determining options and making decisions about reducing or eliminating risks, and informing decision makers and the public about risks.

Risk assessment involves determining the types of hazards involved, estimating the probability that each hazard will occur, and estimating how many people are likely to be exposed to it and how many suffer serious harm.

Comparative risk analysis summarizing the greatest ecological and health risks identified by a panel of scientists and the public.

What are the Greatest Risks people face?

In terms of reduced life span from malnutrition, exposure to disease-causing organisms, and dangerous chemicals, and lack of basic health care, the greatest risk by far is poverty.

After the health risks associated with poverty, the greatest risks of premature death are mostly the result of voluntary choices people make about their lifestyles.

How can we estimate risks for Technological Systems

The more complex a technological system and the more people needed to design and run it, the more difficult it is to estimate the risks.

System reliability % = Technology reliability x Human reliability x 100

What are the limitations of Risk assessment and Risk benefit analysis?

Risk assessment is a young science that has many built-in uncertainties and limitations.

Some see risk analysis as a useful and much needed tool, and others see it as a way to justify premeditated murder in the name of profit.

How should risks be managed?

Risk management includes the administrative, political, and economic actions taken to decide whether and how to reduce a particular societal risk to a certain level and at what cost.

How well do we perceive risks?

People are not really prepared for risks but they become terrified of dying in a plane crash or being shot.

The concept of people's risks is not the same concept that the environment around them has and they must begin to realize this.

Air Pollution

Air pollution detectors:

canaries: died in mines when there was too much methane

lichens: fungi and alga living together that can live almost anywhere for long periods of time

The Atmosphere

Atmosphere - thin envelope of life-sustaining gases surrounding the earth

divided into several spherical layers

troposphere: innermost layer extending about 17 km above sea level

- contains about 75% of the mass of earth's air - weather occurs here

- 78% nitrogen / 21% oxygen / 1% argon / 0.036% carbon dioxide

- average pressure exerted by gases in the atmosphere decreases with altitude because average density (mass of gases per unit of vol.) decreases with altitude

tropopause: top zone of the troposphere where temperature declines with altitude but then abruptly begins to rise

stratosphere: atmosphere's 2nd layer extending from 17-48 km above earth's surface - contains less matter than the troposphere but has similar composition

calm air, little mixing - good for flying planes

ozone: "global sunscreen" keeps about 99% of UV radiation from reaching earth 1) allows humans and other life to exist on land and 2) helps protect humans from sunburn, cancer, cataracts, damage to immune system, and 3) prevents oxygen in the troposphere from being converted to ozone, a harmful air pollutant which causes smog and damage to plants stratopause: top zone of the stratosphere and the beginning of the mesosphere where temperature reverses after rising with altitude

Important natural processes in the atmosphere

Greenhouse Effect: traps heat in the troposphere

global warming: caused by the addition of heat-trapping chemicals to the atmosphere

ozone shield: part of the stratosphere which filters out most UV radiation

ozone depletion: reduction of the concentration of ozone

Disruption of Earth's gaseous nutrient cycles - Burning fossil fuels and clearing forests

disrupts carbon cycle and can alter global climate and food-producing regions, cause huge heated air masses (heat islands) and dust domes over urban areas

nitrous oxides are converted to nitric acid which falls as acid rain

sulfur dioxide from petroleum refining and burning of oil and coal causes acid rain

Air pollution: the presence of 1 or more chemicals in the atmosphere in quantities and duration that cause harm to humans, other forms of life, and materials

primary pollutants: potential pollutants that have been directly added to the air by natural events or humans activities.

secondary pollutants: harmful chemicals formed in the atmosphere when a primary pollutant reacts with normal air components or other air pollutants

stationary sources of pollution: power plants and factories

mobile sources of pollution: cars (responsible for 80-88% of air pollution)

more than 1.1 billion people live in urban areas where the air is unhealthy to breathe cities have higher air-pollution levels than rural areas although prevailing winds can spread long lived primary and secondary pollutants

photochemical smog: (brown-air smog) a mixture of primary and secondary pollutants formed under the influence of sunlight

nitrogen and oxygen in air react at high temps found in automobile engines and boilers in industrial plants to produce colorless nitric oxide which reacts with oxygen to form nitrogen dioxide. Nitrogen dioxide causes the brownish haze over cities on sunny afternoons.

worst on hotter days - can irritate eyes and respiratory tracts

present in virtually all cities

photochemical oxidants: NO_2, O_3 and PANs (peroxyacyl nitrates)

react with (oxidize) certain compounds in the atmosphere that normally aren't oxidized by reaction with oxygen; irritate the respiratory tract, damage plants

industrial smog: (gray-air smog) consists of sulfur dioxide, suspended droplets of sulfuric acid, and a variety of suspended solid particles and droplets

when burned, carbon in coal & oil is converted to CO_2 and CO. Unburned carbon ends up in the atmosphere as suspended particulate matter (soot). Sulfur dioxide (colorless, suffocating gas) and sulfur trioxide (SO_3) produce sulfuric acid

rarely a problem in today's developed countries but bad in countries where large quantities of coal are burned with inadequate pollution controls

Factors influencing the formation of photochemical and industrial smog

local climate and topography, population density, amt. of industry, and the fuels used in industry, heating, and transportation

hills, mountains, and cities reduce air flow and allow pollutants to build up at ground level temperature inversion / thermal inversion: a layer of dense, cool air trapped under a layer of dense, warm air preventing upward-flowing air currents from developing

prolonged inversions cause air pollution in the trapped layer to build up to harmful levels

L.A. is the air-pollution capital of the US because the area has ideal conditions for photochemical smog formation and frequent thermal inversions

"dilution solution" to air-pollution: to reduce local air pollution and meet government standards without having to add expensive pollution control devices, most coal-burning plants, ore smelters, etc., use tall smokestacks to emit sulfur dioxide. This increases pollution downwind

chemicals reach ground:

wet - acid rain, snow, fog, cloud vapor

dry - acidic particles

mixture causes acid deposition (acid rain)

Regional Outdoor Air Pollution from Acid Deposition

pH: a numerical measure of the concentration of hydrogen ions in a solution

pH < 7 - acidic (natural precipitation)

pH > 7 - basic/alkaline

typical rain in east US is now about 10 times more acidic (pH 4.3)

What areas are most affected by acid deposition?

occurs on a regional rather than global basis because acidic components only remain in the air for a few days

areas downwind from coal and oil-burning power plants, industrial plants and urban areas ecosystems containing thin, acidic soils without natural buffering of acids

growing problem in China (40% of its land), former Soviet Union, India, Nigeria, Brazil, Venezuela, Columbia

What are the effects of acid deposition?

medium-risk ecological problem, high-risk to human health

human respiratory diseases (bronchitis, asthma), damages statues, buildings, metals, car finishes, etc.

damages tree foliage, makes trees more susceptible to cold temperatures, diseases, insects, drought, fungi

harmful to fish

How serious is acid deposition in the US?

1980s study called the problem a serious, but not yet at a crisis stage

coal companies and industries claim that pollution control equipment costs more than the resulting health and environmental benefits are worth

1997 study shows that environmental and health benefits in reductions of SO_2 from 1995-2030 will generate more than $12 in benefits for every $1 spent on pollution control.

Clean Air Act of 1990 - decreased sulfur dioxide emissions

What can be done to reduce acid deposition?

prevention

1) reducing energy use & thus air-pollution by improving energy efficiency

2) switching from coal to cleaner-burning natural gas

3) removing sulfur from coal before it is burned

4) burning low-sulfur coal

5) removing SO2 particles, particulates, and nitrogen oxides from smokestack gases

6) removing nitrogen oxides from motor vehicle exhaust

reducing coal use is economically & politically difficult

clean-up approaches are expensive and mask symptoms w/ out treating causes

acidified lakes can be neutralized by treating them or the surrounding soil with large amounts of limestone or lime. This is an expensive and temporary remedy.

Indoor air-pollution

levels of 11 common pollutants are generally 2-5 times higher inside homes and commercial buildings than outdoors

health risks high b/c people spend 70-98% of their time indoors

source of cancer risk

greatest risk people - smokers, infants & children under 5, the old, the sick, pregnant women, people with respiratory or heart problems, factory workers causes dizziness, headaches, coughing, sneezing, nausea, burning eyes, chronic fatigue,

sick building syndrome - flu-like symptoms from indoor pollution

a building is "sick" when at least 20% of its occupants suffer persistent symptoms that stop when they go outside new buildings are more commonly sick b/c of reduce air exchange, chemicals from building materials costs about $100 billion per yr. in absenteeism, reduced productivity, and health costs

caused by mineral fibers, fiberglass, formaldehyde (extremely irritating gas)

burning of wood, dung and crop residues in open fires in developing countries is responsible for many respiratory illnesses

What should be done about asbestos?

asbestos: several different fibrous forms of silicate minerals widely used since the 1940s for fireproofing and thermal insulation

if inhaled, they can remain in the lungs for years

used for fireproofing, soundproofing, insulation of heaters & pipes, brake linings, etc cause asbestosis: a chronic, sometimes fatal disease that eventually makes breathing nearly impossible

causes mesothelioma: an inoperable cancer of the chest cavity lining; can cause lung cancer for those affected. Asbestos miners, insulators, pipe fitters, shipyard employees, workers in asbestos-producing factories. Most asbestos factories have gone out of business or moved to other countries

Is your home contaminated with radon gas?

Radon-222: a colorless, odorless, tasteless, naturally-occurring radioactive gas produced by the radioactive decay of Uranium-238

if inhaled, it can expose lung tissue to large amounts of ionizing radiation

lifetime exposure in a home responsible for 13,600 deaths a year.

How is human health harmed by air pollutants?

1) lung cancer

2) asthma: typically and allergic reaction causing sudden episodes of acute shortness of breath

3) chronic bronchitis: persistent inflammation and damage to the cells lining the bronchi and bronchioles, causing mucus buildup, painful coughing and shortness of breath

4) emphysema: irreversible damage to air sacs or alveoli leading to abnormal dilation of air spaces, loss of lung elasticity, and acute shortness of breath CO reduces the ability of blood to carry oxygen which impairs perception, things, causes headaches, dizziness, nausea, and can trigger heart attacks, damage fetuses

How many people die prematurely from air pollution?

outdoor pollution deaths : 65,000 - 200,000 / yr

total pollution deaths : 150,000 - 350,000 / yr

How are plants damaged by air pollutants?

breaks down waxy coating that prevents water loss and damage from diseases, pests, drought, frost

interferes with photosynthesis and plant growth, reduces nutrient uptake, causes leaves to turn yellow and brown; conifers at high elevations are especially vulnerable forest diebacks in the Appalachian Mountains.

How can air pollutants damage aquatic life?

acid shock: caused by the sudden runoff of large amounts of highly acidic water & aluminum ions into lakes and streams, when snow melts or after unusually heavy rains.

decline in net primary productivity

kill all fish

in US 9,000 lakes are seriously threatened (Great Lakes)

What are the harmful effects of air pollution on materials?

costly cleaning needed, break down exterior paint on cars and houses, deteriorate roofing

deface irreplaceable marble statues, historic buildings, stained glass windows

$5 billion per yr. damage in the US

How have laws been used to reduce air pollution in the US?

Clean Air Acts (1970, 1977, 1990) - federal regulations enforced by each state

require standards set for 7 outdoor pollutants that specify a max level, averaged over a specific period, for a certain pollutant prevention of significant deterioration

national emission standards for toxic air pollutants

How could US air-pollution laws be improved?

rely on pollution prevention rather than cleanup sharply increase the fuel efficiency standards for cars and light trucks

require stricter emission standards for fine particulates

don't give municipal trash incinerators 30-yr permits setting strict standards for air-pollution emissions from incinerators

reduce emissions of carbon dioxide and other greenhouse gases

Should we use the marketplace to reduce pollution?

a power plant is given a certain # of pollution credits or rights each yr that allow it to emit a certain amount of SO_2. If they emit less SO_2 than the limit they receive more pollution credits.

advantages and disadvantages

get older, high-polluting vehicles off the road; stricter emission laws for lawnmowers, chainsaws, leaf blowers, etc.

California's South Coast Air Quality Management District Council developed a drastic program to produce and 80% reduction in ozone, photochemical smog, and other major air pollutants in L.A. by 2009

How can we reduce indoor air pollution?

rooftop greenhouses, breathing wall to absorb dirty air and exhale clean air

How can we protect the atmosphere?

emphasize pollution prevention

improve energy efficiency reduce use of fossil fuels (coal & oil)

slow population growth

integrate air-pollution, water-pollution, energy, land-use, population, economic, and trade policies

regulate air quality for an entire region or air shed phase in full-cost pricing, mostly by taxing the production of air pollutants

distribute cheap & efficient cook stoves & solar cook stoves in developing countries

transfer latest technologies to developing countries

Global Warming and Ozone Loss

The Greenhouse Effect and Global Warming
About the Greenhouse Effect

Greenhouse effect - certain gases in the atmosphere trap heat in the lower atmosphere (troposphere).

most widely accepted theory is by Svante Arrhenius in 1896

without it life would not exist as it does (covered by water)

the amount of trapped heat in the troposphere depends on the concentration of greenhouse gases and how long they stay.

Gases- water, carbon dioxide, ozone, methane, nitrous oxide (N_2O), and CFCs.

Carbon dioxide has a big effect on the amount of heat trapped

Global Warming

Global Warming - an enhancement in the Earth's natural greenhouse effect.

caused by burning fossil fuels, agriculture, deforestation and use of CFCs.

developed countries produce 60% of CO_2 emissions:

US-23% ; China-14% ; Russia-7% ; Japan-5%

altered gases will affect climate for centuries

Consensus About the Earth's Past Temperatures

- to tell about past temperatures - study glaciers
- Holocene - after each ice age the period of warmth
- small temp changes during this time have led to hardships
- Water vapor levels have remained consistent - shown through bubbling gases

Computer Models

General circulation models (GCM) - most sophisticated of computer models

There are 7 computer models:

1 Level of greenhouse gases

2 Average global temp

3 Changes in regional climate

4 Droughts

5 Increased rainfall and storms

6 Rising sea levels

7 Loss of Biodiversity

Many models disagree on how projected rises in average global temperatures may affect the climate in different areas.

About Future Global Warming and Effects

IPCC projects that the Earth's temp will rise to 1-3.5oC if the carbon dioxide doubles it will continue for hundreds of years.

Northern Hemisphere-warm faster because of heat-absorbing ocean and that water cools more slowly

More warming at the poles

5 of 9 ice shelves have broken up since 1950

Global warming may thicken the region's two largest ice shelves

Climate models project as the earth's atmosphere warms

The rate of water evaporation will rise; Global average precipitation will rise at mid-high latitude.

Possible signs of global warming

Increased retreat of glaciers on mountains tops (such as The Alps, Andes, Himalayas).

some warm-climate fish and trees will migrate Northward

warmer water may bleach coral reefs in tropical areas

Sea levels rise-48 centimeters (19 inches)-due to global warming and deforestation.

Warming or cooling by more than 1oC has caused serious disruptions of the current structure and functioning of Earth's ecosystems

Global Warming or A Lot of Hot Air? ; How serious is the threat?

Will Earth Really Get warmer?

There is controversy over whether we are already experiencing global warming

Since we only have 100 years of accurate data it is difficult to distinguish between climate noise and rise in global temperature.

How do Changes in Solar Output Affect Earth's Temperature?

Solar output varies according to 11 and 22 year sunspots

Sunspots - when strong solar magnetic fields periodically protrude through the sun's surface and slightly increase the sun's energy output, temporarily warming or cooling the Earth.

Sunspots account for only 10-30% of the warming during the past century.

If the sun continues to warm and our human activities don’t change, there will be even more greenhouse gases in the troposphere.

How do the Oceans affect Climate?

The world's oceans amplify global warming by releasing carbon dioxide into atmosphere or the world's oceans can dampen global warming by absorbing more heat.29% of excess carbon dioxide is removed by oceans which decreases global warming.

It takes hundreds of years for deep vertical mixing to take place

Deep ocean currents may be disrupted

Currents act as a giant conveyor belt which transfers heat and stores carbon dioxide in the deep sea heat, from tropical waters to Europe.

Global warming will reduce density and salinity of water.

If heat transfer loops stop, it could cause an atmosphere change of more than $5^{o}C$.

Water Vapor Content and Clouds Affect Climate

Warmer temps will increase evaporation and create more clouds.

Increase in water vapor may cause warming

Increase in production of clouds

By trapping heat it could have a warming effect or a cooling effect caused by reflecting sunlight back into space.

Scientists don't know what factors of clouds will be predominate

day: clouds are reflective and have a cooling effect

night: insulate and lead to warmer temps

thin and high: warming effect

low and thick: cooling effect

Changes in Polar Ice Affect Climate

Albedo: ability of the earth's surface to reflect light

Greenland and Antarctic - high albedo - light colored ice sheets reflect sunlight back into space-if they melt, more sunlight would be absorbed and warming would be accelerated.

Global warming increase earth's water stored as ice

Warmer air carries more water vapor that drops snow on polar glaciers, which will effect more ice- perhaps leading to a new ice age.

Air Pollution Affects Climate

Affected by air pollution - offset by aerosols

Sulfur dioxide and tiny particles attract enough water molecules to increase cloud formation - has a high albedo- reflecting more sunlight.

Clouds at night will cause heat to be stored in earth's surface.

Northern Hemisphere - 90% of sulfur dioxide emissions which may offset global warming.

Southern hemisphere - form particles in smoke emitted by burning rain forests, grass, woods, etc.

It is known that aerosols will have little effect on global warming.

Aerosols only stay in atmosphere for a few weeks

Component of acid rain that weakens trees, which creates more carbon dioxide in the atmosphere.

Increasing amount of aerosols in the world will kill people and crops.

Increased Levels of Carbon Dioxide: Does It Affect Photosynthesis and Methane Emissions

Remove carbon dioxide from atmosphere and help slow global warming.

Increase carbon dioxide rate may increase photosynthesis

It will depend on different types of plants in different climate zones.

High plant growth can be offset by plant-eating insects

Carbon Dioxide increase will worsen global warming because the stomata will remain closed for longer periods of time- water can't get out and the plant and its surroundings get warmer.

Forest turnover: how fast trees grow and die in a forest

Reduces the biodiversity because of the reducing removal of carbon dioxide.

Global warming accelerated by increased release of methane.

Increase in carbon dioxide=an increase in methane

If arctic tundras melt, huge amounts of methane are released

Rapid Climate Shift

If global temps change over the next decades we will not be able to switch food-growing regions and relocate the world's population near the coast.

Lead to deaths, chaos and reduction in biodiversity.

Temperatures have shifted as much as 10`F in past decades that lasted 1000+ years

The shifts are disastrous for humans

Human Responses Accelerate Global Warming

As temperatures increase people will use more air conditioning which requires more burning of fossil fuels which releases more carbon dioxide causing additional warming and more of a need for air conditioning.

Aerosols may offset warming but pollution will have serious health impact

Global warming and rises in average sea levels could either be half of current projections or double

Affected Food Production

Climate belts will shift northward -rise in global temperature cause a rise in food production

Depends on:

fertility of the soil

amount of money

Asia productivity will increase while U.S. and Canada will decrease.

Will cause increase in hunger and starvation

Increase in temps will allow insects and pests to live through the winter destroying crops

Seafood supplies decrease due to flooding of coastal wetlands.

Reduce biodiversity because of the average temp and depth of tropical ocean waters

Coral reefs – become bleached & animals will die

Global Warming's Effects on Forests and Biodiversity

The makeup and location of world's forests will change

Due to seed movement by animals forests will move further North

Mountaintops that are far North will become extinct- no where to go-causing release of carbon

Wildfires will happen in up to 90% of forests

Huge amounts of carbon dioxide will then accelerate global warming

Reductions in biodiversity due to mass extinction of animals that can't migrate

Fish would die because the temp would rise

What could happen to Sea Levels?

They will rise because ocean expands when heated

Will not rise because of melting glaciers and ice sliding into the sea

Sea levels will rise by 48 centimeters

Will affect cities near sea level (about 1/3 of world's people) would be flooded

Some islands would completely disappear

Beaches on East Coast might disappear within 25-50 years

Move barrier islands further inland, accelerate coastal erosion, contaminate coastal aquifers with salt water

How Might Weather Extremes Change Our Life

More air will move across the surface because more heat is retained in climate system

There may be higher wind speeds, clashing fronts and more violent weather

Increased intensity of hurricanes, typhoons and tornadoes

Financial challenges for insurance companies who have to pay billions of dollars to flood victims

Some companies are dropping their coverage or raising prices to be prepared and working with the government to decrease possible global warming

How Might Human Health Be Affected

Global warming will bring more heat waves (double number of deaths) increase asthma and bronchitis

Disrupt supplies of food and fresh water

Alter disease patterns

Insect diseases from tropical areas

Higher humidity levels

Rise in fungal skin diseases

Speed up bacterial growth

Climate change would lead to a large number of environmental refugees

Illegal migration would increase

Serious problems for foreign military and economic security policies of nations could occur

Solutions: Dealing with the threat of Global Warming

Do More Research or Act Now?

Three schools of thought:

1. no-problem is a minority view - global warming is not a threat but a hoax.

2. Waiting strategy - Wait until more info is available about the global climate system. Why spend hundreds of billions of dollars phasing out fossil fuels and replacing deforestation with reforestation to help ward off something that might not happen. ;

3. Precautionary strategy - take action instead of doing research

1997-American Economics Association

Oil & Insurance companies showed evidence that Human activities were contributing to Global Warming and they need to begin taking precautionary action.

Boiled Frog System-

How can we slow Possible Global Warming?

We must reduce current global CO_2 emissions by 66-83%

Solutions:

quickest and cheapest way is to use energy more efficiently

increased use of nuclear power

using natural gas- help to make the 40-50 year transition to an age of energy efficiency and renewable energy

phase out gov't subsidies for fossil fuels over a decade/gradually phase in carbon taxes on fossil fuels

1997- Economists & Nobel laureates signed statement:

sound economic analysis shows that greenhouse emissions can be out without harming American living standards

calling for carbon taxes as part of an international system of tradable permits for greenhouse gas emissions

Carbon tax based on

Polluter pays principle - requires industries and consumers to pay directly for the full environmental costs of the fuels they use

Agreement to global & national limits on greenhouse gas emissions

Can Technofixes Save Us?

Technofixes- technological solutions for dealing with possible global warming

Adding iron to oceans-would remove more CO2 through photosynthesis

Unfurling gigantic foil-surfaced sun mirrors in space to reduce solar input.

Injecting sunlight - reflecting sulfate particulates into the stratosphere - mimics cooling effects of giant volcanic eruptions

What has been done to reduce Greenhouse Gas emissions?

2,200 delegates from 161 nations met in Kyoto, Japan negotiated treaty to help slow global warming

The goal:

between 2008 & 2012: 12-38 developed countries should have cut greenhouse emissions to an average of 5.2% below 1990 levels

developing countries won't be required to cut · there would be penalties for countries that violate treaty laws

forested countries get a break in their quotas

since the treaty was made, US cut greenhouse emissions by 7%, Japan by 6% and European countries by 8%

How can we prepare for possible global warming?

waste less water

develop crops that need less water

move hazardous materials (storage tanks) away from the coast

prohibit new construction or remolding on low-lying coastal areas

stockpile 1-5 years supply of key foods

expand existing wild life reserves with corridors

Ozone Depletion: is it a serious threat?

What is the Threat from Ozone Depletion?

Ozone layer- 450 million years old

It allowed life to develop and expand on land and in the surface layers of aquatic systems

oxygen- converted to ozone and back to oxygen by sequence of reactions initiated by ultraviolet radiation from the sun.

$$3\ 0_2 + UV \longrightarrow 2\ 0_3$$

result- a thin veil of renewable ozone at very low concentrations; absorbs about 99% of the harmful incoming ultraviolet radiation from sun & prevents it from reaching the earth's surface UV radiation reaching the stratosphere consists of 3 bands: A, B, C

UV-C ; highest energy, shortest wavelength, most hazardous

UV-B ; next highest and biologically damaging

UV-A ; lowest energy- can also damage living cells

What Causes Ozone Depletion? From Dream Chemicals to Nightmare Chemicals

Thomas Midgely, Jr. (a General Motors chemist) discovered the first chlorofluorocarbon (CFC) in 1930

2 most widely used: known as Freons

CFC-11 (trichlorofluoromethane)

CFC-12 (dichlorofluromethane)

seemed like dream chemicals

cheap to make, stable, odorless, nonflammable, nontoxic & noncorrosive

used as

coolants in air conditioners & refrigerators

propellants in aerosol spray cans

cleaners for electronic parts

sterilants for hospital instruments

1974 - chemists Sherwood Rowland & Mario Molina indicated that CFCs creating a global chemical time bomb by lowering the average concentration of ozone in the stratosphere found that:

spray cans, discarded or leaky refrigeration & air conditioning equipment, and the production & burning of plastic foam products release CFCs into the atmosphere. They rise slowly into the atmosphere (10-20 yrs)

A CFC molecule can last in the stratosphere for 65-110 yrs.

Turned into a nightmare of global ozone destroyers

What other chemicals Deplete Stratospheric Ozone?

ODC's- ozone depleting compounds Halons & HBFC's - long-lived bromine-containing compounds such as methyl bromide

Carbon tetrachloride- cheap/highly toxic solvent

Methyl chloroform - toxic

1,1,1-trichloroethane - cleaning solvent in more than 160 consumer products

Why is There Seasonal Thinning of Ozone over the poles?

1984- researchers discovered 40-50% of ozone in upper stratosphere over Antarctica was being destroyed

1987 - "smoking gun" - CFCs primarily cause of ozone thinning. Polar vortex - huge swirling mass of very cold air that is isolated from the rest of the atmosphere until the sun returns a month later

Is Ozone Depletion Really a Serious Problem?

some say ozone depletion is a hoax & exaggerated problem

others believe it is a problem

Why Should We Be Worried about ozone Depletion? Life in the Ultraviolet Zone

less ozone causes:

worse sunburns

more cataracts

more skin cancer

skin cancer & cataracts - increasing in Australia, New Zealand, South Africa, Argentina & Chile because the ozone layer is thin got several months a year there

Solutions: Protecting the Ozone Layer

How can we protect the ozone layer?

researchers say stop producing all ozone-depleting chemicals

substitutes are available for CFCs: HCFCs - contain fewer chlorine atoms per molecule than CFCs. HFCs contain fluorine but no chlorine. HCs - hydrocarbons - useful as coolants & insulating foam in refrigerators

Can TechnoFixes Save us?

Physicist Alfred Wong - each year wants to launch blimps 20-30 football-fields long.

Blimps are radio-controlled and would contain electrical wires that would inject negatively charged electrons to the stratosphere when exposed to high voltages

Others suggest using lasers to blast CFCs out / but no one knows how it will affect climate, birds, or planes

What is being done to reduce ozone Depletion? Some helpful progress

Montreal Protocol - treaty created in 1987 by 36 nations

Says- cut emissions of CFC's into the atmosphere by about 35% between 1989 & 2000 Met 3 more times

Met in 1997 in Montreal

> adopted a protocol accelerating the phase out of key ozone depleting chemicals
>
> CFC production fell by 85%

Will the International Treaty to Slow Ozone Depletion Work?

still a black-market of CFCs - some countries cheating

prevention is the best way to deal with global environmental problems

Water Pollution

Water Pollution is any chemical, biological, or physical change in water quality that has a harmful effect on living organisms and makes water unsuitable for desired uses

Classes/Categories of Water Pollution

Disease Causing Agents (**pathogens**): i.e., bacteria, viruses, protozoa, and parasitic worms from domestic sewage from human and animal wastes

Oxygen Demanding Wastes: organic wastes that can be decomposed by aerobic bacteria which depletes oxygen

Biological oxygen demand (**BOD**): amount of dissolved oxygen needed by aerobic decomposers to break down over 5-day period @ 20 ^{o}C (68^{o}F)

Water-Soluble Inorganic Materials: water-soluble nitrates and phosphates, can cause excessive growth of algae and other aquatic plants that die and deplete the oxygen content (kills fish)

Organic Chemicals: threatens human, animal and aquatic plant life, i.e., oil, gas, plastic, pesticides, detergents, etc.

Sediments or Suspended Matter (largest class): particles of soil/solid that stay suspended in water and made the water cloudy, reduces photosynthesis and disrupts food webs and clogs harbors, reservoirs, channels and artificial lakes

Water-Soluble Radioactive Isotopes: in tissues and organs and cause birth defects, cancer and genetic damages

Thermal Pollution: rise in water temp b/c of heat absorbed in water to cool power plants: lowers water and makes organisms more vulnerable to disease

Genetic Pollution: deliberate or accidental addition of nonnative species disrupts aquatic systems and crowd out natives: reduces biodiversity: principal way they are introduced = intake and ballast from ships

Good indicator for quality of drinking and swimming water is the number of **coliform bacteria** present in 100-mL sample

WHO recommends 0 colonies for drinking
EPA recommends max of 200 colonies for swimming

Avg. person excretes 2 billion bacteria/day

We detect water pollution through chemical analysis, using living organisms as indicator species, computer models of aquatic life zones

Air and water pollution through chemical analysis, using living organisms as indicator species, computer models aquatic life zones (saves $)

Air and water pollution are closely related because they mix together

Point sources of water pollution have a specific location (pipes, ditches, sewers): fairly easy to find and monitor: developed countries = controlled: developing = uncontrolled

Nonpoint sources of water pollution can't be traced to 1 site (large land areas, runoff, surface flow) In US, sediment, inorganic fertilizer, manure, salts dissolved in water and pollutants = 64% of mass of pollutants in streams and 57% entering lakes

Storm water causes 33% of contaminates in lakes and estuaries

Pollution of Streams and Lakes

Pollution of streams

Flowing streams and rivers recover rapidly from degradable, oxygen demanding wastes and excess heat by a combination of dilution and bacterial decay (natural process which works as long as streams aren't overloaded with pollutants: doesn't get rid of slowly degradable and nondegradable pollutants).

Oxygen sag curve: depends on stream's volume, flow rate, temperature, pH level and volume of incoming degradable wastes. Extracting drinking water downstream rather that upstream (what we do now) would improve water quality. Then each city would be forced to do a better job of cleaning up its waste water.

Pollution control laws from the 1970s have increased the quality and number of wastewater treatment plants

Ohio’s Cayahoga River (Cleveland) prompted city, state and federal officials to enact laws limiting the discharge of industrial wastes. Improvements of dissolved oxygen content in Canada, Japan and most western European countries

1950 Thames River in England was an anaerobic sewer: 30-year $250 million effort to clean it up with taxpayer money

Although, large fish kills and contamination of drinking water still occur

In developing countries waste water treatment is almost nonexistent (Soviet Union: Eastern European countries)

More than 2/3 of India’s water is polluted. 54 out of 78 monitored streams in China are polluted, and 20% of its rivers are too polluted to use for irrigation.

Pollution of Lakes

In lakes, reservoirs, and ponds, dilution is less effective than in streams

Stratified layers, volumes of water with little flow (reduces levels of dissolved oxygen).

Flushing and changing of water in lakes and large artificial reservoirs takes between 1 and 100 years.

More vulnerable to contamination by plant nutrients, oil, pesticides, and toxic substances: destroy bottom life, and fish and birds that feed on contaminated aquatic organisms.

Thousands of waterfowl and fished died at the Kesterson National Wildlife Refuge in the San Joaquin Valley, CA, due to selenium-contaminated water flowing into the lakes

Eutrophication: natural enrichment of lakes

Cultural Eutrophication: process of human activities accelerating the input of nutrients.

Animal wastes fertilizes cropland and is stored in pits and lagoons that can pollute the ai.r

1996: more that 40 animal waste spills killed 670,000 fish in Iowa, Minnesota and Missouri.

Hot weather and droughts produce more bacteria

1/3 of the 100,000 medium-large lakes and 85% of the large lakes near modern population centers in the US suffer from some sort of cultural eutrophication.

Prevention of cultural eutrophication = advanced waste water treatment which bans/limits the amount of phosphates in detergents; soil conservation, and land use control

Cleanup methods = dredging bottom sediments, removing excess weeds, controlling plant growth with herbicides and algaecides, pumping air (oxygen) thorough lakes and reservoirs.

Prevention is more effective and usually cheaper in the long run than pollution control

Seattle's Lake Washington = success story from eutrophication when sewage was diverted into Puget Sound.

The Great Lakes

The five Great Lakes contain at least 95% of fresh surface water in US and 20% of the world's fresh surface water basin of the lakes is home for 30% of the Canadian population and 14% of the US population

Vulnerable to pollution from point and nonpoint sources, i.e., land runoff, acids, pesticides, other toxic chemicals

1960s and 1970s: Lake Erie beaches were closed, lost almost all native fish: 1972 = $20 billion pollution-control program with Canada and US.

DDT and PCBs flow into lakes from land runoff, streams and atmospheric deposition

Great lakes fisheries also face threats form genetic pollution

1986 = zebra mussel (no known natural enemies) invaded the lakes and depleted the food supply for other lake species: costs $500 million per year and could reach $5 billion

1991 = invasion of the quagga mussel

Streams and Lakes Polluted by Heat

2/3 of the energy in the fuel used by coal-burning and nuclear power plants is converted to heat that must be dissipated into the environment; cheapest and easiest way to withdraw the surface water to cool the plant, is to pass it through the plant and return the heated water back to the lake: ½ water withdrawn in US is used for cooling electrical power plants.

Thermal shock: the effect of sharp changes in water temperature (kills fish that can't adapt). Thermal enrichment: beneficial uses of heated water.

Lengthens the commercial fishing season, reduces winter ice cover in cold areas, can extend the growing seasons, help heat nearby buildings and greenhouses

Ways to reduce/control thermal water pollution

> Use and waste less energy
>
> Limit the amount of heated water discharged into a body of water
>
> Return the heated water to a place that is away from the ecologically vulnerable shore zone
>
> Transfer the heat from the water to the atmosphere by means of huge cooling towers
>
> Discharge the heated water into shallow ponds or canals, and reuse it as cooling water

Ocean Pollution

Oceans are the ultimate sink for waste

“Water may flow in a thousand channels, but it all returns to the sea” Oceans can dilute, disperse, and degrade large amounts of raw sewage, sewage sludge, oil, and some types of industrial waste.

It is generally safer to dump sewage sludge and most other hazardous wastes in the deep ocean because marine life is generally more resilient

Coastal areas have enormous inputs of wastes

Half the world’s population lives on or within 100 kilometers (160 miles) of the coast The most polluted seas lie off the densely populated coasts of Bangladesh, India, Pakistan, Indonesia, Malaysia, Thailand, and the Philippines. About 85% of the sewage from large cities along the Mediterranean is discharged directly into the sea untreated.

In the US about 35% of municipal sewage ends up virtually untreated. Actors from Baywatch received extra pay for going into the Santa Monica Bay (because it is so polluted).

Runoff of sewage and agriculture wastes into coastal waters and acid deposition from the atmosphere introduce large quantities of nitrogen and phosphorous, which can cause explosive growth (blooms) of algae or other organisms

Chesapeake Bay

Chesapeake Bay is the largest estuary in the US

Between 1940 and 1995 the number of people living in the Bay Area grew from 3.7 to 15.5 million, and will soon reach 18 million.

The Chesapeake Bay receives wastes from point and nonpoint sources (9 large rivers, 141 smaller streams and creeks from 6 states)

The Bay is shallow and only 1% of the waste entering it is flushed to the Atlantic

Levels of phosphates and nitrates have risen: point sources contribute 60% by weight of the phosphates and nonpoint sources contribute about 60% by weight of the nitrates.

Air pollutants account for almost 35% of the nitrogen entering the estuary.

In the 1980s the Chesapeake Bay Program was the country's most ambitious attempt at integrated coastal management. Results were impressive. Between 1987 and 1993, phosphorus levels dropped 16%; nitrogen levels dropped 7%; the drops led to a 75% increase in the abundance of submerged vegetation between 1978 and 1993 and the bass population rebounded.

In 1997 federal and state officials offered farmers in Maryland more that $250 million in subsidies to leave potential cropland near the bay unplanted.

Back to the Oceans

Dumping of industrial waste off US coasts has stopped but still occurs in other developed and developing countries

Barges and ships still legally dump large quantities of dredge spoils (materials laden with toxic metals scraped from the bottoms of harbors and rivers to maintain shipping channels) at 110 sites off the Atlantic, Pacific and Gulf coasts.

Sewage sludge: a gooey, mudlike mixture of toxic chemicals, infectious agents, and settled solids removed from wastewater at treatment plants. Since 1992 this process has been banned.

50 countries with at least 80% of the world's merchant fleet have agreed not to dump sewage and garbage at sea. But it is difficult to enforce and is often violated. London Dumping Convention of 1972 – 100 countries agreed not to dump highly toxic wastes into the open sea.

1994: became a permanent ban (see page 546, Miller)

Oil

Crude petroleum, refined petroleum and other processed petroleum products are accidentally or deliberately released into the environment from a number of sources.

Tanker spills and blowouts, offshore drilling rig accidents,

Almost ½ of the oil reaching the oceans is waste oil dumped, spilled, or leaked onto the land or into sewers by cities, individuals and industries

The Effects of Oil on the Ocean depend on: the type of oil (crude or refined), amount released, distance of release from shore, time of year, weather conditions, average water temperature, and ocean currents.

Research shows that most (but not all) forms of marine life recover from exposure to large amounts of crude oil within 3 years. Recovery from exposure to refined oil may take 10 years or longer

Moderate oil spills can be cleaned up by mechanical, chemical, fire, and natural methods

Mechanical methods include:

> Floating booms to contain the oil spill or keep it from reaching sensitive areas
>
> Skimmer boats to vacuum up some of the oil into collection barges
>
> Absorbent pads or large feathered filled pillows to soak up oil on beaches or in waters to shallow for skimmer boats

Chemical methods include:

> Coagulating agents to cause floating oil to clump together for easier pick up or sink to the bottom where is usually does less harm
>
> Dispersing agents to break up oil slicks (BP used Corexit 9500 and Corexit 9527 in the Gulf of Mexico oil leak incident).

Methods remove only part of the oil and none work well on a large spill: preventing the spill in the first place is much cheaper.

Oil is responsible for most of the world’s air pollution

Exxon Valdez: March 24, 1989: coated more than 1,600 kilometers (1,000 miles) of shoreline. (see page 547+548);

Gulf of Mexico, April, 2010. Worst oil spill ever.

Key to protecting the oceans is to reduce the flow of pollution from the land and from streams emptying into the ocean (see page 549 for a list of prevention methods and cleanup methods)

Solutions: Preventing and Reducing Surface-Water Pollution

The leading nonpoint source of water pollution is agriculture

Farmers can sharply reduce fertilizer runoff into surface waters and leaching into aquifers by using moderate amounts of fertilizer and by using none at all on steeply-sloped land, planting buffer zones between rows of crops and applying pesticides only when needed.

Livestock growers can control runoff and infiltration of manure from feedlots and barnyards by managing animal destiny, planting buffers and not locating feedlots on land near surface water when land slopes towards the water.

The Federal **Water Pollution Control Act of 1972** (renamed the Clean Water Act in 1977) and the 1987 Water Quality Act form the basis of the US efforts to control pollution of the country's surface waters. EPA developed a discharge trading policy in 1995 to use market forces to reduce water pollution (see page 550 to learn more about the acts)

Septic Tank: in rural and suburban areas with suitable soils. Sewage from each house is usually discharged into these

About 25% of all homes in the US are served by septic tanks which need to be cleaned out every 3-5 years)

Primary Sewage Treatment: a mechanical process that uses screens to filter out debris such as sticks, stones, and rags; suspended solids settle out as sludge in a settling tank.

S**econdary Sewage Treatment**: a biological process in which aerobic bacteria are used to remove up to 90% of biodegradable, oxygen demanding organic wastes.

Trickling filters, activated sludge process

Advanced Sewage Treatment: a series of specialized chemical and physical processes that remove specific pollutants left in the water after primary and secondary treatment. Types of advanced treatment vary according to the specific contaminants being removed.

Before water is discharged after primary, secondary or advanced treatment, it is bleached and disinfected (usually by chlorination, ozonation or UV irradiation).

Some communities and individuals are seeking better ways to purify contaminated water by working with nature.

Scientists at Living Technologies are developing neighborhood–level *sewage walls* that would run along the length of a residential block. In developing countries, a promising new technology for processing domestic waste is the SIRDO system (double vault).

Groundwater Pollution and its Prevention

Pollutants in drinking water is a high-risk health problem

When water becomes contaminated, it cannot cleanse itself of degradable wastes, as surface water can if it is not overloaded.

Crude estimates indicate that up to 25% of usable groundwater in the US is contaminated.

Groundwater can be contaminated from a number of sources:

Underground storage tanks

Landfills

Abandoned hazardous waste dumps

Deep wells used to dispose of liquid hazardous wastes

Industrial waste

Livestock waste storage lagoons

EPA estimates at least 1 million underground tanks of gas, diesel fuel and toxic solvents are leaking into groundwater

Determining the extent of a leak costs between $25,000-$250,000, and cleanup costs range from $10,000-$250,000 depending on the size. A complete cleanup is rarely possible. Replacing a leaking tank adds an additional $10,000-60,000.

Pumping polluted groundwater to the surface and cleaning it up is too expensive and it would take between 50-1,000 years to clean it all up (for more prevention and cleanup methods see page 556)

Drinking Water Quality

Many rivers in Eastern Europe, Latin America, and Asia are used as sources of drinking water, but are contaminated with pesticides, fertilizers and hazardous organic chemicals.

In China 41 large cities get their water from polluted groundwater
In Russia ½ of all tap water is unfit to drink and 1/3 of the aquifers are too contaminated for drinking purposes
About 54 countries (most in N. America and Europe) have safe drinking water standards.

64 contaminates are currently tested for in drinking water

Privately-owned wells don't have to meet federal drinking water standards.
In Milwaukee, Wisconsin and Las Vegas, Nevada there were outbreaks of *Cryptosporidium* in 1993 and 1994

Congress is trying to weaken the Safe Drinking water Act and Environmentalists are trying to get it strengthened (see page 557)
The US has one of the world's best drinking water supply systems. We need to shift our emphasis from pollution cleanup to pollution prevention:

Source reduction

Reuse of wastewater
Recycling pollutants

We need to accept that the environment (air, water, soil, life) is an interconnected whole.

Protecting Food Resources: Pesticides and Pest Control

Types of Pesticides and Their Uses

Pests: Any species that competes with us for food, invades lawns and gardens, destroys wood in houses, spreads disease, or is a nuisance.

Pesticides (Biocides): Chemicals developed to kill organisms that we consider undesirable.

1. Insecticides - Insect-killers

2. Herbicides - Weed-killers

3. Fungicides – Fungus-killers

4. Nematocides – Roundworm-killers

5. Rodenticides – Rat- and Mouse-killers

The First Generation of Pesticides:

1. Sulfur – used as an insecticide since 500 BC
2. Nicotine sulfate – extracted from tobacco leaves in the 1600s
3. Pyrethrum – obtained from the heads of chrysanthemum flowers
4. Rotenone – from the root of the derris plant

The Second Generation of Pesticides:

About 2.5 million tons of pesticides are used yearly, worldwide. In the United States, about 630 different biologically active (pest-killing) ingredients and 1,820 inert (inactive) ingredients are mixed to make 25,000 different pesticide products.

1. DDT – 1939, Entomologist Paul Mueller discovered that DDT (dichlorodiphenyltrichloroethane) was a potent insecticide. It soon became the world's most-used pesticide.
2. Broad-spectrum agents – toxic to many species
3. Selective-spectrum agents – effective against a narrowly defined group of organisms.

Persistence – the length of time in which pesticides remain deadly in the environment.

The Case For Pesticides:

1. Pesticides save human lives: Since 1945 DDT and other insecticides have probably prevented the premature deaths of at least 7 million people from insect-transmitted diseases.

2. Pesticides increase food supplies and lower food costs: About 55% of the world's potential human food supply is lost to pests before or after harvest. Without pesticides, these losses would be worse, and could cause the prices of food in the U.S. to rise nearly 50%.

3. Pesticides increase profits for farmers. Overall, for every dollar spent on pesticides, there is an increase in U.S. crop yields worth approximately two dollars.

4. Pesticides work faster and better than alternatives: Pesticides can control most pests quickly and at a reasonable cost.

5. The benefits overpower the health risks: Safer and more effective pesticides are being developed.

The Case Against Pesticides:

1. Genetic resistance – Insects can develop immunities to pesticides in just a few years.

2. Broad-spectrum insecticides kill good organisms – This includes killing natural predators and parasites that may have been maintaining the population of a pest species at a reasonable level.

3. Unexpected outcome – Wiping out natural predators can also unleash new pests whose populations the predators had previously held in check, causing other unexpected effects.

The Pesticide Treadmill: A situation where farmers are forced to pay more for a pest control program that often becomes less effective as genetic resistance develops.

Although the use of synthetic pesticides has increased 33-fold since 1942, it is estimated that more of the U.S. food supply is lost to pests today than in the 1940s.

The estimated environmental, health, and social costs of pesticide use in the United States range from $4 billion to $10 billion per year.

Alternative pest control practices could halve the use of chemical pesticides on 40 major U.S. crops without reducing crop yields.

A 50% cut in U.S. pesticide use would cause retail prices to rise by only about 0.2% but would raise average income for farmers about 9%.

Where Do Pesticides Go?

Environmental Effects:

Less than 2% of the insecticides applied to crops by aerial spraying or by ground spraying actually reach the targeted pests.

Some pesticides can harm wildlife. DDT had harmful effects in the environment when it biologically magnified in food webs. This resulted in certain birds being listed on the endangered species list in the U.S. because of fatal effects. Each year 20% of honeybee colonies in the U.S. are wiped out by pesticides, while another 15% are damaged, costing farmers over $200 million annually.

Human Health:

An estimated 25 million agricultural workers in developing countries are seriously poisoned by pesticides each year. 220,000 deaths result.

In developed countries an estimated 300,000 farm workers suffer from pesticide-related illnesses yearly. 250,000 Americans get sick each year from home misuse of pesticides.

Approximately 13% of vegetables and fruits consumed in the United States may contain illegal pesticides and levels of approved pesticides above their legally allowed limits.

At least 75% of the active ingredients approved for use in U.S. pesticide products cause cancer in test animals.

Pesticide Regulation in The United States:

All commercial pesticides must be approved by the EPA for general or restricted use

When a pesticide is legally approved for use on fruits or vegetables, the EPA sets a tolerance level, which specifies the amount of toxic pesticide residue that can legally remain on the crop when the consumer eats it.

According the a National Academy of Sciences study, federal laws regulating the use of pesticides in the United States are inadequate and poorly enforced by the EPA, FDA, and USDA.

Exposure to pesticide residues in food causes 4,000-20,000 cases of cancer per year in the United States.

A 1993 study of pesticide safety by the U.S. National Academy of Sciences urged the government to do the following things:

> Make human health the primary consideration for setting limits of pesticide levels allowed in food.
>
> Collect more and better data on exposure to pesticides for different groups, including farm workers, adults, and children.
>
> Develop new and better test procedures for evaluating the toxicity of pesticides, especially for children.
>
> Consider cumulative exposures of all pesticides in food and water, especially for children, instead of basing regulations on exposure to a single pesticide.

The 1996 Food Quality Protection Act:

> Requires new standards for pesticide tolerance levels in foods, based on a reasonable certainty of no harm to human health.
>
> Requires manufacturers to demonstrate that the active ingredients in their pesticide products are safe for infants and children.
>
> Allows the EPA to apply an additional 10-fold safety factor to pesticide tolerance levels to protect infants and children.

Requires the EPA to consider exposure to more than one pesticide when setting pesticide tolerance levels.

Requires the EPA to develop rules for a program to screen all active and inactive ingredients for their estrogenic and endocrine effects by 1999.

Solutions:

How Can Cultivation Practices Control Pests:

Crop rotation

Planting rows of hedges or trees around fields to hinder insect invasions.

Adjusting planting times so that major insect pests either starve or get eaten by their natural predators.

Planting trap crops to lure pests away from the main crop.

How Can Genetically Resistant Plants Help Lower Pest Losses:

Plants and animals that are genetically resistant to certain pests insects, fungi, and diseases can be developed.

We can use genetic engineering to build pest resistance into crops and thus reduce the need for pesticides.

Using Natural Enemies to Help Control Pests: Biological control using predators, parasites, and pathogens to regulate pests populations.

Using Biopesticides to Control Pests

Insect Birth Control, Sex Attractants, and Hormones: Males of some insect pest species can be raised in the laboratory, sterilized by radiation or chemicals, and then released into an infested area to mate unsuccessfully with fertile wild animals.

Hot Water: The ‘Aqua Heat’ Machine sprays boiling water on crops to kill weeds and insects.

Radiation: Exposing certain foods after harvest to gamma rays emitted by radioactive isotopes will extend food shelf life and kill harmful insects, parasitic worms, and bacteria.

Integrated Pest Management (IPM): In this approach, each crop and its pests are evaluated as parts of an ecological system. Then a control program is developed that includes a mix of cultivation and biological and chemical methods applied in proper sequence with the proper timing.

The overall goal is not to eliminate pest populations, but reduce crop damage to an economically tolerable level.

IPM requires expert knowledge about each pest situation, and is much slower acting then conventional pesticides.

Although long-term costs are typically lower than the costs of using conventional pesticides, initial costs may be higher.

Scientists urge the USDA to promote IPM in the U.S. by:

> i) Adding a 2% sales tax on pesticides and using revenue to fund IPM research and education.
>
> ii) Setting up a federally supported IPM demonstration project on at least one farm in every county.
>
> iii) Training USDA field personnel and county farm agents in IPM so that they can help farmers use this alternative.
>
> iv) Providing federal and state subsidies to farmers who use IPM.
>
> v) Gradually phasing out subsidies to farmers who depend almost entirely on pesticides, once effective IPM methods have been developed for major pest species.

Solid and Hazardous Waste

Love Canal Tragedy

1492-1953 Hooker Chemicals and Plastics dumped chemical wastes into the Love Canal

The company filled the canal and sold it to the Niagara Falls school board warning them not to disturb the clay cap covering the wastes.

development of the area causes a “bathtub” effect that released harmful contaminates. Many health problems resulted.

The company was sued for damages

Wasting Resources: The high-waste approach

33% of the world’s solid waste is in the USA

Solid waste: Any unwanted material that is not liquid or gas,

98% of solid waste comes from mining and oil/natural gas production.

Industrial Solid Waste includes: wasted scraps, sludge, fly ash, old machinery

Remaining 1.5% is Municipal Solid Waste- from homes and businesses in urban areas

Often the disposal of this waste often goes unchecked

What is hazardous waste, and how much is produced?

Includes:

contains one or more of the 39 toxic, etc. compounds.

flammable.

explosive, produce toxic fume.

corrosive.

Does not include:

Radioactive wastes

Hazardous wastes discarded by households

Mining wastes

Oil and gas-drilling waste

Liquid waste containing organic hydrocarbon waste

Cement kiln dust

Waste from small businesses and factories

5.5 billion metric tons of hazardous waste are disposed of each year

6% is legal hazardous waste

94% is unregulated waste

Producing Less Waste and Pollution: Reducing Throughput

What are the options? 2 ways:

High-waste approach - Burying, burning, or shipping hazardous waste to another country/county.

Low-waste approach - Views waste as a potential resource: Recycle, compost, or reuse. Also try to avoid contributing to the amount of hazardous waste

Goals:

Reduce
Reuse
Recycle and compos
Incinerate
Bury

Why is producing less waste and pollution the best choice?

Saves energy and virgin resources

Reduces environmental effects of extracting, processing, and using resources

Improves worker health and safety

Decreases pollution control and waste management costs

3M Company - Pollution Prevention Pays (3P) Program: Redesigned equipment and processes, identified chemical outputs, and recycled or sold them as raw material to other companies

waste was down 30%; Air pollution was reduced 70%; saved $750 million in waste disposal costs

Solutions: How can we reduce waste and pollution?

Redesign manufacturing processes to be more efficient

Design products that use less pollution and waste fewer resources in their production

Redesign manufacturing processes to produce less waste

Individual reduction of hazardous cleaning products

Green design and life cycle assessment help develop products that last longer and are easy to repair, reuse, manufacture, compost, or recycle

Trash taxes- Charging money per bag of trash. "Pay as you throw away' system is being used in parts of the US. Reuse

Reuse
What are the advantages of refillable containers?

Extends resource supplies

Keeps high-quality matter resources from being reduced to low-quality matter waste

Reduces energy use and pollution.

Reuse of glass bottles has virtually gone away

Some want the reinstatement of the system because of the money it saves

Examples of reusable containers include lunchboxes and Tupperware

What kind of bags should you use for groceries?

Plastic containers degrade slowly.

Paper bags use trees and pollute the air and water

Overall paper bags do more environmental damage, and cost more to produce.

The best kind of bag to use is **canvas** - reusable

What can we do with used tires?

2.5-4 billion used tires are in landfills, old mines, abandoned houses, and other dump sites.

Fire hazard

Also produces air pollutants and toxic run-off when burned

Reuse by retreading the tires, using for foundations of homes, artificial reefs, walls for highways, or use to produce electricity, or recycle to make resins to manufacture certain products.

Recycling

How can we recycle organic solid wastes? Community Composting

Compost- dark-brown, humus-like material that is rich in organic matter and soil nutrients.

produced when microorganisms break down organic matter

35% of municipal solid waste is biodegradable

To compost - mix unwanted wastes with soil, put the mixture in a pile or container, stir occasionally, and let rot for months.

Resulting compost can be used as an organic soil fertilizer, topsoil, landfill cover

Also restores eroded soil on hills, highways, strip-mined land, overgrazed land, and eroded cropland.

You need to control compost in order to be successful. 3 ways:

Enclosing the facilities and filtering the air inside.

Creating municipal compost operations near existing landfills

Decomposing biodegradable wastes in a closed metal container

What are the two types of Recycling?

Primary or secondary.

Primary or closed-loop recycling - Wastes from consumers are recycled to create products of the same type.

Secondary or open-loop recycling - Waste material is converted into other products.

Primary recycling reduces virgin material use by 20-90%

Secondary reduces virgin material use by only 25%

Case Study: Recycling municipal solid waste in the US

27% of municipal solid waste was recycled or composted in 1996.

A lot of cities in the US have curbside recycling programs showing a 50-80% recycling rate is possible.

"Pay as You Throw"- Charge money for amount of non-recycled garbage per family Recycling also creates jobs.

Is centralized recycling of mixed solid waste the answer?

Large scale recycling can be achieved by collecting mixed urban waste and transporting it to centralized Materials-Recovery Facilities (MRFs)

RECYCLE: Machines separate the materials into paper, plastic, etc. from glass and valuable resources which are sold to companies.

INCINERATE: Plastic and paper are burned to produce electricity.

Negatives:

Plants are expensive and difficult to maintain

There must be a large input of garbage to outweigh the costs

These plants can release toxic air pollutants

Create health threats for the workers

Odor

Noise

Truck Traffic

Is separating solid wastes for recycling the answer?

Most solid waste experts say it makes sense for trash to be sorted into reusable and nonusable before it is picked up.

Many small source separation operations are being squeezed out by large waste management companies operating the material recovery facilities.

Some government contracts allow the large companies to take the business.

The aluminum and paper separated from recycling are worth a lot of money, and are sometimes stolen.

Does recycling make economic sense?

Yes and No

Recycling programs should not be judged on whether they pay for themselves.

Problems with recycling....

Is almost a religion that is above criticism

Doesn't make sense if cost outweighs putting garbage in a landfill or burning it.
Is often not needed to save landfill space

Makes sense for valuable, but plentiful recyclable materials, but does not makes sense for cheap or plentiful resources and most plastics (expensive to recycle).

Benefits of recycling...

Does help the economy, health, and environment overall
Been found to make money in cities with high recycling rates
Reduces the use of virgin resources
Reduces throughput of matter and energy resources
Reduces environmental degradation

Why don't we have more Reuse and Recycling? Three factors that hinder recycling:

Environmental and health costs are not added to the price of raw materials

Resource extracting industries get better tax breaks than recycling companies

There is not a big enough market for recycled goods

The best way to overcome obstacles to recycling is to make recycling cheaper and to make raw materials and waste disposal (non-recyclable) more expensive.

Case studies: Recycling aluminum, wastepaper, and plastics

How much aluminum is being recycled?

Benefits of recycling aluminum as opposed to mining:

95% less air pollution

95% less water pollution

95% less energy used

In 1994 62% of aluminum cans were recycled (only 15% in 1973).

How much wastepaper is recycled?

Paper is one of the easiest materials to recycle

In 1996 the US recycled 40% of its waste paper

Benefits: Saves energy, reduces air pollution, water pollution, groundwater contamination, saves water, saves money.

Is it possible to recycle plastics?

Plastics industry is a leading producer of toxic waste

Most plastics are nondegradable or take 200-400 years to degrade

Environmentalists believe that many uses for plastics are unnecessary

Detoxifying, burning, burying, and exporting wastes

How can hazardous waste be detoxified?

If waste can't be reused and it is toxic, it must be converted into a less toxic form. Denmark has the best toxic waste detoxification program in the world.

Bioremediation- using microorganisms to detoxify

Photoremediation- using plants to remove contaminants

Is burning solid and hazardous waste the answer?

15% of municipal solid waste, and 7% of hazardous waste was burned in 150 incinerators

All incinerators burning hazardous waste pollute the air

Many incinerators are being shut down

Japan uses incinerators the most, and consequently has the most air pollution

Is land disposal of solid waste the answer?

Sanitary landfill- 57% of solid waste

benefits: cheap, easy, reduces air pollution

drawbacks: groundwater pollution, and gases from anaerobic decomposition

Is land disposal of hazardous wastes the answer?

Deep Well Disposal

pumping waste into layers of rock below

aquifers used for groundwater

Surface Impoundment

ponds and lagoons

pollute groundwater and air

Is exporting waste the answer?

Many countries are trying to ban the export of toxic waste

Companies export waste because it is cheaper than proper disposal

Case studies: Lead, dioxins, and chlorine

How can we reduce exposure to lead?

High levels of lead in blood causes lower IQ, hyperactivity, nervous system impairment, and other disorders.

Sources: leaded gasoline, lead paint, etc.

How dangerous are dioxins?

Definition: a family of 75 chlorinated hydrocarbon compounds formed as unwanted by-products in chemical reactions involving chlorine and hydrocarbons.

TCDD is a dioxin - could cause cancer

However, a study in 1996 showed that 86% of dioxins produced in the US could be eliminated without economic sacrifice.

What should we do about chlorine?

Chlorine is used for plastics (manufacturing), solvents, and paper, pulp bleaching

In so many cases, there are alternatives to chlorine use - but they are more expensive to use.

Hazardous-waste regulation in the US

What is the Resource Conservation and Recovery Act?

Passed in 1976: forces EPA to identify and manage disposal of toxic waste, helps states establish waste management programs.

However, most producers of hazardous waste are able to get away with illegal dumping.

What is the Superfund Act?

1980: Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) - Cleans up abandoned dumping sites.

This act forces the polluter to pay in many cases

The government still has to pay billions

Solutions: Achieving a Low-waste society

What is the role of Grassroots action? Bottom-up change

Everyone can help to stop pollution if they oppose: Polluters, hazardous waste landfills, wells, incinerators, and exports

How can we make the transition to a lower-waste society?

The Principals:

Everything is connected

There is no "Away"

Dilution is not the solution (to pollution)

Prevention and recycling is the cheapest way to deal with pollution

Sustaining Ecosystems:
Land Use, Conservation and Management

Frontier Expansion, Native Americans, and Bison

Native American Tribes depended heavily on Bison

By 1906 the bison population had shrunk nearly to extinction

When settlers moved west they killed more bison (Buffalo Bill Cody): they left their carcasses to rot while commercial hunters took their hides and tongues: farmers shot them (damaged crops), Ranchers killed them (competed with cattle for grass): the army killed 2.5 million between 1870-1875

1892 = 85 bison left so they were protected in Yellowstone in 1893

today = 250,000 (97% on private ranches)

Every country has 3 forms of wealth: Material, Cultural, Biological

Conservation Biologists believe that need to use these forms of capital sustainably by protecting some and helping to heal those that we have degraded

Land Use, Conservation, and Public Health in the United States: 1400-1960

Europeans came to N. America in the 15th and 16th centuries. Settled in 1607

Frontier Worldview: viewing undeveloped land as a hostile wilderness to be conquered and exploited for its resources as quickly as possible

1850: 80% of land = govt. owned

1900: more than ½ country's public land was given away or sold

early conservationists = George Caitlin, Horace Greeley, Ralph Waldo Emerson, Frederick Law Olmsted, Charles W. Eliot, Henry David Thoreau

Between 1870 and 1900 the concern for environmental problems increased:

coal burning, horse manure in the street, contaminated water, inadequate garbage collection, overcrowding, horrible working conditions, disease

Theodore Roosevelt = Conservation president

1901-1909 = Golden Age of Conservation

1st Wildlife Refuge = Pelican Island 1903

T. Roosevelt tripled the size of forest reserves and transferred it to the Department of Agriculture

1905: U.S. Forest Service: Gifford Pinchot: used sustainable yield and multiple use theories

1905: Audubon Society (protects birds)

Preservationists: remaining wilderness areas on public lands should be left untouched

1912 = U.S. National Park System was created by Congress

1916 = National Park System Organic Act: parks were to be maintained so they are unimpaired for future generations: established the National Park Service (1st head = Stephen Mather)

early 1990s = improvements in public health

Jane Adams, Mary McDowell, Alice Hamilton

WWI (economic growth and expansion): Presidents Harding, Coolidge, Hoover (1921-1933) = a lot of resource removal

President Franklin D. Roosevelt (1933-1945) (Great Depression)

Civilian Conservation Corps (CCC) 1933: made jobs for 2 million unemployed people: they planted trees, restored waterways, provided flood control, protected wildlife, etc.

Taylor Grazing Act 1934: required permits + fees to use federal grazing lands + limits on the number of livestock that could be grazed

Migratory Bird Hunting Stamp Act 1934: duck hunting licenses had to be purchased by waterfowl hunters

Soil Conservation Service 1935: part of Department of Agriculture to correct soil erosion problems

Federal Aid in Wildlife Restoration Act 1937: (states have received $2.2 billion)

Federal Aid in Fish Restoration Act 1950: helps states agencies conserve and restock game fish through tax on fishing equipment

1940 = merger to form the U.S. Fish and Wildlife Service

Writers that dealt with environmental problems = William Voight , Fairfield Osborn, Aldo Leopold, Jane Jacobs, Vance Packard

· 1938: modern version of the Food, Drug and Cosmetic Act (because 100 people died of kidney failure from ingesting lots of a tainted drug

The Environmental Movement in the United States: 1960-1998

1962 = **Rachel Carson** published Silent Spring which talked about air, water, and wildlife pollution from DDT

Wilderness Act 1964: authorized govt. to protect undeveloped tracts of public land unless Congress decides they are of national good.

1965-1970 = science of ecology: biology writers = Paul Ehrlich, Barry Commoner, Garret Hardin

1970s= first decade of the environment

1st annual Earth Day = April 20, 1970 (proposed by Senator Gaylord Nelson)

1973-1974 = Oil Embargo with Arab members of the Organization of Petroleum Exporting Countries (OPEC)

Federal Land Policy and Management Act 1976: gave the Bureau of Land Management its first real authority to manage public land under its control (85% of which is in 12 western states) late 1970s = **sagebrush rebellion** (ranchers, miners, loggers, developers, farmers, politicians): wanted to remove most western lands from federal ownership and turn them over to the states

Jimmy Carter

created Department of Energy

used the Antiquities Act (1906) to triple the amount of land in the National Wilderness System and double the land in the National Park System

Ronald Reagan (sagebrush rebel)

increased private energy, mineral development and timber cutting on public lands

cut federal funding for energy conservation research (70%) and funding for renewable resources (85%)

lowered gas mileage standards

relaxed federal air and water quality pollution standards

George Bush (promised to be the “environmentalist president” but didn’t do much)

Bill Clinton

appointed respected environmentalists to key positions

vetoed a lot of bills that would have weakened other key environmental acts

June 1992 = **Rio Earth Summit**: concerned with pollution, deforestation, biodiversity loss and global change

December 1997 = **Kyoto (in Japan) Climate Change Summit**: 160 nations signed protocol aimed at decreasing global emissions of greenhouse gases

Biodiversity, Conservation Biology, and Ecological Integrity

Growth since 1980 =

scientific understanding of biological wealth

ecological processes of matter cycling, energy flow and species interactions that sustain biodiversity

Conservation Biology = multidisciplinary science created in the late 1970s to deal with the crisis of maintaining genes, species, communities, and ecosystems that make up the biological diversity on earth

Ecological Integrity = the conditions and natural processes that generate and maintain biodiversity and allow evolutionary change as a key mechanism for adapting to changes in environmental conditions

Ecological Health = the degree to which an area's biodiversity and ecological integrity remain intact Conservation biology has the following principles

Biodiversity and ecological integrity are necessary to all life on earth and should not be reduced by human actions

Humans should not cause or hasten the premature extinction of populations

The best way to preserve biodiversity and ecological integrity is to preserve habitats, niches, and ecological interactions

Goals and strategies for preserving biodiversity and ecological integrity of an area should be based on a deep understanding of ecological properties and processes

Public Lands in the United States

U.S. Land = 42% for public use (73% of it is in Alaska and another 22% is in western states)

156 Forests and 20 grasslands (managed by National Forest Service)

Principle of sustainable yield = (potentially renewable resources should not be harvested or used faster than they are replenished)

Principle of multiple use = the same land should be managed simultaneously for a variety of uses (i.e., timber harvesting, grazing recreation and wildlife conservation)

Today national forests are used for:

logging

mining

livestock grazing

farming

oil and gas extraction

sport and commercial fishing and hunting

conservation of watershed, soil, and wildlife

National resource lands in the western states and Alaska are managed by the Bureau of Land Management.

508 National Wildlife Refuges (managed by the U.S. Fish and Wildlife Service) (24% of it is wilderness)

375 Units of the National Park System (54 major parks: 321 National Recreational areas, monuments, memorials, battlefields, historic sites, parkways, trails, rivers, seashores, and lakeshores: 49% of the park system is wilderness

630 roadless areas of the National Wilderness Preservation System are managed by the National Park Service (42%) Forest Service (33%) Fish and Wildlife Service (20%) and Bureau of Land Management (5%)

Fifth Amendment of the Constitution gives govt. the power of eminent domain (you can force a citizen to sell property needed for a public good

Managing and Sustaining Rangelands

Almost ½ of the earth's ice-free land = rangeland. Rangeland is land that supplies forage or vegetation for grazing and browsing animals and that is not intensively managed

Most rangeland and grasslands are arid and too dry for nonirrigated crops

42% of worlds rangeland is used for grazing livestock (34% of the total US land = rangeland)

2% of cattle and 10% of sheep graze on public rangelands in the US

rangeland grass = renewable resource

84% of wild mammal species and 74% of wild bird species are supported by rangeland ecosystems

rangelands are crucial watersheds and they help replenish groundwater and surface water supplies

The world has 10 billion domesticated animals and 3 billion of those digest cellulose and convert it into meat and milk

Overgrazing = destruction of vegetation when too many grazing animals feed too long and exceed the carrying capacity of a rangeland area

1st symptom = sharp decline in most palatable herbs and grasses

overgrazing compacts the soil so it can't hold as much water, soil erodes and mesquite and prickly cactus takes over Range Condition is classified as either excellent, good fair or poor

Feral animals are domesticated animals that have adopted a wild existence

Riparian Zones = thin strips of lush vegetation along streams

- help prevent floods by storing and releasing water slowly
- they are "centers of biodiversity" · provide habitats, food, shelter and water for wildlife
- 65-75% of the wildlife in the west is totally dependent on these zones
- Arizona and New Mexico have lost 90% of these zones due to overgrazing

Rangeland Management

You need to “maximize livestock productivity without overgrazing rangeland vegetation”

Control the “stocking rate” (the number of each kind of animal in a given area)

Continuous grazing goes throughout the year; **deferred rotation** grazing involves moving livestock between 2 or more areas

predator control involves the Animal Damage Control agency (ADC)

> coyotes are the main target now but the gray wolf and grizzly bears used to be and now they are endangered species
>
> putting cattle and young lambs together and llamas and donkeys together is a good way to fight off predators

29,000 US ranchers have permits to graze about 4 million livestock (3 million of which is cattle)

10% of the permits are held by small livestock operators; the other 90% by large livestock operations (including companies like Union Oil, Vail Ski Corporation and Metropolitan Life Insurance)

permit holders pay the federal govt. a grazing fee

Managing and Sustaining National Parks

There are 1,100 national parks in more than 120 countries that are larger than 1,000 hectares (2500 acres) each

The US national park system = “America’s crown jewels”; Parks are being threatened by:

> tourists
>
> poachers / hunters (3,000 elk killed in Eagle Creek Montana each year)
>
> too little money being available

too few personnel

roads, cars, snowmobiles

mining, logging, livestock grazing, coal burning, water diversion, and urban development, and waste

54 major US parks are managed under the principle of natural regulation (the parks will sustain and restore themselves)

The two goals of the US National Park Service:
1) preserve nature in parks, and
2) make nature more available to the public: they have a $1.5 billion annual budget

see page 633 (Miller) for a list of suggestions that the Wilderness Society and the National Parks and Conservation Association made for sustaining and expanding the park system

Protecting and Managing Wilderness and Other Biodiversity Sanctuaries

6% of the world's land is either strictly or partially protected in more than 20,000 reserves and parks

North and Central America have set aside the most land (12%) and Oceania (10%) the Soviet Union set aside the least (1.1%)

Conservation biologists say 10% of the earth’s land should be set aside.

The Biosphere has 3 zones

1) **Core Area**: contains an important ecosystem with little or no disturbance from human activities

2) **Buffer Zone**: where activities and uses are managed in ways that help protect the core

3) **Second Buffer Zone / Transition Zone**: combines conservation and sustainable forestry, grazing, agriculture and recreation

Conservation Biologists believe in having habitat corridors between reserves

Economists and developers think that protecting even 6% of the earth's land is too much wilderness (areas "where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain"). About 34% of the earth's land is wilderness.

1968 = National Wild and Scenic Rivers Act which allows certain rivers to be kept free of development

1968= National Trails Act: protects scenic trails

Land Management, Biodiversity, and Sustainable Ecosystems

To conservation biologists protecting biodiversity involves a whole ecosystem approach and a species-by-species approach

Gap Analysis - scientific method used to determine how adequately native plant and animal species and natural communities are protected by the existing network of conservation lands. Species and communities not adequately represented in existing conservation lands constitute conservation gaps. The idea is to identify these gaps and then eliminate them through the establishment of new reserves or changing land management practices

Sustaining Ecosystems:
Deforestation, Biodiversity & Forest Management

I. Forests: Types and Importance

A) Major Types of Forests

1) Tropical

2) Temperate

3) Polar

Human activities have reduced Earth's forest cover - from 34% to 26% of world's land area. More than 1/2 of world's forests are located in the tropics. Forests are disappearing due to deforestation and degradation. Even though they are renewable resources, forests are disappearing mostly in the tropic countries.

Between 1990-1995 at least 2 million kilometers squared of forests were lost.

Old Growth Forests: uncut forest and regenerated forests that haven't been touched for thousands of years. e.g., Douglas Fir Forests

In the US, 95-98% of these forests are gone. These forests provide homes for much of the wildlife that live in the world today.

Second Growth Forests: stands of trees resulting form secondary-ecological succession after cutting.

about 40% of all tropical forests are second-growth forests.

Tree farms/Plantations: managed forests with old trees that are harvested.

B) Importance of Forests

a) Uses of Lumber

1. housing

2. biomass for fuel wood

3. pulp for paper

4. medicines

b) Forests - lands are used for :

1. mining

2. grazing livestock

3. recreation

Over 1/2 of timber cut is used by 20% of the people for domestic purposes.

55%of wood is used for fuel wood/charcoal for heating and cooking

The US has the highest per capita use of **paper**-about 7 times the average global use.

Also the US is the highest importer of wood products,

C) Ecological Importance of Forests

1) They act as sponges and work like dams to stop flooding in streams

2) Influence climate

3) Vital to carbon cycle

a) They take up 90% of carbon removed form atmosphere.

4) They absorb noise, air pollutants, and nourish the human spirit.

II. Old-Growth Deforestation in the US and Canada

A) How Fast are Forests are Being Cleared in the US

30% faster than 1950.

1. Why?

a) reversion of marginal farmlands to forests

b) planting of tree farms,

c) efficient use of paper and wood products

d) paper and wood recycling

e) substitution of all other materials for construction lumber

Most of the remaining old-forests are in US public lands in Washington, Oregon and Northern California

Current rate of cutting the forests will be gone within the next 2-3 decades.

B) Ecology of Old-Growth Forest sin the Northwest

350 years for an Old-Growth forest to make its prime.

1. Functions of forests

a) recycle nutrients in the forests ecosystem

b) unusually rich in wildlife species

c) act as giant sponges that hold and slowly release moisture to help protect against fires and floods and recharge nearby streams and aquifers.

C) Remaining Old-Growth Forests on US Public Lands Be Cut or Preserved?

Pacific Northwest's old-growth forests are valuable resources that could provide biologists say that the forests provide ecological, scientific, aesthetic, and recreational values which exceed the reason for the cutting for short-term use. If they stop cutting, there will be thousands of jobs lost and millions of dollars lost. Also there will have to be a substitute for the use of wood.

Many endangered species like the Northern spotted owl live in the forests.

D) Destruction of Old-Growth Forest in Western Canada

holds 10% of worlds' forests Largest exporter of timber products--> value at more than $30 billion per year.

They have lost 60% of its forests because of logging. (Old-Growth forests)

Enacted the Forest Practices Code in 1995 which is largely being ignored.

--In 1997 the Government eased the code.

But in response to this, many labor union members, environmentalists, and citizens formed the Canada's Future Forest Alliance. --They hoped to attract attention to this problem.

awarded the Goldman Environmental Prize, Colleen McCrory.

III. Tropical Deforestation and Loss of Biodiversity

A) How Fast are Tropical Forests Being Cleared and Degraded

Cover about 6% of earth's land area.

1. Four Countries that contain more than half of world's total:

    a) Brazil

    b) Indonesia

    c) Zaire

    d) Peru

2. Tropical forests are described as:

    a) dry and very dry deciduous forests

    b) forests on hills and mountains

    c) rain forests-->rainfall daily

    d) tropical deciduous forests-->1 or 2 receive rainfall almost daily

Between 1960-1990 about 1/5 of all tropical forest cover was lost.

With about 40% of deforestation is taking place in South America.

B) Madagascar: A Threatened Jewel of Biodiversity

1. Located on Indian Ocean off the east of African coast

2. estimated about 160,000 species that are unique to this island.

3. About 800 butterfly species, and all its reptiles and mammals are considered a crown jewel among the Earth's ecosystem.

4. Because of population growth, this country will have to be careful of its species in losing them. It will have to decrease.

C) Why Should We Care about Tropical Forests?

1. Home to 50-90% of earth’s terrestrial species.

2. They supply 1/2 of world’s annual harvest of hardwood and hundreds of food products

3. They supply the world with materials like oils, dyes, drugs and medicines, and resins.

D) Cultural Extinction in Tropical Forests

1. 250 million people belong to indigenous cultures found in about 70 countries

they obtain their food from hunting and gathering in these forests.

2. Many tribes are being forced to leave because of the loss of their homes in the forests and the loss of their food sources.

3. 1996 Brazilian president issued a decree allowing commercial interests to challenge the tribes for land rights.

4. Governments protect the rights of the people by:

a) establishing a UN Declaration on the Rights of Indigenous Peoples enforceable by international law

b) mapping their homelands and giving them full ownership of their land and all mineral rights

c) protecting their lands from intrusion and illegal resource extraction

d) giving legal control over drugs and other products derived from their lands

e) international org. to fight for their legal rights.

E) What Causes Tropical Deforestation

1. Primary Causes of Deforestation

a) poverty

b) rapid population growth

c) exploitive government policies

d) exports to developed countries

e) failure to include ecological services in evaluating forest resources

2. Secondary Causes

a) roads

b) logging

c) unsustainable peasant farming

d) Cash crops

e) cattle ranching

f) tree plantations

g) flooding from dams

h) mining

i) oil drilling

F) Japan: Ecovillain or Ecosavior?

NEGATIVE SIDE

1. logged lots of its forests, destroyed reefs, and built nuclear power plants in earthquake zones

2. 53% of world's timber imports

3. bought logging rights to clear-cut 63% of forests in Alberta, Canada.

4. major illegal importer of endangered and threatened species and products from them.

5. wants international ban on commercial whaling lifted

6. finances large, harmful projects...ex. dams, and roads.

7. developed country without a strong environmental movement

POSITIVE SIDE

1. leader of industrial and urban air pollution.

2. high recycling rate using a resource recovery system

3. makes/sells most cost-effective incinerators and air pollution control scrubbers

4. world's most energy-efficient country 5. slashed birth rate during 1960's 6. Gives more than $1 billion to environmental projects

7. assumed major leadership role in 1992 and helped developing countries.

8. plans to stabilize its carbon dioxide levels

9. plans to protect and restore the earth’s natural functions.

G) How Serious is the Fuel Wood Crisis In Developing Countries?

1. Harmful effects:

a) deforestation

b) accelerated soil erosion

c) burden on poor families which lead to poverty and malnutrition

IV. Managing and Sustaining Forests

A) Major Types of Forest Management

1. Systems

a) Even-aged management- trees in a given stand are maintained at about the same age and size.

Begins with 1 or 2 cuttings of all or most trees form an area. Then the site is replanted with species the same age.

b) Uneven-aged management- a variety of tree species in a given stand are maintained at many ages and sizes to foster natural regeneration.

mature trees are cut only in small patches.

B) Trees are Harvested by:

1. Selective Cutting - mature trees are cut singly or in small groups.

a) type of this is high grading or creaming: which removes the most valuable trees.

2. Shelterwood Cutting - removes all mature trees in 2 or 3 cuttings over a period of 10 yrs.

3. Seed-tree Cutting - harvest nearly all of a stand's trees in one cutting leaving a few uniformly distributed seed-producing trees to regenerate the stand.

4. Clear-Cutting- removal of all trees in the area.

5. Strip Cutting - A strip of trees is clear cut along the contour of the land with the corridor narrow enough to allow regeneration within a few yrs.

C) Forests need to be protected from Pathogens and Insects

Other countries have introduced diseases to the trees.

a) Chestnut blight

b) Dutch elm disease

c) White-pine blister rust.

d) Fires

1. Types of Fires:

a) Surface fires-usually burn only undergrowth and leaf litter on forest floor.

b) Crown fires-hot fires burn whole trees and leap from treetop to treetop.

c) ground fires- burn underground

2. Prevention of forest fires

a) prescribed burning - setting controlled ground fires

b) presuppression - early detection

c) Suppression - fighting fires once they have started

E) Forests Threatened by Air Pollution and Climate Change

Air pollutants and industrial centers are harming the trees and making it easier to cause drought, diseases and insects.

Reducing coal-burning and motor vehicles.

F) Sustainable Industrial Forestry

Biologists say to leave the forests alone, the forest cutters are messing up nature's way of dealing with itself.

New Forestry-cutting trees on public lands.

G) Solutions

1. recycle more paper to reduce the harvest of pulpwood trees
2. growing more timber on long rotations
3. practicing selective cutting of individual trees
4. using road building and logging methods
5. leaving most standing dead trees
6. have services of recreation explaining their value.

H) How are Forests Managed?

1. Sustained yield
2. Multiple use

V. Solutions: Reducing Tropical Deforestation and Fuel Wood Shortages

A) Reduce Tropical deforestation and degradation

Let people know about these problems

Debt-for-nature swap

conservation easements

programs

new logging contracts

cutting canopy vines before felling a tree can reduce damage to neighboring trees by 20-40%

reducing waste and pollution

VI. Solutions Individual Action

A) Change that I can Make?

Use as little as possible! Save and recycle everything. Don’t think your help doesn’t matter because it does.

Sustaining Wild Species

Why Preserve Wild Species?

All species have economic, medical, scientific, ecological, aesthetic, and recreational values

Economic and Medical Importance of Wild Species

90% of today's crops were domesticated from wild tropical plants. Wild species are needed to derive crop strains

Pollination by birds and insects essential to food crops

80% of the world's population uses plant extracts for medicine. Used for anticancer drugs and popular antibiotics

Scientific and Ecological Importance

Each species helps scientists understand evolution

Sustain biodiversity and ecological integrity

Recycle nutrients, generate and maintain soil

Absorb pollution and moderate climate

Make up a vast gene pool for future evolution

Aesthetic and Recreational Importance

Ecotourism is a quickly growing segment of global travel industry

Ecotourism is often destructive to the natural habitats because of construction of large hotels

Ethical Importance of Preserving Wild Species

Some believe each species has intrinsic value, or an inherent right to exist

We have an ethical obligation to protect species from becoming prematurely extinct

Some people distinguish between killing different animal species (cockroach vs. deer)

Some emphasize that each individual organism, not just species, has the right to survive

The Rise and Fall of Species

Background Extinction vs. Mass Extinction

Background - natural rate of extinction, a small number of species become extinct each year

Average rate is 3 species for every 10 million

Mass - abrupt rise in extinction rates, catastrophic and widespread

Usually a result of global climate changes

Five great mass extinctions have occurred in the past 500 million year.

Mass extinctions are followed by adaptive radiations- increase in diversity

The New Mass Extinction Crisis

We are rapidly losing biodiversity

We have little understanding of Earth’s 1.75 million identified species, and 100 million unidentified species

Precautionary principle - should be used to prevent premature extinction

Biologists estimate 18,000-73,000 species become extinct each year, the rate accelerating

Differences between current mass extinction and mass extinctions of the past

1. Current extinction crisis is cause by a single species, humans

2. Current mass wildlife extinction is taking place in a few decades rather than thousands of years

3. We are not only killing off species, but also eliminating biologically diverse environments, including areas such as tropical rainforests, coral reefs, and wetlands that have served as centers for recovery of biodiversity after mass extinctions.

Is there really an Extinction Crisis?

Critics point out:

1. We don’t really know how many species there are

2. We cannot observe extinction for species we know little or nothing about

Endangered and Threatened Species

There are three levels of extinction:

> 1. Local extinction- species is no longer found in an area it once inhabited but is still found elsewhere
>
> 2. Ecological extinction- there are so few members of a species left it cannot play its ecological roles
>
> 3. Biological extinction- species is no longer found anywhere on the earth

Endangered species- so few individuals are left that it could soon become extinct.

> e.g., California condor, giant panda

Threatened species - still abundant in its natural range but is declining and will likely become endangered.

e.g., grizzly bear, American alligator

Factors that make a species more vulnerable to premature extinction:

· Low reproductive rate

· Specialized feeding habits

· Feed at high trophic levels

· Large size

· Specialized nesting area

· Found in only one region

· Fixed migratory pattern

· Preys on livestock or people

Each species has a critical population density and a minimum viable population size

Status of Wild Species and Ecosystems in the United States

32% of plant and animal species are vulnerable to premature extinction

Ecosystems are particularly threatened in California, Hawaii, Texas, and the Southeast

Causes of Depletion and Premature Extinction of Wild Species

Main Causes of Wildlife Depletion and Extinction

Underlying Causes for depletion and extinction:

1. Human population growth

2. Economic systems that fail to value the environment

3. Greater per capita resource use

Direct Causes for depletion and extinction:

1. Habitat loss and degradation
2. Habitat fragmentation
3. Commercial hunting and poaching
4. Overfishing
5. Predator and pest control
6. Sale of exotic pets and decorative plants
7. Climate change and pollution
8. Introduction of nonnative species into ecosystems

Protecting Wild Species from Depletion and Extinction

Three basic approaches to protecting biodiversity:

1. Ecosystem approach: tries to preserve balanced populations of species in their native habitats and eliminate nonnative species
2. Species approach: based on protecting individual endangered species by identifying them and propagating them in captivity and reintroducing them into their habitats
3. Wildlife management approach: manages game species by using laws that regulate hunting

Bioinformatics - the applied science of managing, analyzing, and communicating biological information. It involves:

1. Building computer databases to store information
2. Providing computer tools to find, visualize, and analyze the information
3. Providing means for communicating the information

International treaties

Convention on International Trade in Endangered Species (CITES) - 1975, lists 700 species that cannot be traded commercially because they are endangered or threatened

United States Laws

Lacey Act of 1900 - prohibits transporting live or dead wild animals across state borders without a federal permit

US Endangered Species Act of 1973 - illegal for Americans to import or trade products made from endangered or threatened species unless it is to enhance the survival of the species

Attempts to weaken this act by:

Making the protection of endangered species on private land voluntary

Having government pay landowners if they must stop using part of their land to protect an endangered species

Making it harder to list new species by requiring hearings and peer-review panels

Giving the Secretary of the Interior the power to permit a species to become extinct without attempting to save it

Allowing the Secretary of the interior to give anyone exemption from the law

Allowing landowners habitat conservation plans that exempt the owners from obligations for 100 years or more

Prohibiting the public from bringing lawsuits on changes in habitat conservation plans for endangered species

Funds for protecting endangered species should be concentrated on species that:

1. Have a good chance for survival
2. Have the most ecological value
3. Are potentially useful for agriculture, medicine, or industry

Refuges and Protected Areas

US National Wildlife Refuge System has 508 refuges, 85% are in Alaska

¾ of refuges are for protection of migratory waterfowl

World Conservation Union has helped other countries set up marine protected areas

Gene Banks and Botanical Gardens

Seeds of endangered plant species are stored in refrigerated, low-humidity environments

Maintaining these banks is very expensive

Existing sanctuaries are too small to preserve most of the world's threatened plants

Zoos

Are increasingly being used to preserve endangered species

Egg pulling - collecting wild eggs laid by endangered species and hatching them in zoos

Captive breeding - individuals are captured for breeding in captivity with the aim of reintroduction in the wild.

Other techniques:

Artificial insemination

Surgical implantation of eggs into a surrogate mother of another species

Incubators

Cross-fostering

Wildlife Management

Wildlife management: entails manipulating wildlife populations and their habitats for their welfare and for human benefit

Manipulation of Vegetation and Water Supplies

Four types of wildlife species: early successional, mid-successional, late successional, and wilderness

Habitat management can be used to attract a desired species and encourage growth

Sport Hunting for Wildlife Management

Licensed hunters can hunt only in certain parts of the year to protect animals in mating season

Limits set on size, number, and sex of animals killed

Animals such as deer, raccoons, geese, and beavers are pests in suburban areas and on farms and some people support the killing of these animals

Defenders argue that they are preserving biological diversity by preventing depletion of other plants and animals

Opponents argue that hunting causes wild animals to suffer and few that are killed supply food that is needed for human survival

Management of Migratory Waterfowl

Birds migrate to find conditions suitable for reproduction

Flyways- north-south routs the birds take

Some countries along flyways have made agreements to protect habitats needed by the birds

Wildlife officials regulate hunting, protect existing habitats, and develop new habitats for the birds

Fishery Management and Protecting Marine Biodiversity

Sustaining Freshwater Fisheries

Techniques:

> Increase certain commercial and sport species and reduce less desirable species by regulating fishing seasons
>
> Build reservoirs and farm ponds stocked with fish
>
> Fertilize nutrient-poor lakes
>
> Protect spawning sites
>
> Control predators, parasites, and diseases

Managing Marine Fisheries

Exclusive economic zones- a country's offshore fishing zone that extends 370 kilometers from shore, foreign fishing vessels can fish only with the government's permission. High seas- ocean area beyond the legal jurisdiction of any country, limitations are set by international maritime law

Ways to reduce overfishing in US waters:

1. Gradually phase out government subsidies of the fishing industry

2. Impose fees for harvesting fish and shellfish from publicly owned and managed offshore waters

Why it is difficult to maintain marine biodiversity?

Shore-hugging species are adversely affected by coastal development and sediment and wastes from land

Damage is not visible to most people

Seas are viewed as an inexhaustible resource

Most of the ocean area lies outside the legal jurisdiction of any country and is an open-access resource

Case Study: The Whaling Industry

Whales are divided into two groups:

Toothed whales- porpoise, sperm whale, killer whale - bite and chew food

Baleen whales- blue, gray, humpback- filter feeders - filter plankton and krill

Whales are easy to kill because of size and invention of harpoon guns and inflation lances

Harvesting is mostly in international waters

8 of 11 major species have been driven to commercial extinction in the past 75 years

The Blue Whale

World's largest animal. Have been hunted to near biological extinction for oil, meat, and bone

Reproductive rate is very slow, making it difficult to recover from low populations

Have been classified as endangered since 1975

Some biologists believe that too few blue whales remain to avoid extinction

The International Whaling Commission (IWC) regulates the whaling industry, has been unable to stop the decline of most whale species

Whaling is a traditional part of some cultures and economies, such as Japan, Norway, and Iceland- some argue the ban on whaling should be lifted for this reason

In 1994 a permanent whale sanctuary was established in the Antarctic Ocean

Sustainable Cities Urban Land Use and Management

How Fast are Urban Areas Growing?

For more than 6,000 years, cities (often called the cradles of civilization) have been centers of commerce, communication, technological developments, education, religion, social change, political power, and progress. They have also been centers of crowding, pollution, and disease.

For almost 300 years, since the beginning of the industrial revolution, cities have been growing rapidly in size. They are now called urban areas - towns or cities plus their adjacent suburban fringes with populations of more than 2,500 people.

A rural area is usually defined as an area with a population of less than 2,500 people.

A country’s degree of urbanization is the percentage of its population living in an urban area. Urban growth is the rate of increase of urban populations. Between 1950 and 1998, the number of people living in the world’s urban areas increased 12-fold, from 200 million to 2.6 billion. By 2025 it is projected to reach 5.5 billion, almost equal to the world’s current population.

About 90% of this urban growth will occur in developing countries. At current rates the world’s population will double in 47 years, the urban population in 22 years, and the urban population of developing countries in 20 years.

Several trends are important in understanding the problems and challenges of urban growth on this rapidly urbanizing planet.

The proportion of the global population living in urban areas increased between 1850 and 1998 from 2% to 44%. This degree of urbanization varies in major areas of the world.

During the 1990s, more than 70% of the world’s population increase is expected to occur in urban areas. By 2025 about 63% of the world’s people will be living in urban areas. The number of large cities is mushrooming. By 2025, there will be at least 400 cities with populations of more than 1 million.

• Developing countries, with 36% urbanization, contain 1.7 billion urban dwellers- more than the total populations of Europe, North America, Latin America, and Japan combined. The urban population in developing countries is growing at 3.5% per year and they are projected to reach at least 57% urbanization by 2025.

• In developed countries, urban growth is less than 1% per year, much slower than in developing countries. Still, developed countries should reach 84% urbanization by 2025.

• Poverty is becoming increasingly urbanized as more poor people migrate from rural to urban areas.

At least 1 billion people, 17% of the world's current population, live in the crowded slums of inner cities or in vast, mostly illegal squatter settlements and shantytowns, where people move onto undeveloped land and build shacks made of packing crates, plastic sheets, corrugated metal pipes, or whatever they can find. In Manila, Philippines, for example, some 20,000 people live in city dumps in shacks built on huge mounds of garbage and burning industrial waste.
In 1984 the world's worst industrial accident occurred at the Union Carbide factory in Bhopal, India. The release of toxic gas killed at least 5,100 people and caused at least 200,000 serious injuries.

About 100 million people are homeless and sleep on the streets. Half of all urban children under age 15 in developing countries live in conditions of extreme poverty, and about 1/5 of them are street children with little or no family support.

In Villa El Salvador outside Lima, Peru, for example, a network of women's groups and neighborhood associations planted half a million trees, trained hundreds of door-to-door health workers, and built 300 community kitchens, 150 day-care centers, and 26 schools. Illiteracy has fallen to 3% - one of the lowest rates in Latin America, and infant mortality is 40% below the national average.

What causes urban growth?

• Urban populations grow in 2 ways: by natural increase (more births than deaths) and by immigration (mostly from rural areas).
• Improved food supplies and better sanitation and health care in urban areas lower the death rate and cause urban populations to grow.

• Modern mechanized agriculture, for example, uses fewer farm laborers and allows large landowners to buy out subsistence farmers who cannot afford to modernize.

• Urban growth in developing countries is also fueled by government policies that distribute most income and social services to urban dwellers at the expense of rural dwellers.

Case Study: Mexico City

• Mexico City is the world's 4th most populous city. • Immigration is the main reason for Mexico City's high rate of population growth. • Mexico City suffers from severe air pollution, high unemployment (close to 50%), deafening noise, congestion, and a soaring crime rate.

• At least 8 million people have no sewer facilities.

• Air pollution is intensified because the city lies in a basin surrounded by mountains, and frequent thermal inversions trap pollutants at ground level.

What are the major urban problems in the US?

Since 1920, many of the worst urban environmental problems in the US have been significantly reduced.

The biggest problems facing numerous cities in the US are:

- Deteriorating services
- Aging infrastructures (streets, schools, bridges, housing, sewers)
- Budget crunches from lost tax revenues and rising costs as businesses and more affluent people move out
- Rising poverty in many central city areas

What are the major spatial patterns of urban development?

• A **concentric-circle city** develops outward from its central business district (CBD) in a series of rings as the area grows in population and size. Ex. NYC

• A **sector city** grows in pie-shaped wedges or strips. Growth sectors develop when commercial, industrial, and housing districts push outward from the CBD along major transportation routes. Ex. the large urban area extending from San Francisco to San Jose, California

• A **multiple-nuclei city** develops around a number of independent centers, or satellite cities, rather than a single center, e.g., L.A.

Urban Resource and Environmental Problems

The 44% of the world's people currently living in urban areas occupy only about 5% of the planet's land area but consume 75% of the world's resources. Some analysts call for seeking more sustainable relationship between cities and the living world. To do this will require converting high-waste, unsustainable cities with a linear metabolism (based on an ever increasing throughput of resources and output of wastes) to low-waste, sustainable cities with a circular metabolism (based on efficient use of resources, reuse, recycling, pollution prevention, and waste reduction).

One city tree provides over $57,000 worth of air conditioning, erosion and storm water control, wildlife shelter, and air pollution control over a 50-year lifetime.

Urban gardens currently provide about 15% of the world's food and this proportion could be increased.

What are the water supply problems of cities?

Many cities have water supply and flooding problems. As cities grow and their water demands increase, expensive reservoirs and canals must be built and deeper wells drilled.

Many cities are built on floodplain areas subject to natural flooding. Floodplains are considered prime land for urbanization because they are flat, accessible, and near rivers.

What are the pollution problems of cities?

Urban residents are generally subjected to much higher concentrations of pollutants than are rural residents.

In the developing world, it is estimated that 90% of all sewage is discharged into rivers, lakes, and coastal waters without treatment of any kind. In Latin America, 98% of the urban sewage receives no treatment.

According to the World Bank, at least 220 million people in the urban areas of developing countries don't have safe drinking water.

How do urban and rural climates differ?

Urbanization alters the local (and sometime the regional) climate.

The enormous amounts of heat generated by cars, factories, furnaces, lights, air conditioners, and people in cities create an **urban heat island** surrounded by cooler suburban and rural areas. The dome of heat also traps pollutants, especially tiny solid particles, creating a dust dome above urban areas. If wind speeds increase, the dust dome elongates downwind to form a dust plume, which can spread the city's pollutants for hundreds of kilometers.

How serious is noise pollution?

Most urban dwellers are subjected to excessive noise. According to the U.S. Environmental Protection Agency, nearly half of all Americans, mostly urban residents, are regularly exposed to noise pollution.

Noise pollution is any unwanted, disturbing, or harmful sound that impairs or interferes with hearing, causes stress, hampers concentration and work efficiency, or causes accidents.

Harmful effects from prolonged exposure to excessive noise include permanent hearing loss, high blood pressure, muscle tension, migraine headaches, higher cholesterol levels, gastric ulcers, irritability, insomnia, and psychological disorders, including increased aggression.

5 Major Ways to Control Noise:

1. Modify noisy activities and devices to produce less noise
2. Shield noisy devices or processes
3. Shield workers or other receivers from the noise
4. Move noisy operations or things away from people
5. Use anti-noise, a new technology that cancels out one noise with another

How does urban life affect human health?

Urban areas have beneficial and harmful effects on human health

Many aspects of urban life benefit human health, including better access to education, social services, and medical care. In many parts of the world urban populations live longer and have lower infant mortality rates than do rural populations

On the other hand, high-density city life increases the spread of infectious diseases (especially if adequate drinking water and sewage systems are not available), physical injuries (mostly from industrial and traffic accidents), and health problems caused by increased exposure to pollution and noise.

How does urban growth affect nearby rural land and small towns?

Another problem is the loss of rural land, fertile soil, and wildlife habitats as cities expand.

Each year in the U.S. about 526,000 hectares of rural land (mostly prime cropland and forestland) is converted to urban development, right-of-way, highways, and airports.

According to a 1997 study by the American Farmland Trust, the United States may lose 13% of its prime farmland by 2050.

Transportation and Urban Development

Who has most of the world's motor vehicles? There are 2 main types of ground transportation:

- **Individual** - such as cars, motor scooters, bicycles, and walking
- **Mass** - mostly buses and rail systems

About 89% of the world's 501 million cars and trucks are in developed countries. Despite such production, only about 8% of the world's population own cars, and only 10% can afford to. Despite having only 4.6% of the world's people, the U.S. has 35% of the world's cars and trucks. Motor scooters produce more air pollution than cars. Most burn a mixture of oil and kerosene in small, inefficient, and noisy engines that emit clouds of air pollution. Because they are cheap, their numbers are increasing three times faster than cars and trucks in developing countries.

Is riding bicycles the answer?

Globally, bicycles outsell cars by almost 3 to 1 because most people can afford a bicycle whereas fewer than 10% can afford a car.

In China, at least 50% of urban trips are made by bicycle and the government gives subsidies to those who bicycle to work.

Only about 2% of commuters in the U.S. bicycle to work, even though half of all U.S. commutes are less than 8 kilometers. However, according to recent polls, 20% of Americans say they would bicycle to work if safe bike lanes were available and if their employers provided secure bike storage and showers at work.

Case Study: Mass Transit in the U.S.

In the U.S. mass transit accounts for only 3% of all passenger travel, compared with 15% in Germany and 47% in Japan.

In 1917, all major U.S. cities had efficient electric trolley or streetcar systems.

Rail systems, usually operated by electric engines, fall into 3 categories:

- **Rapid rail** (also called the underground, tube, metro, or subway), which operates on exclusive rights-of-way in tunnels or on elevated tracks.
- **Suburban or regional trains**, which connect the central city with surrounding areas or provide transportation between major cities in a region
- **Light rail** (such as trolleys) or trams, more modern versions of streetcars, which can run either with other traffic or on exclusive rights-of-way.

Pros and Cons:

Rail systems are much more energy-efficient, produce less air pollution, cause fewer injuries and deaths, and take up less land than highway and air transport.

However, such train systems are efficient only where many people live along a narrow corridor and can easily reach properly spaced stations.

Pros and Cons of High-Speed Regional Trains

For every kilometer of travel, such trains consume only one-third as much energy per rider as a commercial airplane and one-sixth as much as a car carrying only one driver.

High-speed train systems are expensive to run and maintain, however, and they must operate along heavily used transportation routes to be profitable.

Pros and Cons of Buses:

Bus systems require less capital and have lower operating costs than heavy-rail systems.

However, because they must offer low fares to attract riders, bus systems often cost more to operate than they bring in.

Currently, U.S. drivers pay low gasoline taxes that are used to build roads and other transportation infrastructures, but these taxes cover only 60-69% of the total costs.

It's estimated that heavy trucks cause 95% of all damage to U.S. highways, with one heavy truck causing as much highway wear and tear as 9,600 cars. According to a study by the World Resources Institute, federal, state, and local government automobile subsidies in the United States amount to $300-600 billion a year.

Urban Land-Use Planning and Control

What is conventional land-use planning?

Most urban areas and some rural areas use some form of land-use planning to determine the best present and future use of each parcel of land in the area. Zoning regulations or other means are then used to control how the land is used.

A major reason for this often destructive process is that in the U.S. 90% of the revenue that local governments use to provide schools, police and fire protection, public water and sewer systems, and other public services comes from property taxes levied on all buildings and property based on their economic value.

What is Ecological Land-use planning?

Environmentalists urge communities to use comprehensive, regional ecological land-use planning, in which additional variables are integrated into a model designed to anticipate a region's present and future needs and problems. It is a complex process that takes into account geological, ecological, economic, health and social factors.

6 steps are involved:

1. Make an environmental and social inventory.
2. Identify and prioritize goals.
3. Develop individual and composite maps.
4. Develop a master composite.
5. Develop a master plan.
6. Implement the master plan.

How can land use be controlled?

The most widely used approach to control the uses of various parcels of land by legal and economic methods is zoning, in which various parcels of land are designated for certain uses.

To reduce auto use and the costs of providing services for cars, cities have:

Developed an efficient mass transportation system

Used zoning to encourage high-density development along major transit lines

Allowed mixed development of offices, shops, and residences in the same area

Placed a ceiling on downtown parking spaces

Solutions: Making Urban Areas More Livable and Sustainable

What Urban Maintenance and Repair Problems does the United States face?

America's older cities have enormous maintenance and repair problems, most of them aggravated by decades of neglect Some 39% of America's bridges are unsafe. About 56% of the paved highways in the U.S. are in poor or fair condition and need expensive repairs.

Maintenance, repair and replacement of existing U.S. bridges, roads, mass transit systems, water supply systems, sewers, and sewage treatment plants during the next decade could cost a staggering $2 trillion or more, an average expenditure of $2.1 million per minute during the next 10 years.

How can urban open space be preserved?

One way to provide open space and control urban growth is to surround a large city with a **greenbelt**: an open area used for recreation, sustainable forestry, or other nondestructive uses.

Some cities have converted abandoned railroad rights-of-way and dry creek beds into bicycle, hiking, and jogging paths, often called greenways.

Pros and Cons of Building New Cities and Towns:

Although urban problems must be solved in existing cities, building new cities and towns could take some of the pressure off overpopulated and economically depressed urban areas.

There are 3 types of towns:

Satellite towns: located fairly close to an existing large city

Freestanding new towns: located far from any major city

In-town new towns: located within existing urban areas

New towns rarely succeed without government financial support. Some don't succeed even then, primarily because of poor planning and management.

How can we make cities more sustainable?

In a sustainable and ecologically healthy city, called an ecocity or green city, people walk or cycle for most short trips; they walk or bike to bus, metro, or trolley stops for longer urban trips.

Ways to make existing and new suburbs more sustainable and livable include:

- Giving up big lawns
- Building houses and apartments in small, dense clusters so that more community open space is available
- Developing a town center that is a focus of civic life and community cohesiveness
- Planting lots of new trees and not cutting down existing ones
- Discouraging excessive dependence on the automobile and encouraging walking and bicycling

Case Study: Chattanooga, Tennessee

In the 1950s Chattanooga was known as one of the dirtiest cities in the U.S.

Since the mid-1980s the combined efforts of thousands of Chattanooga citizens have helped clean up the city's air, revitalize its river front, and diversify its economy.

How can we improve urban living?

The primary problem is not urbanization, but our failure to make most cities more sustainable and livable and to provide economic support for rural areas.

Economics and Environment

Economic Goods, Resources, and Systems

What supports and drives economies?

Economy- a system of production, distribution, and consumption of economic goods: any material items or services that satisfy people's wants or needs. Economic decisions- are made in an economy about goods and services to produce, how to produce them, how much to produce, how to distribute them, and what to buy and sell.

Three Economic Resources:

Earth capital or natural resources

Manufactured Capital

Human capital

What are the Major Types of Economic Systems?

Two types:

Centrally planned - all economic decisions are made by the government. This command-and-control system assumes that government control and ownership of the means of production are the most efficient and equitable way to produce, use, and distribute goods and services.

Market Based (Pure Capitalism) - all economic decisions are made in markets, in which buyers (demanders) and sellers (suppliers) of economic goods freely interact without government or other interference.

Economists often depict pure capitalism as a circular flow of economic goods and money between households and businesses operating essentially independently of the ecosphere.

Economic decisions in a pure market system are governed by interactions of DEMAND, SUPPLY, and PRICE.

Market equilibrium occurs when the quantity supplied equals the quantity demanded, and the price is no higher than buyers are willing to pay and no lower than sellers are willing to accept.

*If price, supply, and demand are the only factors involved, the demand and supply curves for an economic good intersect at the market equilibrium point.

Why do we find mixed economic systems in the real world?

ALL countries have mixed economic systems that fall somewhere between the pure market and pure command systems.

China and North Korea- their economic systems fall toward the command-and-control end of the economic spectrum.

U.S. and Canada- fall toward the market-based end of the spectrum.

MOST other countries fall somewhere in between.

Pure free-market economies don't exist because they have flaws that require government intervention in the marketplace. This can prevent a single seller or buyer (monopoly) or a single group of sellers or buyers (oligopoly or cartel) from dominating the market and thus controlling supply or demand and price. **Governments intervene** in economies to....

> provide national security, education, and public goods
>
> help redistribute some income and wealth
>
> protect people from fraud, trespass, theft, and bodily harm
>
> protect the health and safety of workers and consumers
>
> help ensure economic stability

Pure command economies don't exist either. Countries in Eastern Europe, the former Soviet Union, and China have moved away from command economic systems and toward market-based approaches.

Economic Growth and External Costs

How is economic growth measured?

Economic growth is the increase in the capacity of the economy to provide goods and services for people's final use. Such growth is usually accomplished by maximizing the flow of matter and energy resources (throughout) by means of population growth (more consumers), more consumption per person, or both. Economic growth is usually measured by the increase in a country's gross domestic product (GDP), the market value of all goods and services produced by an economy within its borders for final use during a year, and by its gross national product (GNP). The GDP plus the net income from abroad. To get the real GNP or GDP: the GNP or GDP adjusted for inflation (any increase in the average price level of final goods and services).

The real per capita GNP or GDP: the real GNP or GDP divided by the total population.

*If the population expands faster than economic growth, then real per capita GNP or GDP falls.

Is economic growth sustainable?

To environmentalists and a small but growing number of economists and business leaders, the notion of sustainable growth is nonsense because nothing that is based on the consumption of the earth capital that sustains all economies can grow indefinitely.

Instead of unlimited economic growth, such critics call for economically sustainable development. This occurs when the total human population size and resource use in the world are limited to a level that does not exceed the carrying capacity of the existing natural capital, and are therefore sustainable.

Are GNP and GDP useful measures of quality of life and environmental degradation?

GNP and GDP indicators are poor measures of human welfare, environmental health, or even economic health, for the following reasons:

They hide the negative effects of producing many goods and services. Pollution, crime, sickness, death, and depletion of natural resources are all counted as positive gains in the GDP or GNP.

Pollution is counted as a triple positive gain even though it decreases the quality of life for hundreds of millions of people and should be subtracted from the GNP.

GNP and GDP don’t include the depletion and degradation of natural resources or earth capital on which all economies depend. GNP and GDP hide or underestimate some of the positive effects of responsible behavior on society.

Solutions: How can environmental accounting help?

Environmentalists and a growing number of economists believe that GNP and GDP indicators should be replaced or supplemented with widely publicized environmental and social indicators that give a more realistic picture by subtracting from the GDP and GNP things that lead to a lower quality of life and depletion of Earth capital.

The net national product (NNP) includes the depletion and destruction of natural resources as a factor in GNP.

The index of sustainable economic welfare (ISEW) measures per capita GNP adjusted for inequalities in income distribution, depletion of nonrenewable resources, loss of wetlands, loss of farmland from soil erosion and urbanization, the cost of air and water pollution, and estimates of long-term environmental damage from ozone depletion and possible global warming.

A more recent similar indicator is called the genius progress indicator (GPI). When this indicator is applied to the United States, the GPI per person has steadily declined since 1973.

Case Study: Kerala: Improving life quality without conventional economic growth

Kerala has sought to better the lot of its people by economic redistribution.

Life expectancy in Kerala is 70 years, compared with 64 years in developing countries and 59 years in India.

Kerala demonstrates that a very low-level economy can provide its citizens with education, health services, and a sense of community and hope.

What are internal and external costs?

Internal costs - all direct costs, that are paid for by the seller and the buyer of an economic good.

Making, distributing, and using any economic good or service also involve externalities: social costs or benefits not included in the market price.

Harmful effects are external costs passed on to workers, the public, and in some cases future generations.

To conventional economists, external costs are minor defects in the flow of production and consumption in a self-contained economy not significantly dependent one earth capital.

To environmentalists and an increasing number of economists and business leaders, harmful externalities are a warning sign that our economic systems are stressing the ecosphere and depleting earth capital.

Solutions: Using economics to improve environmental quality

Should we shift to full-cost pricing?

One way of dealing with the problem of harmful external costs is for the government to levy taxes, pass laws, provide subsidies, or use other strategies that encourage or force producers to include all or most of these costs in the market prices of economic goods and services.

Then that price would be the full cost of these goods and services: internal costs plus short- and long-term external costs.

The two main goals are to:

1. Close the gap between real and false prices by having prices that tell the environmental truth

2. Have people and businesses pay the full costs of the harm they do to others and the environment.

Full-cost pricing involves internalizing the external costs, which requires government action because few companies will intentionally increase their cost of doing business unless their competitors must do so as well.

How useful is cost-benefit analysis?

Cost-benefit analysis- comparing the estimated short-term and long-term costs (losses) with the estimated benefits (gains) for various courses of action.

Environmental problems, like most important policy issues, involve more than costs and benefits; they also involve rights and wrongs, values and visions.

To minimize possible abuses, the following guideline should be done for all cost-benefit analyses:

Use uniform standards

Clearly state all assumptions

Evaluate the reliability of all data inputs as high, medium, and high discount rates

Make projections using low, medium, and high discount rates

Show the estimated range of costs and benefits based on various sets of assumptions

Estimate the short- and long-term benefits and costs to all affected population groups

Estimate the effectiveness of the project or form of regulation instead of assuming that all projects and regulations will be executed with 100% efficiency and effectiveness

Open the evaluations to public review and discussion

Should we rely mostly on regulations or market forces?

Regulation is a **command-and-control approach**. It involves **enacting and enforcing laws.**

Market forces can help improve environmental quality and reduce resource waste, mostly by encouraging the internalization of external costs.

One way to put the principle of the marketplace into practice would be to phase in government subsidies that encourage earth-sustaining behavior and phase out current perverse subsidies that encourage earth-degrading behavior.

Another market approach is for the government to grant tradable pollution and resource-use rights.

Another market-based method is to enact green taxes or effluent fees that would help internalize many of the harmful external costs of production and consumption.

Charging user fees is another market-based method. Users would pay fees to cover all or most costs for grazing livestock, extracting lumber and minerals from public lands, etc.

Another market approach would require businesses to post a pollution prevention or assurance bond when they plan to develop a new mine, plant, incinerator, landfill, or development and before they introduce a new chemical or new technology.

Should we emphasize pollution control or pollution prevention?

Our goal should be zero pollution, but not necessarily because...

> First, natural processes can handle some of our wastes, as long as we don’t destroy, degrade, or overload these processes.
>
> Second, as long as we continue to rely on pollution control, we can’t afford zero pollution. Is encouraging global free trade environmentally helpful or harmful?

Uruguay Round of the General Agreement on Tariffs and Trade (GATT)-

establishes a World Trade Organization (WTO), giving it the status of a major international organization and the power to oversee and enforce the agreement.

Agreements to reduce global trade barriers have a number of important benefits:

> Will benefit developing countries, whose products are often at a competitive disadvantage in the global market place because of trade barriers erected by developed countries.
>
> Can allow consumers to buy more things at cheaper prices, this stimulating economic growth in all countries.
>
> Can raise the overall global levels of environmental protection and worker health and safety.

Most environmental groups, and those concerned with consumer protection ad worker safety and health, oppose the new GATT for several reasons:

> They believe that the GATT will not provide ample economic benefits for everyone.
>
> They think the GATT will increase the economic and political power of multinational corporations and decrease the power of small businesses, citizens, and democratically elected governments.
>
> GATT will probably weaken environmental and health and safety standards in developed countries.

Faced with cheaper foreign products, domestic businesses operating in the international marketplace will have three choices:

> Go out of business
>
> Move some or all of their operations abroad to take advantage of cheaper labor and less restrictive environmental and worker safety regulations
>
> Lobby to weaken domestic environmental, health, and worker and consumer safety laws.

Solutions: Reducing Poverty

Does the trickle-down approach to reducing poverty work?

Poverty - the inability to meet one's basic economic needs

Causes premature deaths

Causes preventable health problems

Increases birth rates

Pushes people to use potentially renewable resources unsustainably in order to survive.

Instead of trickling down, most of the benefits of economic growth as measured by income have flowed up since 1960, making the top one-fifth of the world's people much richer and the bottom one-fifth poorer. A major component of the flow-up system is government subsidies that encourage resource depletion, pollution, and environmental degradation-

this is called **perverse subsidies**.

How can poverty be reduced?

Several controversial ways to reduce poverty are:

Forgiving at least 60% of the almost $2 trillion that developing countries owe to developed countries and international lending agencies

increasing the nonmilitary aid to developing countries from developed countries

shifting most international aid from large-scale to small-scale projects intended to benefit local communities of the poor

encouraging banks and other organizations to make small loans to poor people wanting to increase their income

Solutions: Converting to Earth-Sustaining Economies

How can we make working with the earth profitable?

Principles for transforming the planet's current earth-degrading economic systems into earth-sustaining, or restorative, economies over the next several decades:

Reward earth-sustaining behavior

Discourage earth-degrading behavior

Use full-cost accounting to include the ecological value of natural resources in their market prices

Use environmental and social indicators to measure progress toward environmental and economic sustainability and human well being

Use full-cost pricing to include the external costs of goods and services in their market prices

Replace taxes on income and profits with taxes on throughput of matter and energy

Use low discount rates for evaluating future worth of irreplaceable or vulnerable resources

Establish public utilities to manage and protect public lands and fisheries

Revoke the government-granted charters of environmentally and socially irresponsible businesses

Make environmental concerns a key part of all trade agreements and of all loans made by international lending agencies

Reduce waste of energy, water, and mineral resources

Preserve biodiversity

Reduce future ecological damage and repair past ecological damage

Reduce poverty

Slow population growth

How can we make the transition to an earth-sustaining economy?

The environmental revolution is also an economic revolution that uses a mix of regulations and market-based approaches to reward earth-sustaining behavior by businesses and consumers and discourage earth-degrading behavior.

This system for change represents a shift in determining which economic actions are rewarded (profitable) and which ones are discouraged.

The problem in making this shift is not economics, but politics.

Case Studies: Ecological and Economic policies in Germany and the Netherlands

How is Germany investing in the future and the earth?

Stricter environmental standards and regulations in Germany have paid off in a cleaner environment and the development of innovative green technologies that can be sold at home and abroad in a rapidly growing market.

Germany continues to heavily subsidize its coal-mining industry, which increases environmental degradation and pollution and adds large amounts of carbon dioxide to the atmosphere.

What is the Netherlands' Green Plan to achieve and ecologically sustainable economy? 1989- the Netherlands began implementing their National Environmental Policy Plan (or Green Plan) for creating an economy that doesn't destroy the environment. The government identified 4 general themes for each target group to focus on:

I. Integrated life cycle management, which makes producers after users are through with them

II. Improving energy efficiency with the government committing $385 million per year to energy conservation programs

III. Invention of new or improved more sustainable technologies, supported by a government program to help develop such technologies

IV. Improving public awareness through a massive government-sponsored public education program.

Can we change economic gears in the next few decades?

Critics claim that a shift toward an earth-sustaining economy won't happen because it would be opposed by people whose subsidies were being eliminated and whose activities were being taxed. Companies and countries fail to invest in a green future may find that they do not have a future.

The environmental revolution is also an economic revolution.

Politics and Environment

Politics—the process by which individuals and groups try to influence or control the policies and actions of the government at the local, state, national, or international levels. - example of how politics can be used to benefit the government—the Nashua River cleanup in Mass.- spearheaded by Marion Stoddart (pp 776-777) POLITICS AND ENVIRONMENTAL POLICY

How does social change occur in democratic gov'ts??

Constitutional democracies are designed to allow for gradual change in order to ensure political and economic stability

Special interest groups are those competing factions that put pressure on gov't officials to advocate those laws that favor their cause or weaken those laws that oppose it. They can be profit-making organizations (corporations) or nonprofit, nongovernmental organizations (NGOs)

Most decisions result from bargaining, accommodating, and compromising among the elite, or power brokers, of the gov't who are attempting to maintain the status quo of the political system

Disadvantage of this system results from the fact that democratic gov'ts tend to react to issues rather than take measures to prevent them. This approach does not work in environmental issues, which acquire a long-term preventative plan.

How is environmental policy made in the U.S.??

Major function of the U.S. gov't is to develop and implement policy - composed of various laws, regulations, and funding

Lawmakers must first feel the environmental issue is one the gov't should address and then they create laws for the consideration of the House and Senate. Sometimes environmental bills are reviewed by 10 committees in both the House and Senate.

The most difficult process comes after the law is passed when Congress must appropriate funds for the enforcing of the new policy

Regulations are developed by the appropriate gov't agencies and often times a revolving-door relationship develops between regulators and those businesses affected by the regulations as those businesses try to get people sympathetic to their cause appointed to administrative positions in the regulatory agency

All of this results in incremental decision making in which only small changes are made in existing policies

How can the courts be used to implement or weaken environmental regulations??

Almost every environmental regulation is challenged in court by industry, environmental orgs, or both

Plaintiff - individual, group, corporation, or gov't agency bringing the charges

Defendant - individual, group, corporation, or gov't agency being charged

Civil suit - plaintiff seeks to collect damages for injuries to health or for economic losses, to have the court issue a permanent injunction against any further wrongful action, or both

Class action suit - civil suit filed by a group, often a public interest group or environmental org, on behalf of a larger number of citizens who allege similar damages

Environmental lawsuits limited by:

1. permission to file a damage suit is granted only if the harm to the individual plaintiff is clearly unique or different enough to be distinguished from the general public

2. The financial cost of a law suit.

3. public interest law firms cannot recover attorneys’ fees unless Congress has specifically authorized such recovery in the laws the firms seek to have enforced

4. difficult for plaintiff to prove that a defendant is liable and responsible for a harmful action

5. court or courts may take years to come to a decision

6. sometimes plaintiffs abuse the system by bringing frivolous suits that delay and run up costs of projects

Despite these handicaps, more than 20,000 attorneys in 100 public interest law firms now specialize in environmental law. Environmental law is the fastest growing sector in American legal profession

INFLUENCING ENVIRONMENTAL POLICY

Solutions: how can individuals affect environmental policy??

Change comes from grassroots political movements—bottom up, not top down - ways to influence and change govt policies:

1. vote for candidates and ballot measures

2. contribute money and time to candidates seeking office

3. lobby, write, e-mail, or call elected officials, asking them to pass or oppose certain laws, establish certain policies, or fund various projects

4. use education and persuasion

5. expose fraud, waste, and illegal activities in govt

6. file lawsuits

7. participate in grassroots activities to bring about change

Solutions: what are the three types of environmental leadership??

1. Leading by example- use your lifestyle to show others that is possible and beneficial

2. Working within existing economic and political systems to bring about environmental improvement

3. Challenging the system and basic societal values, as well as proposing and working for better solutions to environmental problems

ENVIRONMENTAL GROUPS

What are the roles of mainstream environmental groups?

Multi-million dollar organizations led by chief executive officers and a staff of experts

Active primarily on the national level, often form coalitions to work together on issues

Greenpeace- funnels funds to local activists and projects,

Sierra Club- prefers grassroots action but still works to influence national environmental policy,

The Environmental Defense Fund- prefers legal action against corporations that degrade the environment or against govt agencies that fail to enforce environmental laws

National Audubon Society, National Wildlife Federation, Wilderness Society, etc—focus on specific issues Worldwatch Institute, World Resources Institute- concentrate on education and research

Citizens' Clearinghouse for Hazardous Waste- provide info, training, and assistance to localities and grassroots orgs - these mainstream groups work within the political system, major forces in persuading Congress to pass environmental laws

"Group of 10"- 10 largest U.S. mainstream environmental agencies rely heavily on corporate donations and many chief corporate execs serve on the orgs' boards and staff—this causes opponents to believe that big corps are only trying to strong arm environmental policies thru these large environmental orgs—cause division b/w mainstream and grassroots

What are the roles of Grassroots Environmental Group?

At least 6000 grassroots' citizens groups exist in the U.S. - basic rules for effective political action by grassroots orgs:

1. have a fulltime continuing org
2. limit the number of targets and hit them hard

3. organize for action, not just for study, discussion, or education

4. form alliances with other orgs on a particular issue

5. communicate your positions in an accurate, concise, and moving way

6. persuade and use positive reinforcement

7. concentrate efforts mostly at the state and local levels

Grassroots movement for environmental justice- growing coalition to protect human and environmental rights

Environmental groups are also very active on college campuses and in public schools

THE ANTI-ENVIRONMENTAL MOVEMENT

What are the goals of the anti-environment movement?

Since 1980, anti-environmentalists have mounted a massive campaign to weaken and repeal existing environmental legislation
This attack includes:

1. stepped-up lobbying efforts against environmental laws and regulations in both Washington and state capitals

2. similar efforts by mayors and govt officials fed up with having to implement federal environmental laws w/o federal funding

3. coalition of grassroots front groups, Wise Use Movement- organized and funded by anti-environmentalists such as ranchers, loggers, and mining companies

4. global trade agreement (GATT) that many environmentalists feel could weaken existing environmental standards

5. attempts to pass federal laws that require highly uncertain risk-benefit analysis as the primary tool for determining govt environmental regulations

What are the tactics of the anti-environmentalist movement?

Establish an enemy - "green menace"- to create fear and divert attention away from real issues—"green menace" paints environmentalists as anti-business, antireligious radical extremists who cripple the economy and spend taxpayers money needlessly - weaken and intimidate- spy on activists and environmental groups, fire whistle-blowers who expose illegal environmental practices

Threaten or use violence- in the past, American environmentalists have been harassed by menacing phone calls, had their tires slashed, their pets killed, their homes trashed, their houses burned, and their jobs wrongfully taken from them

Influence public opinion- commission books, pamphlets, and PR firms in order to spread your opinions, start letter-writing campaigns

Either don't collect data or keep it secret - don't allow for info harmful to your position to leak to the public, exert political pressure on gov't agencies that are doing studies that weaken your position - falsify data, and attack independent scientists whose work challenges yours

Exploit the limitations of science and the ignorance of the public

Build up your public environmental image

Delay and wear out reformers

Use paralysis-by-analysis- urge that all government environmental decisions be evaluated by a cost-benefit and risk-benefit analysis

Support unenforceable legislation and regulations

When unfavorable environmental laws are passed, urge legislators not to fund the laws

Divide and conquer- keep people and interest groups fighting with one another so no vital issues can be addressed

EVALUATING CLAIMS OF ENVIRONMENTALISTS AND ANTI-ENVIRONMENTALISTS

Are environmental threats exaggerated?

Some cases of environmental regulatory overkill have occurred, i.e., acid rain and asbestos

In response to this problem, environmentalists must take a close look at the laws and regulations that already exist and evaluate which ones worked and why

It has already been discovered that the past way of approaching environmental legislation in a fragmented, isolated way- such as passing laws in regards to a certain chemical or a certain species- is not the best way to improve the environment

These issues require an integrated and holistic approach that takes into consideration the system as a whole- such as protecting and rehabilitating whole ecosystems

Confrontational environmental politics that pits corporate leaders (“bad guys”) against environmentalists (“good guys”) must be avoided

Whom should we believe?

Tough questions need to be posed to both sides

Citizens are encouraged to identify with consensus science and avoid the view of a small minority

Many of the issues that we face today are very complex and require a good grasp of general environmental issues in order to be understood

IMPROVING U.S. POLITICAL SYSTEM

How can we make government more responsive to ordinary citizens?

Most of the money that gets gov’t officials elected comes from wealthy individuals and powerful companies, thus restricting them from responding to ordinary citizens demands and the environmental issues

It costs the average U.S. senator $3.9 million dollars to get elected

Drastic reform is needed in the election process to fix this problem

How can bureaucracies be improved?

In the beginning, many new gov't agencies achieve some good if they are run well and stay current

After many years, most agencies become stagnant and are increasingly influenced by the businesses that they are supposed to regulate

Problems arise when many federal and state agencies overlap their policies, duplicate funds, and contradict one another

Pass a sunset law that automatically terminates any govt agency after a certain number of years- at which time it can be reviewed by a committee as to its fate

Slow the intermingling of regulatory agencies and the businesses they are regulating

How can we level the legal playing field for ordinary citizens?

1. allow citizens to sue violators of environmental laws for triple damages

2. award citizens attorney fees in successful lawsuits

3. let citizens sue gov't officials or damages caused by failure to do their duty

4. raise fines for violators of environmental laws and punish more violators with jail sentences

5. call for courts to do a better job at regulating frivolous suits brought against environmental activists that are not factually based

How can reducing crime help the environment?

Robbery, assault, and shootings keep people out of cities and push them into the suburbs where they clear more land and waste more energy

People are less willing to ride bikes, walk, or use public transit where crime is high

People leave lights, TVs, etc on to deter burglars

By reducing crime, the environment can benefit

GLOBAL ENVIRONMENTAL POLICY

Should we expand the concept of security?

National, economic, and military security all tie into environmental security because all countries are dependent on the ecosphere and require an integration of all three

What progress has been made in developing international environmental cooperation and policy?

1972 UN Conference on Human Environment in Stockholm, Sweden created the UN Environmental Programme (UNEP) to negotiate and implement treaties

Today, 115 nations have environmental agencies and there are more than 215 int'l environmental treaties have been signed

1992 Rio Earth Summit Results:

1. Earth Charter- non-binding document of broad principles for guiding environmental policy

2. Agenda 21- non-binding detailed plan to guide countries toward sustainable growth in the 21st century

3. forestry agreement

4. convention on climate change

5. convention on protecting biodiversity

6. est. of UN Commission on Sustainable Development

Leaders met in 1995 and found that little improvement had occurred as all the agreements of the 1992 summit were non-binding, the results were:

1. emissions of CO_2 rose in all but 3 countries

2. air pollution in most of world's cities worsened

3. freshwater supplies are in more peril

4. area of forest the size of Idaho is burned and cut each year

5. loss of biodiversity hasn't slowed

6. little has been done to reduce poverty

7. gaps b/w rich and poor have widened

8. no national govt has developed a plan for sustainable growth and production

9. World Bank has supplied $9.4 billion for fossil-fuel projects that increase global warning since 1992

All of this is discouraging, but the 1992 conference did give the world a forum to discuss environmental problems and it was paralleled by the Global Forum that brought together 18,000 people from 1400 NGOs from 178 countries

How can we help ensure environmental justice for all?

Forging on an alliance between human rights and environmental movement called environmental justice or eco-justice movement.

In the past, the two movements have been suspicious of one another, but an overlapping has occurred as many environmentalists are harassed for their beliefs

Both emphasize fundamental civil and political freedoms

Can we develop earth-sustaining political and economic systems over the next few decades?

Environmentalists believe that we can develop such a society but it will require a new eco-industrial revolution and the fulfillment of "the green vision". It is not just a special interest, but an ultimate interest of all people. We cannot save the world, but we can sustain our lifestyles as we know them.

Environmental Worldviews, Ethics, and Sustainability

A.D. 2060: Green Times in Planet Earth

Now is the time to decide what to do about our environment

Fossil fueling, fish harvesting, population, and extinction rates are all out of control. If they stay at current levels, we may not have much of an earth to live on in the future.

Environmental Worldviews in Industrial Societies

Clash of cultures and values

Environmental ethics: right versus wrong environmental behavior.

Environmental worldviews: the ways people think the world works, what they think their role in the world should be, and what they feel is right and wrong environmental ethics.

1. **Individual centered** (atomistic): usually human centered (anthropocentric) or life centered (biocentric).

2. **Earth centered** (holistic): either ecosystem centered or ecosphere centered.

Major Human-centered Worldviews

Most have planetary management worldview: human beings, as the planet's most important and dominant species, can and should manage the planet mostly for their own benefit. Other species merely have instrumental value: their value depends on whether they are useful to us.

Basic beliefs:

> We are the most important species, and we are in charge of nature.
>
> There are always more resources.
>
> All economic growth is good, and our potential for economic growth is limitless.

Success depends on how well we can understand, control, and manage earth's life-support systems for our benefit. Schools of thought:

No problem school - all problems can be solved with technology.

Free-Market school - the best way to manage earth is to use a free-market global with minimal government interference and regulation. All public property would become private.

Responsible planetary management - hold enlightened self-interest, or the thought that better earth-care is better self-care. Want to mix economy, technology, and government intervention

Space-ship-earth view - earth is a spaceship, with a complex machine that we can understand and manage.

Stewardship - we have a responsibility to care for and be responsible for the earth and we should treat it as our guardian.

Life-Centered and Environmental-Centered Worldviews

Managing the Planet

Some feel that we will not necessarily be able to learn technology fast enough to save the Earth. Also, a free market would rely too much on resources.

We don't understand the Earth, so they question how we could possibly manage it. Major Biocentric and Ecocentric Worldviews

We should realize the inherent value of nature. Everything has a right to exist.

Some go so far as to have a species-centered view, also known as the animal rights movement

They think preventing injury to species will save the money it takes to protect endangered species.

Some hold the **Earth-Wisdom Worldview**:

Nature exists for all of earth's species. There is not always more.

Some forms of economic growth are environmentally beneficial, but some are destructive.

Success depends on our willingness to cooperate with earth.

Are Biocentrists Antihuman/Antireligious

Those with the views of ecocentrism feel they are prohuman.

They feel they are helping the earth, which helps us.

Ecofeminist Worldview

Idea that being human centered and androcentric (male-centered) is the problem with the environment.

Being male-dominant, we are destroying nature.

Want to emphasize gentleness, caring, compassion, non-violence, cooperation, and love.

Social Ecology Worldview

As long as we have an industrial society, we will be damaging the environment.

This will cause decentralization of political and economic systems.

Living Sustainably

Evaluating Sustainability

We don't know the answer to environmental questions, so we ought to follow the pre-cautionary principle - use prevention guidelines and strategies for developing sustainable societies. Ethical Guidelines for Earth

Ethical Guidelines for Working with the Earth

1. Ecosphere and Ecosystems

We should try to understand nature.

When we must alter nature, first we should do our best to avoid environmental harm.

2. Species and Cultures

We should work to preserve genetic diversity.

We may do what we must to stay alive, but we should do what it takes to avoid premature extinction of other species.

We must protect ecosystems to save species.

No human culture should become extinct because of present actions.

3. Individual Responsibility-

We should not cause any suffering to our food sources.

We should leave the earth better than we found it.

We should use only what we have.

We should heal the wounds we have already caused.

Earth Education - We should teach our children about our earth:

Respect life.

Understand earth.

Understand interactions of humans and the earth.

Seek wisdom.

Evaluate personal worldviews.

Evaluate consequences of lifestyles and professions

Use critical thinking skills.

Want to help the earth.

Learning to work with Earth

Listen to our children, who favor saving the earth.

Learn to make our own area sustainable.

Have fun saving the earth.

Learning to Live Simple: Gandhi's **Philosophy of Voluntary Simplicity** – "Do and enjoy things more with less."

It is based on Gandhi's **Principle of Enoughness**- the earth provides enough to satisfy every person's need but not every person's greed. We should use the minimal amounts of everything. This is not the same as forced simplicity that plagues those that cannot afford to have possessions.

Law of Progressive Simplification - we must transfer energy from material to nonmaterial.

Moving on

We need to stop blaming and start taking responsibility.

We must avoid the four traps:

1. Avoid the common mental traps that lead to denial, indifference and inaction:

    Gloom and doom pessimism - feeling it's over

    Blind technological optimism - science will save us

    Fatalism - we have no control of the future

    Extrapolation to infinity - if there's no quick fix, why bother?

    Paralysis by analysis - try to find the perfect solution before acting

Only faith in simple answers

2. We must realize no one can do it all.

3. Hope is vital.

4. There is more than one possible solution.

Components of the Earth-Wisdom Revolution

Efficiency revolution to make the most of the earth

Pollution prevention

Sufficiency revolution- being sure that everyone has his or her basic needs.

Demographic revolution- balance population growth.

Seeing the world as a flow of matter and energy.

AP Environmental Science
Review of Common Ambient Air Pollutants

Name	Criteria	1 / 2	Source & Impact
1. Carbon monoxide (CO)	Yes	1	Sources: Incomplete combustion of fuel, combustion of waste.
			Impact: Out-matches O_2 for hemoglobin, potentially suffocating.
2. Lead (Pb)	Yes	1	Sources: Exhaust fumes from leaded gasoline, metal smelting.
			Impact: A heavy metal that is toxic to nerve cells.
3. Nitrogen dioxide (NO_2)	Yes	1 + 2	Sources: Transportation (cars, trucks, trains, boats & planes), electrical utilities and some factories. N_2 + O_2 -7 NO_2
			Impact: A component of photochemical smog and acid deposition.
4. Particulate matter (suspended particulate matter / SPM)	Yes	1 + 2	Sources: Soot and SO_2 from coal combustion, dust from human activities, natural dust sources
			Impact: Inhalation causes respiratory diseases, ranging from asthma to respiratory distress and lung cancer
5. Sulfur dioxide (SO_2)	Yes	1	Sources: Combustion of coal and petroleum.
			Impact: Reacts in atmosphere to form SO_3 and H_2SO_4, components of acid deposition. (see reactions sheet)
6. Tropospheric ozone (O_3) (aka: ground level ozone)	Yes	2	Sources: Reaction of NO from motor vehicles with sunlight, heat and O_2
			Impact: Damage to plants and respiratory system, traps heat, and contributes to thermal inversion
7. Carbon dioxide (CO_2)	No	1	Sources: Combustion of any organic material. Gasoline, petroleum, coal, natural gas, biomass. Also respiration.
			Impact A greenhouse gas, CO_2 absorbs thermal radiation and re-emits it at lower wavelengths.
8. Mercury (Hg)	No	1	Sources: Combustion of coal.
			Impact: A heavy metal that is toxic to nerve cells. Capable of bioaccumulation and biomagnification.
9. Nitric Oxide (NO)	No	1	Sources: Transportation (cars, trucks, trains, boats & planes). High heat of engine causes O_2 + N_2 -7 NO
			Impact: Poisonous. Reacts with O_2 to form NO_2, leading to ground-level ozone production.
10. Nitric Acid (HNO_3)	No	2	Source: Transportation (cars, trucks, trains, boats and planes). NO_2 + H_20 -7 NO + HNO_3
			Impact: Contributes to acid deposition. Harms respiratory system.
11. Peroxacyl nitrates (PANs)	No	2	Source: Transportation (cars, trucks, trains, boats and planes). NO_2 + hydrocarbons ("HC") -7 PANs
			Impact: A strong respiratory and eye irritant. Potentially mutagenic. Can damage vegetation.
12. Sulfur trioxide (SO_3)	No	2	Sources: Combustion of coal and petroleum. Coal has variable quantities of sulfur.
			Impact: Reacts with water in the atmosphere to form sulfuric acid (H_2SO_4). Contributes to acid deposition.
13. Sulfuric acid (H_2SO_4)	No	2	Sources: Combustion of coal and petroleum. Coal has variable quantities of sulfur.
			Impact Contributes to acid deposition. Harms respiratory system.
14. Volatile Organic Compounds (VOCs)	No	1 + 2	Sources: Automobile exhaust, solvents, industrial processes, household chemicals.
			Impact: Contribute to climate change & ground level O_3. Some are carcinogenic, some harm respiratory system

*Note: The category labeled "1 + 2" indicates whether the pollutant is a "primary air pollutant", a "secondary air pollutant" or both.

Other Important Information

Endangered Species

Most Endangered Species: have a small range, require large territory, have long generations, have a very specialized niche, or live on an island.

Atlantic Salmon: interbreeding with and competition from escaped farm-raised salmon from the aquaculture industry threaten the wild salmon population.
California Condor: reasons for decline include shootings, poisoning, lead poisoning, collisions with power lines, egg collecting, pesticides, habitat loss, and the decline of large and medium-size native mammals due to encroachments of agriculture and urbanization.
Delhi Sands Flower-Loving Fly: a 1-inch long insect currently restricted to only 12 known populations in San Bernardino and Riverside counties. An estimated 98% of its habitat has been converted to residential, agricultural, and commercial use.
Florida Panther: hunting and development that resulted in habitat loss and fragmentation.
Gray Wolf: subject of predator eradication programs sponsored by the Federal government. Prior to Endangered Species Act (1973), exterminated from the lower 48 states except for a few hundred inhabiting extreme northeastern Minnesota and a small number on Isle Royale, Michigan
Grizzly Bear: conflict with humans and development that resulted in habitat loss and fragmentation
Piping Plover: predation and human disturbance are thought to be the main causes of the plover's decline. It is listed as endangered in the Great Lakes region and as threatened in the Great Plains and on the Atlantic coast
Manatee: initial population decreases resulted from overharvesting for meat, oil, and leather. Today, heavy mortality occurs from accidental collisions with boats and barges, and from canal lock operations.
Whooping Crane: drainage of wetlands, conversion of grasslands to agriculture, and hunting for feathers.

NOT Endangered Species

American Alligator: overhunting and destruction of habitat caused original listing, removed from the list of endangered species by the Fish and Wildlife Service in 1987.
Bald Eagle: ingested DDT by eating contaminated fish. The pesticide caused the shells of the bird's eggs to thin and resulted in nesting failures. Loss of nesting habitat and hunting for feathers also contributed to the population decline. Reclassified from endangered to threatened (1995).
Peregrine Falcon: ingested DDT by eating smaller birds, which had eaten contaminated prey. The pesticide caused the shells of the bird's eggs to thin and resulted in nesting failures. Removed from the list of endangered species by the Fish and Wildlife Service in August 1999.
Gray Whale: the eastern North Pacific stock of gray whale has the distinction of being the first population of a marine mammal species to be removed from the List of Endangered and Threatened Species.

Biomes

Biome: large distinct terrestrial region having similar climate, soil, plants & animals.
Tropical Rain Forests: characterized by the greatest diversity of species, believed to include many undiscovered species. Occur near the equator. Soils tend to be low in nutrients. Distinct seasonality: winter is absent, and only two seasons are present (rainy and dry).
Temperate Forests: occur in eastern North America, Japan, northeastern Asia, and western and central Europe. Dominated by tall deciduous trees. Well-defined seasons include a distinct winter. Logged extensively, only scattered remnants of original temperate forests remain.
Boreal Forests or Taiga: represent the largest terrestrial biome. Dominated by needleleaf, coniferous trees. Found in the cold climates of Eurasia and North America: two-thirds in Siberia with the rest in Scandinavia, Alaska, and Canada. Seasons are divided into short, moist, and moderately warm summers and long, cold, and dry winters. Extensive logging may soon cause their disappearance.
Temperate Shrub Lands: occurs along the coast of Southern California and the Mediterranean region. Characterized by areas of Chaparral–miniature woodlands dominated by dense stands of shrubs.
Savannas: grassland with scattered individual trees. Cover almost half the surface of Africa and large areas of Australia, South America, and India. Warm or hot climates where the annual rainfall is 20-50 inches per year. The rainfall is concentrated in six or eight months of the year, followed by a long period of drought when fires can occur.
Temperate Grasslands: dominated by grasses, trees and large shrubs are absent. Temperatures vary more from summer to winter, and the amount of rainfall is less than in savannas. Temperate grasslands have hot summers and cold winters. Occur in South Africa, Hungary, Argentina, the steppes of the former Soviet Union, and the plains and prairies of central North America.
Deserts: covers about one fifth of the Earth’s surface and occur where rainfall is less than 50 cm/year. Most deserts occur at low latitudes, have a considerable amount of specialized vegetation, as well as specialized animals. Soils have abundant nutrients, need only water to become productive, and have little or no organic matter. Common disturbances include occasional fires or cold weather, and sudden, infrequent, but intense rains that cause flooding.
Tundra: treeless plains that are the coldest of all the biomes. Occur in the arctic and Antarctica. Dominated by lichens, mosses, sedges, and dwarfed shrubs Characterized by extremely cold climate, permanently frozen ground (permafrost) low biotic diversity, simple vegetation structure, limitation of drainage, short season of growth and reproduction.
Wetlands: areas of standing water wet all or most of the year that support aquatic plants including marshes, swamps, and bogs. Species diversity is very high. Includes bogs, swamps, sloughs, marshes
Fresh Water: defined as having a low salt concentration (less than 1%). Plants and animals are adjusted to the low salt content and would not be able to survive in areas of high salt concentration (i.e., ocean). There are different types of freshwater regions: ponds and lakes, streams and rivers, and estuaries.
Oceans: the largest of all the ecosystems. The ocean regions are separated into separate zones: intertidal, pelagic, abyssal, and benthic. All four zones have a great diversity of species.

Places to Know

Chernobyl, Ukraine: April 26, 1986, unauthorized safety test (irony), leads to fire and explosion at nuclear power plant—millions exposed to unsafe levels of radiation.

Three-Mile Island, Pennsylvania: March 29, 1979, nuclear power plant loses cooling water 50% of core melts, radioactive materials escape into atmosphere, near meltdown (disaster).

Yucca Mountain, Nevada: controversial as proposed site for permanent storage of high-level nuclear waste, 70-miles northwest of Las Vegas, near volcano and earthquake faults.

Aral Sea, Uzbekistan/Kazakhstan (former Soviet Union)**:** large inland sea is drying up as a result of water diversion.

Love Canal, NY: chemicals buried in old canal, school and homes built over it led to birth defects and cancers.

Aswan High Dam, Egypt: the silt that made the Nile region fertile fills the reservoir. Lack of irrigation controls causes waterlogging and salinization. The parasitic disease schistosomiasis thrives in the stagnant water of the reservoir.

Three Gorges Dam, China: world's largest dam on Yangtze River will drown ecosystems, cities, archeological sites, fragment habitats, and displace 2 million people.

Ogallala Aquifer: world's largest aquifer; under parts of Wyoming, South Dakota, Nebraska, Kansas, Colorado, Oklahoma, New Mexico, and Texas (the Midwest). Holds enough water to cover the U.S. with 1.5 feet of water. Being depleted for agricultural and urban use.

Minamata, Japan: mental impairments, birth defects, and deaths were caused by mercury dumped in Minamata Bay by factory. Mercury entered humans through their diet (fish).

Bhopal, India: December 2,1984, methyl isocyanate released accidentally by Union Carbide pesticide plant kills over 5,000.

Valdez, Alaska: March 24, 1989, tanker Exxon Valdez hits submerged rocks in Prince William Sound—worst oil spill in US waters.

Environmental Laws and Treaties

Safe Drinking Water Act: set maximum contaminant levels for pollutants that may have adverse effects on human health.

Ocean Dumping Ban Act: bans ocean dumping of sewage sludge & industrial waste.

National Wild and Scenic Rivers Act: protects rivers with due to aesthetic, recreational, wildlife, historical, or cultural reasons.

Clean Water Act: set maximum permissible amounts of water pollutants that can be discharged into waterways. Aim: to make surface waters swimmable and fishable.

Surface Mining Control & Reclamation Act: requires coal strip mines to reclaim the land.

National Environmental Policy Act (NEPA): Environmental Impact Statements must be done before any project affecting federal lands can be started.

Clean Air Act: Set emission standards for cars, and limits for release of air pollutants.

Kyoto Protocol: controlling global warming by setting greenhouse gas emissions targets for developed countries.

Montreal Protocol: phase out of ozone depleting substances.

Resource Conservation & Recovery Act (RCRA): controls hazardous waste with a cradle to grave system.

Comprehensive Environmental Response, Compensation & Liability Act (CERCLA): The "Superfund" act, designed to identify and clean up abandoned hazardous waste dumpsites.

Endangered Species Act: identifies threatened and endangered species in the US, and puts their protection ahead of economic considerations.

Convention on International Trade in Endangered Species: (CITES) lists species that cannot be commercially traded as live specimens or wildlife products.

Lacey Act: prohibits interstate transport of wild animals dead or alive without federal permit.

U.S. Marine Mammal Protection Act: prohibits taking marine mammals in U.S. waters and by U.S. citizens, and the importing marine mammals and marine mammal products into the U.S.

Federal Insecticide, Fungicide, and Rodenticide Act: regulates the effectiveness of pesticides.

Food Quality Protection Act: set pesticide limits in food, & all active and inactive ingredients must be screened for estrogenic/endocrine effects.

Low-Level Radioactive Policy Act: all states must have facilities to handle low-level radioactive wastes.

Nuclear Waste Policy Act: US government must develop a high level nuclear waste site by 2015 (see Yucca Mountain).

People to Know

Rachel Carson: published *Silent Spring* in 1962; documented the environmental damage done by DDT and other pesticides. Which heightened public awareness at the start of the modern environmental movement.

John Muir: founded Sierra Club in 1892; fought unsuccessfully to prevent the damming of the Hetch Hetchy Valley in Yosemite National Park.

Gifford Pinchot: first chief of the US Forest Service; advocated managing resources for multiple use using principles of sustainable yield.

Garrett Hardin: published “The Tragedy of the Commons” in the journal *Science* in 1968; argued that rational people will exploit shared resources (commons).

Aldo Leopold: wrote *A Sand County Almanac* published a year after his death in 1948; promoted a “Land Ethic” in which humans are ethically responsible for serving as the protectors of nature.

Sherwood Rowland & Mario Molina: in 1974, determine that CFCs destroy stratospheric (good) ozone.

Top Ten Populations

World~ 7 Billion

Rank	Country	Population
1	China	1,343,239,923
2	India	1,205,073,612
3	United States	313,847,465
4	Indonesia	248,645,008
5	Brazil	199,321,413
6	Pakistan	190,291,129
7	Nigeria	170,123,740
8	Bangladesh	161,083,804
9	Russia	142,517,670
10	Japan	127,368,088

World Top Ten Countries by Coal Production

Country	**Coal Production (2010e) in MT**
China	3162
USA	932
India	538
Australia	353
South Africa	255
Russia	248
Indonesia	173
Kazakhstan	105
Poland	77
Colombia	74

Top Ten Oil Reserves Countries

Country	**Billions of Barrels**
Saudi Arabia	261.8
Canada	180
Iraq	112.5
U.A.E.	97.8
Kuwait	96.5
Iran	89.7
Venezuela	77.8
Russia	60
Libya	29.5
Nigeria	24

World Top Ten Countries With Most Reliance On Nuclear Power

Country	Nuclear Electricity As Percentage Of Total Electricity
Lithuania	78
France	77
Belgium	58
Slovakia	53
Ukraine	46
Sweden	44
Bulgaria	42
Hungary	39
Slovenia	39
South Korea	39

Top 10 wind power countries

Country	**Total capacity end 2012 (MW)**
China	75,564
United States	60,007
Germany	31,332
Spain	22,796
India	18,421
United Kingdom	8,445
Italy	8,144
France	7,196
Canada	6,200
Portugal	4,525

- Technically because of tar sand, Canada's oil supply is second to Saudi Arabia.
- Most likely on AP exam, France will be known for highest Nuclear energy production.
- US has most Geothermal but Iceland depends more on it.
- US consumes the most of almost everything.
- Energy waste should be prevented.

Math Review

One BTU is the energy required to raise the temperature of one pound of water by one degree Fahrenheit.

The density of water is 1 gram/milliliter or approximately 8 pounds/gallon (U.S.).

Per Capita= divide by the total population

US Population currently about 300,000,000

Rate of Change: (old-new) / old

Percent Change: {(old-new) / old } x 100

Annual % Change:

$$\frac{(\text{births} + \text{immigrants}) - (\text{deaths} + \text{emigrants})}{\text{number of people}} \times 100$$

Doubling Time: 70 / % growth = years to double

Determining Percentage: $\frac{\text{part}}{\text{whole}} = \frac{\%}{100}$

Half Life Fractions:

1/2; 1/4; 1/8; 1/16; 1/32; 1/64; 1/128; 1/256

Primary Productivity:

Net Productivity = Gross Product. – Cell Respiration

Conversions:

1 Megawatt = 1,000 kilowatts

1 kilowatt = 1,000 watts

1 kilowatt hour = 10,000 BTU’s

kilowatts x hours = kwh

1L = 1,000 mL

Scientific Notation:

**To S.N.

0.00068 → 6.8×10^{-4}

6,845 → 6.8×10^{3}

**To Standard

5.56×10^{-6} → 0.00000556

5.56×10^{6} → 5,560,000

Messing with Scientific Notation:

**Multiplication→ add exponents; multiply bases

$(3 \times 10^{3})(4 \times 10^{5}) = 12 \times 10^{8} = 1.2 \times 10^{9}$

** Division→ subtract exponents; divide bases

$(5.2 \times 10^{4}) / (2.6 \times 10^{2}) = 2 \times 10^{2}$

**Addition→ convert both #'s to the same exponent; add bases; exponents stay the same

$(3000 \times 10^{6}) + (14 \times 10^{5}) = 3001.4 \times 10^{6} = 3.0 \times 10^{9}$

**Subtraction→ convert both #'s to same exponent; subtract bases; exponents stay the same

$(2000 \times 10^{3}) – (1000 \times 10^{2}) = 1900 \times 10^{3} = 1.9 \times 10^{6}$

Chemistry Review

Basics

→ Neutrons, protons, and electrons are the components of atoms, which combine to form molecules.

→ The basic unit of all chemical compounds, whether natural or man-made, is the molecule.

Abbreviations

C ≡ carbon	S ≡ sulfur	U ≡ uranium	Cl_2 ≡ chlorine
O_2 ≡ oxygen	N_2 ≡ nitrogen	H_2 ≡ hydrogen	P ≡ phosphorus
NO_2^{-1} ≡ nitrite	NO_3^{-1} ≡ nitrate	SO_4^{-2} ≡ sulfate	NH_3 ≡ ammonia

NO_x ≡ oxides of nitrogen or nitrogen oxides (NO, NO_2)

SO_x ≡ oxides of sulfur or sulfur oxides (SO_2, SO_3)

VOC ≡ volatile organic compounds (compounds containing carbon which readily evaporate, ex. methane, benzene)

PAN ≡ peroxyacyl nitrates

pH

→ pH is the negative log of the hydrogen ion concentration (sometimes called the potential of hydrogen ion).

→ Mathematically it is represented by the equation: $pH = -\log[H^+]$ <u>or</u> $pH = -\log[H_3O^+]$

→ $[H^+]$ is the molarity (# of moles per liter) of H^+ ions

→ $[H^+]$ and $[H_3O^+]$ are essentially the same. H_3O^+ is called the hydronium ion, it results when H^+ are in water.

→ Low pH corresponds to being more acidic. High pH corresponds to being more basic.

→ The opposite of acidic is basic.

→ The range of pH is from 0 to 14.

pH=1 ∴ $[H^+]=1 \times 10^{-1}$ moles/liter (very acidic)	pH=4 ∴ $[H^+]=1 \times 10^{-4}$ moles/liter (acidic)
pH=6 ∴ $[H^+]=1 \times 10^{-6}$ moles/liter (slightly acidic)	pH=7 ∴ $[H^+]=1 \times 10^{-7}$ moles/liter (neutral)
pH=8 ∴ $[H^+]=1 \times 10^{-8}$ moles/liter (slightly basic)	pH = 13 ∴ $[H^+]=1 \times 10^{-13}$ moles/liter (very basic)

NuclearFission

→ Nuclear fission (splitting atoms) is the source of energy in today's nuclear power plants. The reactions used are chain reactions, in which one neutron initiates the reaction of millions of Uranium nuclei.

1 U-235 + 1 n → 1 Kr-92 + 1 Ba-141 + 3 n + energy (the 3 neutrons (n) initiate further reactions)

3 U-235 + 3 n → 3 Kr-92 + 3 Ba-141 + 9 n + energy (the 9 neutrons initiate further reactions)

9 U-235 + 9 n → 9 Kr-92 + 9 Ba-141 + 27 n + energy (the 27 neutrons initiate further reactions)

This continues until there are millions of neutrons being produced and millions of times more energy, as well.

→ A moderator and control rods are used to absorb neutrons to prevent the chain reaction from getting out of control which would result in a meltdown.

Air Pollution in the Troposphere

→ All fossil fuels contain large amounts of carbon (from the molecules of decomposed life forms). The combustion of fossil fuels (reaction with oxygen) produces carbon dioxide and carbon monoxide:

$C + O_2 \rightarrow CO_2$ (the #1 man-made greenhouse gas)

$2C + O_2 \rightarrow 2CO$ (incomplete combustion)

→ Coal may also contain sulfur which reacts during combustion:

$S + O_2 \rightarrow SO_2$

→ During combustion, the nitrogen that composes 80% of the air in the troposphere reacts:

$N_2 + O_2 \rightarrow 2NO$

→ The reactions above all show the formation of primary air pollutants

→ Primary air pollutants undergo reactions in the atmosphere to form secondary air pollutants.

Photochemical Smog

$2NO + O_2 \rightarrow 2NO_2$ (causes brownish haze)

NO_2 + UV light $\rightarrow NO + O$ followed by:

$O + O_2 \rightarrow O_3$ (O_3 is ozone and is very hazardous to plants, animals, and materials in the troposphere)

hydrocarbons + $O_2 + NO_2 \rightarrow$ PANs (peroxyacyl nitrates cause burning eyes and damage vegetation)

Acid Precipitation

$3NO_2 + H_2O \rightarrow 2HNO_3 + NO$ (HNO_3 is nitric acid and causes acid precipitation)

$2SO_2 + O_2 \rightarrow 2SO_3$ followed by:

$SO_3 + H_2O \rightarrow H_2SO_4$

→ Acid deposition can be neutralized by the addition of lime ($CaCO_3$) which is a base (a base will neutralize an acid)

Air Pollution in the Stratosphere

The reaction that is supposed to happen, which protects the Earth from UV light

$2O_3$ + UV light $\rightarrow 3O_2$

The destruction of ozone by CFCs

CCl_3F + UV light $\rightarrow CCl_2F + Cl$ (CCl_3F is a CFC) followed by:

$Cl + O_3 \rightarrow ClO + O_2$ followed by:

$ClO + O \rightarrow Cl + O_2$ followed by:

$Cl + O_3 \rightarrow ClO + O_2$ (same as first step above) followed by:

$ClO + O \rightarrow Cl + O_2$ (same as second step above) followed by:

(these reactions are repeated thousands of times to destroy thousands of ozone molecules)

APES

Easter Island

Sustainability

- A system/process can continue indefinitely without depleting resources used.

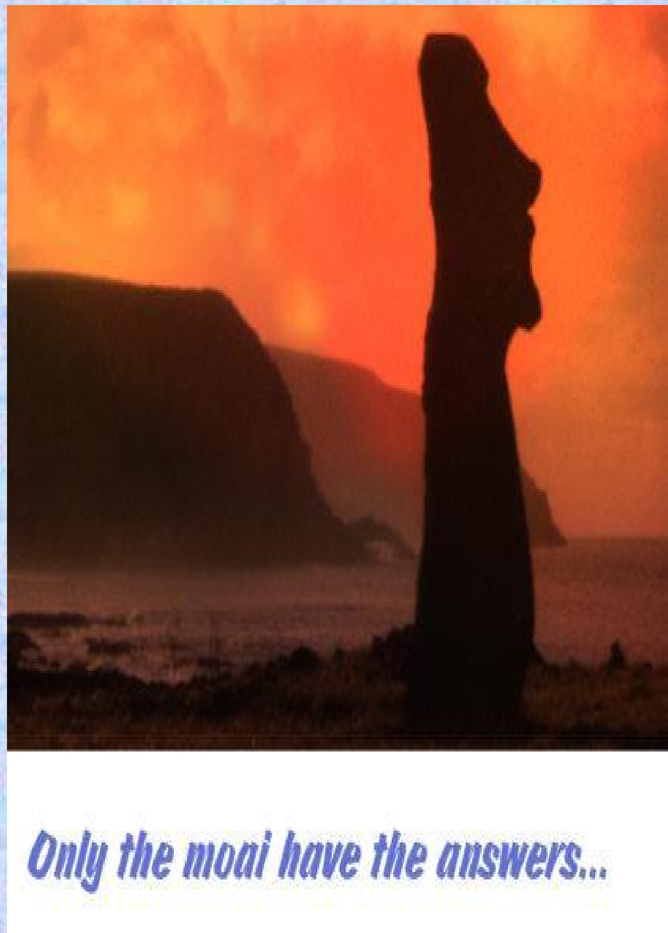
no sacrifice to future generations

Stewardship

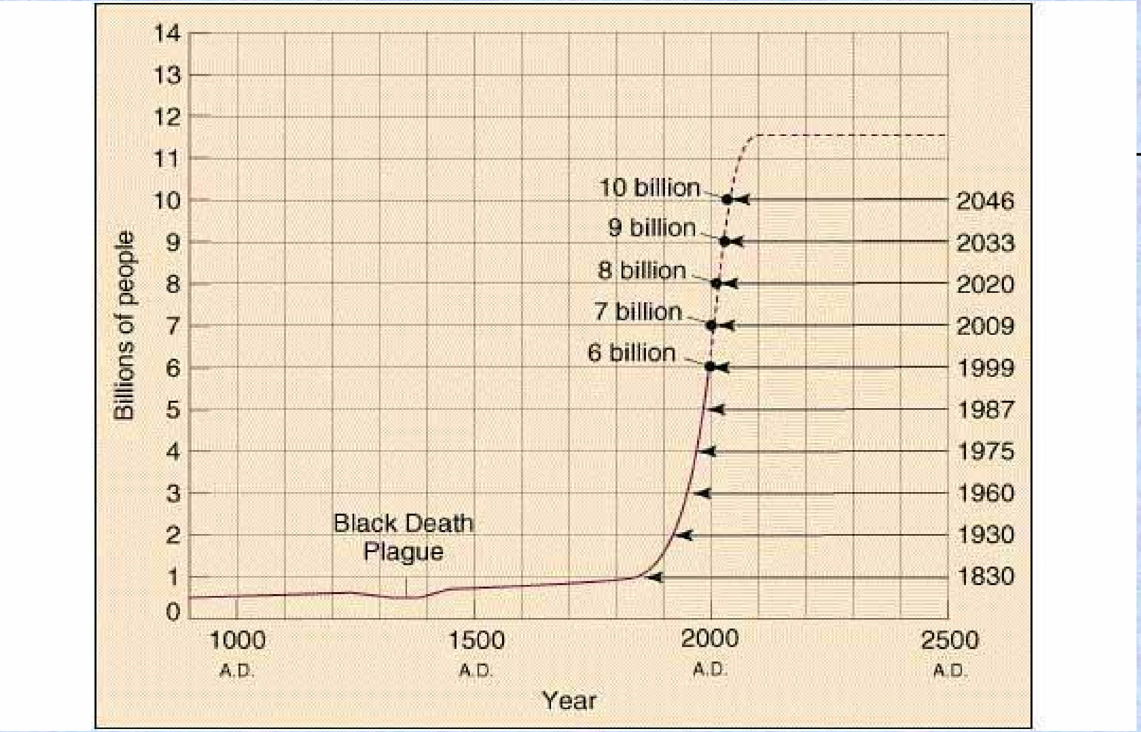
Caring for something that does not belong to you

Sound Science

Use the scientific method



A. Human population growth



- More than 7 billion people currently
- last 25 yrs population grew by 2 billion
- Birth Rate-Death Rate= Pop Growth Rate
- Rule of 70. 70 divided by % rate of increase= doubling time
- 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

- 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

$CFCl_3$ + UV Light ==> $CFCl_2$ + Cl

Cl + O_3 ==> ClO + O_2

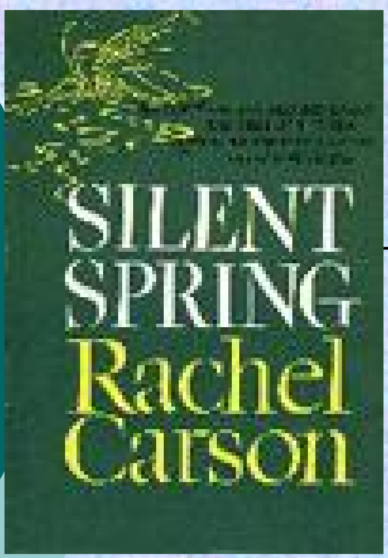
ClO + O ==> Cl + O_2

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

OZONE DEPLETION AND CLIMATE CHANGE ARE DIFFERENT FROM EACHOTHER AND HAVE DIFFERENT CAUSES!

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 Environmentalist

- 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

Cool Web Animation (Click Here)

Ecosystems

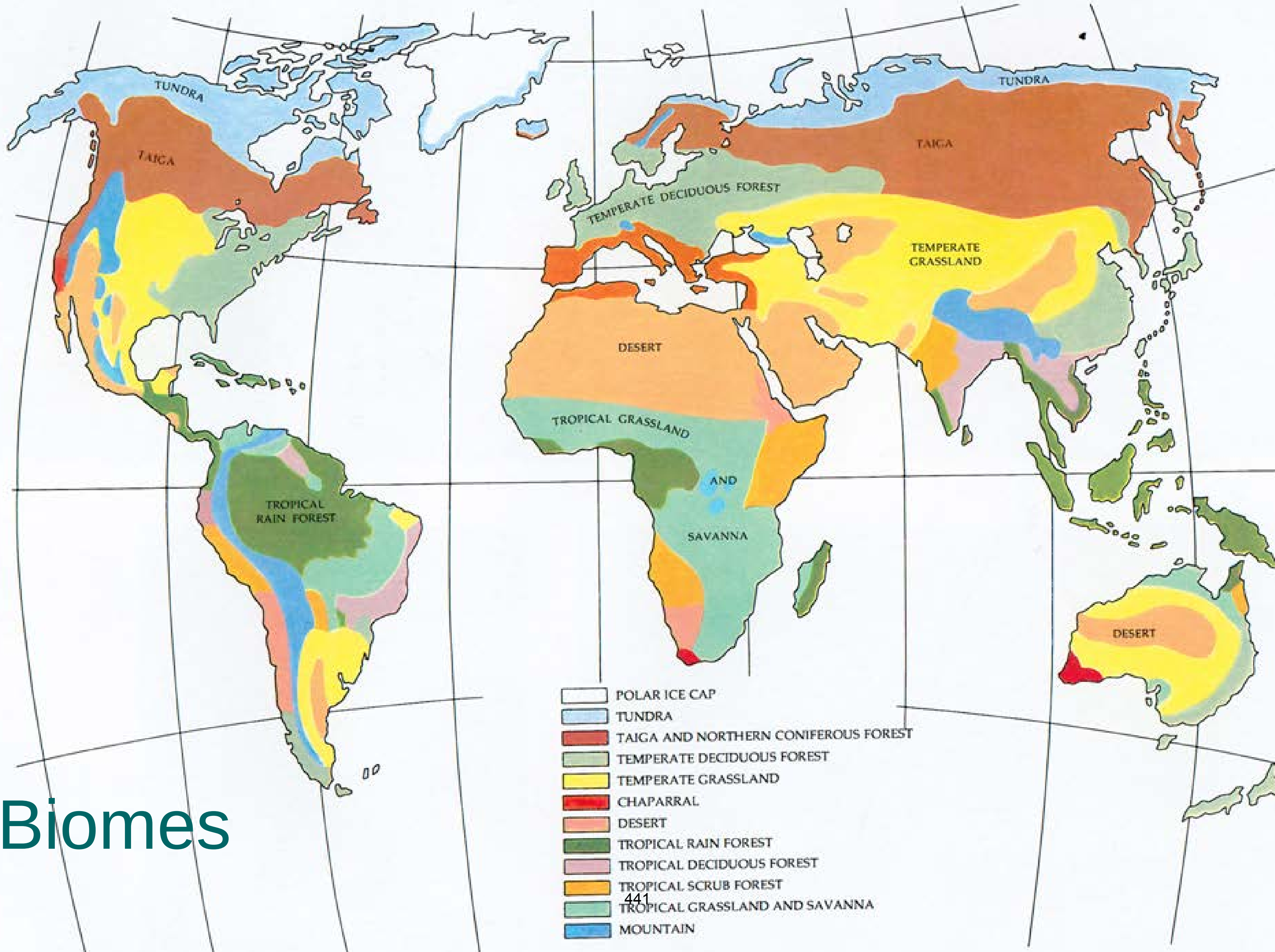
Plants and animals interacting with their abiotic environment. Ecosystems exist in biomes.

- Climate – ave temperature over time
- *Weather – daily variations in temp and precipitation
- Microclimate and Other Abiotic Factors

  * light intensity

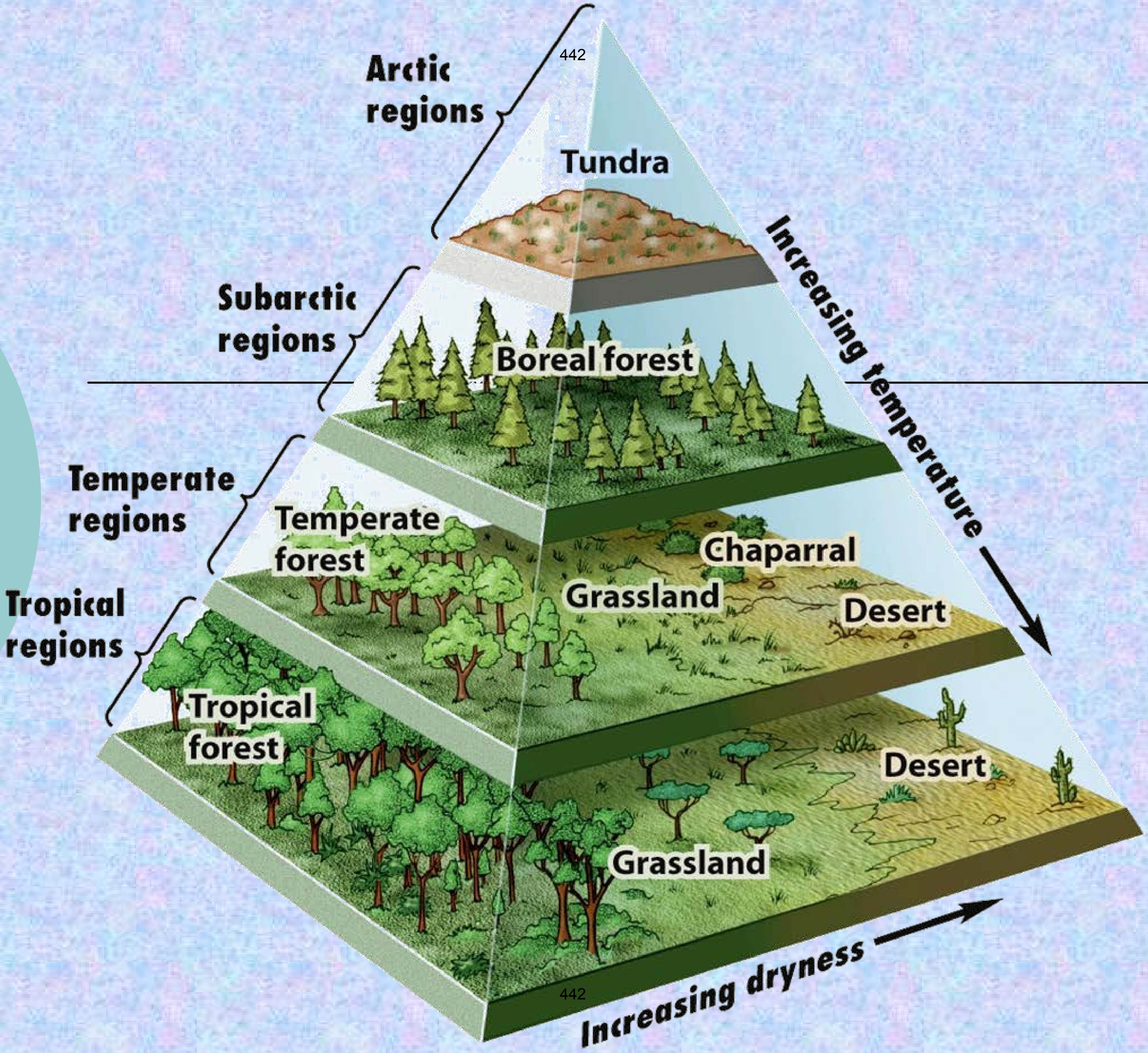
  * Soil type

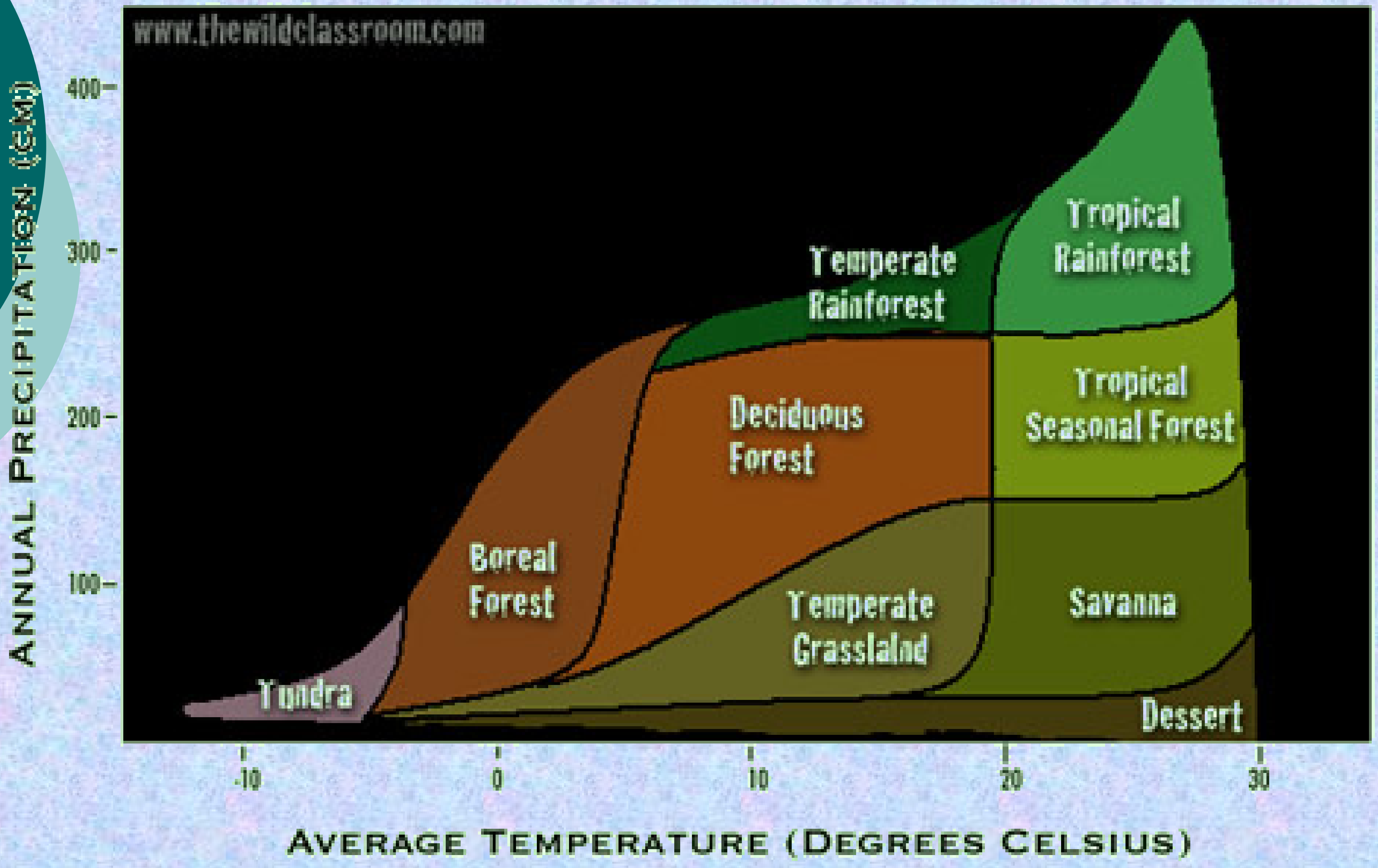
  * topography

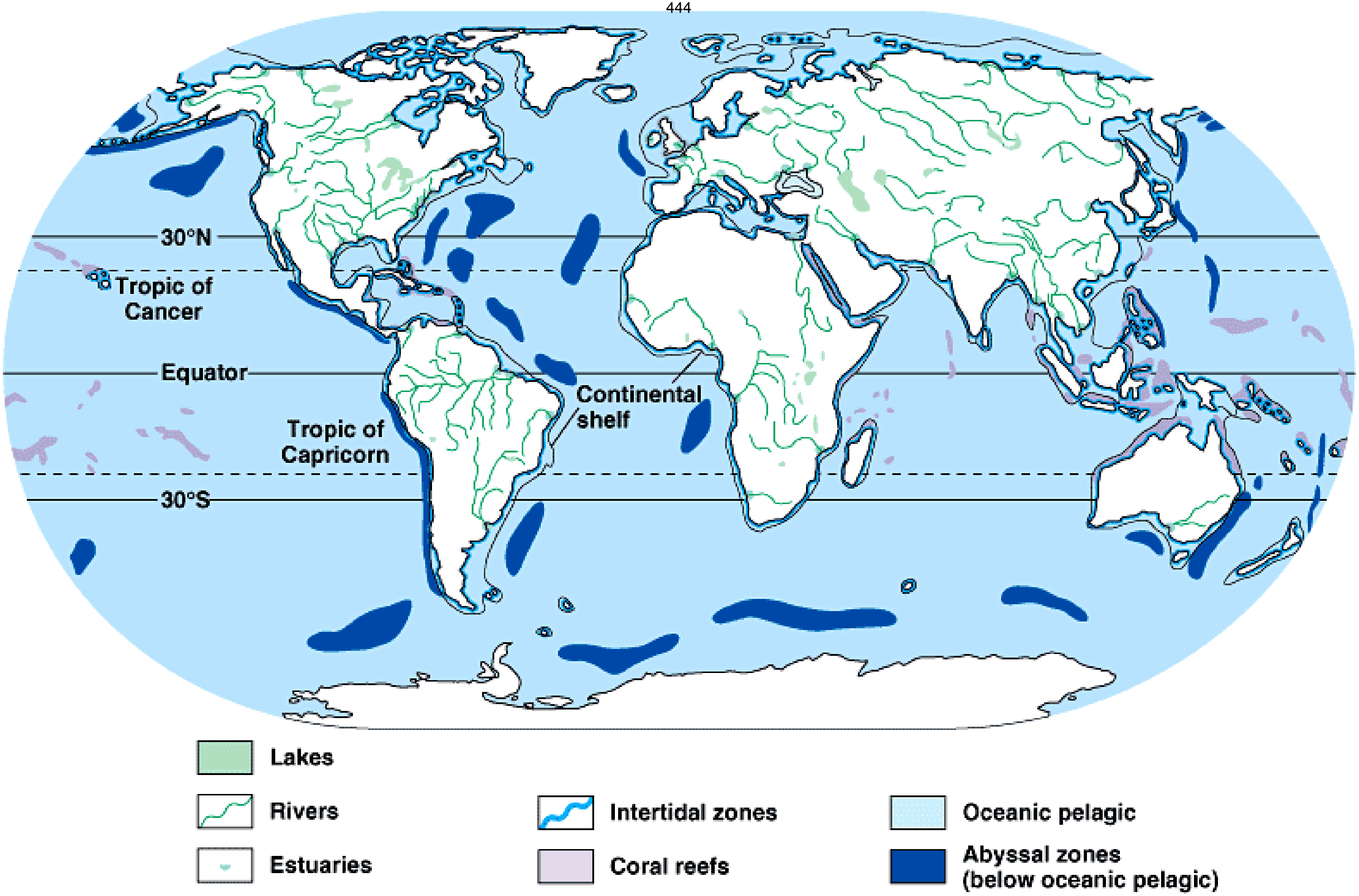

TUNDRA
TAIGA
TUNDRA
TAIGA
TEMPERATE DECIDUOUS FOREST
TEMPERATE GRASSLAND
DESERT
TROPICAL GRASSLAND AND SAVANNA
TROPICAL RAIN FOREST
DESERT
POLAR ICE CAP
TUNDRA
TAIGA AND NORTHERN CONIFEROUS FOREST
TEMPERATE DECIDUOUS FOREST
TEMPERATE GRASSLAND
CHAPARRAL
DESERT
TROPICAL RAIN FOREST
TROPICAL DECIDUOUS FOREST
TROPICAL SCRUB FOREST
TROPICAL GRASSLAND AND SAVANNA
MOUNTAIN

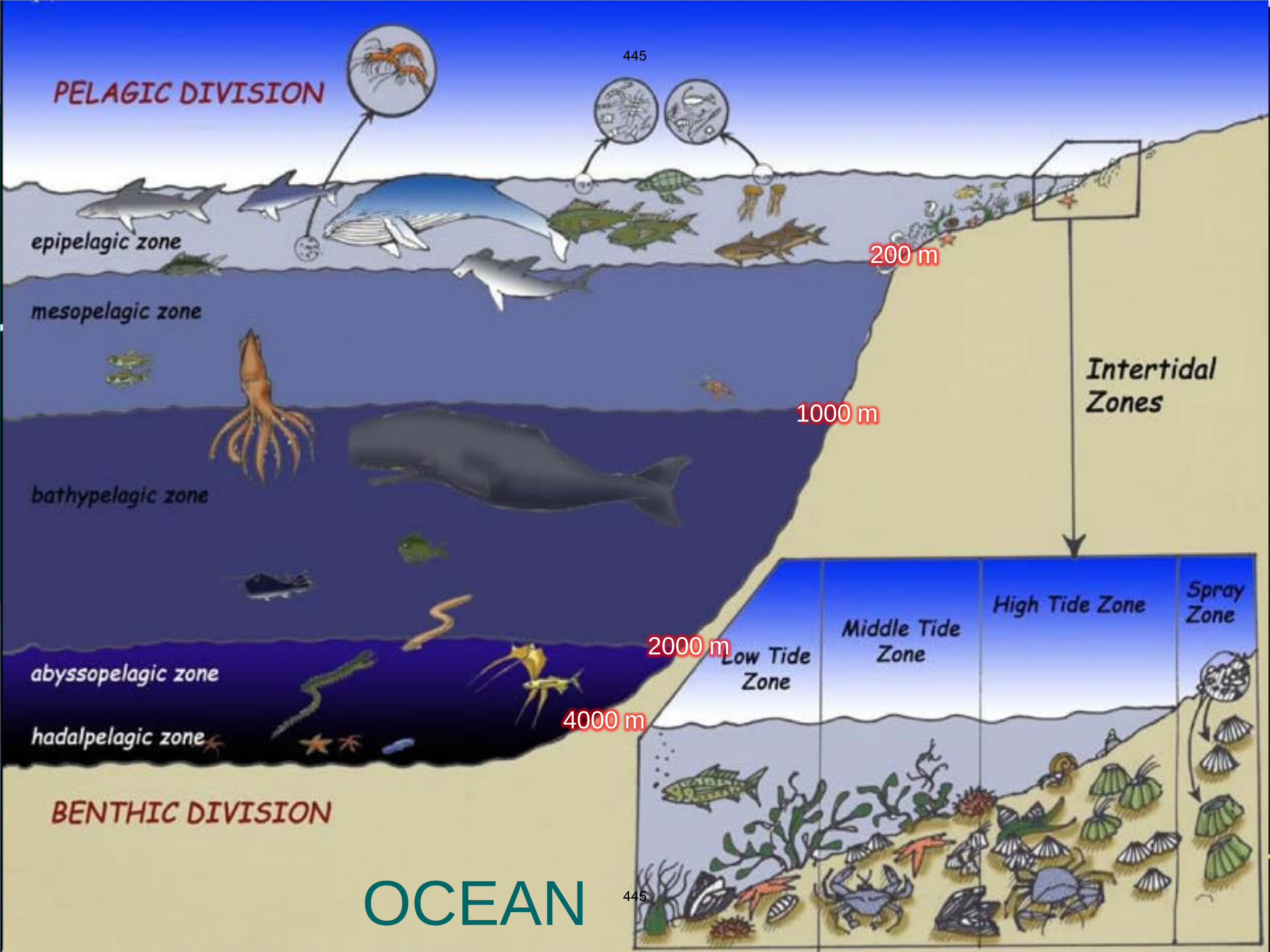
Biomes

441

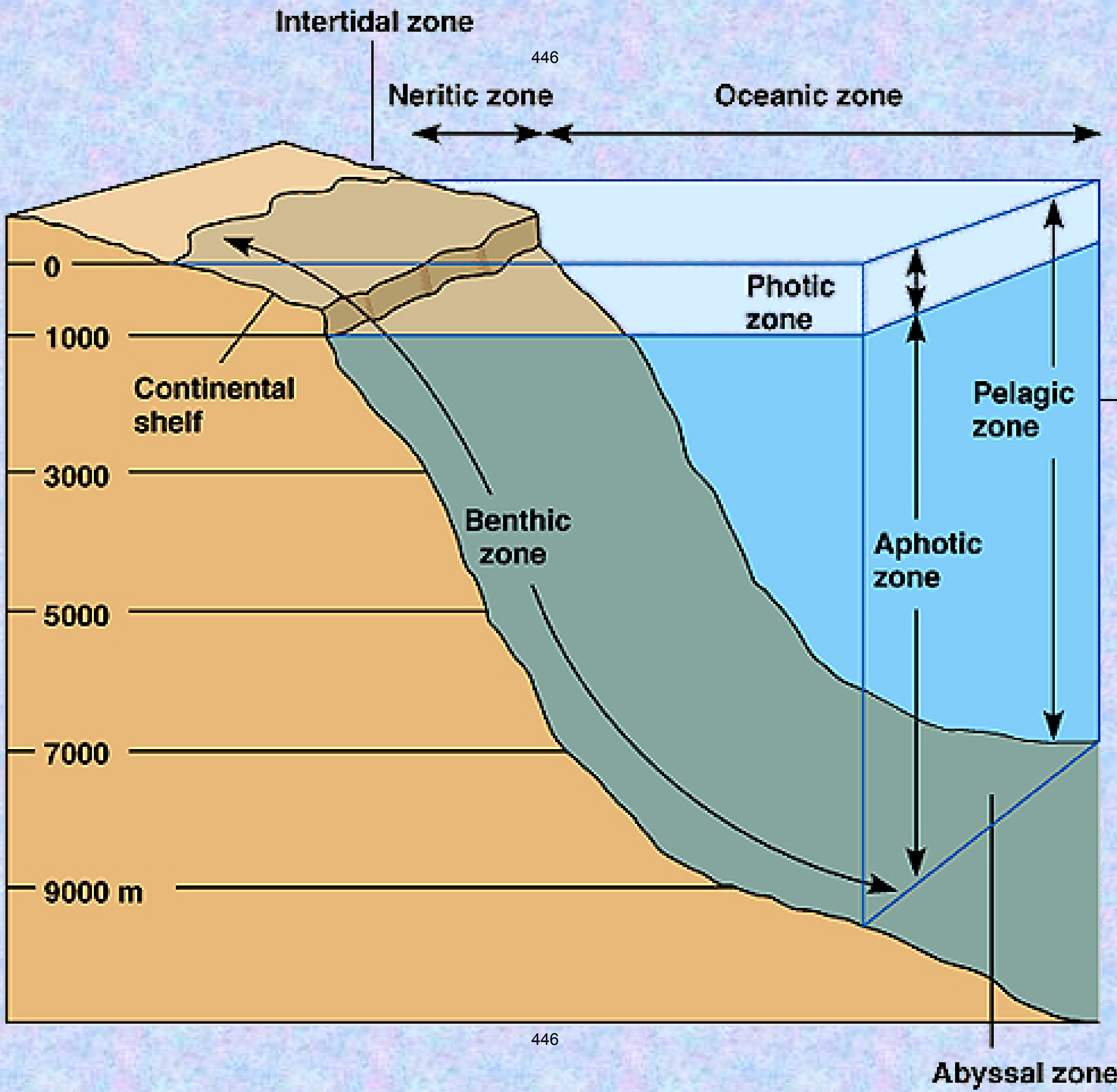

Arctic regions
Tundra
Subarctic regions
Boreal forest
Increasing temperature
Temperate regions
Temperate forest
Chaparral
Grassland
Desert
Tropical regions
Tropical forest
Desert
Grassland
Increasing dryness


www.thewildclassroom.com
400
300
200
100
Annual Precipitation (cm)
Tropical Rainforest
Temperate Rainforest
Tropical Seasonal Forest
Deciduous Forest
Boreal Forest
Temperate Grasslalnd
Savanna
Tundra
Dessert
-10
0
10
20
30
Average Temperature (Degrees Celsius)

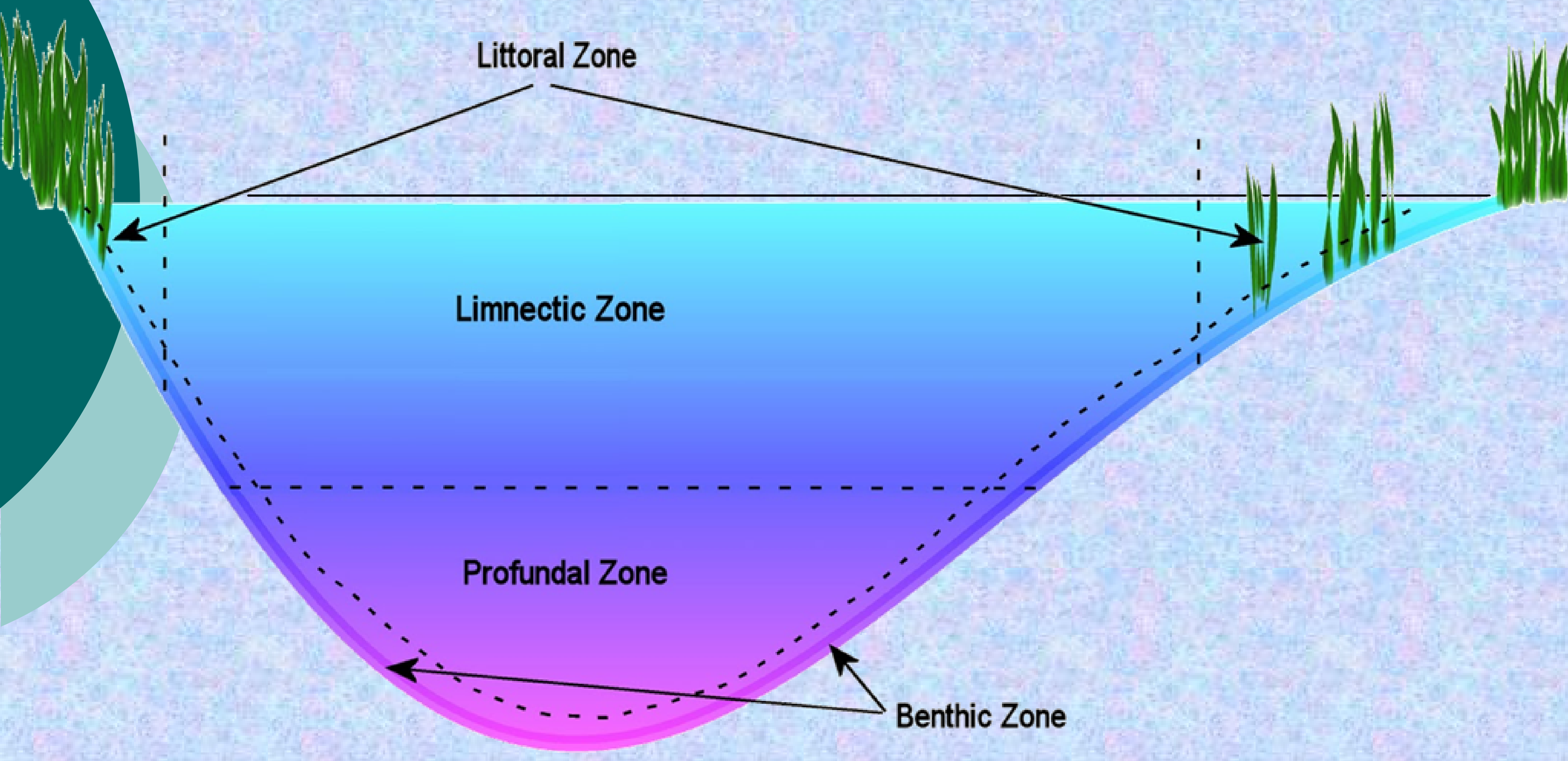

30°N
Tropic of Cancer
Equator
Continental shelf
Tropic of Capricorn
30°S
Lakes
Rivers
Estuaries
Intertidal zones
Coral reefs
Oceanic pelagic
Abyssal zones (below oceanic pelagic)


PELAGIC DIVISION
epipelagic zone
mesopelagic zone
bathypelagic zone
abyssopelagic zone
hadalpelagic zone
200 m
1000 m
2000 m
4000 m
Intertidal Zones
Low Tide Zone
Middle Tide Zone
High Tide Zone
Spray Zone
BENTHIC DIVISION

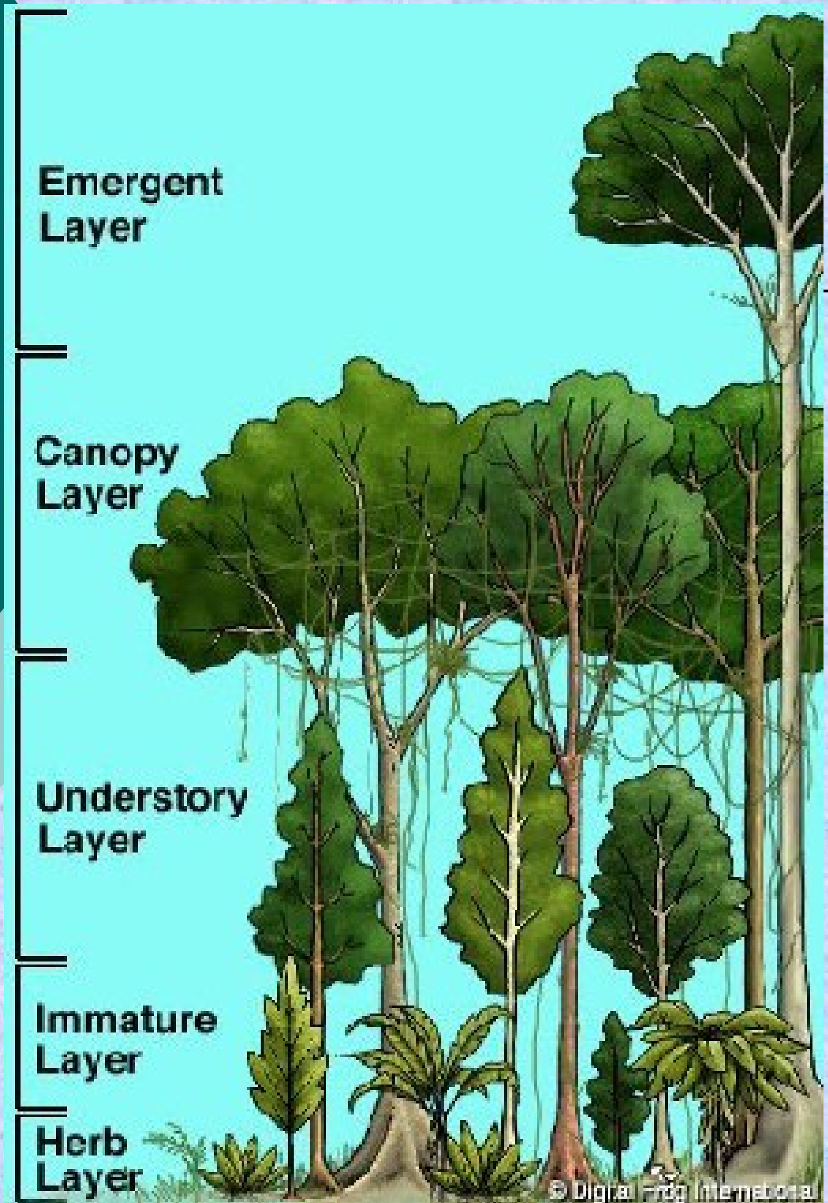
OCEAN

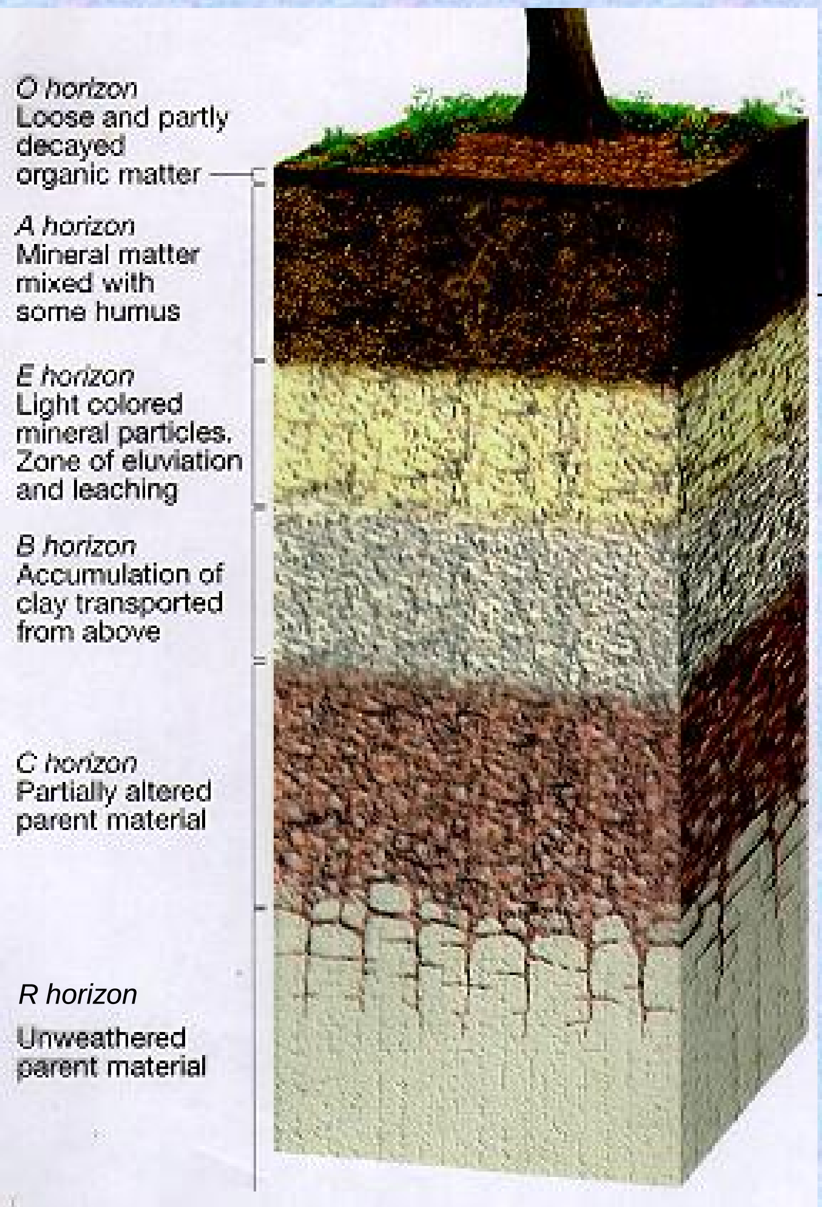

Intertidal zone
Neritic zone
Oceanic zone
0
1000
3000
5000
7000
9000 m
Continental shelf
Photic zone
Pelagic zone
Benthic zone
Aphotic zone
Abyssal zone

Lake



More Layers (Rain Forest & Soil Profile)





TROPHIC RELATIONSHIP

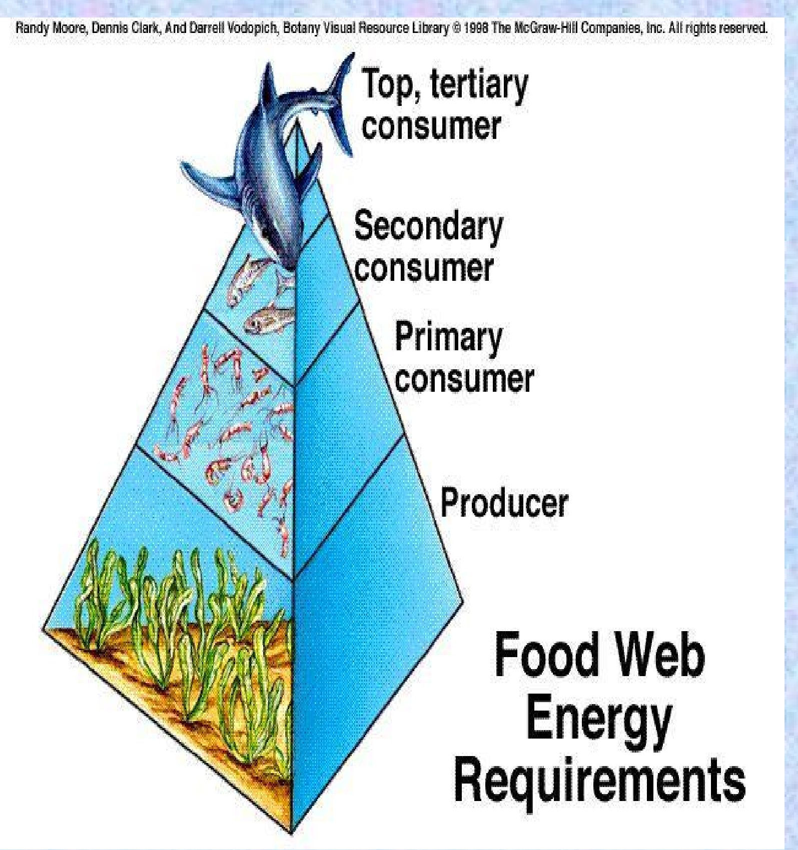
Food webs

- Trophic levels

  * producers

  * herbivores

  *primary carni



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

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.

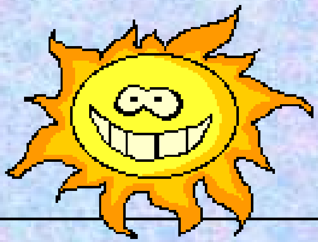
CHEMISTRY

- **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

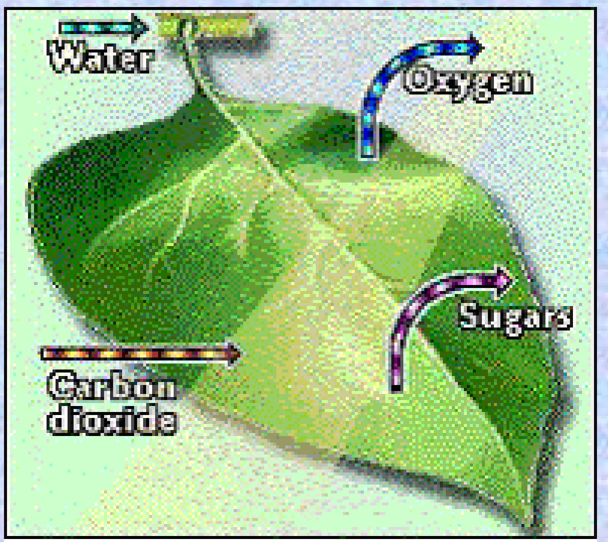
Organic Compounds

- 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) fig 3-10
  - 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 CO_2	Carbohydrates $(CH_2O)_n$ And all organic molecules	Hydro Carbonate (CO_3^{-2}) Bicarbonate (HCO_3^-) Litho minerals	Global warming Carbon from fossil fuels underground are burned and released into the air as CO_2
Nitrogen N	Atmo N_2	Proteins and other N-containing organic molecules	Hydro Ammonium NH_4^+ Nitrate NO_3^- Nitrite NO_2^-	Eutrophication Fertilizers contain human-made nitrates that end up in the water
Phos-phorous P	Litho rocks as PO_4^{-3} *no gas phase	DNA ATP phospholipids	Hydro Phosphate PO_4^{-3}	Eutrophication Fertilizers contain human-made phosphates that end up in the water Cutting down rainforest stops recycling of P

POPULATION AND SUCCESSION

•Top 6 most abundant elements in living things (not in order)

* NCHOPS

•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 (REMEMBER ECOCOLUMNS)

Purpose: recreate conditions of Earth (Biosphere I)

* to understand our world better
* space travel

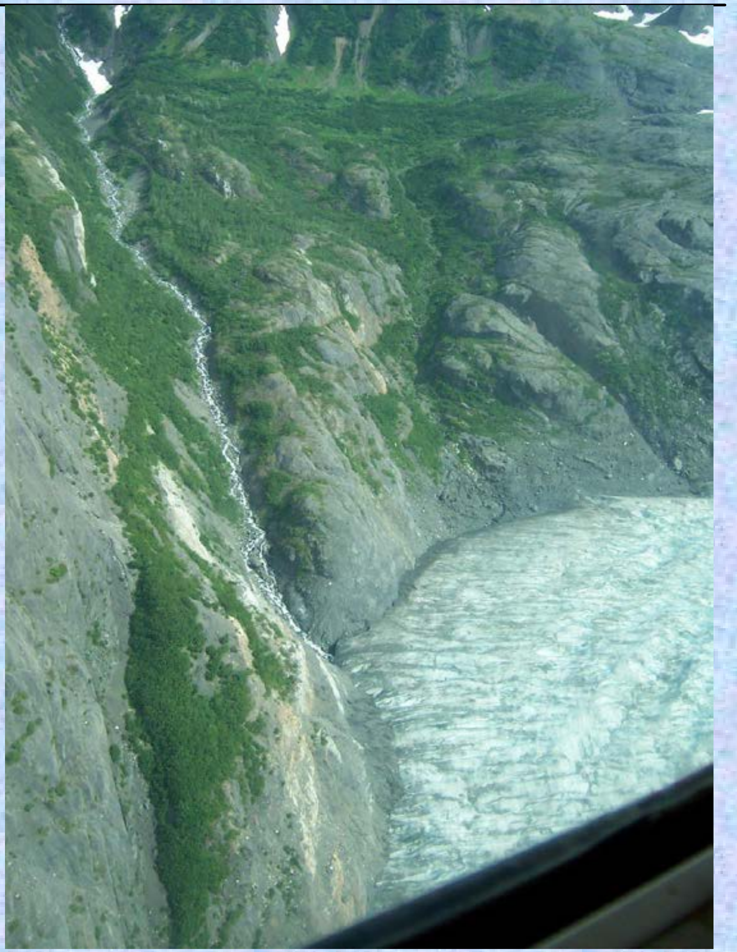
- 5 acres in Arizona, 4000 species, 10 humans
  * problem: 0_2 + CO_2 were absorbed by concrete
  * ants and cockroaches took over

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 huckle berries. Grizzlies eat both

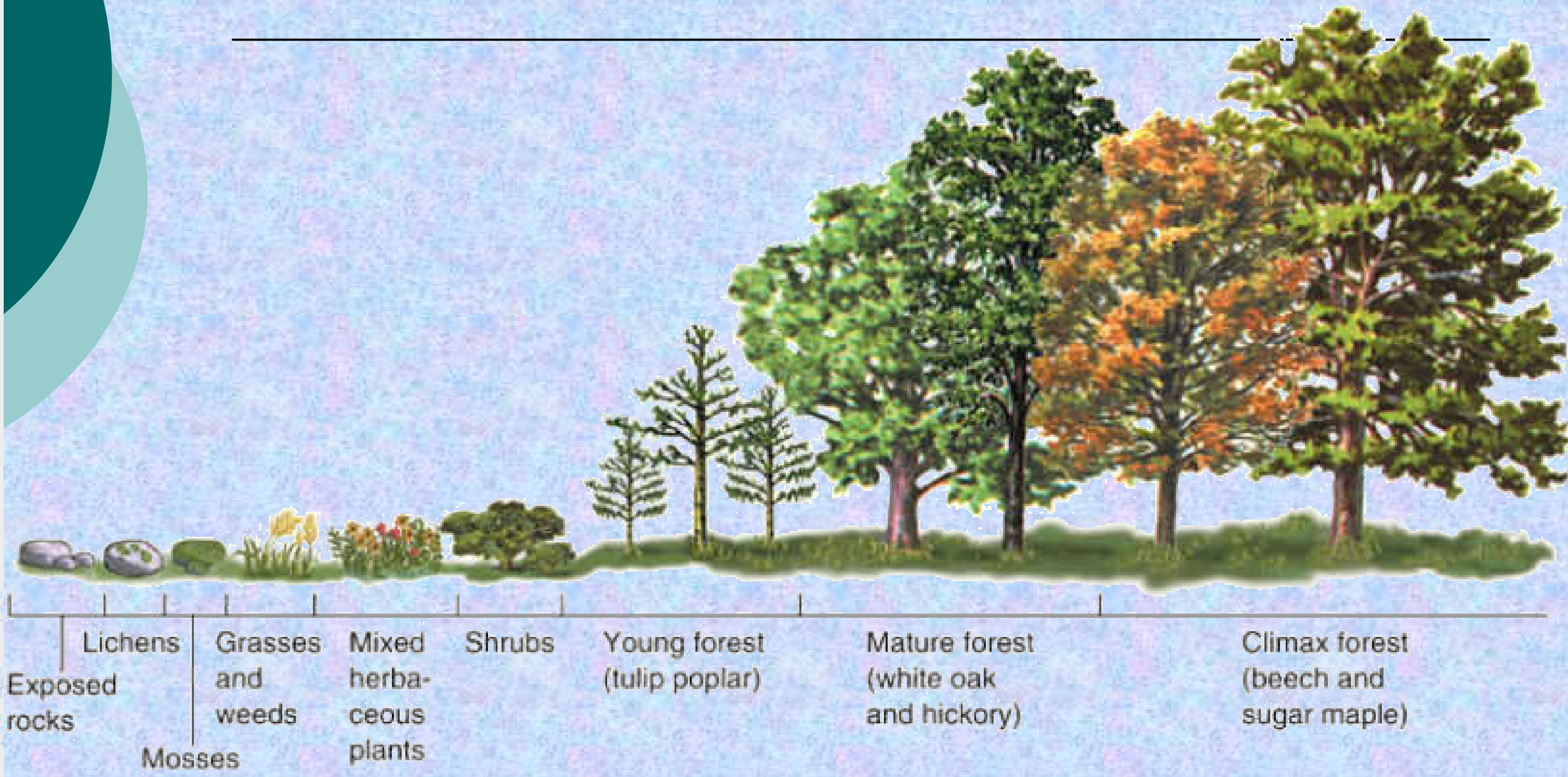
Succession - One species gradually replaced by another in an ecosystem

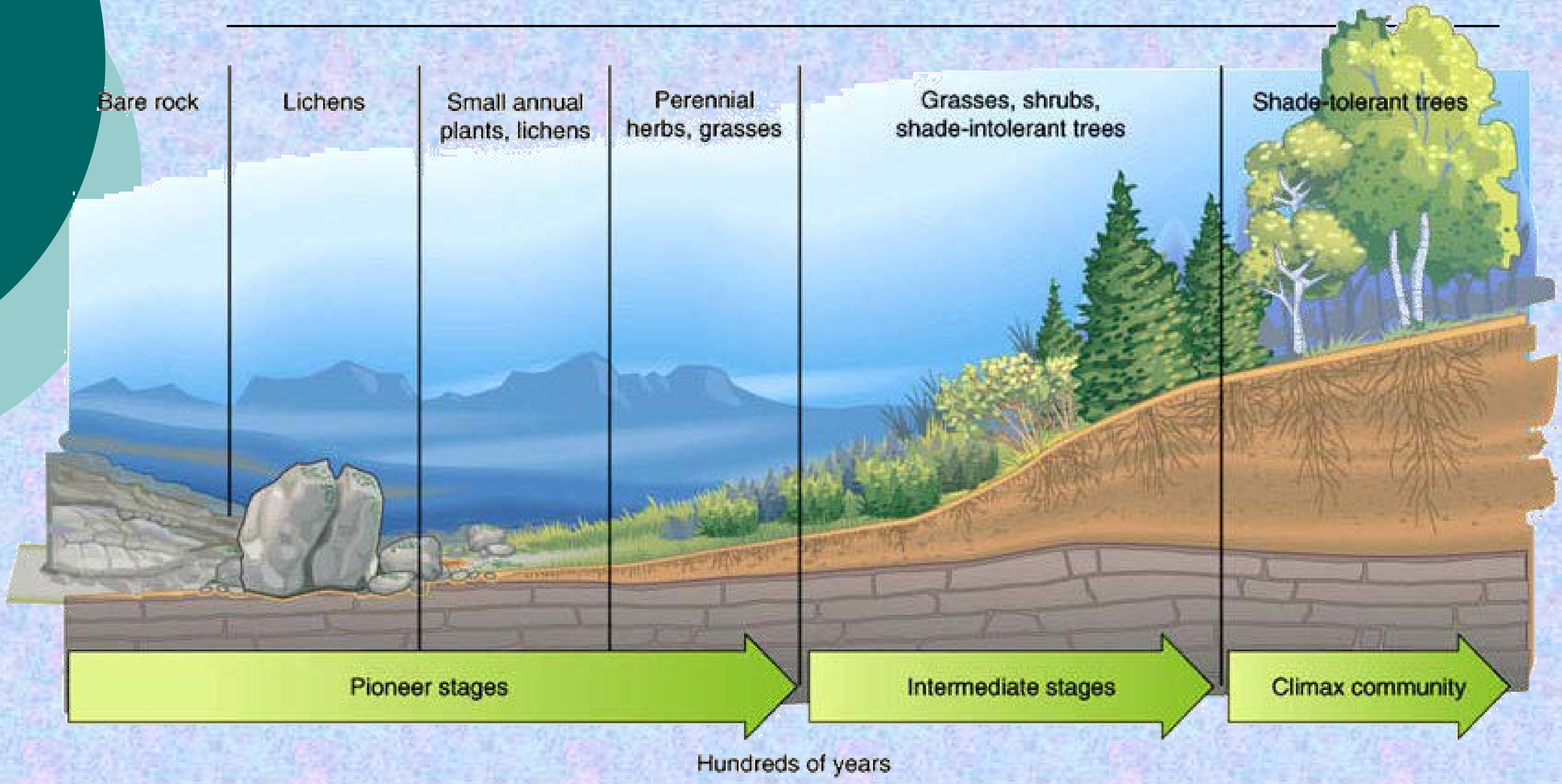
- Primary – new ecosystem where there were no living things before. Cooled lava, receded glacier, mud slide
- Secondary- ecosystem used to be there. Fire, humans clear an area
- Aquatic – lakes taken over by terrestrial ecosystem
- Climax ecosystem- in balance only changes if major interference



Primary succession

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


Exposed rocks
Lichens
Mosses
Grasses and weeds
Mixed herbaceous plants
Shrubs
Young forest (tulip poplar)
Mature forest (white oak and hickory)
Climax forest (beech and sugar maple)



Bare rock
Lichens
Small annual plants, lichens
Perennial herbs, grasses
Grasses, shrubs, shade-intolerant trees
Shade-tolerant trees
Pioneer stages
Intermediate stages
Climax community
Hundreds of years

Main Topics

1. Energy flow and the biomass pyramid figs 3-13 and 3-21
2. Population dynamics fig 4-2, 4-3
3. Biotic potential vs environmental resistance fig 4-4
4. Population equilibrium and balanced herbivory figs 4-5, 4-15
5. Introduced species effects on ecosystems fig 4-6, 4-7

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

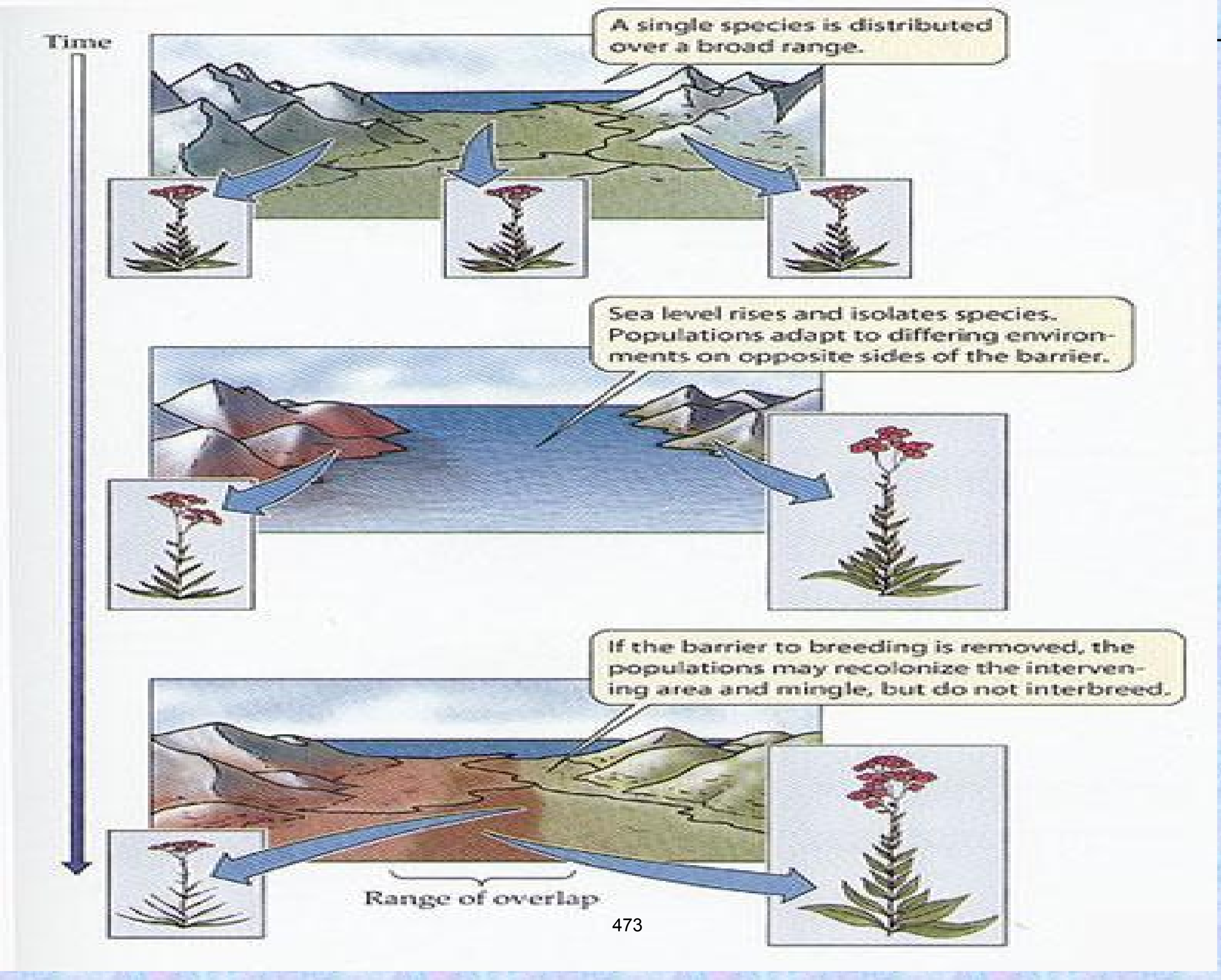
- <u>Genetic Trait</u>- only passed down if an organism reproduces

WHY DO SPECIES CHANGE?

- Environmental resistance and biotic potential
- Selective pressure on mutations
- Speciation

  * creation of a new species based on reproductive isolation

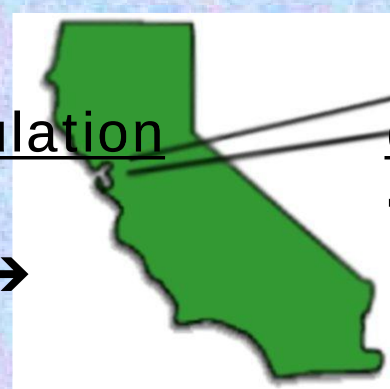
Speciation (Galapagos Finches)



GEOLOGICAL CONTEXT (SPACE AND TIME FOR EVOLUTION)

- Plate tectonics
- Geological time scale (fig. 5-21)
- Cambrian explosion
- Selective breeding
- Artificial selection
- Natural selection

Population Growth Rates



<u>increase population</u> <u>decrease population</u>

births ➔ ➔ deaths

immigration ➔ ➔ 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

(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
(s) (If this number is negative, the population is shrinking.)

equation:

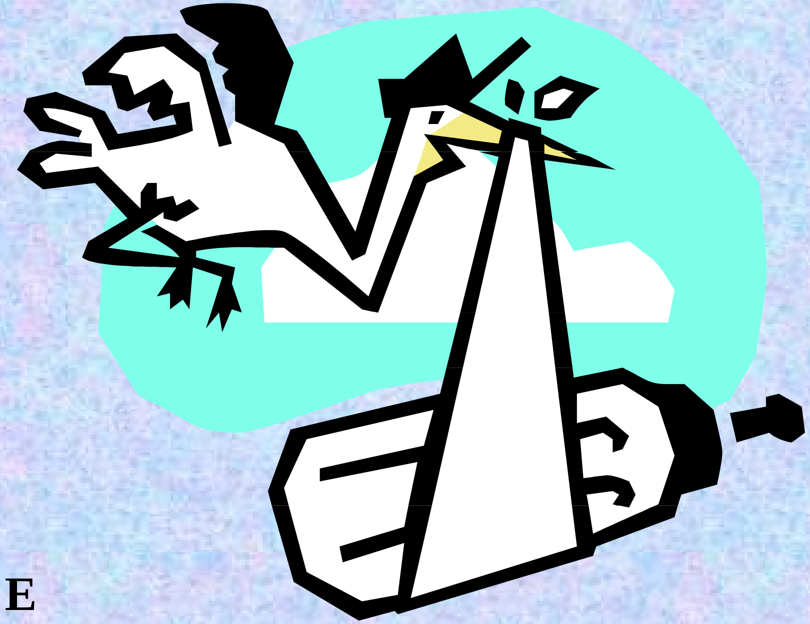
rate = birth – death

But other factors affect population growth in a certain area…

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!!!!!!!!

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 Countries

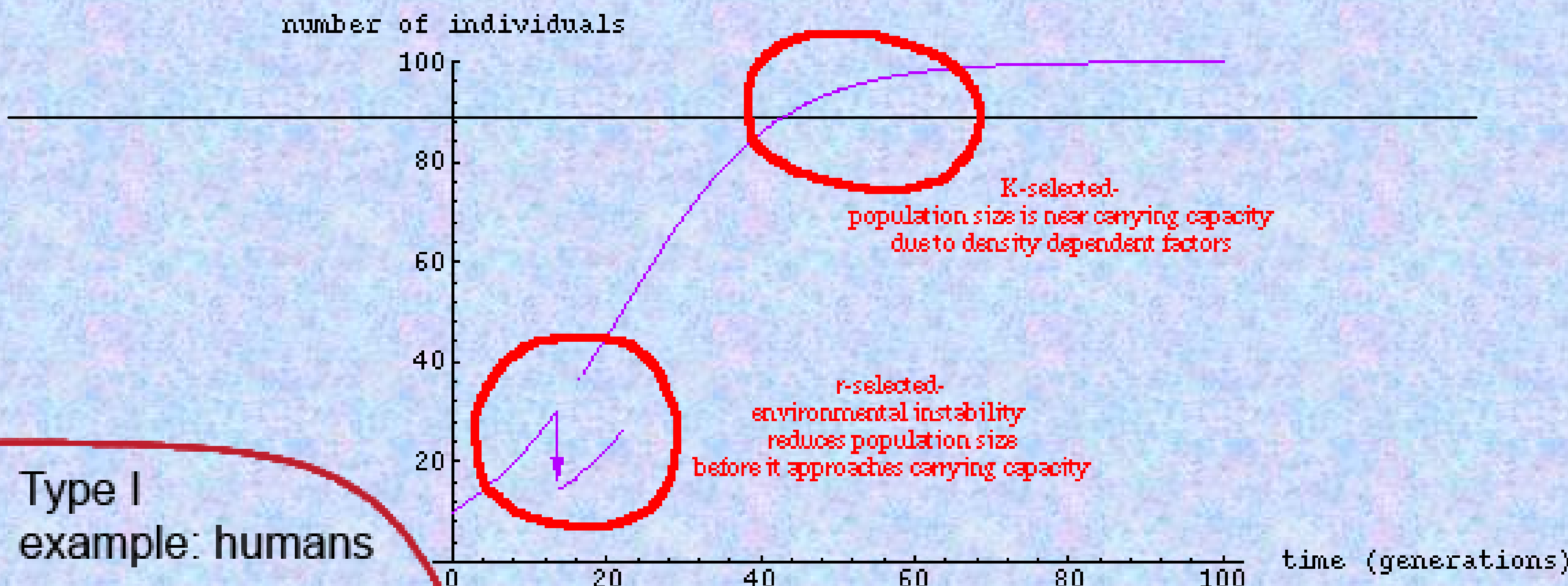
- Canada, U.S., Australia, Western Europe (Denmark)

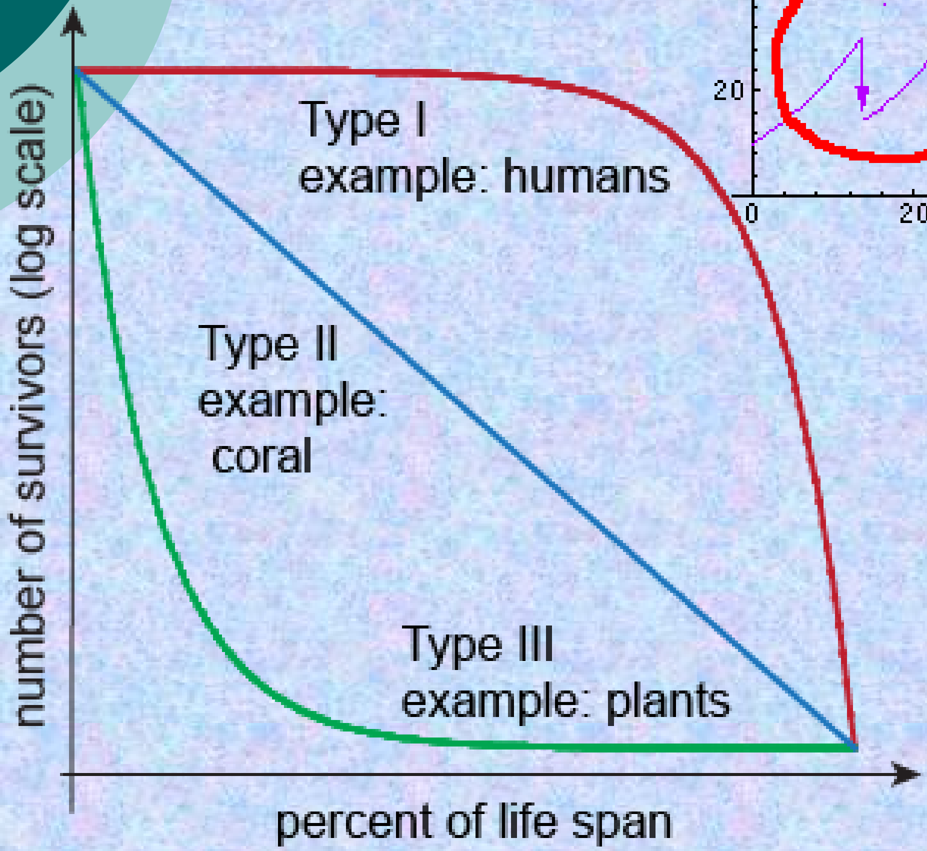
Developing Countries

- Latin America, China, Africa (Kenya)
  - 1/5 of the world's pop. Lives in absolute pove illiterate, lack clean H_2O and don't have enough food
  - 80% of world's pop. Lives in developing co. and growing

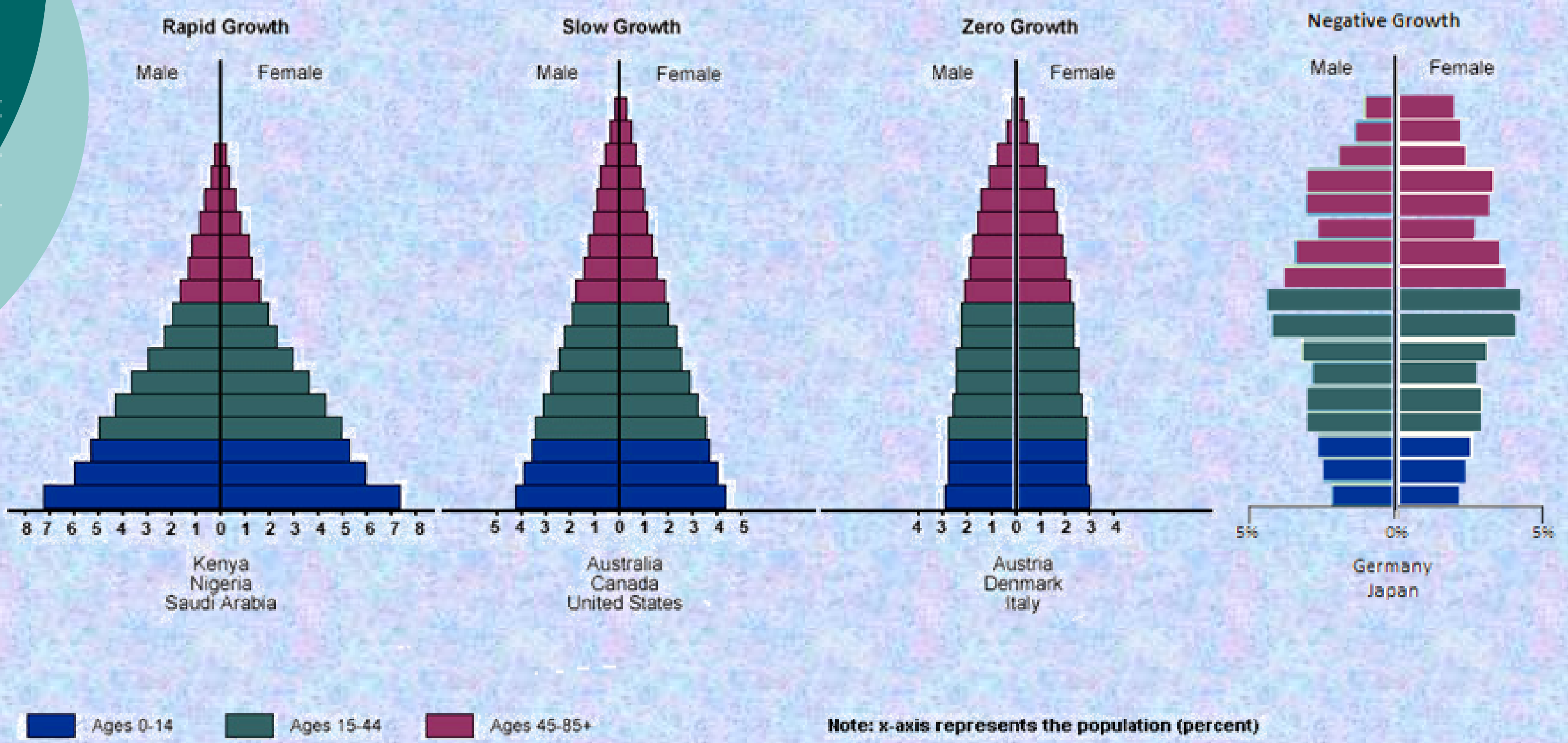
- Total fertility= avg. # of children born per woman
- For developed countries = 2.1
- For developing countries = 2.6
- Fertility of 2.0= replacement level
  - Under 2.0 = shrinking population
  - Over 2.0 = growing pop.
- For developed countries = 2.1
- For developing countries = 2.6(or higher)

Reproduction

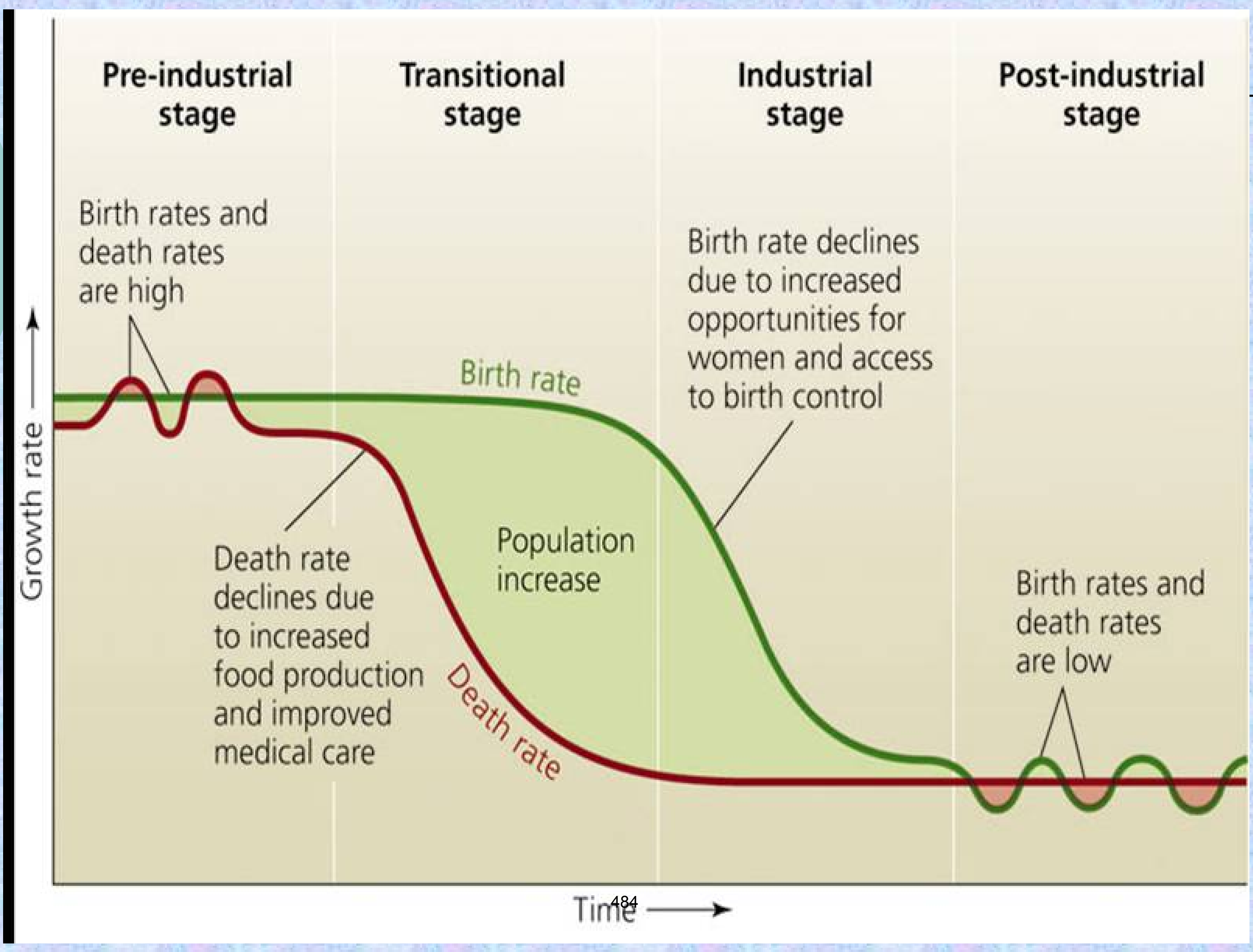




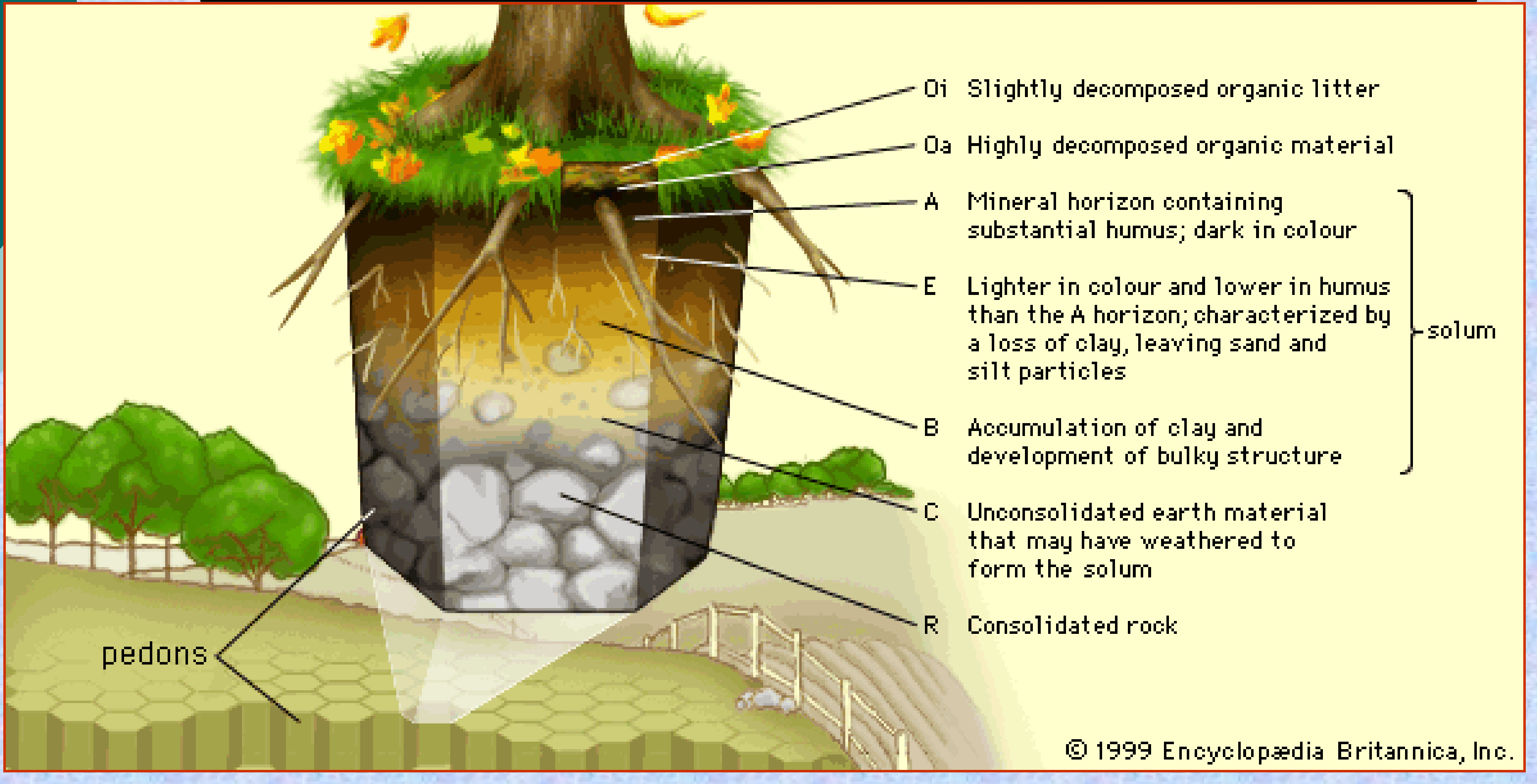
Age Structure Diagrams



Demographic Transition



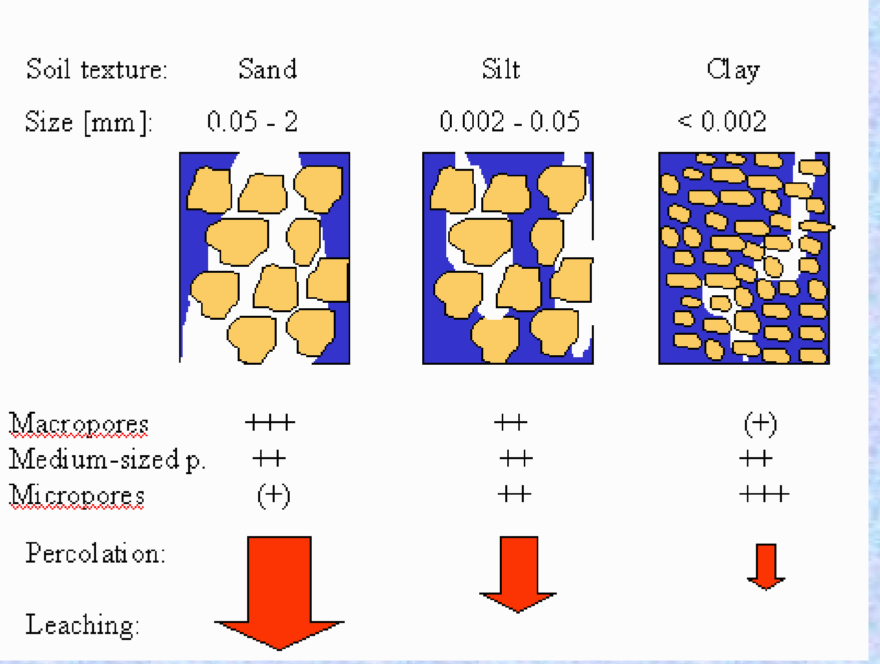
Soil


Oi Slightly decomposed organic litter
Oa Highly decomposed organic material
A Mineral horizon containing substantial humus; dark in colour
E Lighter in colour and lower in humus than the A horizon; characterized by a loss of clay, leaving sand and silt particles
B Accumulation of clay and development of bulky structure
solum
C Unconsolidated earth material that may have weathered to form the solum
R Consolidated rock
pedons
© 1999 Encyclopædia Britannica, Inc.

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

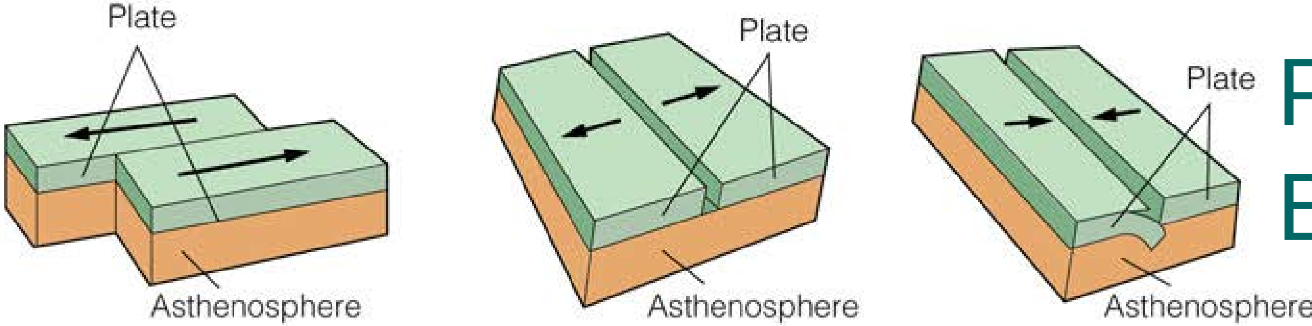
Mollisols- very fertile, dark, found in temperate grasslands, best agricultural soil, Deep A horizon

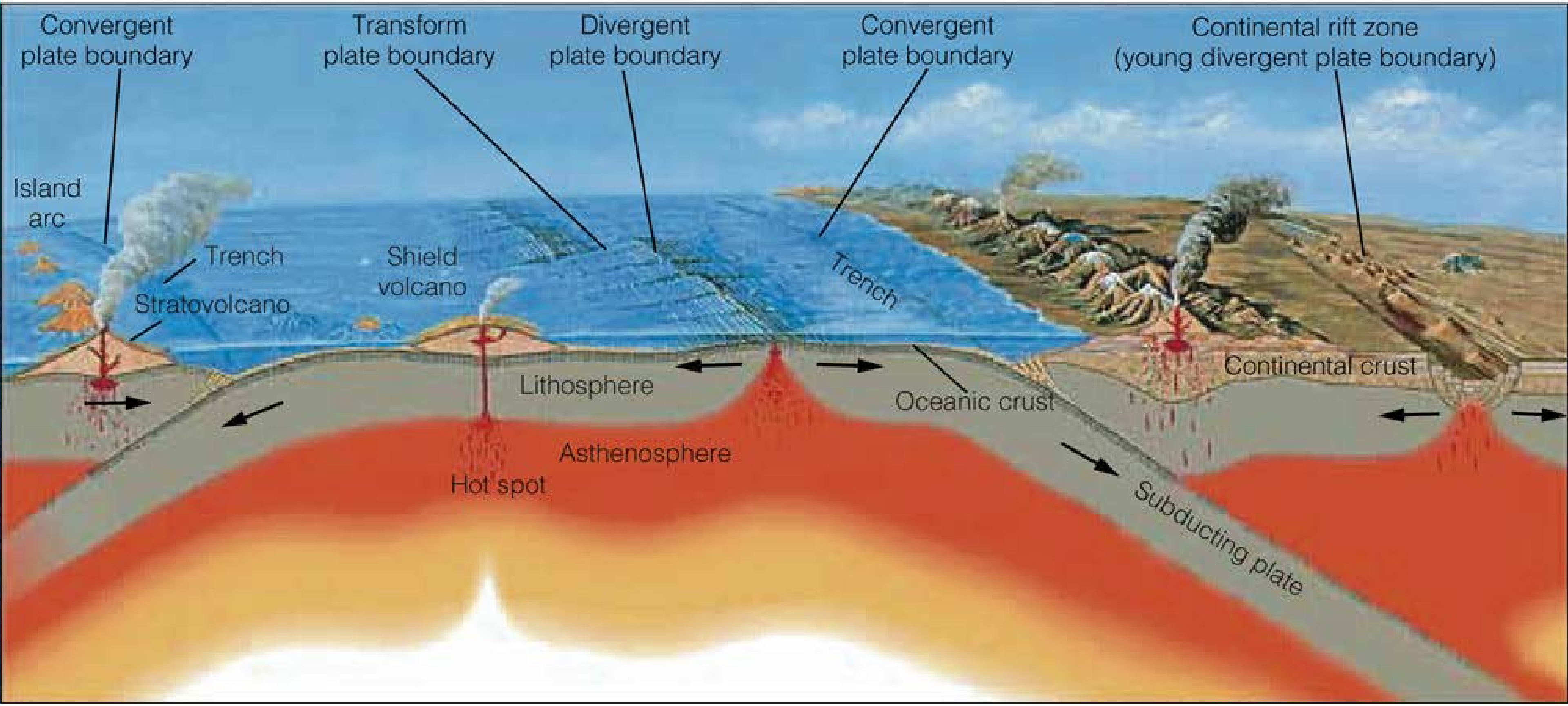
Oxisols- soil of tropical and subtropical rainforest layer of iron and Al oxides in B horizon, little O horizon

Alfisols- weathered forest soil, not deep, but developed OAE+B typical of most temperate forest biome. Need fertilizer for agriculture

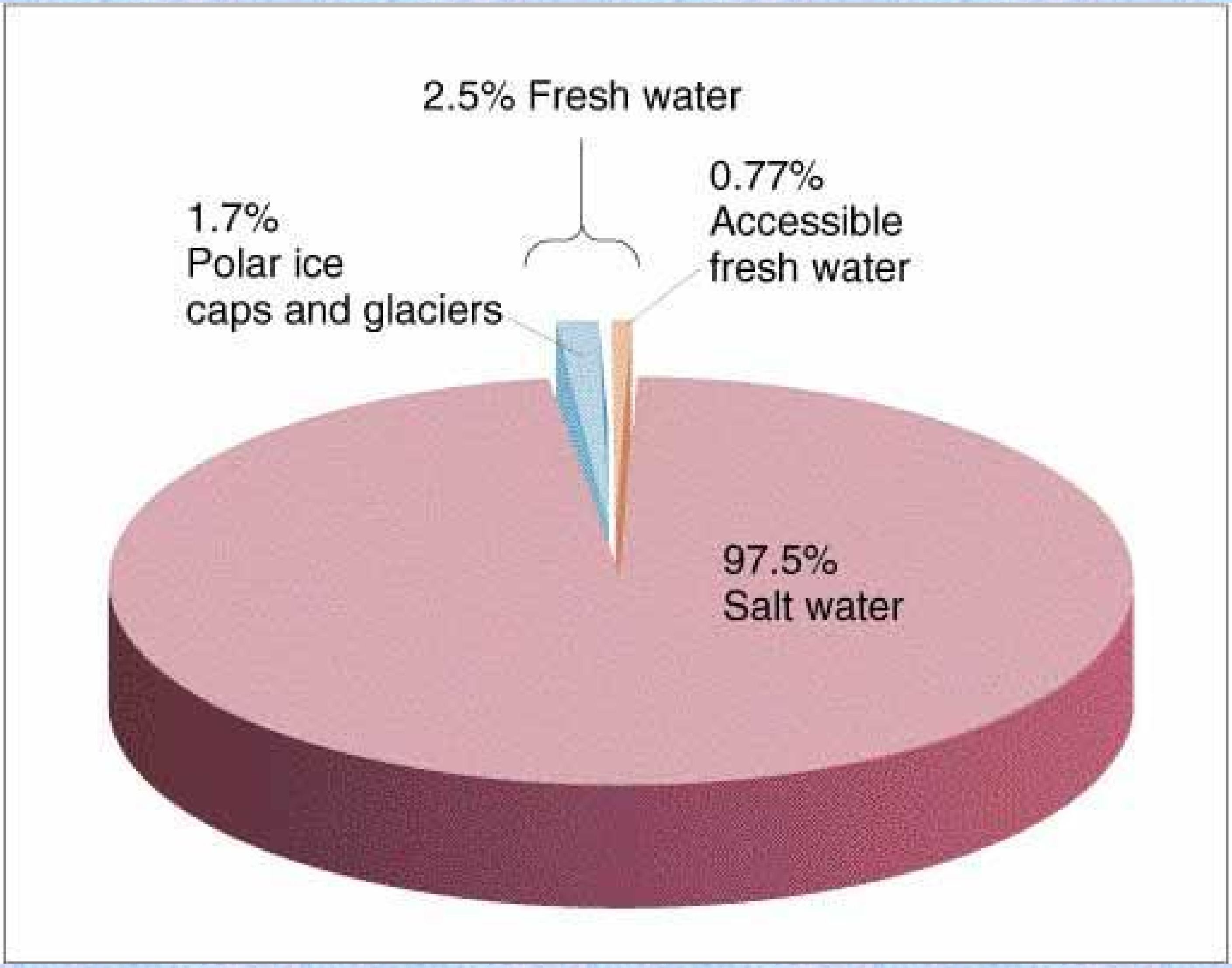
Aridsols- dry lands + desert, lack of vegetation, lack of rain → unstructured vertically, irrigation leads to salinization b/c of high evaporation.

Plate Boundaries





Water



- Figure 9-1 Earth's water supply

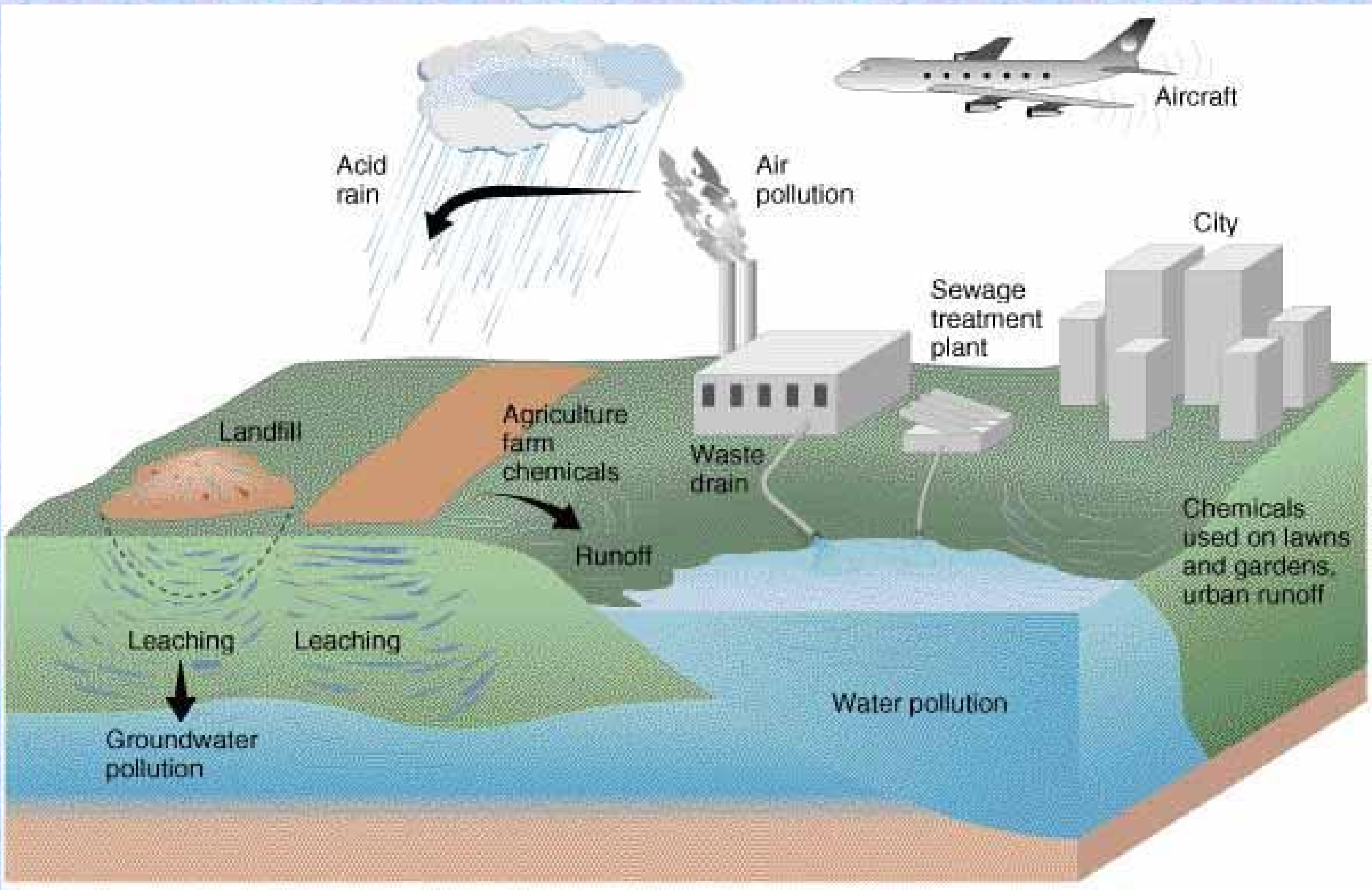
Water Facts

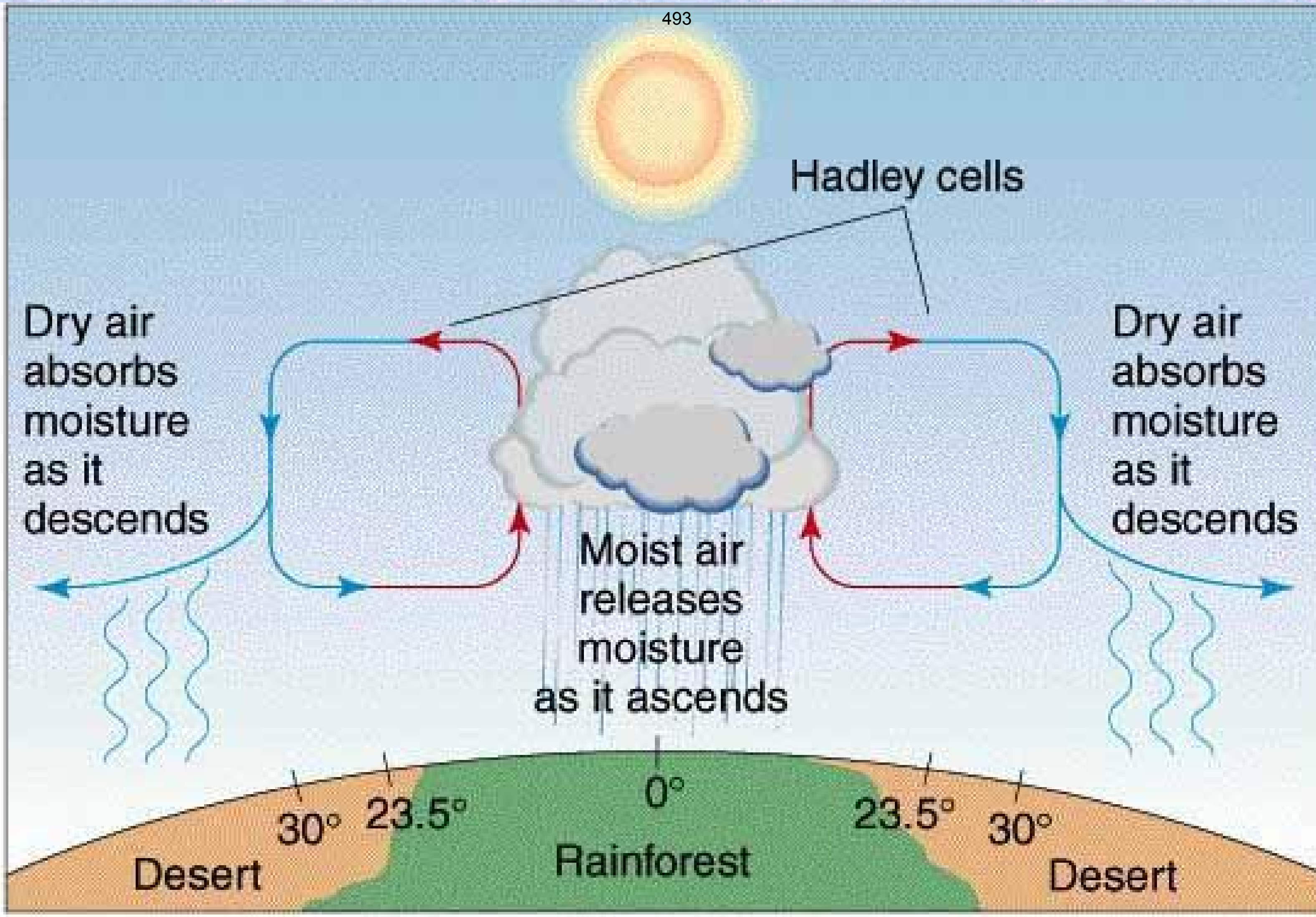
- The primary use for fresh water in U.S. is for agriculture.

- 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

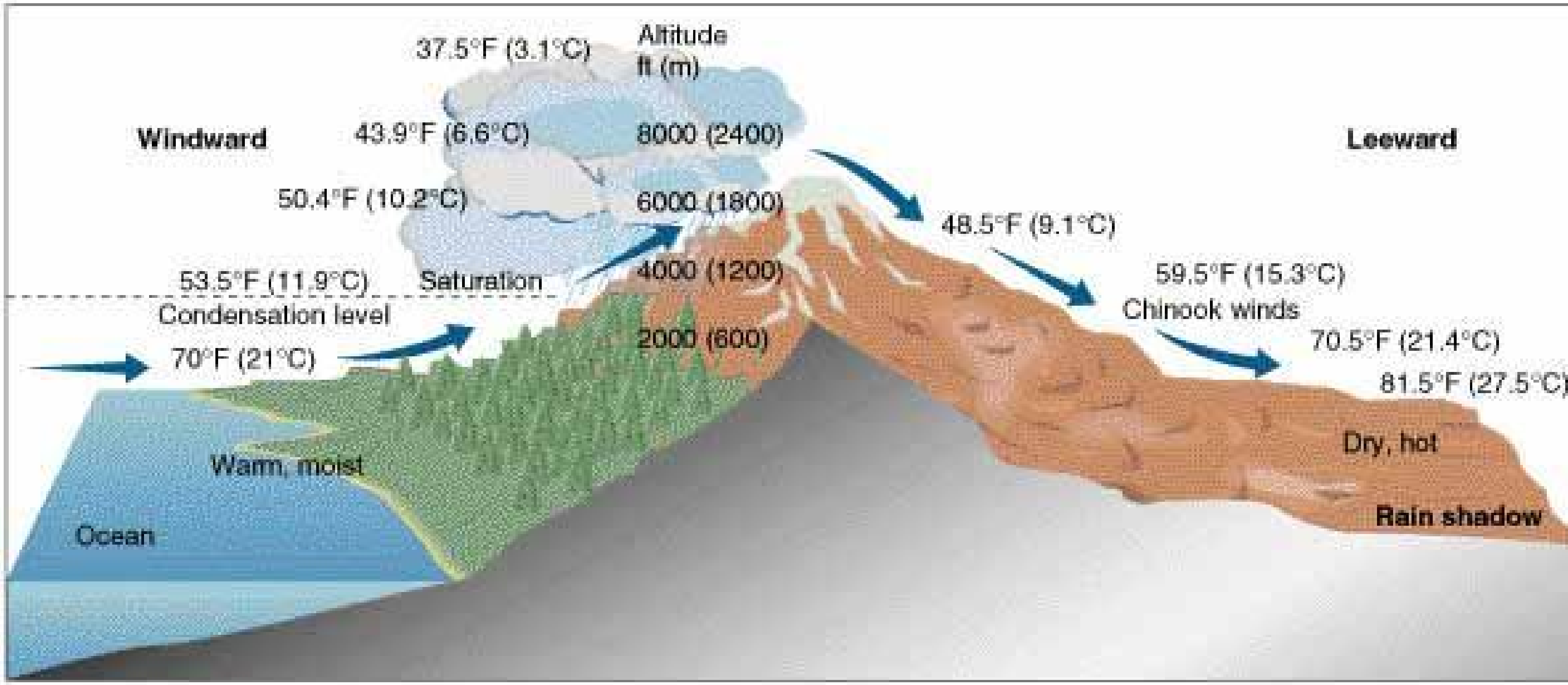


Figure 9-6 Rain shadow

The Ogallala Aquifer

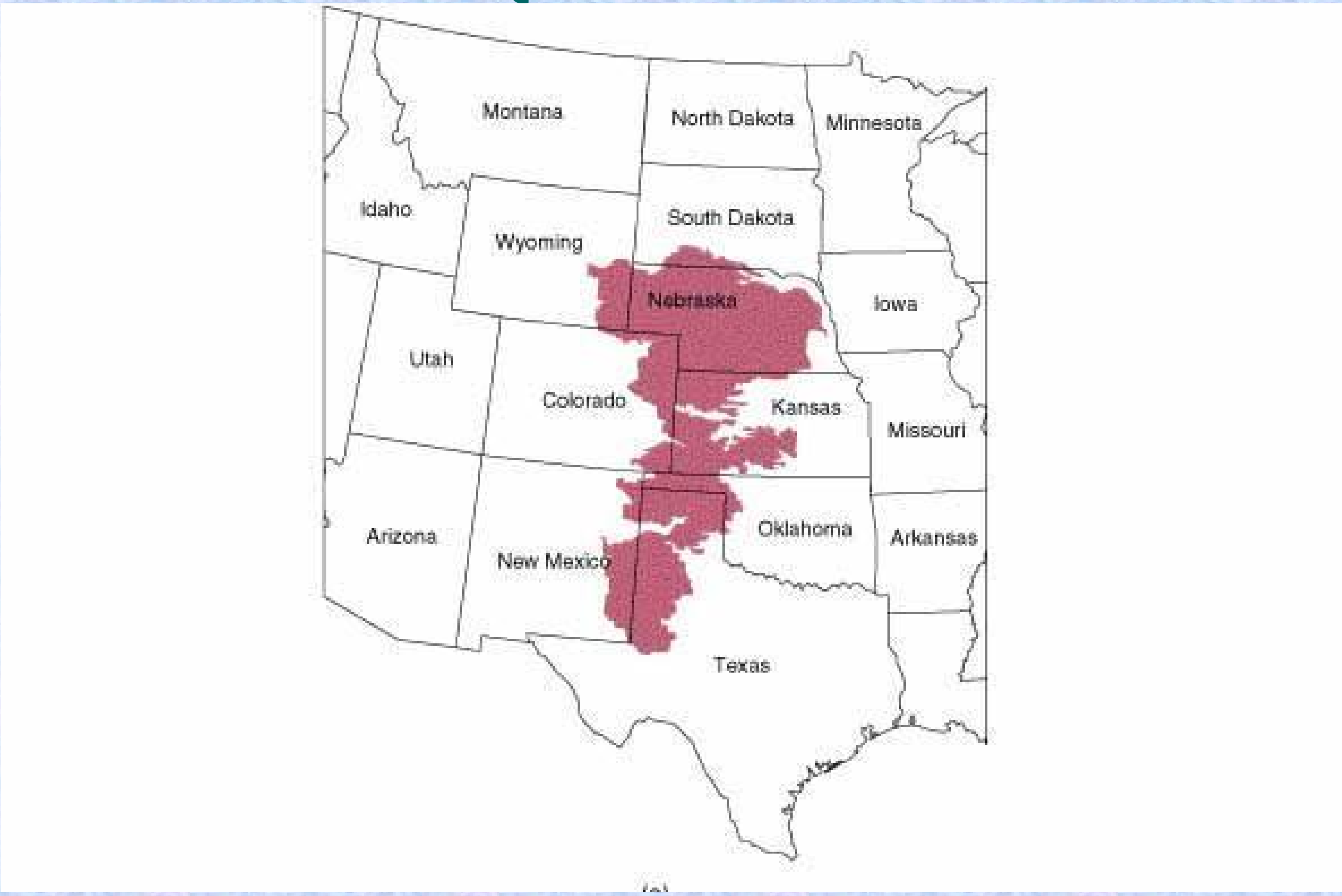


Figure 9-16 Exploitation of an aquifer

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

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

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

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

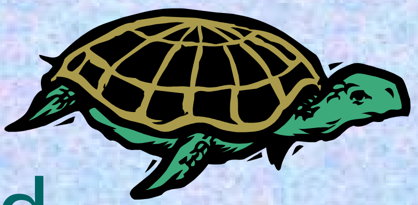
- Nitrates in drinking water
- Pesticide residues in drinking water, food, and air
- Contamination of drinking and swimming water with disease organisms from livestock wastes

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):

- 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

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)

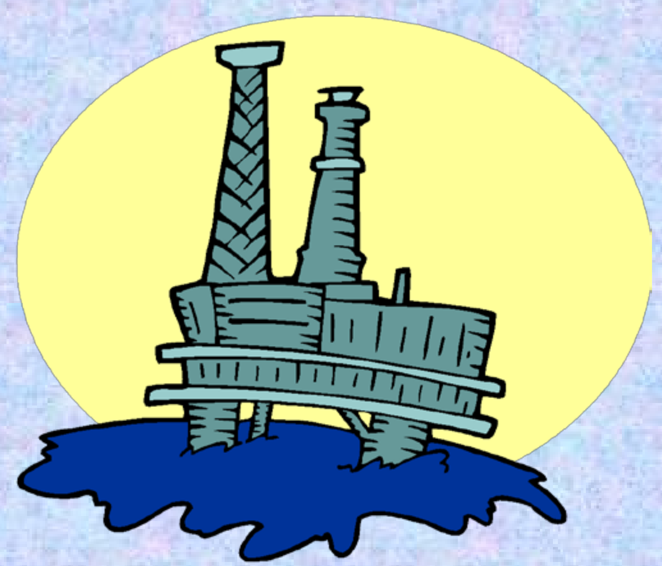
More Energy Facts

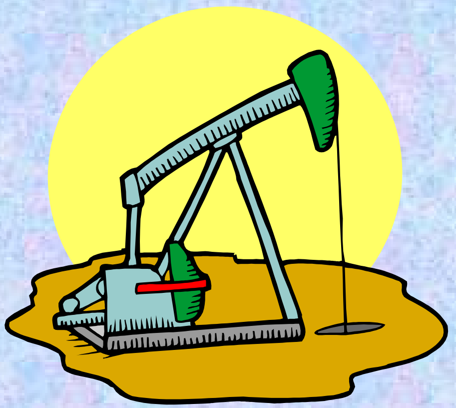
- We get 50% of our crude oil from foreign sources
- Alaska pipeline built to help increase production of domestic crude oil
- Types of coal:
- Peat (not coal) → Lignite (brown coal) → Bituminous coal (soft coal with high sulfur) → Anthracite (hard coal with low sulfur)

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

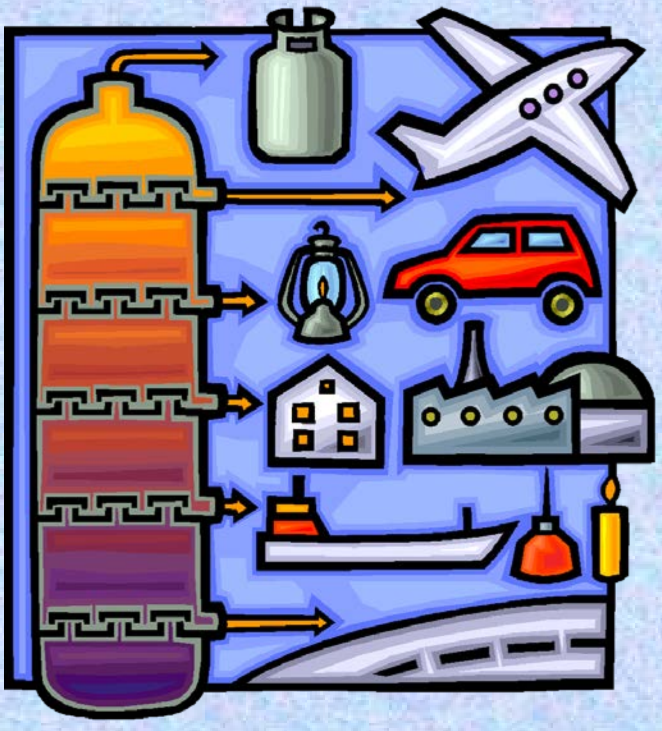
1. Production: ecosystem damage, reclamation difficult, acid mine runoff, mine tailings, erosion, black lung, radon
2. Transport: energy intensive because of weight and number of train cars needed
3. Use: fossil fuel with largest source of carbon dioxide and greatest quantity of contaminants, large volume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

Natural Gas

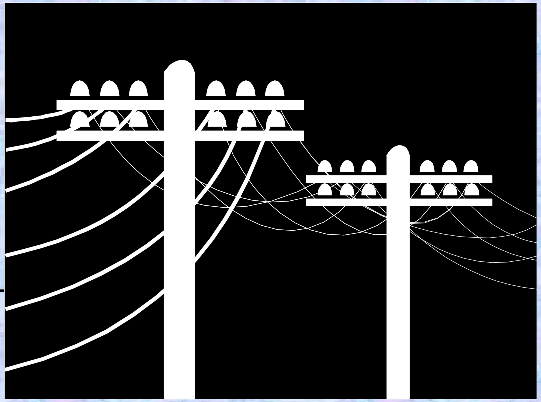
Possibly a transition fuel between fossil fuel and alternative energy sources.

- 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



- Electricity is a secondary energy source because it relies on another energy source to create the electricity.
- Basic production of electricity-boil water to produce steam to turn turbines to generate electron flow through a wire.
- Examples of primary sources for electrical production
- 20% from nuclear
- 57% from coal
- 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

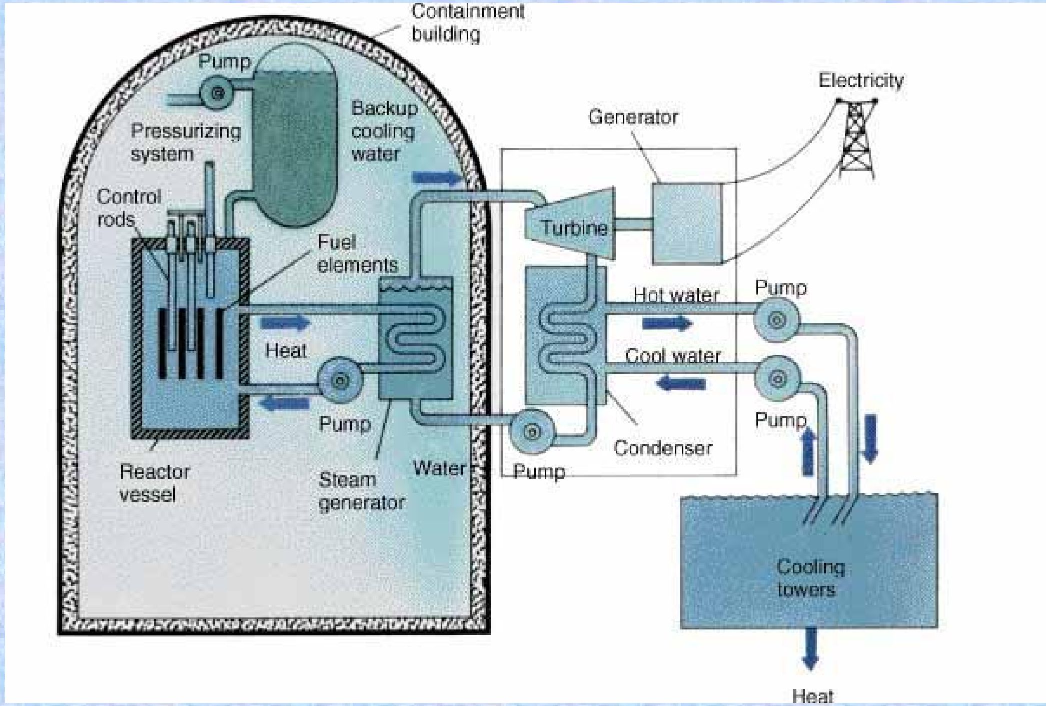
b. Neutron-absorbing material- control rod

c. Fuel Rods- approximately one third replaced each year

d. Heat transfer system

e. Cooling system

f. Redundant safety systems

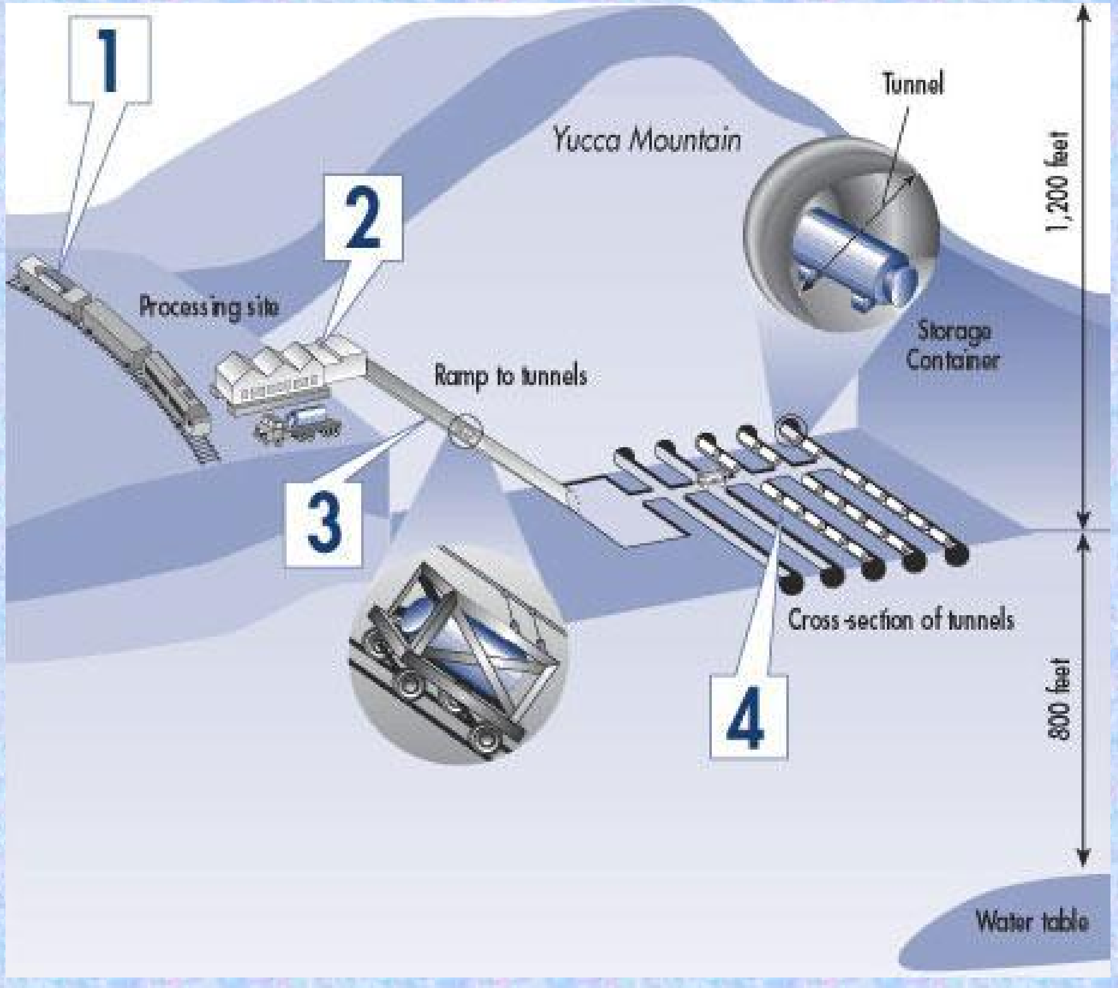


WASTE DISPOSAL

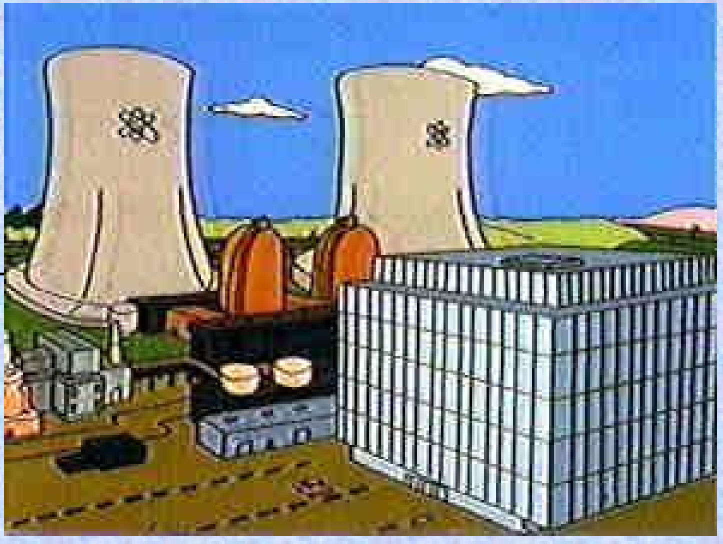
All fuel rods are still in cooling ponds at commercial nuclear facilities

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



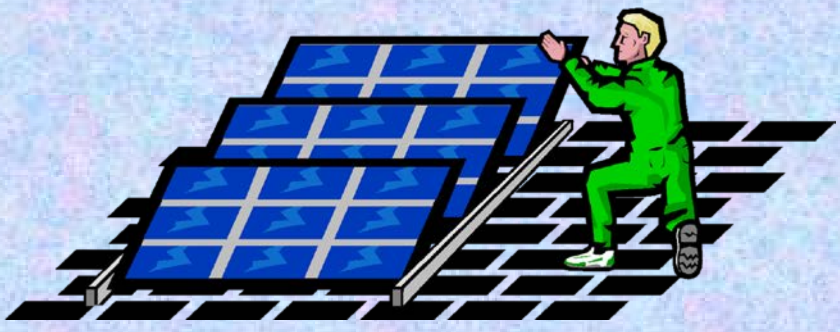
ACCIDENTS

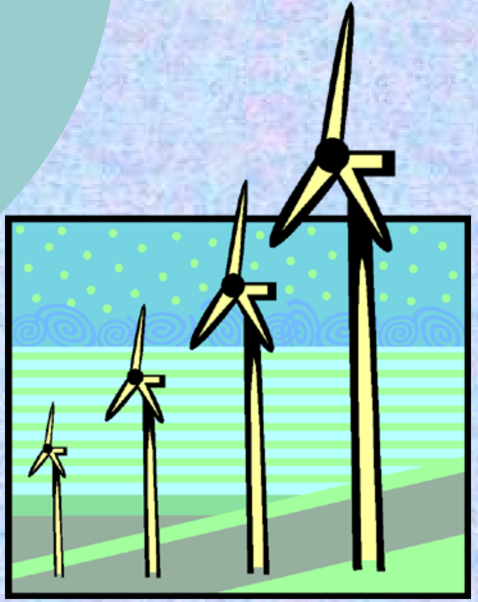


- Chernobyl:
  - 4/26/86
  - Ukraine
  - complete meltdown.
- Three Mile Island:
  - 3/28/79
  - Pennsylvania (Harrisburg)
  - partial meltdown, no one known to be hurt.

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, Toxicology and Pests Borneo (DDT), MTBE

Hazard - Anything that causes:

- Injury, disease, or death to humans
- Damage to property
- 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

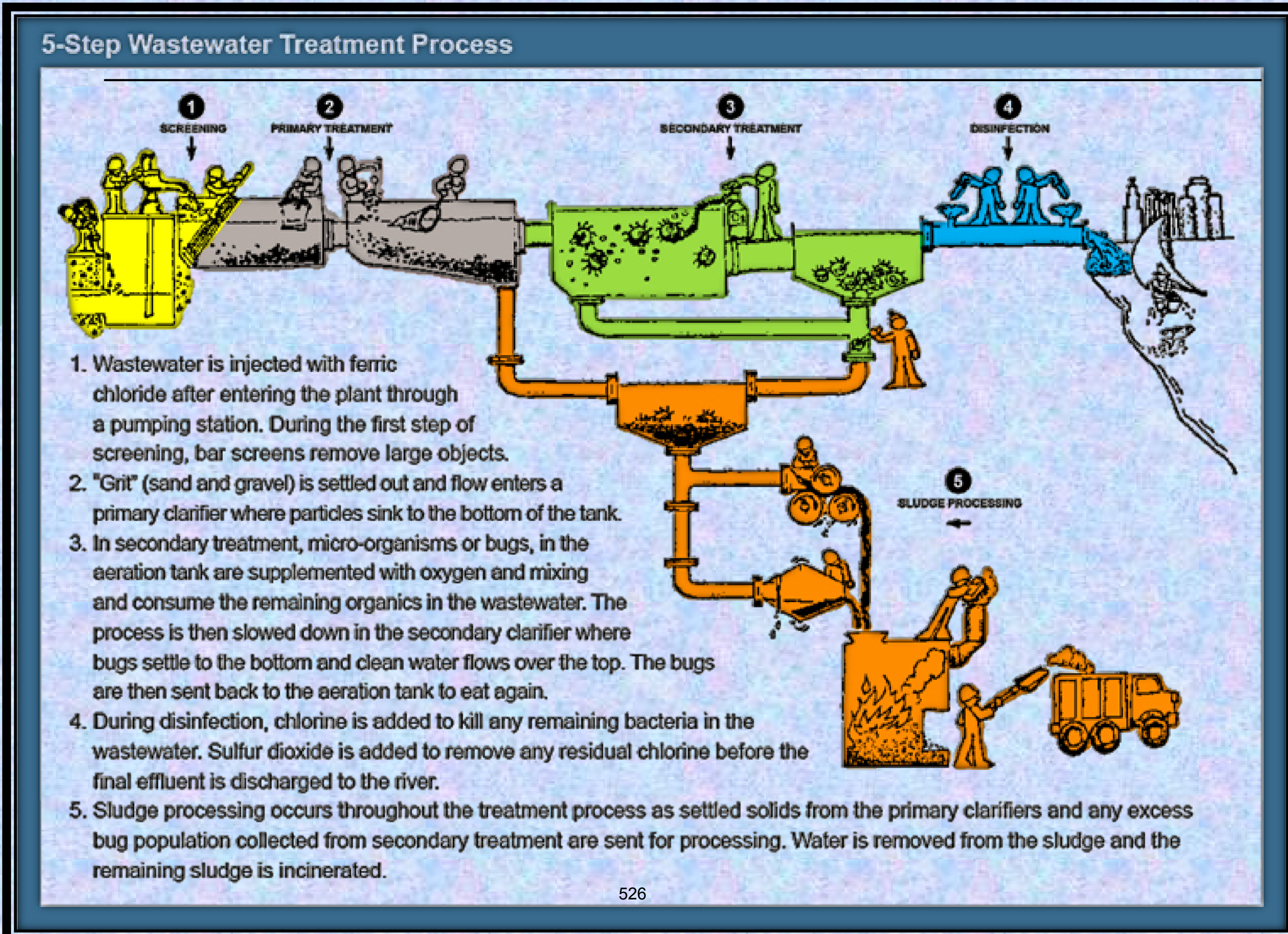
Diseases cont'd

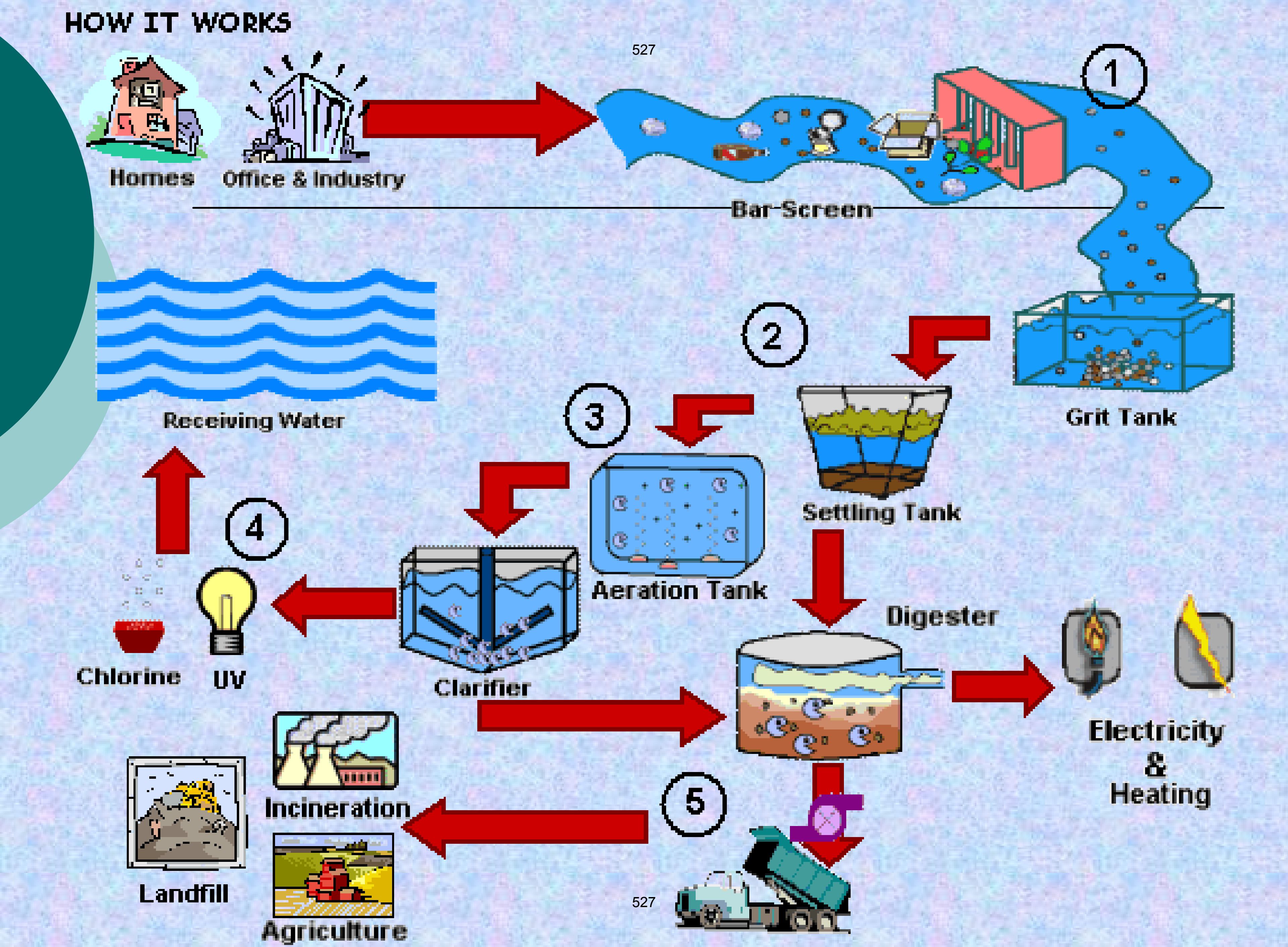
- Lack of access to safe drinking water is a major cause of disease transmission in developing countries.
- Epidemiology is the study of the presence, distribution and control of a diseases in a population
- Morbidity is the incidence of disease in a population
- Mortality is the incidence of death in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

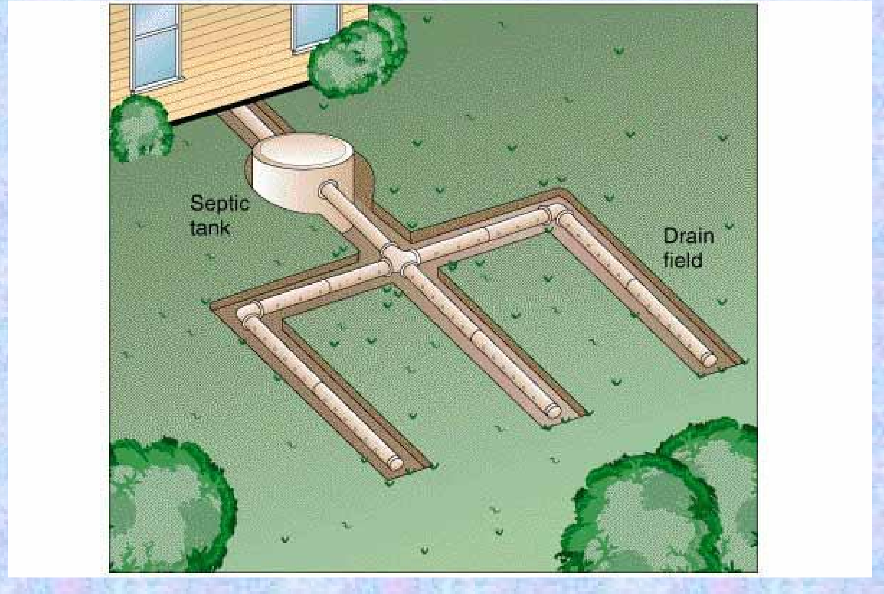



HOW IT WORKS
Homes
Office & Industry
1
Bar Screen
Grit Tank
2
Settling Tank
3
Aeration Tank
Receiving Water
4
Clarifier
Chlorine
UV
Digester
Electricity
&
Heating
5
Incineration
Landfill
Agriculture

HOME SEPTIC SYSTEMS:

→do not use Chlorine

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



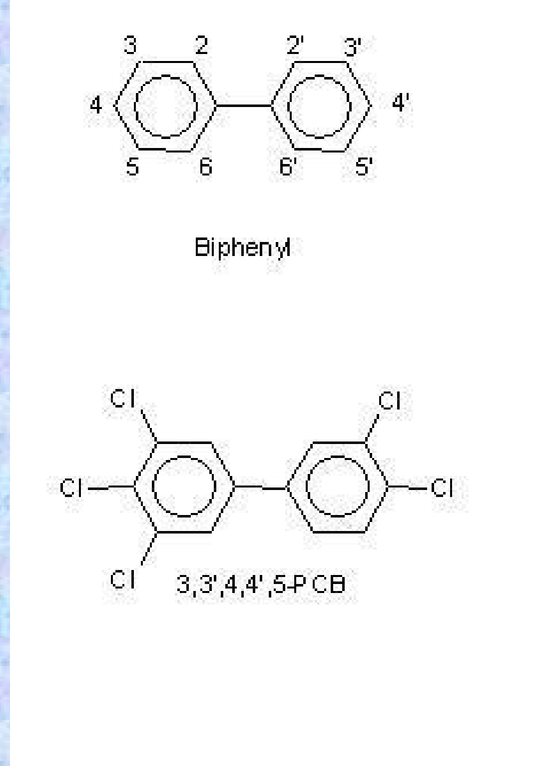
Solid Waste

- 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

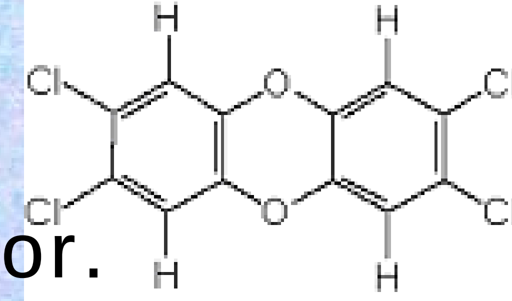
Halogenated hydrocarbons

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



Chlorinated hydrocarbons

- **Chlorinated hydrocarbons**
- Are synthetic organic compounds
- **Dioxin**
- 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.

Superfund sites:

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

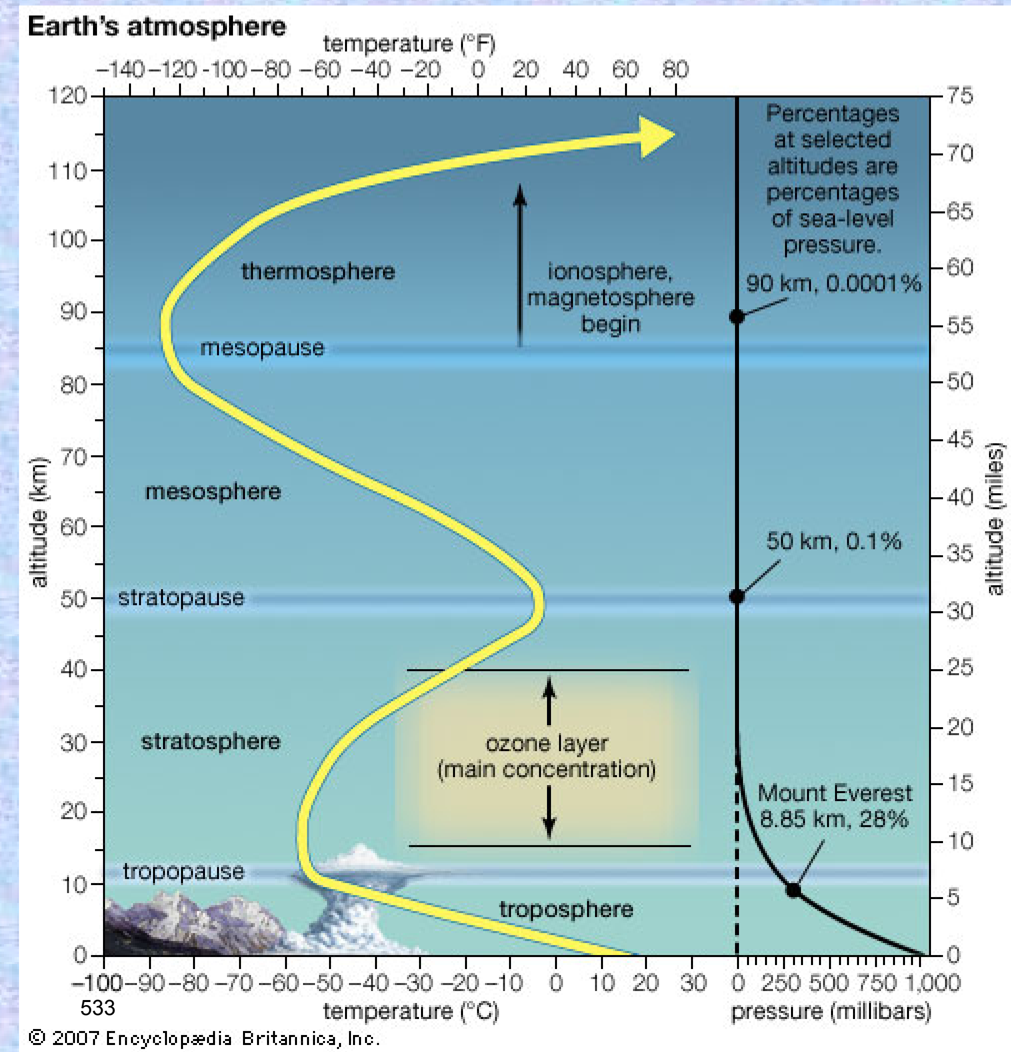
Layers of the Atmosphere

- Troposphere

  ---------Tropopause
- Stratosphere

Stratopause
- Mesosphere

  --------- Mesopause
- Thermosphere



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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

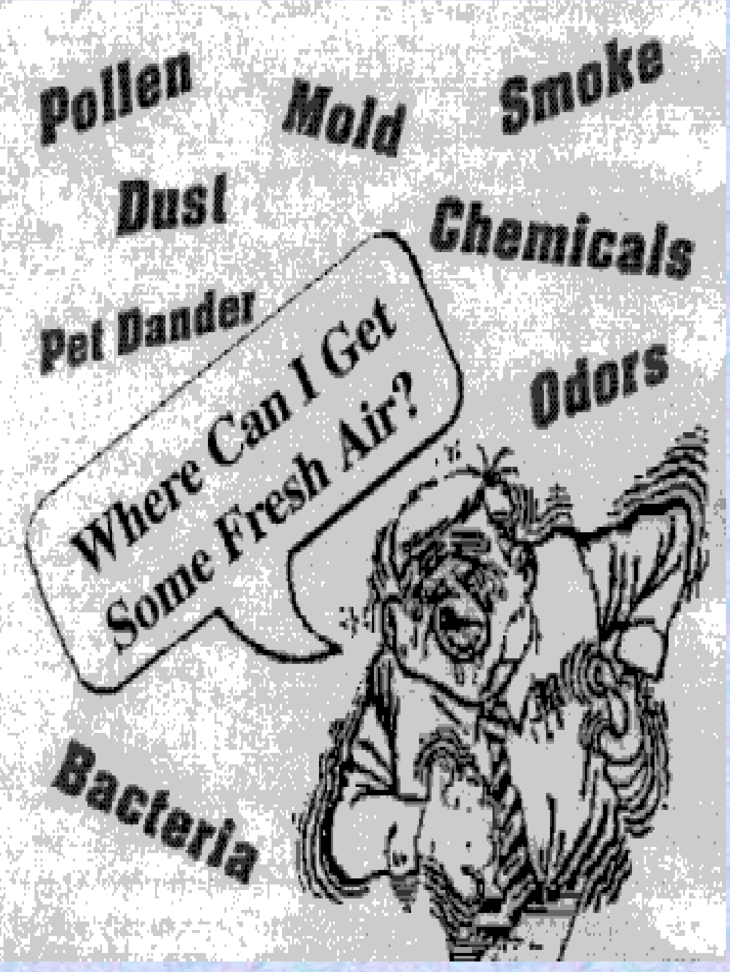
Acids and Bases

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

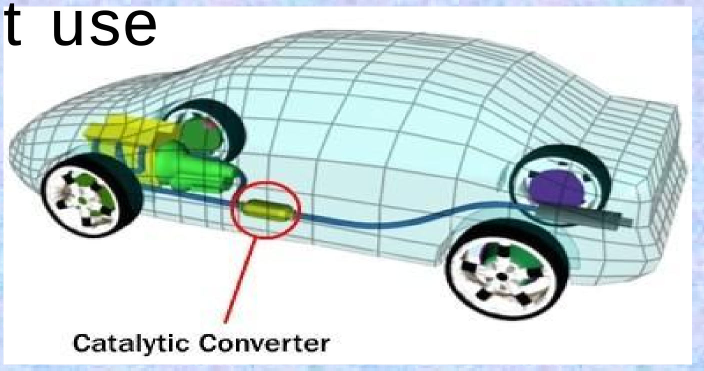
c. Effect areas hundreds of miles from the source of emissions, generally not the whole globe

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



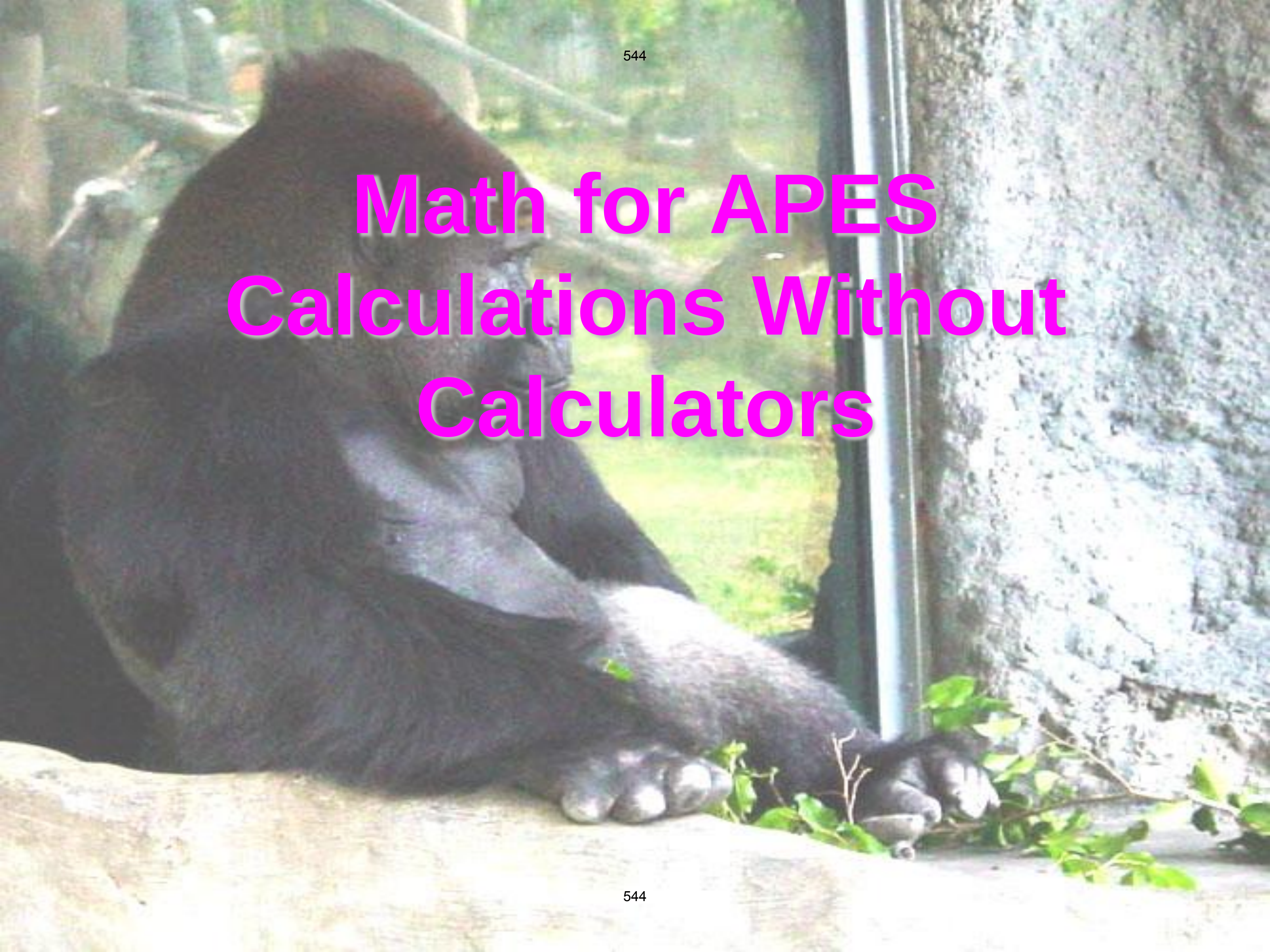
OUTPUT CONTROL

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)

Math for APES Calculations Without Calculators



The Problem:

How do we help our students achieve success on AP Environmental Science Exams when they cannot use calculators?

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AP® ADVANCED PLACEMENT PROGRAM®

Solutions:

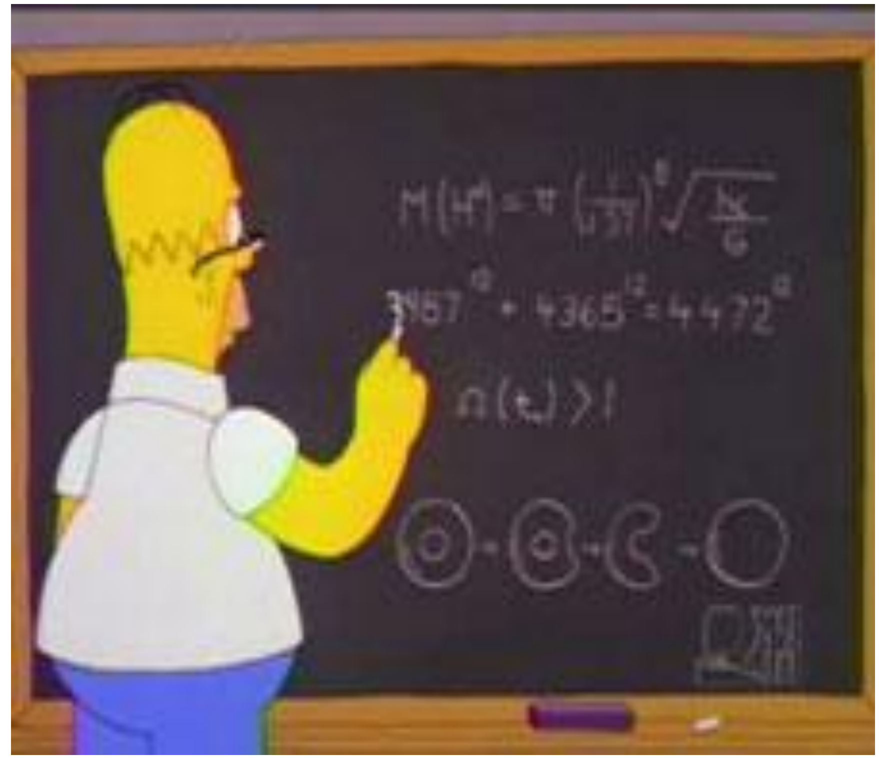
1. Teach your students to use exponents whenever numbers are especially large or small.

Scientific notation **is a way to express, numbers the form of exponents as the product of a number (between 1 and 10) and raised to a power of 10.**

For 650000 use 6.5×10^5

For 0.000543 use 5.43×10^{-4}

In scientific notation remember to have one number to the left of the decimal and to use correct significant figures.



2. Practice math manipulations with exponents

- **When adding or subtracting numbers with exponents the exponents of each number must be the same before you can do the operation.**

Example: $(1.9 \times 10^{-3}) - (1.5 \times 10^{-4}) =$

$(19 \times 10^{-4}) - (1.5 \times 10^{-4}) = 17.5 \times 10^{-4}$

When multiplying numbers with base 10 exponents, multiply the first factors, and then add the exponents.

Example, $(3.1 \times 105)\ (4.5 \times 10^5) =$

$$13.95 \times 10^{10} \text{ or } 1.4 \times 10^{11}$$

When dividing numbers, the exponents are subtracted, numerator exponent minus denominator exponent.

Example: $$\frac{9 \times 10^{5}}{3 \times 10^{3}} = 3 \times 10^{2}$$

3. Use Dimensional analysis or factor/label method for calculations

The following formula based on the cancellation of units is useful:

$$\text{Given Value} \times \frac{\text{Conversion factor}}{1} = \text{Answer}$$

OR

$$\text{old unit} \times \frac{\text{new unit}}{1 \text{ old unit}} = \text{new unit}$$

Example: Convert 12 km into mm. Report your answer using scientific notation.

$$12\text{ km} \times \frac{1000\text{m}}{1\text{ km}} \times \frac{1000\text{ mm}}{1\text{ m}} = 12000000\text{mm} = 1.2 \text{ X } 10^{7}\text{mm}$$

4. Be sure to know how to convert numbers to percentages and percent change.

Example: If 200 households in a town of 10000 have solar power, what percent does this represent?

200/10000 x 100 = ?

answer = 2.0%

Example: If a city of population 10,000 experiences 100 births, 40 deaths, 10 immigrants, and 30 emigrants in the course of a year, what is its net annual *percentage* growth rate?

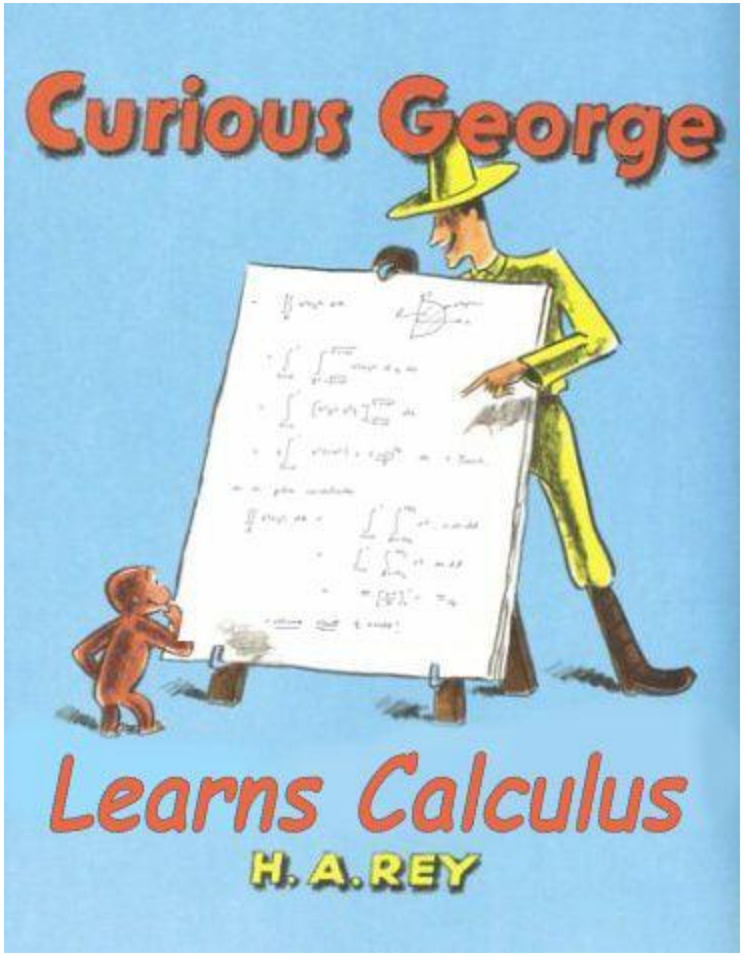
answer = 4.0%

5. Keep it simple. They don't expect you to do calculus without a calculator!

Try reducing the fraction from the previous problem 200/10000 to 20/100= 1/50

Then solve:

1/50 x 100%= 2.0%

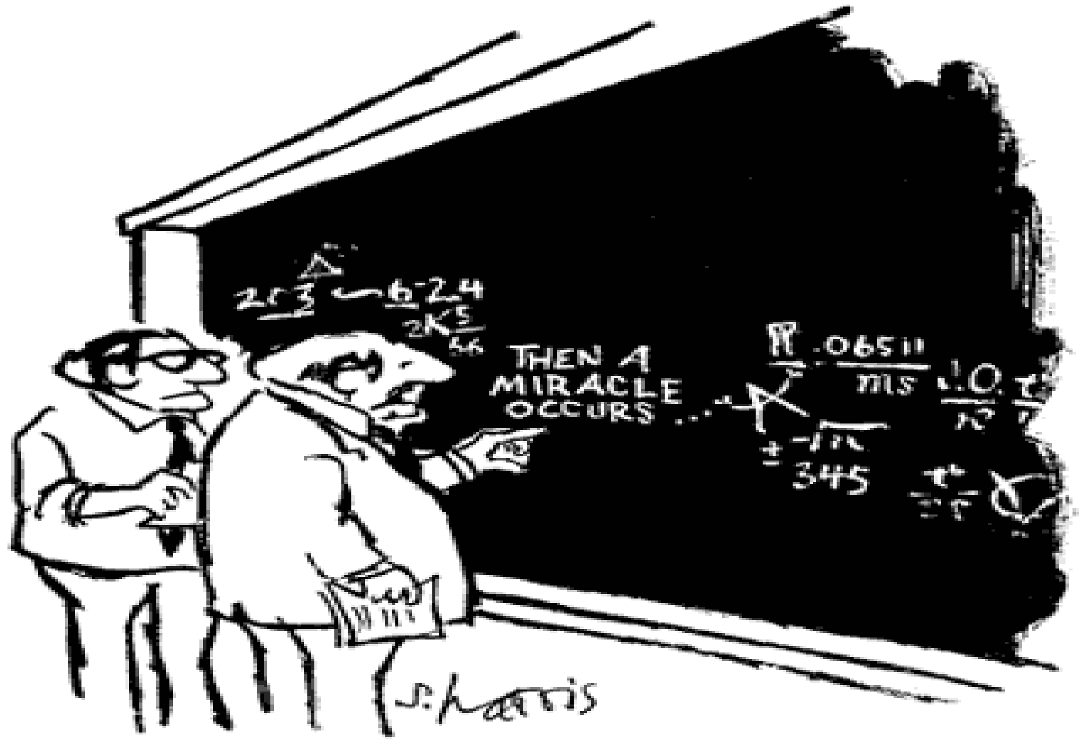


6. Remember that the numbers will likely be simple to manipulate.

- The APES folks know you only have limited time to do 100 multiple choice and 4 essays
- If you are getting answers like 1.365, then it is likely wrong

7. Show ALL of your work and steps of calculations, even if they are so simple you think they are implied.

NO WORK – NO CREDIT !



“I think you should be more explicit here in step two.”

8. Show all of your units, too!

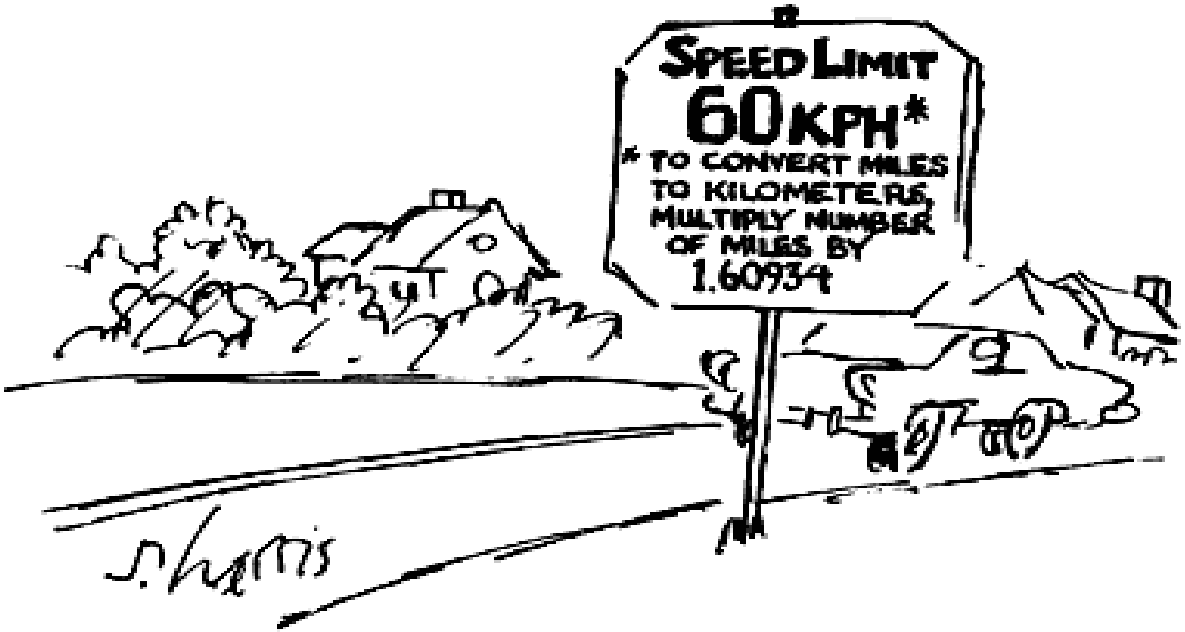
Numbers given without units are often not counted even if correct.

9. Answers should make sense! LOOK them over before you finish

Example:

No one is going to spend 1 billion dollars per gallon of water or $10,000 per kWh electrical energy!

10. Know some basic metric prefixes for simple conversions



Giga	G	$10^{9} = 1\ 000\ 000\ 000$
Mega	M	$10^{6} = 1\ 000\ 000$
Kilo	k	$10^{3} = 1\ 000$
Hecto	h	$10^{2} = 100$
Deka	dk	$10^{1} = 10$
Base Unit	(m, l, g)	$10^{0} = 1$
Deci	d	$10^{-1} = .1$
Centi	c	$10^{-2} = .01$
Milli	m	$10^{-3} = .001$
Micro	µ	$10^{-6} = .000\ 001$
Nano	n	$10^{-9} = .000\ 000\ 01$

Conversions from US to metric will probably be given and do not need to be memorized. They should be practiced, however.

Gallons to Liters	1 gal= 3.8 L
Liters to Gallons	1 L, l= .264 gal
Meters to Yards	1 m= 1.094 yd
Yards to Meters	1 yd= .914 m
Grams to Ounces	1 g= .035 oz
Ounces to Grams	1 oz= 28.35 g
Kilograms to Pounds	1 kg= 2.2 lb
Pounds to Kilograms	1 lb= 454 g
Miles to Kilometers	1 mi= 1.609km
Kilometers to Miles	1 km= .621 mi

11. Know some simple energy calculations.

2004 Exam: West Freemont is a community consisting of 3000 homes. The capacity of the power plant is 12 megawatts (MW) and the average household consumes 8,000 kilowatt hours (kWh) of electrical energy each year. The price paid for this energy is $0.10 per kWh.

(a) Assuming that the existing power plant can operate at full capacity for 8,000 hours per year, how many kWh of electricity can be produced by the plant in one year?

$$\frac{12\text{ MW}}{} \times \frac{1000\text{ kW}}{1\text{ MW}} \times \frac{8000\text{ hours}}{\text{Year}} = 96000000\text{ kWh/year}$$

or 9.6 X 107 kWh/year

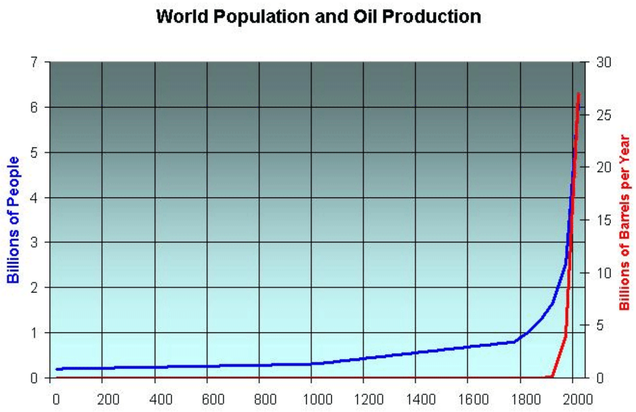
(b) How many kWh of electricity does the community use in one year?

$$3000\text{ houses} \times \frac{8000\text{ kWh}}{\text{yr}} = 24000000\text{ kWh/yr}$$

or 2.4 X 107 kWh/yr

12. Rule of 70

- Based on exponential growth
- Doubling Time = 70/annual growth rate

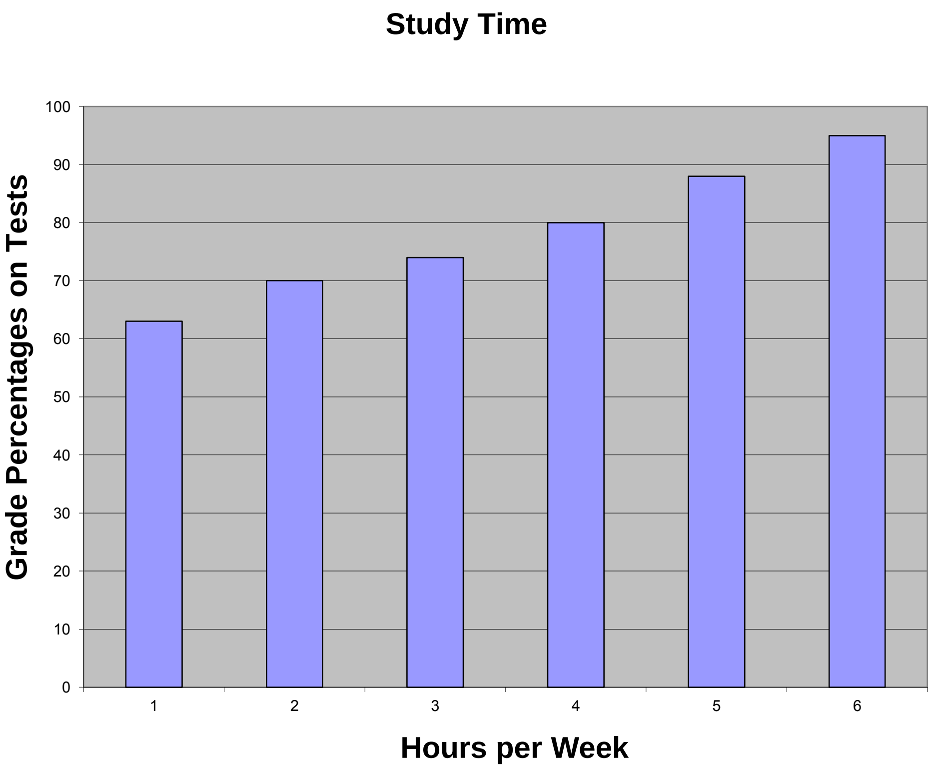


For example, if a population is growing at an annual rate of 2%, the number of years it will take for that population to double can be found by dividing 70 by 2, i.e., DT = 70/2 = 35 years.

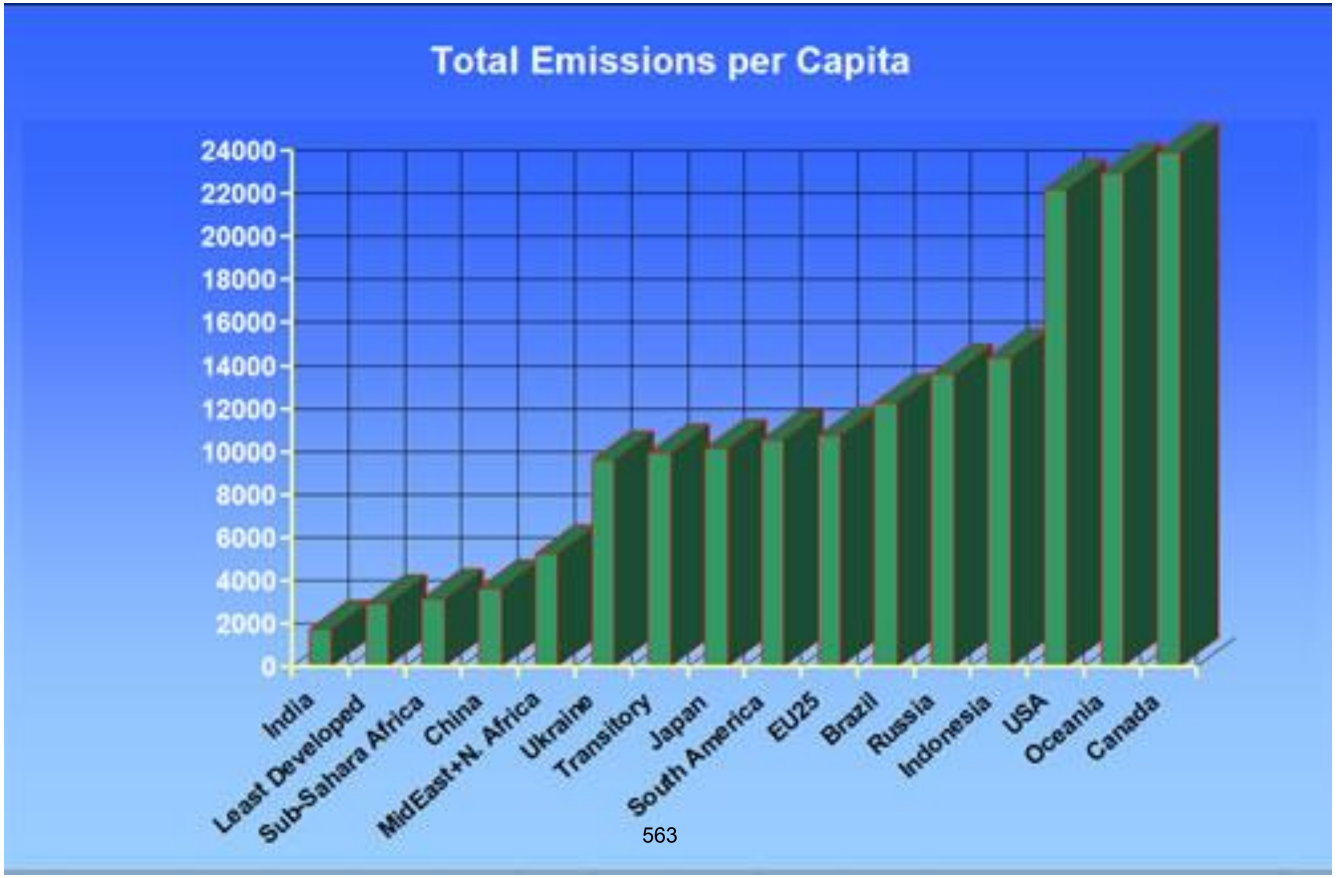
Calculate the doubling time for a population growing at 1.4%.
Answer = 70/1.4 = 50 years

14. Know how to graph data

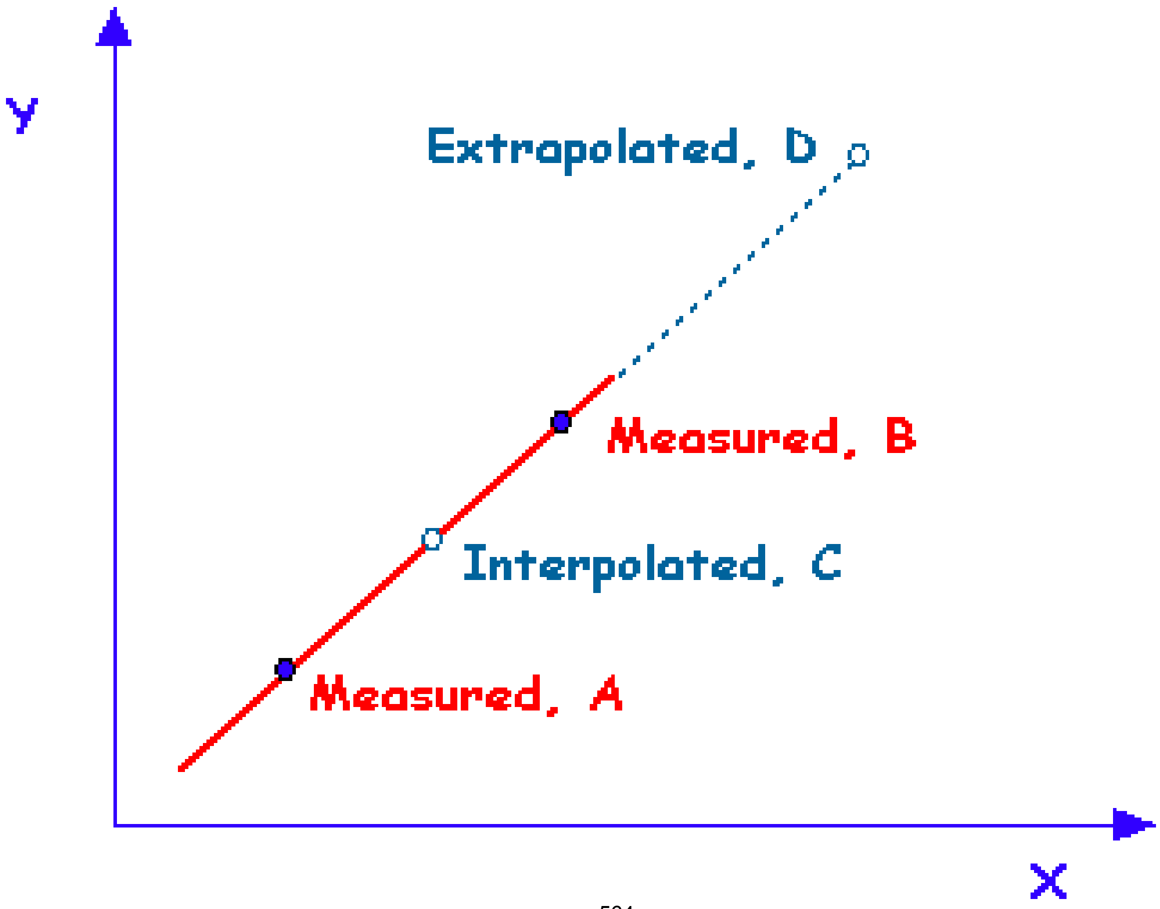
- Title the graph
- Set up the independent variable along the X axis
- Set up the dependent variable along the Y axis
- Label each axis and give the appropriate units
- Make proportional increments along each axis so the graph is spread out over the entire graph area
- Plot points and sketch a curve if needed. Use a straight edge to connect points unless told to extrapolate a line.
- Label EACH curve if more than one is plotted.



15. Know what is meant by “per capita” when solving a problem or interpreting a graph



16. Be able to *interpolate* and *extrapolate* data



17. Practice real APES exam multiple choice and free response questions!

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GLOSSARY 1

pH	Scientists use pH as a measure of acidity, based on the amount of hydrogen ions (H^+) and hydroxide ions (OH^-) contained in a particular volume of a solution.
physical change	When a sample of matter undergoes a physical change, its *chemical composition*, or the arrangement of its atoms or ions within molecules does not change.
positive feedback loop	causes a system to change further in the same direction.
potential energy	The other major type of energy is potential energy, which is stored and potentially available for use.
protons (p)	If you could view atoms with a supermicroscope, you would find that each different type of atom contains a certain number of three different types of *subatomic particles*: positively charged protons (p), neutrons (n) with no electrical charge, and negatively charged electrons (e).
radioactive decay	occurs when nuclei of unstable isotopes spontaneously emit fast-moving chunks of matter (alpha particles or beta particles), high-energy radiation (gamma rays), or both at a fixed rate. A particular radioactive isotope may emit any one or a combination of the three items shown in the diagram.
radioactive isotopes or radioisotopes	unstable isotopes
reliable science	consists of data, hypotheses, theories, and laws that are widely accepted by scientists who are considered experts in the field under study.
science	an endeavor to discover how nature works and to use that knowledge to make predictions about what is likely to happen in nature.
scientific hypothesis	a possible and testable explanation of what they observe in nature or in the results of their experiments.
scientific law, or law of nature	a well-tested and widely accepted description of what we find happening over and over again in the same way in nature.
scientific theory	A well-tested and widely accepted scientific hypothesis or a group of related hypotheses
second law of thermodynamics	When energy changes from one form to another, we always end up with lower-quality or less usable energy than we started with. This lower-quality energy usually takes the form of heat given off at a low temperature to the environment.
synergistic interaction, or synergy	occurs when two or more processes interact so that the combined effect is greater than the sum of their separate effects.
system	a set of components that function and interact in some regular way.
tentative science or frontier science	Sometimes, preliminary results that capture news headlines are controversial because they have not been widely tested and accepted by peer review. They are not yet considered reliable, and can be thought of as tentative science or frontier science.
time delays	Complex systems often show time delays between the input of a feedback stimulus and the response to it.
tipping point	Time delays can also allow an environmental problem to build slowly until it reaches a *threshold level*, or tipping point, causing a fundamental shift in the behavior of a system.
trait	Each of these coded units of genetic information concerns a specific trait, or characteristic passed on from parents to offspring during reproduction in an animal or plant.

unreliable science	Scientific hypotheses and results that are presented as reliable without having undergone the rigors of peer review, or that have been discarded as a result of peer review, are considered to be unreliable science.
abiotic	Two types of components make up the biosphere and its ecosystems: One type, called abiotic, consists of nonliving components such as water, air, nutrients, rocks, heat, and solar energy.
aerobic respiration	Producers, consumers, and decomposers use the chemical energy stored in glucose and other organic compounds to fuel their life processes. In most cells this energy is released by aerobic respiration, which uses oxygen to convert glucose (or other organic nutrient molecules) back into carbon dioxide and water.
anaerobic respiration, or fermentation	Some decomposers get the energy they need by breaking down glucose (or other organic compounds) in the absence of oxygen. This form of cellular respiration is called anaerobic respiration, or fermentation.
aquatic life zones	Scientists divide the watery parts of the biosphere into aquatic life zones, each containing numerous ecosystems.
atmosphere	a thin spherical envelope of gases surrounding the earth's surface.
biogeochemical cycle	(literally, life-earth-chemical cycles) or nutrient cycles—prime examples of one of the four scientific principles of sustainability
biomass	the dry weight of all organic matter contained in its organisms.
biomes	large regions such as forests, deserts, and grasslands, with distinct climates and certain species (especially vegetation) adapted to them.
biosphere	consists of the parts of the earth's air, water, and soil where life is found.
biotic	Two types of components make up the biosphere and its ecosystems: The other type, called biotic, consists of living and once living biological components—plants, animals, and microbes.
carbon cycle	Carbon is the basic building block of the carbohydrates, fats, proteins, DNA, and other organic compounds necessary for life. It circulates through the biosphere, the atmosphere, and parts of the hydrosphere, in the carbon cycle.
cell theory	The idea that all living things are composed of cells is called the cell theory and it is the most widely accepted scientific theory in biology.
cells	All organisms (living things) are composed of cells: the smallest and most fundamental structural and functional units of life.
chemosynthesis	A few producers, mostly specialized bacteria, can convert simple inorganic compounds from their environment into more complex nutrient compounds without using sunlight, through a process called chemosynthesis.
community, or biological community	consists of all the populations of different species that live in a particular place.
consumers	All other organisms in an ecosystem are consumers, or heterotrophs ("other-feeders"), that cannot produce the nutrients they need through photosynthesis or other processes and must obtain their nutrients by feeding on other organisms (producers or other consumers) or their remains.
decomposers	primarily certain types of bacteria and fungi, are consumers that release nutrients from the dead bodies of plants and animals and return them to the soil, water, and air for reuse by producers. They feed by secreting enzymes that speed up the break down of bodies of dead organisms into nutrient compounds such as water, carbon dioxide, minerals, and simpler organic compounds.

detritus	Detritus feeders, or detritivores, feed on the wastes or dead bodies of other organisms, called detritus ("di-TRI-tus," meaning debris).
detritus feeders, or detritivores	feed on the wastes or dead bodies of other organisms, called detritus ("di-TRI-tus," meaning debris). Examples include small organisms such as mites and earthworms, some insects, catfish, and larger scavenger organisms such as vultures.
ecological efficiency	The percentage of usable chemical energy transferred as biomass from one trophic level to the next is called ecological efficiency.
Ecology	(from the Greek words oikos, meaning "house" or "place to live," and logos, meaning "study of") is the study of how organisms interact with their living (biotic) environment of other organisms and with their nonliving (abiotic) environment of soil, water, other forms of matter, and energy mostly from the sun.
ecosystem	is a community of different species interacting with one another and with their nonliving environment of soil, water, other forms of matter, and energy, mostly from the sun.
eukaryotic cell	is surrounded by a membrane and has a distinct nucleus and several other internal parts called organelles, which are also surrounded by membranes.
food chain	A sequence of organisms, each of which serves as a source of food or energy for the next, is called a food chain.
food web	organisms in most ecosystems form a complex network of interconnected food chains called a food web
genetic diversity	In most natural populations, individuals vary slightly in their genetic makeup, which is why they do not all look or act alike. This variation in a population is called genetic diversity.
geosphere	consists of the earth's intensely hot core, a thick mantle composed mostly of rock, and a thin outer crust.
greenhouse gases	The remaining 1% of the air includes water vapor, carbon dioxide, and methane, all of which are called greenhouse gases, because they trap heat and thus warm the lower atmosphere. Almost all of the earth's weather occurs in this layer.
gross primary productivity (GPP)	is the rate at which an ecosystem's producers (usually plants) convert solar energy into chemical energy as biomass found in their tissues.
habitat	The place where a population or an individual organism normally lives is its habitat.
hydrologic cycle, or water cycle	collects, purifies, and distributes the earth's fixed supply of water.
hydrosphere	consists of all of the water on or near the earth's surface.
limiting factor principle	A variety of abiotic factors can affect the number of organisms in a population. Sometimes one or more factors, known as limiting factors, are more important in regulating population growth than other factors are. This ecological principle is called the limiting factor principle: Too much or too little of any abiotic factor can limit or prevent growth of a population, even if all other factors are at or near the optimal range of tolerance.
limiting factors	A variety of abiotic factors can affect the number of organisms in a population. Sometimes one or more factors, known as limiting factors, are more important in regulating population growth than other factors are.
natural greenhouse effect	Without this the earth would be too cold to support the forms of life we find here today.
net primary productivity (NPP)	is the rate at which producers use photosynthesis to produce and store chemical energy minus the rate at which they use some of this stored chemical energy through aerobic respiration.

nitrogen cycle	Fortunately, two natural processes convert or fix N2 into compounds useful as nutrients for plants and animals. One is electrical discharges, or lightning, taking place in the atmosphere. The other takes place in aquatic systems, soil, and the roots of some plants, where specialized bacteria, called nitrogen-fixing bacteria, complete this conversion as part of the nitrogen cycle.
omnivores	such as pigs, foxes, cockroaches, and humans, play dual roles by feeding on both plants and animals.
phosphorus cycle	Phosphorus circulates through water, the earth's crust, and living organisms in the phosphorus cycle.
photosynthesis	Most producers capture sunlight to produce energy-rich carbohydrates (such as glucose, C6H12O6) by photosynthesis, which is the way energy enters most ecosystems.
population	is a group of individuals of the same species that live in the same place at the same time.
primary consumers, or herbivores	(plant eaters), are animals such as rabbits, grasshoppers, deer, and zooplankton that eat producers, mostly by feeding on green plants.
producers	sometimes called autotrophs (self-feeders), make the nutrients they need from compounds and energy obtained from their environment.
prokaryotic cell	is also surrounded by a membrane, but it has no distinct nucleus and no other internal parts surrounded by membranes.
pyramid of energy flow	The more trophic levels there are in a food chain or web, the greater is the cumulative loss of usable chemical energy as it flows through the trophic levels. The pyramid of energy flow illustrates this energy loss for a simple food chain, assuming a 90% energy loss with each transfer.
range of tolerance	Each population in an ecosystem has a range of tolerance to variations in its physical and chemical environment. Individuals within a population may also have slightly different tolerance ranges for temperature or other factors because of small differences in genetic makeup, health, and age.
secondary consumers, or carnivores	(meat eaters), are animals such as spiders, hyenas, birds, frogs, and some zooplankton-eating fish, all of which feed on the flesh of herbivores.
species	For a group of sexually reproducing organisms, a species is a set of individuals that can mate and produce fertile offspring.
stratosphere	The next layer, stretching 17–50 kilometers (11–31 miles) above the earth's surface, is the stratosphere. Its lower portion contains enough ozone (O3) gas to filter out most of the sun's harmful ultraviolet radiation.
sulfur cycle	Sulfur circulates through the biosphere in the sulfur cycle.
third- and higher-level consumers	are carnivores such as tigers, wolves, mice-eating snakes, hawks, and killer whales (orcas) that feed on the flesh of other carnivores.
transpiration	Over land, about 90% of the water that reaches the atmosphere evaporates from the surfaces of plants through a process called transpiration.
trophic level	Ecologists assign every organism in an ecosystem to a feeding level, or trophic level, depending on its source of food or nutrients.
troposphere	a thin spherical envelope of gases surrounding the earth's surface. Its inner layer, the troposphere, extends only about 17 kilometers (11 miles) above sea level at the tropics and about 7 kilometers (4 miles) above the earth's north and south poles.
adaptation, or adaptive trait	any heritable trait that enables an individual organism to survive through natural selection and to reproduce more than other individuals under prevailing environmental conditions.

background extinction	Throughout most of history, species have disappeared at a low rate, called background extinction.
biological diversity, or biodiversity	the variety of the earth's species, the genes they contain, the ecosystems in which they live, and the ecosystem processes such as energy flow and nutrient cycling that sustain all life.
biological evolution	the process whereby earth's life changes over time through changes in the genes of populations.
differential reproduction	For natural selection to occur, a trait must be heritable, meaning that it can be passed from one generation to another. The trait must also lead to differential reproduction, which enables individuals with the trait to leave more offspring than other members of the population leave.
ecological niche	Scientists describe the role that a species plays in its ecosystem as its ecological niche, or simply niche (pronounced "nitch"). It is a species' way of life in a community and includes everything that affects its survival and reproduction, such as how much water and sunlight it needs, how much space it requires, and the temperatures it can tolerate.
endemic species	Species that are found in only one area are called endemic species and are especially vulnerable to extinction.
extinction	Another process affecting the number and types of species on the earth is extinction, in which an entire species ceases to exist.
fossils	Most of what we know of the earth's life history comes from fossils: mineralized or petrified replicas of skeletons, bones, teeth, shells, leaves, and seeds, or impressions of such items found in rocks.
foundation species	Another important type of species in some ecosystems is a foundation species, which plays a major role in shaping communities by creating and enhancing their habitats in ways that benefit other species.
generalist species	Generalist species have broad niches. They can live in many different places, eat a variety of foods, and often tolerate a wide range of environmental conditions.
geographic isolation	occurs when different groups of the same population of a species become physically isolated from one another for long periods.
indicator species	Species that provide early warnings of damage to a community or an ecosystem are called indicator species.
keystone species	A keystone is the wedge-shaped stone placed at the top of a stone archway. Remove this stone and the arch collapses. In some communities and ecosystems, ecologists hypothesize that certain species play a similar role. Keystone species have a large effect on the types and abundances of other species in an ecosystem.
mass extinction	is a significant rise in extinction rates above the background level.
mutations	The first step in this process is the development of genetic variability in a population.This genetic variety occurs through mutations: random changes in the structure or number of DNA molecules in a cell that can be inherited by offspring.
native species	are those species that normally live and thrive in a particular ecosystem.
natural selection	Darwin and Wallace concluded that these survival traits would become more prevalent in future populations of the species through a process called natural selection, which occurs when some individuals of a population have genetically based traits that enhance their ability to survive and produce offspring with the same traits.
nonnative species	Other species that migrate into or are deliberately or accidentally introduced into an ecosystem are called nonnative species, also referred to as invasive, alien, or exotic species.
reproductive isolation	mutation and change by natural selection operate independently in the gene pools of geographically isolated populations.

specialist species	In contrast, specialist species occupy narrow niches. They may be able to live in only one type of habitat, use one or a few types of food, or tolerate a narrow range of climatic and other environmental conditions.
speciation	Under certain circumstances, natural selection can lead to an entirely new species. In this process, called speciation, two species arise from one.
species diversity	An important characteristic of a community and the ecosystem to which it belongs is its species diversity the number of different species it contains (species richness) combined with the relative abundance of individuals within each of those species (species evenness).
species evenness	An important characteristic of a community and the ecosystem to which it belongs is its species diversity: the number of different species it contains (species richness) combined with the relative abundance of individuals within each of those species (species evenness).
species richness	An important characteristic of a community and the ecosystem to which it belongs is its species diversity: the number of different species it contains (species richness) combined with the relative abundance of individuals within each of those species (species evenness).
age structure	A population's age structure—the proportions of individuals at various ages—can have a strong effect on how rapidly it increases or decreases in size.
biotic potential	Species vary in their biotic potential or capacity for population growth under ideal conditions.
carrying capacity (K)	Together, biotic potential and environmental resistance determine the carrying capacity (K): the maximum population of a given species that a particular habitat can sustain indefinitely without being degraded.
coevolution	When populations of two different species interact in this way over a such long period of time, changes in the gene pool of one species can lead to changes in the gene pool of the other species. Such changes can help both sides to become more competitive or can help to avoid or reduce competition. Biologists call this process coevolution.
commensalism	is an interaction that benefits one species but has little, if any, effect on the other.
ecological succession	The gradual change in species composition in a given area is called ecological succession, during which, some species colonize an area and their populations become more numerous, while populations of other species decline and may even disappear.
environmental resistance	is the combination of all factors that act to limit the growth of a population.
inertia, or persistence	It is useful to distinguish among two aspects of stability in living systems. One is inertia, or persistence: the ability of a living system, such as a grassland or a forest, to survive moderate disturbances.
interspecific competition	occurs when members of two or more species interact to gain access to the same limited resources such as food, light, or space.
intrinsic rate of increase (r)	is the rate at which the population of a species would grow if it had unlimited resources.
K-selected species	At the other extreme are competitor or K-selected species. They tend to reproduce later in life and have a small number of offspring with fairly long life spans.
logistic growth	involves rapid exponential population growth followed by a steady decrease in population growth until the population size levels off.
mutualism	two species behave in ways that benefit both by providing each with food, shelter, or some other resource.
parasitism	occurs when one species (the parasite) feeds on the body of, or the energy used by, another organism (the host), usually by living on or in the host.

population density	is the number of individuals in a population found in a particular area or volume.
population dynamics	Populations differ in factors such as their distribution, numbers, age structure (proportions of individuals in different age groups), and density (number of individuals in a certain space). Population dynamics is a study of how these characteristics of populations change in response to changes in environmental conditions.
predation	In predation, a member of one species (the predator) feeds directly on all or part of a living organism of another plant or animal species (the prey) as part of a food web.
predator	In predation, a member of one species (the predator) feeds directly on all or part of a living organism of another plant or animal species (the prey) as part of a food web.
predator–prey relationship	Together, the two different species, such as lions (the predator or hunter) and zebras (the prey or hunted), form a predator–prey relationship.
prey	In predation, a member of one species (the predator) feeds directly on all or part of a living organism of another plant or animal species (the prey) as part of a food web.
primary succession	involves the gradual establishment of biotic communities in lifeless areas where there is no soil in a terrestrial ecosystem or no bottom sediment in an aquatic ecosystem.
r-selected species	Species have different reproductive patterns that can help enhance their survival. Species with a capacity for a high rate of population increase (r) are called r-selected species
resilience	A second factor is resilience: the ability of a living system to be restored through secondary succession after a moderate disturbance.
resource partitioning	It occurs when species competing for similar scarce resources evolve specialized traits that allow them to use shared resources at different times, in different ways, or in different places.
secondary succession	The other more common type of ecological succession is called secondary succession, in which a series of communities or ecosystems with different species develop in places containing soil or bottom sediment.
tipping point	there are limits to the stresses that ecosystems and global systems such as climate can take. As a result, such systems can reach a tipping point, where any additional stress can cause the system to change in an abrupt and usually irreversible way that often involves collapse.
age structure	the distribution of males and females among age groups in a population—in this case, the world population.
birth rate, or crude birth rate	the number of live births per 1,000 people in a population in a given year
cultural carrying capacity	This would be an optimum level that would allow most people to live in reasonable comfort and freedom without impairing the ability of the planet to sustain future generations.
death rate, or crude death rate	the number of deaths per 1,000 people in a population in a given year
demographic transition	as countries become industrialized, first their death rates and then their birth rates decline.
family planning	provides educational and clinical services that help couples choose how many children to have and when to have them.
fertility rate	the number of children born to a woman during her lifetime.
infant mortality rate	the number of children per 1,000 live births who die before one year of age.
life expectancy	the average number of years a newborn infant can expect to live
migration	the movement of people into (immigration) and out of (emigration) specific geographic areas.

population change	We can calculate population change of an area by subtracting the number of people leaving a population (through death and emigration) from the number entering it (through birth and immigration) during a specified period of time (usually one year).
replacement-level fertility rate	is the average number of children that couples in a population must bear to replace themselves.
total fertility rate (TFR)	is the average number of children born to women in a population during their reproductive years.
biomes	large terrestrial regions characterized by similar climate, soil, plants, and animals, regardless of where they are found in the world.
climate	an area's general pattern of atmospheric or weather conditions measured over long periods of time ranging from decades to thousands of years.
currents	Prevailing winds blowing over the oceans produce mass movements of surface water called currents.
desert	In a desert, annual precipitation is low and often scattered unevenly throughout the year. During the day, the baking sun warms the ground and causes evaporation of moisture from plant leaves and soil. But at night, most of the heat stored in the ground radiates quickly into the atmosphere.
forest systems	are lands dominated by trees.
grasslands	occur mostly in the interiors of continents in areas too moist for deserts and too dry for forests. Grasslands persist because of a combination of seasonal drought, grazing by large herbivores, and occasional fires—all of which keep large numbers of shrubs and trees from growing.
greenhouse effect	The natural warming effect of the troposphere.
greenhouse gases	allow mostly visible light and some infrared radiation and ultraviolet (UV) radiation from the sun to pass through the atmosphere.
permafrost	underground soil in which captured water stays frozen for more than 2 consecutive years.
rain shadow effect	The loss of moisture from the landscape and the resulting semiarid or arid conditions on the leeward side of high mountains create the rain shadow effect.
weather	a local area's
aquatic life zones	The aquatic equivalents of biomes are called aquatic life zones.
benthos	The third type, benthos, consists of bottom dwellers such as oysters, which anchor themselves to one spot; clams and worms, which burrow into the sand or mud; and lobsters and crabs, which walk about on the sea floor.
coastal wetlands	coastal land areas covered with water all or part of the year
coastal zone	the warm, nutrient-rich, shallow water that extends from the high-tide mark on land to the gently sloping, shallow edge of the continental shelf.
coral reefs	form in clear, warm coastal waters of the tropics and subtropics.
cultural eutrophication	Human inputs of nutrients from the atmosphere and from nearby urban and agricultural areas can accelerate the eutrophication of lakes, a process called cultural eutrophication.
decomposers	A fourth major type is decomposers (mostly bacteria), which break down organic compounds in the dead bodies and wastes of aquatic organisms into nutrients that can be used by aquatic primary producers.
estuaries	are where rivers meet the sea
eutrophic lake	A lake with a large supply of nutrients needed by producers is called a eutrophic (well-nourished) lake.

freshwater	lakes, rivers, streams, and inland wetlands
hypereutrophic	Cultural eutrophication often puts excessive nutrients into lakes, which are then described as hypereutrophic.
inland wetlands	lands covered with freshwater all or part of the time (excluding lakes, reservoirs, and streams) and located away from coastal areas.
intertidal zone	The area of shoreline between low and high tides is called the intertidal zone.
lakes	large natural bodies of standing freshwater formed when precipitation, runoff, or groundwater seepage fills depressions in the earth's surface.
mesotrophic lakes	Many lakes fall somewhere between the two extremes of nutrient enrichment. They are called mesotrophic lakes.
nekton	A second major type of organisms is nekton, strongly swimming consumers such as fish, turtles, and whales.
oligotrophic lakes	Lakes that have a small supply of plant nutrients are called oligotrophic (poorly nourished) lakes. Often, this type of lake is deep and has steep banks.
open sea	The sharp increase in water depth at the edge of the continental shelf separates the coastal zone from the vast volume of the ocean called the open sea.
plankton	Saltwater and freshwater life zones contain several major types of organisms. One such type consists of weakly swimming, free-floating plankton.
runoff	Precipitation that does not sink into the ground or evaporate becomes surface water. It becomes runoff when it flows into streams.
saltwater or marine	oceans and their accompanying estuaries, coastal wetlands, shorelines, coral reefs, and mangrove forests
surface water	Precipitation that does not sink into the ground or evaporate
turbidity	The depth of the euphotic zone in oceans and deep lakes can be reduced when the water is clouded by excessive algal growth (algal blooms) resulting from nutrient overloads. This cloudiness, called turbidity, can occur naturally, such as from algal growth, or can result from disturbances such as clearing of land, which causes silt to flow into bodies of water.
watershed, or drainage basin	the land area that delivers runoff, sediment, and dissolved substances to a stream.
background extinction	During most of the 3.56 billion years that life has existed on the earth, there has been a continuous, low level of extinction of species known as background extinction.
endangered species	has so few individual survivors that the species could soon become extinct over all or most of its natural range (the area in which it is normally found).
extinction rate	expressed as a percentage or number of species that go extinct within a certain time period such as a year.
HIPPCO	Habitat destruction, degradation, and fragmentation; Invasive (nonnative) species; Population and resource use growth (too many people consuming too many resources); Pollution; Climate change; and Overexploitation.
instrumental value	their usefulness to us in providing many of the ecological and economic services that make up the earth's natural capital
intrinsic or existence value	Some scientists and philosophers believe that each wild species has intrinsic or existence value based on its inherent right to exist and play its ecological roles, regardless of its usefulness to us.
mass extinction	The extinction of many species in a relatively short period of geologic time

precautionary principle	When substantial preliminary evidence indicates that an activity can harm human health or the environment, we should take precautionary measures to prevent or reduce such harm, even if some of the cause-and-effect relationships have not been fully established, scientifically.
threatened species	(also known as a vulnerable species) is still abundant in its natural range but, because of declining numbers, is likely to become endangered in the near future.

biodiversity hotspots	an idea first proposed in 1988 by environmental scientist Norman Myers. These “ecological arks” are areas especially rich in plant species that are found nowhere else and are in great danger of extinction.
deforestation	the temporary or permanent removal of large expanses of forest for agriculture, settlements, or other uses.
ecological restoration	the process of repairing damage caused by humans to the biodiversity and dynamics of natural ecosystems.
old-growth forest	an uncut or regenerated primary forest that has not been seriously disturbed by human activities or natural disasters for 200 years or more.
overgrazing	occurs when too many animals graze for too long and exceed the carrying capacity of a rangeland area.
pastures	managed grasslands or enclosed meadows usually planted with domesticated grasses or other forage.
rangelands	unfenced grasslands in temperate and tropical climates that supply *forage*, or vegetation, for grazing (grass-eating) and browsing (shrub-eating) animals.
reconciliation or applied ecology	This science focuses on inventing, establishing, and maintaining new habitats to conserve species diversity in places where people live, work, or play.
second-growth forest	a stand of trees resulting from secondary ecological succession
tree plantation, also called a tree farm or commercial forest	a managed tract with uniformly aged trees of one or two genetically uniform species that usually are harvested by clear-cutting as soon as they become commercially valuable.
undergrazing	Some grasslands suffer from undergrazing, where absence of grazing for long periods (at least 5 years) can reduce the net primary productivity of grassland vegetation and grass cover.
wilderness	One way to protect undeveloped lands from human exploitation is by legally setting them aside as large areas of undeveloped land called wilderness.

fishprint	is defined as the area of ocean needed to sustain the consumption of an average person, a nation, or the world.
	the dung and urine of cattle, horses, poultry, and other farm animals. It improves soil structure, adds organic nitrogen, and stimulates beneficial soil bacteria and fungi.
aquaculture	raising marine and freshwater fish in ponds and underwater cages
chronic malnutrition	deficiencies of protein and other key nutrients—which weakens them, makes them more susceptible to disease, and hinders the normal physical and mental development of children.

chronic undernutrition, or hunger	People who cannot grow or buy enough food to meet their basic energy needs suffer from chronic undernutrition, or hunger.
commercial inorganic fertilizer	The best way to maintain soil fertility is through soil conservation. The next best option is to restore some of the plant nutrients that have been washed, blown, or leached out of the soil, or that have been removed by repeated crop harvesting. To do this, farmers can use commercial inorganic fertilizer produced from various minerals.
compost	produced when microorganisms in soil break down organic matter such as leaves, crop residues, food wastes, paper, and wood in the presence of oxygen.
desertification	It occurs when the productive potential of soil, especially on arid or semiarid land, falls by 10% or more because of a combination of prolonged drought and human activities that reduce or degrade topsoil.
famine	occurs when there is a severe shortage of food in an area accompanied by mass starvation, many deaths, economic chaos, and social disruption.
fishery	a concentration of particular aquatic species suitable for commercial harvesting in a given ocean area or inland body of water.
food insecurity	living with chronic hunger and poor nutrition, which threatens their ability to lead healthy and productive lives.
food security	means that every person in a given area has daily access to enough nutritious food to have an active and healthy life.
green manure	consists of freshly cut or growing green vegetation that is plowed into the topsoil to increase the organic matter and humus available to the next crop.
green revolution	Since 1950, about 88% of the increase in global food production has come from using high-input industrialized agriculture to increase yields in a process called the green revolution.
industrialized agriculture, or high-input agriculture	uses heavy equipment and large amounts of financial capital, fossil fuel, water, commercial fertilizers, and pesticides to produce single crops, or monocultures.
integrated pest management (IPM)	Many pest control experts and farmers believe the best way to control crop pests is a carefully designed integrated pest management (IPM) program. In this more sustainable approach, each crop and its pests are evaluated as parts of an ecological system. Then farmers develop a control program that uses a combination of cultivation, biological controls, and chemical tools and techniques, applied in a carefully coordinated way.
organic agriculture	crops that are grown with little or no use of synthetic pesticides, synthetic fertilizers, or genetically engineered seeds.
organic fertilizer	The best way to maintain soil fertility is through soil conservation. The next best option is to restore some of the plant nutrients that have been washed, blown, or leached out of the soil, or that have been removed by repeated crop harvesting. To do this, farmers can use organic fertilizer made from plant and animal wastes.
overnutrition	occurs when food energy intake exceeds energy use and causes excess body fat. Too many calories, too little exercise, or both can cause overnutrition.
pest	any species that interferes with human welfare by competing with us for food, invading lawns and gardens, destroying building materials, spreading disease, invading ecosystems, or simply being a nuisance.
pesticides	chemicals used to kill or control populations of organisms that humans consider undesirable.

plantation agriculture	is a form of industrialized agriculture used primarily in tropical developing countries.
polyculture	Some traditional farmers focus on cultivating a single crop, but many grow several crops on the same plot simultaneously, a practice known as polyculture.
salinization	Repeated annual applications of irrigation water in dry climates lead to the gradual accumulation of salts in the upper soil layers—a soil degradation process called salinization.
slash-and-burn agriculture	This type of subsistence agriculture involves burning and clearing small plots in tropical forests, growing a variety of crops for a few years until the soil is depleted of nutrients, and then shifting to other plots.
soil conservation	involves using a variety of ways to reduce soil erosion and restore soil fertility, mostly by keeping the soil covered with vegetation.
soil erosion	the movement of soil components, especially surface litter and topsoil, from one place to another by the actions of wind and water.
traditional intensive agriculture	farmers increase their inputs of human and draft-animal labor, fertilizer, and water to obtain higher crop yields.
traditional subsistence agriculture	uses mostly human labor and draft animals to produce only enough crops for a farm family's survival, with little left over to sell or store as a reserve in hard times.
waterlogging	Another problem with irrigation is waterlogging, in which water accumulates underground and gradually raises the water table.
aquifers	underground caverns and porous layers of sand, gravel, or bedrock through which groundwater flows.
dam	a structure built across a river to control the river's water flow.
desalination	involves removing dissolved salts from ocean water or from brackish (slightly salty) water in aquifers or lakes for domestic use.
drought	a prolonged period in which occasional precipitation is at least 70% lower and evaporation is higher than normal in an area that is normally not dry.
floodplain	A flood happens when water in a stream overflows its normal channel and spills into the adjacent area, called a floodplain.
groundwater	Some precipitation infiltrates the ground and percolates downward through spaces in soil, gravel, and rock until an impenetrable layer of rock stops it. The water in these spaces is called groundwater—one of our most important sources of freshwater and a key component of the earth's natural capital.
reliable surface runoff	the amount of surface runoff that we can generally count on as a source of freshwater from year to year.
reservoir	After a river is dammed, the river's flow creates an artificial lake, or reservoir, behind the dam.
surface runoff	Precipitation that does not infiltrate the ground or return to the atmosphere by evaporation is called surface runoff.
surface water	the freshwater from precipitation and snowmelt that flows across the earth's land surface and into rivers, streams, lakes, wetlands, estuaries, and ultimately to the oceans.
water table	The top of this groundwater zone
watershed or drainage basin	The land from which surface water drains into a particular river, lake, wetland, or other body of water.

zone of saturation	The spaces in soil and rock close to the earth's surface hold little moisture. Below a certain depth, in the zone of saturation, these spaces are completely filled with water.
area strip mining	In area strip mining, used where the terrain is fairly flat, gigantic earthmovers strip away the overburden, and power shovels—some as tall as a 20-story building—remove the mineral deposit.
contour strip mining	Contour strip mining is used mostly to mine coal on hilly or mountainous terrain.
core	the earth's innermost zone. It is extremely hot and has a solid inner part, surrounded by a liquid core of molten or semisolid material.
crust	The outermost and thinnest zone of the earth is the crust.
depletion time	the time it takes to use up a certain proportion—usually 80%—of the reserves of a mineral at a given rate of use.
earthquake	When a fault forms, or when there is abrupt movement on an existing fault, energy that has accumulated over time is released in the form of vibrations, called seismic waves, which move in all directions through the surrounding rock. This internal geological process is called an earthquake.
geology	the science devoted to the study of dynamic processes occurring on the earth's surface and in its interior.
high-grade ore	A high-grade ore contains a fairly large amount of the desired nonrenewable mineral resource
igneous rock	forms below or on the earth's surface when magma wells up from the earth's upper mantle or deep crust and then cools and hardens.
lithosphere	thick plates are composed of the continental and oceanic crust and the rigid, outermost part of the mantle (above the asthenosphere), a combination called the lithosphere.
low-grade ore	A high-grade ore contains a fairly large amount of the desired nonrenewable mineral resource, whereas a low-grade ore contains a smaller amount.
mantle	Surrounding the core is a thick zone called the mantle.
metamorphic rock	forms when a preexisting rock is subjected to high temperatures (which may cause it to melt partially), high pressures, chemically active fluids, or a combination of these agents.
mineral	an element or inorganic compound that occurs naturally in the earth's crust as a solid with a regular internal crystalline structure.
mineral resource	a concentration of naturally occurring material from the earth's crust that can be extracted and processed into useful products and raw materials at an affordable cost.
mountaintop removal	Another surface mining method is mountaintop removal. In the Appalachian Mountain area of the United States, where this form of mining is prominent, explosives, large power shovels, and huge machines called draglines are used to remove the top of a mountain and expose seams of coal, which are then removed.
open-pit mining	The type of surface mining used depends on two factors: the resource being sought and the local topography. In open-pit mining machines dig holes and remove ores (of metals such as iron, copper, and gold), sand, gravel, and stone (such as limestone and marble).
ore	rock that contains a large enough concentration of a particular mineral—often a metal—to make it profitable for mining and processing.
overburden	In surface mining, gigantic mechanized equipment strips away the overburden, the soil and rock overlying a useful mineral deposit.
reserves	identified resources from which the mineral can be extracted profitably at current prices.

rock	a solid combination of one or more minerals found in the earth's crust.
rock cycle	The interaction of physical and chemical processes that change rocks from one type to another.
sedimentary rock	made of sediments—dead plant and animal remains and existing rocks that are weathered and eroded into tiny particles.
smelting	Heating ores to release metals is called smelting.
spoils	In surface mining, gigantic mechanized equipment strips away the overburden, the soil and rock overlying a useful mineral deposit. It is usually discarded as waste material called spoils.
strip mining	Strip mining is useful and economical for extracting mineral deposits that lie close to the earth's surface in large horizontal beds.
subsurface mining	After suitable mineral deposits are located, several different mining techniques are used to remove them, depending on their location and type. Shallow deposits are removed by surface mining, and deep deposits are removed by subsurface mining.
surface mining	After suitable mineral deposits are located, several different mining techniques are used to remove them, depending on their location and type. Shallow deposits are removed by surface mining.
tectonic plates	The flows of energy and heated material in the mantle's convection cells cause a dozen or so huge rigid plates, called tectonic plates, to move extremely slowly atop the denser mantle on hot soft rock in the underlying asthenosphere.
tsunami	a series of large waves generated when part of the ocean floor suddenly rises or drops
volcano	An active volcano occurs where magma reaches the earth's surface through a central vent or a long crack, called a fissure.
weathering	the physical, chemical, and biological processes that break down rocks into smaller particles that help build soil.

coal	a solid fossil fuel that was formed in several stages out of the remains of land plants that were buried 300–400 million years ago and subjected to intense heat and pressure over many millions of years.
liquefied natural gas (LNG)	So that it can be transported across oceans, natural gas is converted to liquefied natural gas (LNG) at a very low temperature and high pressure. This highly flammable liquid is then put aboard refrigerated tanker ships.
liquefied petroleum gas (LPG)	When a natural gas field is tapped, propane and butane gases are liquefied and removed as liquefied petroleum gas (LPG). LPG is stored in pressurized tanks for use mostly in rural areas not served by natural gas pipelines.
natural gas	a mixture of gases of which 50–90% is methane (CH_4). It also contains smaller amounts of heavier gaseous hydrocarbons such as ethane (C_2H_6), propane (C_3H_8), and butane (C_4H_{10}), and small amounts of highly toxic hydrogen sulfide (H_2S).
nuclear fusion	a nuclear change in which two isotopes of light elements, such as hydrogen, are forced together at extremely high temperatures until they fuse to form a heavier nucleus, releasing energy in the process.
oil sand, or tar sand	a mixture of clay, sand, water, and a combustible organic material called *bitumen*—a thick and sticky, heavy oil with a high sulfur content that makes up about 10% of the gooey mixture.
petrochemicals	Some of the products of oil distillation, called petrochemicals, are used as raw materials in industrial organic chemicals, cleaning fluids, pesticides, plastics, synthetic fibers, paints, medicines, and many other products.

petroleum, or crude oil	Petroleum, or crude oil (oil as it comes out of the ground), is a thick and gooey liquid consisting of hundreds of different combustible hydrocarbons along with small amounts of sulfur, oxygen, and nitrogen impurities.
shale oil	Oily rocks are another potential supply of heavy oil. Such rocks, called *oil shales*, contain a solid combustible mixture of hydrocarbons called *kerogen*. It can be extracted from crushed oil shales by heating them in a large container, a process that yields a distillate called shale oil.
synthetic natural gas (SNG)	Solid coal can be converted into synthetic natural gas (SNG) by a process called *coal gasification* and into a liquid fuel such as methanol or synthetic gasoline by *coal liquefaction*.

active solar heating system	An active solar heating system absorbs energy from the sun by pumping a heat-absorbing fluid (such as water or an antifreeze solution) through special collectors usually mounted on a roof or on special racks to face the sun.
biofuels	Biomass consists of plant materials (such as wood and agricultural waste) and animal wastes that can be burned directly as a solid fuel or converted into gaseous or liquid biofuels.
cogeneration, or combined heat and power (CHP)	Some companies save energy and money by using cogeneration, or combined heat and power (CHP), systems. In such a system, two useful forms of energy (such as steam and electricity) are produced from the same fuel source.
energy conservation	a decrease in energy use based primarily on reducing unnecessary waste of energy.
energy efficiency	the measure of how much work we can get from each unit of energy we use.
geothermal energy	heat stored in soil, underground rocks, and fluids in the earth’s mantle.
passive solar heating system	A passive solar heating system absorbs and stores heat from the sun directly within a well-insulated structure without the need for pumps or fans to distribute the heat.
photovoltaic (PV) cells	Solar energy can be converted directly into electrical energy by photovoltaic (PV) cells, commonly called solar cells.
carcinogens	Carcinogens are chemicals, types of radiation, or certain viruses that can cause or promote cancer
dose	the amount of a harmful chemical that a person has ingested, inhaled, or absorbed through the skin.
dose-response curve	Scientists estimate the toxicity of a chemical by determining the effects of various doses of the chemical on test organisms and then by plotting the results in a dose-response curve. One approach is to determine the lethal dose—the amount needed to kill an animal.
infectious disease	An infectious disease is caused when a pathogen such as a bacterium, virus, or parasite invades the body and multiplies in its cells and tissues.
mutagens	The second major type of toxic agent, mutagens, includes chemicals or forms of radiation that cause mutations, or changes, in the DNA molecules found in cells, or that increase the frequency of such changes.
nontransmissible disease	A nontransmissible disease is caused by something other than a living organism and does not spread from one person to another.
pathogen	A pathogen is a living organism that can cause disease in another organism.
risk	the probability of suffering harm from a hazard that can cause injury, disease, death, economic loss, or damage.

risk analysis	involves identifying hazards and evaluating their associated risks ranking risks (comparative risk analysis), determining options and making decisions about reducing or eliminating risks and informing decision makers and the public about risks.
risk assessment	The scientific process of using statistical methods to estimate how much harm a particular hazard can cause to human health or to the environment.
risk management	involves deciding whether or how to reduce a particular risk to a certain level and at what cost.
toxic chemical	A toxic chemical is one that can cause temporary or permanent harm or death to humans and animals.
toxicity	a measure of how harmful a substance is—its ability to cause injury, illness, or death to a living organism.
toxicology	the study of the harmful effects of chemicals on humans and other organisms. In effect, it is a study of poisons.
transmissible disease	(also called a contagious or communicable disease) is an infectious disease that can be transmitted from one person to another.
acid deposition	Acidic substances remain in the atmosphere for 2–14 days, depending mostly on prevailing winds, precipitation, and other weather patterns. During this period, they descend to the earth's surface in two forms: wet deposition consisting of acidic rain, snow, fog, and cloud vapor with a pH less than 5.6* and dry deposition consisting of acidic particles. The resulting mixture is called acid deposition—sometimes termed acid rain.
air pollution	the presence of chemicals in the atmosphere in concentrations high enough to harm organisms, ecosystems, or human-made materials.
atmospheric pressure	the force, or mass, per unit area of a column of air. This force is caused by the bombardment of a surface such as your skin by air molecules.
carbon oxides	Carbon monoxide (CO) is a colorless, odorless, and highly toxic gas that forms during the incomplete combustion of carbon-containing materials.
density	the air we breathe at sea level has a higher density—more molecules per liter—than the air we would inhale on top of the world's highest mountain.
industrial smog	consisting mostly of sulfur dioxide, suspended droplets of sulfuric acid, and a variety of suspended solid particles.
nitrogen oxides and nitric acid	Nitric oxide (NO) is a colorless gas that forms when nitrogen and oxygen gas in air react at the high-combustion temperatures in automobile engines and coal-burning plants.
ozone	Ozone (O3), a colorless and highly reactive gas, is a major component of photochemical smog.
ozone laye	Much of the atmosphere's small amount of ozone (O3) is concentrated in a portion of the stratosphere called the ozone layer, found roughly 17–30 kilometers (11–19 miles) above sea level.
particulates	Suspended particulate matter (SPM) consists of a variety of solid particles and liquid droplets small and light enough to remain suspended in the air for long periods.
photochemical smog	a mixture of primary and secondary pollutants formed under the influence of UV radiation from the sun.
primary pollutants	harmful chemicals emitted directly into the air from natural processes and human activities.
secondary pollutants	While in the atmosphere, some primary pollutants react with one another and with the basic components of air to form new harmful chemicals, called secondary pollutants.
stratosphere	The atmosphere's second layer is the stratosphere, which extends from about 17 to about 48 kilometers (from 11 to 30 miles) above the earth's surface.

sulfur dioxide and sulfuric acid	Sulfur dioxide (SO2) is a colorless gas with an irritating odor. About one-third of the SO2 in the atmosphere comes from natural sources as part of the sulfur cycle.
temperature inversion	Under certain atmospheric conditions, however, a layer of warm air can temporarily lie atop a layer of cooler air nearer the ground. This is called a temperature inversion.
troposphere	About 75–80% of the earth's air mass is found in the troposphere, the atmospheric layer closest to the earth's surface.
volatile organic compounds (VOCs)	Organic compounds that exist as gases in the atmosphere are called volatile organic compounds (VOCs).

carbon capture and storage (CCS).	It involves removing CO_2 from the smokestacks of coal-burning power and industrial plants and then storing it somewhere.

cultural eutrophication	Near urban or agricultural areas, human activities can greatly accelerate the input of plant nutrients to a lake—a process called cultural eutrophication involving mostly nitrate- and phosphate-containing effluents from various sources.
eutrophication	the name given to the natural nutrient enrichment of a shallow lake, estuary, or slowmoving stream, mostly from runoff of plant nutrients such as nitrates and phosphates from surrounding land.
nonpoint sources	broad, and diffuse areas, rather than points, from which pollutants enter bodies of surface water or air.
point sources	discharge pollutants at specific locations through drain pipes, ditches, or sewer lines into bodies of surface water.
primary sewage treatment	Raw sewage reaching a treatment plant typically undergoes one or two levels of wastewater treatment. The first is primary sewage treatment—a physical process that uses screens and a grit tank to remove large floating objects and to allow solids such as sand and rock to settle out.
secondary sewage treatment	Raw sewage reaching a treatment plant typically undergoes one or two levels of wastewater treatment. The second level is secondary sewage treatment—a biological process in which aerobic bacteria remove as much as 90% of dissolved and biodegradable, oxygen-demanding organic wastes.
septic tank	In rural and suburban areas with suitable soils, sewage from each house usually is discharged into a septic tank with a large drainage field.
water pollution	any chemical, biological, or physical change in water quality that harms living organisms or makes water unsuitable for desired uses.

environmental justice	an ideal whereby every person is entitled to protection from environmental hazards regardless of race, gender, age, national origin, income, social class, or any political factor.
hazardous, or toxic, waste	Another major category of waste is hazardous, or toxic, waste, which threatens human health or the environment because it is poisonous, dangerously chemically reactive, corrosive, or flammable.
industrial solid waste	Solid waste can be divided into two types. One type is industrial solid waste produced by mines, agriculture, and industries that supply people with goods and services.

integrated waste management	a variety of strategies for both waste reduction and waste management.
municipal solid waste (MSW)	Solid waste can be divided into two types. The other is municipal solid waste (MSW), often called *garbage* or *trash*, which consists of the combined solid waste produced by homes and workplaces.
open dumps	There are two types of landfills. Open dumps are essentially fields or holes in the ground where garbage is deposited and sometimes burned.
primary or closed-loop recycling	Households and workplaces produce five major types of materials that can be recycled: paper products, glass, aluminum, steel, and some plastics. Such materials can be reprocessed in two ways. In primary or closed-loop recycling, these materials are recycled into new products of the same type—turning used aluminum cans into new aluminum cans, for example.
recycle	Waste reduction is based on three Rs: Recycle: separate and recycle paper, glass, cans, plastics, metal, and other items, and buy products made from recycled materials.
reduce	Waste reduction is based on three Rs: Reduce: consume less and live a simpler lifestyle.
reuse	Waste reduction is based on three Rs: Reuse: rely more on items that can be used repeatedly instead of on throwaway items. Buy necessary items secondhand or borrow or rent them. Take a refillable coffee cup to class or to the coffee shop and use it instead of using throwaway cups.
sanitary landfills	In newer landfills, called sanitary landfills, solid wastes are spread out in thin layers, compacted, and covered daily with a fresh layer of clay or plastic foam, which helps to keep the material dry and reduces leakage of contaminated water (leachate) from the landfill.
secondary recycling	In secondary recycling, waste materials are converted into different products.
solid waste	any unwanted or discarded material we produce that is not a liquid or a gas.
waste management	We can deal with the solid wastes we create in two ways. One is waste management, in which we attempt to reduce the environmental impact of MSW without seriously trying to reduce the amount of waste produced.
waste reduction	We can deal with the solid wastes we create in two ways. The second approach is waste reduction, in which much less waste and pollution are produced, and the wastes that are produced are viewed as potential resources that can be reused, recycled, or composted.

land-use planning	Most urban and some rural areas use some form of land-use planning to determine the best present and future use of each parcel of land.
noise pollution	any unwanted, disturbing, or harmful sound that impairs or interferes with hearing, causes stress, hampers concentration and work efficiency, or causes accidents.
smart growth	one way to encourage more environmentally sustainable development that reduces dependence on cars, controls and directs sprawl, and cuts wasteful resource use. It recognizes that urban growth will occur. At the same time, it uses zoning laws and other tools to channel growth into areas where it will cause less harm.
urban growth	the rate of increase of urban populations.
urban sprawl	the growth of low-density development on the edges of cities and towns—is eliminating surrounding agricultural and wild lands.

urbanization	the creation and growth of urban areas or cities and their surrounding developed land. It is measured as the percentage of the people in a country or in the world living in urban areas.
zoning	Once a land-use plan is developed, governments control the uses of various parcels of land by legal and economic methods. The most widely used approach is zoning, in which various parcels of land are designated for certain uses.
cost–benefit analysis	Another widely used tool for making economic decisions about how to control pollution and manage resources is cost–benefit analysis. This is done by comparing estimated costs and benefits for actions such as implementing a pollution control regulation, building a dam on a river, or preserving an area of forest.
discount rate	an estimate of a resource's future economic value compared to its present value.
economic system	a social institution through which goods and services are produced, distributed, and consumed to satisfy people's needs and wants, ideally in the most efficient possible way.
high-throughput economies	Most of today's advanced industrialized countries have high-throughput economies, which attempt to boost economic growth by increasing the flow of matter and energy resources extracted from the environment through their economic systems to produce goods and services.
human capital, or human resources	Three types of capital, or resources, are used to produce goods and services. Human capital, or human resources, includes people's physical and mental talents, which provide labor, innovation, culture, and organization.
low-throughput (low-waste) economy	The three scientific laws governing matter and energy changes and the four scientific principle of sustainability suggest that the best long-term solution to our environmental and resource problems is to shift from an economy based on high and increasing matter and energy flow to a more sustainable low-throughput (low-waste) economy.
manufactured capital, or manufactured resources	Three types of capital, or resources, are used to produce goods and services. Manufactured capital, or manufactured resources, are items such as machinery, equipment, and factories made from natural resources with the help of human resources.
matter recycling and reuse economies	mimic nature by recycling and reusing most matter outputs instead of dumping them into the environment.
natural capital	Three types of capital, or resources, are used to produce goods and services. Natural capital includes resources and services produced by the earth's natural processes, which support all economies and all life.
poverty	the inability to meet basic economic needs.

administrative laws	consist of administrative rules and regulations, executive orders, and enforcement decisions related to the implementation and interpretation of statutory laws.
arbitration	a formal effort, somewhat similar to a trial, to resolve a dispute.
civil suits	Most environmental lawsuits are civil suits brought to settle disputes or damages between one party and another.
common law	a body of unwritten rules and principles derived from thousands of past legal decisions along with commonly accepted practices, or norms, within a society.
defendant	the party being charged, for injuries to health or for economic loss.
democracy	government by the people through elected officials and representatives.
environmental	a body of statements defining what is acceptable environmental behavior for individuals and

law	groups, according to the larger community, and attempting to balance competing social and private interests.
environmental policy	environmental laws and regulations that are developed, implemented, and enforced and the environmental programs that are funded by one or more government agencies.
lobbying	Converting a bill introduced in the U.S. Congress into a law is a complex process. An important part of this process is lobbying, in which individuals or groups use public pressure, personal contacts, and political action to persuade legislators to vote or act in their favor.
mediation	Another approach for settling a dispute is mediation, in which the parties involved are encouraged to sit down and talk under the guidance of a professional mediator.
plaintiff	the party bringing the charge
policies	The exact role played by a government is determined by its policies—the set of laws and regulations it enforces and the programs it funds.
politics	the process by which individuals and groups try to influence or control the policies and actions of governments at local, state, national, and international levels.
statutory laws	The body of law includes statutory laws, administrative laws, and common laws. Statutory laws are those developed and passed by legislative bodies such as federal and state governments.

deep ecology worldview	Another earth-centered environmental worldview is the deep ecology worldview. It consists of eight premises developed in 1972 by Norwegian philosopher Arne Naess, in conjunction with philosopher George Sessions and sociologist Bill Devall.
environmental ethics	what one believes about what is right and what is wrong in our behavior toward the environment.
environmental wisdom worldview	One earth-centered worldview is called the environmental wisdom worldview. According to this view, we are part of—not apart from—the community of life and the ecological processes that sustain all life.
environmental worldviews	how people think the world works and what they believe their role in the world should be.
planetary management worldview	One human-centered worldview held by many people is the planetary management worldview. According to this view, we are the planet’s most important and dominant species, and we can and should manage the earth mostly for our own benefit. Other species and parts of nature are seen as having only *instrumental value* based on how useful they are to us.
stewardship worldview	Another largely human-centered environmental worldview is the stewardship worldview. It assumes that we have an ethical responsibility to be caring and responsible managers, or *stewards*, of the earth.

GLOSSARY 2

1. **Ionizing radiation:** enough energy to knock electrons from atoms forming ions, capable of causing cancer (gamma-Xrays-UV)
2. **High Quality Energy: organized & concentrated, can perform useful work (fossil fuel & nuclear)**
3. **Low Quality Energy: disorganized, dispersed (heat in ocean or air wind, solar)**
4. **First Law of Thermodynamics: energy is neither created nor destroyed, but may be converted from one form to another**
5. **Second Law of Thermodynamics: when energy is changed from one form to another, some useful energy is always degraded into lower quality energy (usually heat)**
6. **Natural radioactive decay: unstable radioisotopes decay releasing gamma rays, alpha & beta particles**
7. **Half life: the time it takes for ½ the mass of a radioisotope to decay**
8. **Estimate of how long a radioactive isotope must be stored until it decays to a safe level: approximately 10 half-lives**
9. **Nuclear Fission: nuclei of isotopes split apart when struck by neutrons**
10. **Nuclear Fusion: 2 isotopes of light elements (H) forced together at high temperatures till they fuse to form a heavier nucleus. Expensive, break even point not reached yet**
11. **Ore: a rock that contains a large enough concentration of a mineral making it profitable to mine**
12. **Organic fertilizer: slow acting & long lasting because the organic remains need time to be decomposed**
13. **Best solution to Energy shortage: conservation and increase efficiency**
14. **Surface mining: cheaper & can remove more mineral, less hazardous to workers**
15. **Humus: organic, dark material remaining after decomposition by microorganisms**
16. **Leaching: removal of dissolved materials from soil by water moving downwards**
17. **Illuviation: deposit of leached material in lower soil layers (B)**
18. **Loam: perfect agricultural soil with equal portions of sand, silt, clay**
19. **Conservation: allows the use of resources in a responsible manner**
Preservation: setting aside areas & protecting them from human activities
20. **Parts of the hydrologic cycle: evaporation, transpiration, runoff, condensation, precipitation, infiltration**
21. **Aquifer: any water bearing layer in the ground**
22. **Cone of depression: lowering of the water table around a pumping well**
23. **Salt water intrusion: near the coast, overpumping of groundwater causes saltwater to move into the acquifer**
24. **ENSO: El Nino Southern Oscillation, see-sawing of air pressure over the S. Pacific**
25. **During an El Nino year: trade winds weaken & warm water sloshed back to SA**
During a Non El Nino year: Easterly trade winds and ocean currents pool warm water in the western Pacific, allowing upwelling of nutrient rich water off the West coast of South America
26. **Effects of El Nino: upwelling decreases disrupting food chains, N US has mild winters, SW US has increased rainfall, less Atlantic Hurricanes**
27. **Nitrogen fixing: because atmospheric N cannot be used directly by plants it must first be converted into ammonia by bacteria (rhizobium)**
28. **Ammonification: decomposers covert organic waste into ammonia**
29. **Nitrification: ammonia is converted to nitrate ions (NO-3)**
30. **Assimilation: inorganic N is converted into organic molecules such as DNA/amino acids & proteins**
31. **Denitrification: bacteria convert ammonia back into N**
32. **Phosphorus does not circulate as easily as N because: it does not exist as a gas, but is released by weathering of phosphate rocks**
33. **Sustainability: the ability to meet humanities current needs without compromising the ability of future generations to meet their needs**
34. **Excess phosphorus is added to aquatic ecosystems by: runoff of animal wastes, fertilizer, discharge of sewage**
35. **Photosynthesis: plants convert atmospheric C (CO2) into complex carbohydrates (glucose C6H12O6)**
36. **Aerobic respiration: oxygen consuming producers, consumers & decomposers break down complex organic compounds & convert C back into CO2**

37. Largest reservoirs of C: carbonate rocks first, oceans second
38. Biotic/abiotic: living & nonliving components of an ecosystem
39. Producer/Autotroph: photosynthetic life
40. Fecal coliform/Enterococcus: : indicator of sewage contamination
41. Energy flow in food webs: only 10% of the usable energy is transferred because usable energy lost as heat (2nd law), not all biomass is digested & absorbed, predators expend energy to catch prey
42. Chlorine: (good>disinfection of water)(bad>forms trihalomethanes)
43. Primary succession: development of communities in a lifeless area not previously inhabited by life (lava)
Secondary succession: life progresses where soil remains (clear cut forest, fire)
44. Cogeneration: using waste heat to make electricity
45. Mutualism: symbiotic relationship where both partners benefit
46. Commensalism: symbiotic relationship where one partner benefits & the other is unaffected
47. Parasitism: relationship in which one partner obtains nutrients at the expense of the host
48. Biome: large distinct terrestrial region having similar climate, soil, plants & animals
49. Carrying capacity: the number of individuals that can be sustained in an area
50. R strategist: reproduce early, many small unprotected offspring
K strategist: reproduce late, few, cared for offspring
51. Positive feedback: when a change in some condition triggers a response that intensifies the changing condition (EX: warmer Earth - snow melts - less sunlight is reflected & more is absorbed, therefore warmer earth)
52. Natural selection: organisms that possess favorable adaptations pass them onto the next generation
53. Malthus: said human population cannot continue to increase..consequences will be war, famine & disease
54. Doubling time: rule of 70 70 divided by the percent growth rate
55. Replacement level fertility: the number of children a couple must have to replace themselves (2.1 developed, 2.7 developing)
56. World Population is: 6 1/2 billion
US Population: 300 million
57. Preindustrial stage: birth & death rates high, population grows slowly, infant mortality high
58. Transitional stage: death rate lower, better health care, population grows fast
59. Industrial stage: decline in birth rate, population growth slows
60. Postindustrial stage: low birth & death rates
61. Age structure diagrams: (broad base, rapid growth)(narrow base, negative growth)(uniform shape, zero growth)
62. 1st & 2nd most populated countries: China & India
63. Most important thing affecting population growth: low status of women
64. Ways to decrease birth rate: family planning, contraception, economic rewards & penalties
65. Percent water on earth by type: 97.5% seawater, 2.5% freshwater
66. Salinazation of soil: in arid regions, water evaporates leaving salts behind
67. Ways to conserve water: (agriculture, drip/trickle irrigation)(industry,recyling)(home, use gray water, repair leaks, low flow fixtures)
68. Point vs non point sources: (Point, from specific location such as pipe)(Non-point, from over an area such as runoff)
69. BOD: biological oxygen demand, amount of dissolved oxygen needed by aerobic decomposers to break down organic materials
70. Eutrophication: rapid algal growth caused by an excess of N & P
71. Hypoxia: when aquatic plants die, the BOD rises as aerobic decomposers break down the plants, the DO drops & the water cannot support life
72. Minamata Disease: mental impairments caused by mercury
73. Primary air pollutants: produced by humans & nature (CO,CO_2,SO_2,NO,hydrocarbons, particulates)
74. Negative feedback: when a changing in some condition triggers a response that counteracts the changed condition (EX: warmer earth - more ocean evaporation - more stratus clouds - less sunlight reaches the ground - therefore cooler Earth)

75. Particulate matter (source,effect,reduction): (burning fossil fuels & diesel exhaust) (reduces visibility & respiratory irritation) (filtering, electrostatic precipitators, alternative energy)
76. Nitrogen Oxides: (Source: auto exhaust) (Effects: acidification of lakes, respiratory irritation, leads to smog & ozone) (Equation for acid formation: NO + O2 = NO2 + H2O = HNO3) (Reduction: catalytic converter)
77. Sulfur oxides: (Source: coal burning) (Effects: acid deposition, respiratory irritation, damages plants) (Equation for acid formation: SO2 + O2 = SO3 + H2O = H2SO4) (Reduction: scrubbers, burn low sulfur fuel)
78. Carbon oxides: (Source: auto exhaust, incomplete combustion) (Effects: CO binds to hemoglobin reducing bloods ability to carry O, CO2 contributes to global warming) (Reduction: catalytic converter, emission testing, oxygenated fuel, mass transit)
79. Ozone: (Formation: secondary pollutant, NO2+UV=NO+O O+O2=O3, with VOC's) (Effects: respiratory irritant, plant damage) (Reduction: reduce NO emissions & VOCs)
80. Radon: radioactive gas, formed from the decay of Uranium, causes lung cancer and is a problem in the Reading Prong
81. Photochemical smog: formed by chemical reactions involving sunlight (NO, VOC,O)
82. Acid deposition: caused by sulfuric and nitric acids resulting in lowered pH of surface waters
83. Greenhouse gases: (Examples: H2O, CO2, O3, methane (CH4), CFC's) (EFFECT: they trap outgoing infrared (heat) energy causing earth to warm
84. Effects of global warming: rising sealevel (thermal expansion), extreme weather, droughts (famine), extinctions
85. Ozone depletion caused by: CFC's, methyl chloroform, carbon tetrachloride, halon, methyl bromide all of which attack stratospheric ozone
86. Effects of ozone depletion: increased UV, skin cancer, cataracts, decreased plant growth
87. Love Canal, NY: chemicals buried in old canal and school & homes built over it causing birth defects & cancer
88. Municpal solid waste is mostly: paper and most is landfilled
89. True cost / External costs: harmful environmental side effects that are not reflected in a products price
90. Sanitary landfill problems and solutions: (leachate, liner with collection system) (methane gas, collect gas and burn) (volume of garbage, compact & reduce)
91. Incineration advantages: volume of waste reduced by 90% & waste heat can be used
92. Incineration disadvantages: toxic emissions (polyvinyl chloride—dioxin), scrubbers & electrostatic precipitators needed, ash disposal (contains heavy metals)
93. Best way to solve waste problem: reduce the amounts of waste at the source
94. Keystone species: species whose role in an ecosystem are more important than others, ex sea otter
95. Indicator species: species that serve as early warnings that an ecosystem is being damaged ex trout
96. Most endangered species: have a small range, require large territory or live on an island
97. In natural ecosystems, 50-90% of pest species are kept under control by: predators, diseases, parasites
98. Major insecticide groups and examples: (chlorinated hydrocarbons, DDT) (organophosphates, malathion) (carbamates, aldicarb)
99. Pesticide pros: saves lives from insect transmitted disease, increases food supply, increases profits for farmers
100. Pesticide cons: genetic resistance, ecosystem imbalance, pesticide treadmill, persistence, bioaccumulation, biological magnification
101. Natural pest control: better agricultural practices, genetically resistant plants, natural enemies, biopesticides, sex attractants
102. Electricity is generated by: using steam (from water boiled by fossils fuels or nuclear) or falling water to turn a generator
103. Petroleum forms from: microscopic aquatic organisms in sediments converted by heat & pressure into a mixture of hydrocarbons
104. Pros of petroleum: cheap, easily transported, high quality energy
105. Cons of petroleum: reserves depleted soon, pollution during drilling, transport and refining, burning makes CO2
106. Steps in coal formation: peat, lignite, bituminous, anthracite

107. Major parts of a nuclear reactor: core, control rods, steam generator, turbine, containment building
108. Two most serious nuclear accidents: (Chernobyl,Ukraine) (Three Mile Island, PA)
109. Alternate energy sources: wind, solar, waves, biomass, geothermal, fuel cells
110. LD50: the amount of a chemical that kills 50% of the animals in a test population
111. Mutagen, Teratogen, Carcinogen: causes hereditary changes, Fetus deformities, cancer
112. Endangered species: North spotted Owl (loss of old growth forest), Bald Eagle (thinning of eggs caused by DDT), Piping Plover (nesting areas threatened by development)
113. LI Exotic species: gypsy moth, Asian Long Horned Beetle
114. Garret Hardin & The Tragedy of the Commons: Freedom to breed is bringing ruin to all. Global commons such as atmosphere & oceans are used by all and owned by none
115. Volcanoes and Earthquakes occur: at plate boundaries (divergent, spreading, mid-ocean ridges) (convergent, trenches) (transform, sliding, San Andreas)
116. Sources of mercury: burning coal, Compact Fluorescent bulbs
117. Major source of sulfur: burning coal
118. Threshold dose: the maximum dose that has no measurable effect

LAWS, LAWS & MORE LAWS

MINING

1. Surface Mining Control & Reclamation Act: requires coal strip mines to reclaim the land
2. Madrid Protocol: Moratorium on mineral exploration for 50 years in Antarctica

WATER

3. Safe Drinking Water Act: set maximum contaminant levels for pollutants in drinking water that may have adverse effects on human health
4. Clean Water Act: set maximum permissible amounts of water pollutants that can be discharged into waterways..aim to make surface waters swimmable and fishable
5. Ocean Dumping Ban Act: bans ocean dumping of sewage sludge & industrial waste in the ocean

AIR

6. Clean Air Act: Set emission standards for cars, and limits for release of air pollutants
7. Kyoto Protocol: controlling global warming by setting greenhouse gas emissions targets for developed countries
8. Montreal Protocol: phaseout of ozone depleting substances

WASTE

9. Resource Conservation & Recovery Act: controls hazardous waste with a cradle to grave system
10. Comprehensive Environmental Response, Compensation & Liability Act: Superfund, designed to identify and clean up abandoned hazardous waste dump sites
11. Nuclear Waste Policy Act: US government must develop a high level nuclear waste site (Yucca Mtn)

LIFE

12. Endangered Species Act: identifies threatened and endangered species in the US, and puts their protection ahead of economic considerations
13. Convention on International Trade in Endangered Species: lists species that cannot be commercially traded as live specimens or wildlife products
14. Magnuson- Stevens Act: Mangaement of marine fisheries
15. Food Quality Protection Act: set pesticide limits in food, & all active and inactive ingredients must be screened for estrogenic/endocrine effects

GENERAL

16. National Environmental Policy Act: Environmental Impact Statements must be done before any project affecting federal lands can be started
17. Stockholm Convention on Persistent Organic Pollutants: Seeks to protect human health from the 12 most toxic chemicals (includes 8 chlorinated hydrocarbon pesticides / DDT can be used for malaria control)

GLOSSARY 3

First Law of Thermodynamics: energy is neither created nor destroyed, but may be converted from one form to another.

Second Law of Thermodynamics: when energy is changed from one form to another, some useful energy is always degraded into lower quality energy (usually heat).

Ionizing radiation: radiation w/enough energy to free electrons from atoms forming ions, may cause cancer (ex. gamma, X-rays, UV).

High Quality Energy: organized & concentrated, can perform useful work (ex. fossil fuels & nuclear).

Low Quality Energy: disorganized, dispersed (ex. heat in ocean or air/wind, solar).

Natural radioactive decay: unstable radioisotopes decay releasing gamma rays, alpha & beta particles (ex. Radon).

Half-life: the time it takes for 1⁄2 of the mass of a radioisotope to decay. A radioactive isotope must be stored for approximately 10 half-lives until it decays to a safe level.

Nuclear Fission: nuclei of isotopes split apart when struck by neutrons.

Nuclear Fusion: 2 isotopes of light elements (H) forced together at high temperatures till they fuse to form a heavier nucleus. Happens in the Sun, very difficult to accomplish on Earth, prohibitively expensive.

Ore: a rock that contains a large enough concentration of a mineral making it profitable to mine.

Mineral Reserve: identified deposits currently profitable to extract.

Surface mining: cheaper, can remove more minerals, less hazardous to workers.

Humus: organic, dark material remaining after decomposition by microorganisms.

Leaching: removal of dissolved materials from soil by water moving downwards through soil.

Loam: perfect agricultural soil with equal portions of sand, silt, and clay.

Soil Conservation Methods: conservation tillage, crop rotation, contour plowing, organic fertilizers.

Soil Salinization: in arid regions, water evaporates leaving salts behind. (ex. Fertile crescent, southwestern US)

Water Logging: water completely saturates soil starves plant roots of oxygen, rots roots

Hydrologic Cycle Components: evaporation, transpiration, runoff, condensation, precipitation, and infiltration.

Watershed: all of the land that drains into a body of water.

Aquifer: underground layers of porous rock allow water to move slowly.

Cone of Depression: lowering of the water table around a pumping well.

Salt Water Intrusion: near the coast, overpumping of groundwater causes saltwater to move into the aquifer.

ENSO: El Nino Southern Oscillation, trade winds weaken & warm surface water moves toward South America. Diminished fisheries off South America, drought in western Pacific, increased precipitation in southwestern North America, fewer Atlantic hurricanes.

La Nina: "Normal" year, easterly trade winds and ocean currents pool warm water in the western Pacific, allowing upwelling of nutrient rich water off the West coast of South America.

Nitrogen Fixation: because atmospheric N cannot be used directly by plants, it must first be converted into ammonia by bacteria.

Ammonification: decomposers covert organic waste into ammonia.

Nitrification: ammonia is converted to nitrate ions (NO_3^-).

Assimilation: inorganic N is converted into organic molecules such as DNA/amino acids & proteins.

Denitrification: bacteria convert ammonia back into N.

Phosphorus: does not exist as a gas; released by weathering of phosphate rocks, it is a major limiting factor for plant growth. Phosphorus cycle is slow, and not atmospheric.

Photosynthesis: plants convert CO_2 (atmospheric carbon) into complex carbohydrates (glucose $C_6H_{12}O_6$).

Aerobic Respiration: oxygen consuming producers, consumers & decomposers break down complex organic compounds & convert C back into CO_2.

Biotic: the living components of an ecosystem.

Abiotic: the nonliving components of an ecosystem.

Producer/Autotroph: organisms that make their own food—photosynthetic life (plants).

Trophic Levels: producers → primary consumer → secondary consumer → tertiary consumer.

Energy Flow through Food Webs: 10% of the usable energy is transferred to the next trophic level. Reason: usable energy lost as heat (2nd law of Thermodynamics), not all biomass is digested & absorbed, predators expend energy to catch prey.

Primary succession: development of communities in a lifeless area not recently inhabited by life (ex. lava flow, retreating glacier).

Secondary succession: life progresses where soil remains (ex. clear-cut/burned forest, old farm, vacant lot).

Mutualism: symbiotic relationship where both organisms benefit.

Commensalism: symbiotic relationship where one organism benefits & the other is unaffected.

Parasitism: relationship in which one organism (the parasite) obtains nutrients at the expense of the host.

Carrying Capacity: the number of individuals that can be sustained in an area.

r-strategist: reproductive strategy in which organisms reproduce early, bear many small, unprotected offspring (ex. insects, mice).

K-strategist: reproductive strategy in which organisms reproduce late, bear few, cared for offspring (ex. humans, elephants).

Natural Selection: organisms that possess favorable adaptations pass them onto the next generation.

Thomas Malthus: “human population cannot continue to increase. Consequences will be war, famine & pestilence (disease).”

Doubling Time: (rule of 70) doubling time equals 70 divided by percent growth rate. (ex. a population growing at 5% annually doubles in 70 ÷ 5 = 14 years)

Replacement Level Fertility: the number of children a couple must have to replace themselves (averages 2.1 in more developed nations, 2.7 in less developed nations).

World Population: a little over 6 billion.

Demographic Transition Model:

Preindustrial stage: birth & death rates high, population grows slowly, infant mortality high.

Transitional stage: death rate (infant mortality) lower, birth rates remain high, better health care, population grows fast.

Industrial stage: decline in birth rate, population growth slows.

Postindustrial stage: low birth & death rates.

Age Structure Diagrams: broad base → rapid growth; narrow base → negative growth; uniform shape → zero growth

Most Populous Nations: (1) China; (2) India; (3) U.S.; (4) Indonesia

Low Status of Women: Most important factor keeping population growth rates high.

Methods to Decrease Birth Rates: family planning, contraception, economic rewards & penalties.

Composition of Water on Earth: 97.5% seawater, 2.5% freshwater.

Aquaculture: farming aquatic species, commonly salmon, shrimp, tilapia, oysters.

Point Source: source from specific location such as pipe or smokestack

Non-Point Source (Area/Dispersed Source): source spread over an area such as agricultural/feedlot runoff, urban runoff, traffic.

Primary Sewage Treatment: first step of sewage treatment; eliminates most particulate material from raw sewage using grates, screens, and gravity (settling).

Secondary Sewage Treatment: second step of sewage treatment; bacteria breakdown organic waste, aeration accelerates the process.

BOD: Biological Oxygen Demand, amount of dissolved oxygen needed by aerobic decomposers to break down organic materials.

Eutrophication: rapid algal growth (algal bloom) caused by an excess of nitrogen & phosphorus, blocks sunlight, causing the death/decomposition of aquatic plants, decreasing dissolved oxygen (DO), suffocating fish.

Hypoxia: water with very low dissolved oxygen levels, the end result of eutrophication, for example.

CAFE standards: Corporate Average Fuel Economy standards enacted into law in 1975, established fuel efficiency standards for passenger cars and light trucks. The fuel economy ratings for a manufacturer's entire line of passenger cars must currently average at least 27.5 mpg for the manufacturer to comply with the standard.

Primary Air Pollutants: produced by humans & nature (CO, CO_2, SO_2, NO, hydrocarbons, particulates).

Secondary Air Pollutants: formed by reaction of primary pollutants.

Particulate Matter: sources include burning fossil fuels and car exhaust. Effects include reduced visibility, respiratory irritation. Methods of reduction include filtering, electrostatic precipitators, alternative energy).

Nitrogen Oxides: (NO_x) Major source is auto exhaust. Primary and secondary effects include acidification of lakes, respiratory irritation, leads to smog and ozone. Reduced using catalytic converters.

Equation for acid formation: $NO + O_2 \rightarrow NO_2 + H_2O \rightarrow HNO_3$.

Ozone: Secondary pollutant, $NO_2 + UV \rightarrow NO + O$; $O + O_2 \rightarrow O_3$, with VOCs. Causes respiratory irritation and plant damage. Reduced by reducing NO emissions and VOCs.

Sulfur Oxides: (SO_x) Primary source is coal burning. Primary and secondary effects include acid deposition, respiratory irritation, plant damage. Reduction methods include: scrubbers, burn low sulfur fuel.

Equation for acid formation: $SO_2 + O_2 \rightarrow SO_3 + H_2O \rightarrow H_2SO_4$

Carbon Dioxide: (CO_2) Sources include the combustion of fossil fuels. Effects: greenhouse gas–contributes to global warming. Reduction accomplished by increased fuel efficiency (gas mileage), mass transit (reduction).

Carbon Monoxide: (CO) Sources include incomplete combustion of fossil fuels. Effects: binds to hemoglobin reducing bloods ability to carry O_2. Reduction accomplished by catalytic converters, oxygenated fuel, mass transit (reduction).

Photochemical Smog: formed by chemical reactions involving sunlight (NO, VOC, O_2)

Acid Deposition: caused by sulfuric and nitric acids resulting in lowered pH of surface waters

Greenhouse Gases: Most significant: H_2O, CO_2, methane (CH_4), CFCs. Trap outgoing infrared energy (heat) causing earth to warm.

Greenhouse Effect: a vital process, required for life to exist on Earth. If accelerated, bad, leads to global warming.

Effects of Global Warming: rising sea level (due to thermal expansion not melting ice), extreme weather, droughts (famine), and extinctions.

Ozone Depletion: caused by CFCs, methyl chloroform, carbon tetrachloride, halon, methyl bromide all of which attack stratospheric ozone. Negative effects of ozone depletion include increased UV, skin cancer, cataracts, and decreased plant growth.

Municipal Solid Waste: is mostly paper and mostly put into landfills.

Sanitary Landfill: problems include leachate, which is solved using a liner with a collection system; methane gas, which may be collected and burned; and the volume of garbage, which may be compacted and/or reduced.

Incineration: Advantages–volume of waste reduced by 90% and waste heat can be used. Disadvantages–toxic emissions (polyvinyl chloride, dioxin), scrubbers and electrostatic precipitators needed, ash disposal.

Best Solution for Waste Problem: reduce the amount of waste at the source.

Brownfield: abandoned industrial sites.

Keystone Species: species whose role in an ecosystem is more important than others.

Indicator Species: species that serve as early warnings that an ecosystem is being damaged.

In Natural Ecosystems: 50-90% of pest species are kept under control by: predators, diseases, parasites.

Major Insecticide Groups: chlorinated hydrocarbons—ex. DDT; organophosphates—ex. malathion; carbamates—ex. aldicarb

Pesticide Pros: saves lives from insect transmitted disease, increases food supply, and increases profits for farmers. Cons: genetic resistance, ecosystem imbalance, pesticide treadmill, persistence, bioaccumulation, and biological magnification.

Natural Pest Control: better agricultural practices, genetically resistant plants, natural enemies, and biopesticides, sex attractants.

Genetically Modified Organisms (GMOs): new organisms created by altering the genetic material (DNA) of existing organisms; usually in an attempt to remove undesirable or create desirable characteristics in the new organism.

Electricity Generation: steam, from water boiled by fossils fuels or nuclear energy, or falling water is used to turn a generator.

Petroleum (Crude Oil) Formation: microscopic aquatic organisms in sediments converted by heat & pressure into a mixture of hydrocarbons.

Petroleum Pros: cheap, easily transported, high-quality energy. Cons: reserves depleted soon, pollution during drilling, transport and refining, land subsidence, burning oil produces CO_2.

Coal Formation: prehistoric plants buried un-decomposed in oxygen-depleted water of swamps/bogs converted by heat and pressure.

Ranks of Coal: peat, lignite, bituminous coal, anthracite coal.

Nuclear Reactor: consists of a core, control rods, moderator, steam generator, turbine, containment building.

Alternate Energy Sources: wind, solar, waves, biomass, geothermal, fuel cells

Remediation: return a contaminated area to its original state.

LD-50: the amount of a chemical that kills 50% of the animals in a test population.

Troposphere: first layer of atmosphere 0-10 miles above the Earth's surface. Contains weather, greenhouse gases (bad ozone).

Stratosphere: second layer of atmosphere 10-30 miles above the Earth's surface. Contains protective ozone layer (good ozone).

Inversion Layer (Temperature Inversion): a warm layer of air above a cooler layer traps pollutants close to the Earth's surface.

Mutagen: substances that cause changes in DNA; may result in hereditary changes.

Teratogen: substances that cause fetus deformities (birth defects).

Carcinogen: substances that cause cancer.

Dioxin: one of the most toxic human-made chemicals. Stable, long-lived, by-product of herbicide production enters environment as fallout from the incineration of municipal and medical waste and persists for many years.

PCBs (Polychlorinated Biphenyls): Stable, long-lived, carcinogenic chlorinated hydrocarbons. Produced by the electronics industry.

Multiple Use Public Lands: National Forest & National Resource lands.

Moderately Restricted Use Public Lands: National Wildlife Refuges

Restricted Use Public Lands: National Parks & National Wilderness Preservation System

Divergent Plate Boundaries: tectonic plates spreading apart, new crust being formed (ex. mid-ocean ridges, rift valleys).

Convergent Plate Boundaries: tectonic plates with the oldest crustal material on Earth moving together, one moving under another (ex. mid-ocean trenches). Mineral deposits and volcanoes are most abundant at convergent plate boundaries

Transform Fault: tectonic plates sliding past one another (ex. San Andreas fault).

And Because I Know This Study Guide Itself May Not Have All The Answers You Need..................................

Informational videos

https://www.youtube.com/user/APESinaBOX

http://www.hippocampus.org/HippoCampus/Earth%20Science

http://www.learner.org/resources/series209.html

Animations

http://www.sumanasinc.com/webcontent/animations/environment.html

http://highered.mcgraw-hill.com/sites/0070294267/student_view0/simple_animations.html

http://highered.mcgraw-hill.com/sites/0072315474/student_view0/animation_activities.html

An app for your iOS device

https://itunes.apple.com/us/app/apesinabox/id582470629

Exam Review Flashcards

http://quizlet.com/22232448/ap-environmental-science-exam-review-flash-cards/

http://quizlet.com/22209406/ap-environmental-science-final-flash-cards/

Study Groups

http://www.facebook.com/group.php?gid=114430001915985

http://openstudy.com/study#/groups/hippocampus%20environmental%20science

Encyclopedia about Your Home Planet

http://www.eoearth.org/view/

Online APES course

http://www.montereyinstitute.org/courses/AP%20Environmental%20Science/nroc%20prototype%20files/coursestartc.html

https://sites.google.com/a/collegiate-va.org/cougar-apes/textbook-friedland-et-al

Practice Tests and Quizzes

Site 1

Site 2

Site 3

Site 4

Site 5

Site 6

Site 7

Site 8

APES Midterm

http://www.mhhe.com/biosci/pae/cunningham/quizindex.mhtml

Useful Downloads

http://apestogo.webs.com/

Environmental Groups

EPA

U.S. National Forest Service

U.S. Fish and Wildlife Service

U.S. National Park Service

African Wildlife Foundation

Clean Water Network

Environmental Literacy Council

Environmental Science Agencies

Link to Even More Environmental Groups

Links by Topic

Links by Topic

Other Useful Links

Atmosphere
Bottled vs. Tap Water
Brownfield
Calculate your ecological footprint
Cartoon about "Meat Factories"
Climate Change 2007: Synthesis Report SUMMARY FOR POLICYMAKERS
Climate Change Impact Map
Coal Comfort Video Clip - The Colbert Report
Do YOU Recycle all that you can in Cary?
Does your diet benefit the world?
Energy
Environmental Science and Technology
EPA Listing of Superfund information
Fracking Song
Fracking Video Clip - The Colbert Report
Green Career Guide
Harmony
Hazardous Chemicals in YOUR Household
How Efficient is YOUR car?
How much Water do YOU use?
Invasive Species Video clip (Gobi Fish & Zebra Mussel)
PCB Contamination in the Hudson River
PCBs @ Crabtree Lake - Ward Transformer Site video
Popular Science
Proof that Climate Change is causing Polar ice to melt
Rainforests
Recycling Guide
Resources
Science Daily
Science Media
Sea Level Rise Clip - The Colbert Report
Stop Wildlife Crime
Story of Bottled Water
SymbioCity
TED Talk on Fracking by Duke Professor at NCSSM
TED Talk on Glacial Ice Loss
Think Globally, Eat Locally
This gives information on Emissions Trading.
Time lapse of the planet from 1980's
Time will Tell: Sharks of the Great Barrier Reef

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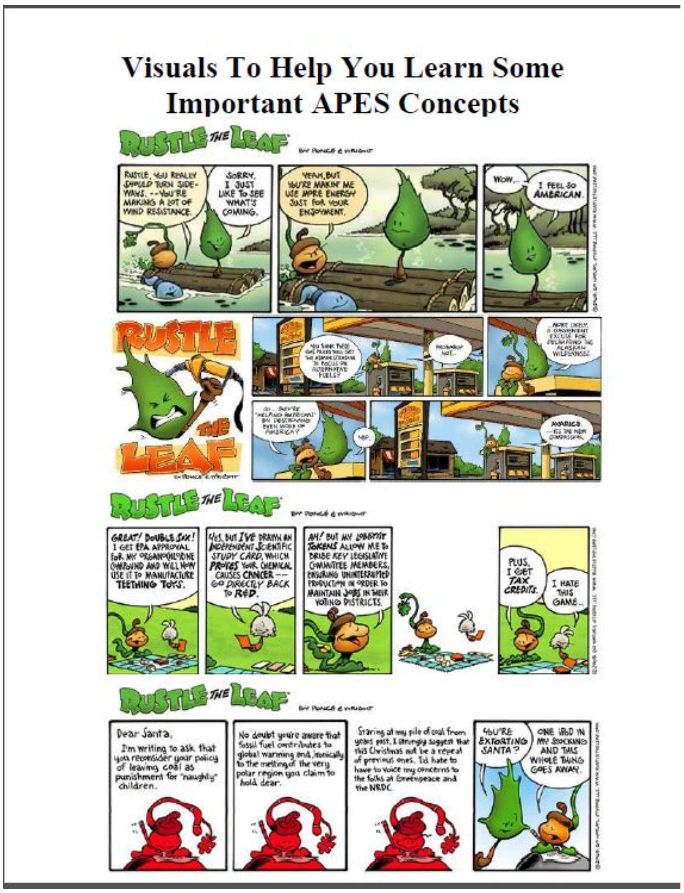

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Need 170 MB of Free Space


AP Environmental Science Summed Up
The best way to save the planet is to lower population growth and live sustainably.

AP Exam Tips – Environmental Science

Multiple Choice Hints

One hundred questions – use #2 pencil
Only 50% of questions correct = a 3 on the exam!
Scoring 80-100% on multiple choice and get a 5
The answers are NEVER "all of the above" or "none of the above"
Always guess! Score = # correct (no longer do they take off ¼ for wrong answer)

Essay Hints

Four questions – use black ball point pen
- one document reading (ex. Read this article and explain X),
- one evaluation of data set (ex. Interpret this data chart and explain Y),
- two synthesis of base knowledge (ex. Design an experiment to test Z)

Read the question! Read the question! Read the question!
Write an essay. Answer in sentence form, NO points awarded for lists/outlines
Only write on the pink section that will be graded, don't worry about the green sheet that is returned to the school
If asked to describe three things, for example, only the first three answers provided will be graded – don't waste time putting down extra answers
Show every step in calculations, no calculators allowed.
Be specific, no penalties for wrong statement, only positive points for correct one
No points for rewording the question.
Pay close attention to verbs in the question (describe, compare, graph, calculate)
Define and/or explain any terms you use; just throwing in buzzwords doesn't work
Don't use acronyms
Answer the question parts in the order called for and label them "a", "b", etc., as they are labeled in the question. It is best not to skip around.
Write clearly and neatly. Points cannot be awarded if handwriting is illegible.
Be sure to include the obvious (ex. light is necessary for photosynthesis). No detail is too small.
If questions ask you to indicate the relationship between two or more concepts and you do not know the relationship, at least tell what you do know about them individually
The test is written to be hard. The national average for the essay section will be about 50% correct. It is very likely that you will not know everything. This is expected, but it is likely that you do know something about each essay, so relax and do the best you can. Write thorough answers.
If you are asked to design an experiment, be sure to:
- Identify hypothesis, independent variable(s), dependent variable(s)
- describe methods in detail, describe how data will be collected and analyzed

If you are asked to graph, be sure to:
- Set up the independent variable on the x-axis and the dependent variable on the y-axis, marking the axes in equal increments, label axes and title

Spelling does not count, however, very poor spelling and grammar hurt your chances
Make an effort on every question. Don't Quit.

Know major laws, soil triangle, tropo/strato ozone, wastewater treatment, age structure diagrams, bioaccumulation, nutrient cycles, natural selection, biomes, point/nonpoint source pollution, renewable/nonrenewable energy sources, biodiversity, and every thing else about environmental science!
Get a good night sleep and eat a healthy snack before the test. Good Luck!

Check out http://www.collegeboard.com/ap/students/envsci/index.html

WRITING A FREE RESPONSE FOR A.P. ENVIRONMENTAL SCIENCE

The Free Response section has 4 problems (1 data, 1 document-based, 2 synthesis) worth 40% of the exam.
The Multiple Choice section has 100 problems worth 60% of the exam.
Calculators are not allowed and no Formula Sheets are provided.
90 minutes is given for this section.

Before answering any questions

- Read the question twice.
- Underline (highlight, outline, etc.) what the question is asking for.
- Begin answering the question in the order it is written; **DO NOT restate the question or write an introductory paragraph!**

If the question says to '**discuss**' or '**describe**'

1. Define the topic
2. Describe or elaborate on the topic
3. State an example of that topic

If the question says to '**compare and contrast**'

1. Clearly state what the items have in common
2. Clearly state how items are different

If the question asks for a **graph** to be made

1. Label each axis with a name and with units
2. Title the graph
3. Scale and number the axes correctly
4. Use the correct type of graph (2 sets of numbers = line graph, 1 set of numbers & 1 set of words = bar graph)

If the question asks a **mathematical** problem, (especially APES)

1. Show every single step of all work
2. Set up problems so that labels cancel out (dimensional analysis)
3. Write answers with labels
4. If numbers are very large or very small, use scientific notation if at all possible

If the question asks for **lab design**

1. State a hypothesis in the "If, then" format
2. Describe each step of a planned experiment in detail
3. State exactly what the controls are
4. Make sure to mention that the experiment uses multiple samples (50+) or is repeated multiple times
5. Describe expected results

For ALL questions

- Answer in <u>complete sentences</u>; do NOT use lists, charts, outlines, etc.
- <u>Label each section as it is labeled in the question</u> (e.g. a, b, c or i, ii, iii)
- Add a clearly labeled diagram to support your answer, but it cannot be the entire answer
- For every statement you write, ask yourself "WHY." If there is an answer to that 'why' keep on writing!!!!!
- <u>Do not answer more than what is asked</u> for; e.g. If the questions says to choose 3 out of 5 topics, ONLY answer three out of 5; e.g. If the question asks specifically about RNA, don't discuss DNA duplication.

Remember - time is of the essence. You have 22.5 minutes per question.

Hints for doing well on the APES Exam

1. DO NOT STAY UP LATE STUDYING THE NIGHT BEFORE THE EXAM! Have your favorite snack and go to bed early. A clear, rested mind is the most important thing you can take to the AP Exam.
2. Dress comfortably and make sure to bring plenty of sharpened pencils and good erasers.
3. Think before you bubble. Read questions completely before answering. Eliminate careless mistakes.
4. Do not waste time on multiple-choice questions that are extremely difficult. Skip them; then return to them after you get warmed up.
5. Use leftover time to double check your answers.
6. On the free-response section, distribute the 90 minutes equally on the four essay questions (22 minutes each). Do not make the mistake of wasting a large percent of your time on one question, and then not having enough time to answer the other three.
7. Devote time to answering all the sections (a, b, c, d, etc.) for each essay question.
8. Take a few moments to think and organize your thoughts before you start to answer each essay question.
9. Write very clearly and large enough for the reader to read your words.
10. If you use diagrams, label and explain them. A diagram without an explanation gets zero points.
11. Eliminate “fluff.” You don not need fancy introductions or conclusions on your essays. Get right to the point.
12. Be a point sponge! Write down what you know best, <u>first</u>. Think broadly when you are answering the essay questions; you have more information in your head than you realize. Don’t forget to add detail and examples. Don’t fabricate information that you don’t know is true, it is a waste of time and will not earn any points.
13. Use underlining, especially if you are a poor writer, but be sure to give a full explanation. Just listing things will earn zero points.
14. If you are going to write down several points, write down the best ones first. Graders may be instructed to just grade the first one or two things you write, ignoring the rest.
15. When answering the essay questions, stay on the topics that are being asked. Do not add extraneous information that does not pertain to the question being asked.
16. Go in with a positive attitude—you have the knowledge to do a great job on this test!

More Hints for doing well on the APES Exam

1. YOU MUST SHOW YOUR WORK, be certain to write out all the steps clearly so the reader/grader can easily see and understand your work. Many students lose points because they do their math calculations in their heads or on a sheet of paper other that the answer sheet, and then fail to transfer the information onto the answer sheet.
2. No points are taken off for wrong or incorrect information, but simply writing a lot will not necessarily earn points—you must answer the question being asked. It is not uncommon for answers that fill two or three pages to earn no points.
3. Students will not receive points for restating the question. Embellishing and embroidering the question and then writing it down as an answer will receive no credit. Students <u>must</u> demonstrate knowledge and understanding.
4. Be careful when you interpret charts and graphs. Many students draw erroneous conclusions because the have misinterpreted a graph or chart.
5. Practice your math! Every AP Environmental Science student should be comfortable working with percentages, decimals, rounding, fractions, algebra, exponents, and scientific notation.
6. Outline form and bullets are <u>not</u> acceptable, answers must be written in prose style.
7. Students must demonstrate a deep understanding of the subject whether it’s a biogeochemical cycle or a solar panel. Just throwing out terms, vocabulary and factoids is not enough.
8. Do not be fragmentary in your explanations, everything should fit together logically into a complete answer. Make sure you tie all the “pieces” of your answer together.
9. Make sure, whenever possible, to support your statements with examples. Good examples will let the reader/grader know that you understand what you are talking about. Often, examples are required to earn some of the points available on a question.