AP Environmental Science Study Guide

Unit 1-2: The Living World

- **Ecosystem Structure**
  - **Abiotic vs. Biotic Components**
    - **Abiotic**
      - Nonliving components of Earth
        - Eg: Atmosphere, Hydrosphere, and Lithosphere
    - **Biotic**
      - Living components of Earth
        - Eg: Animals, plants, fungi, protists, and bacteria which form the biosphere
  - **Interactions of Organisms with the Environment**
    - **Population**
      - A group of organisms of the same species
    - **Community**
      - Populations of different species that occupy the same geographic area
      - Every species occupies a habitat and has an ecological niche
    - **Habitat**
      - The area or environment where an organism lives, or where an ecological community occurs
    - **Ecological Niche**
      - The role and position a species has in its environment
      - Includes how a species uses biotic and abiotic resources in its environment, where the species lives, and what it eats
  - **Interactions of Organisms Among Each Other**
    - **Competition**
      - Occurs when two individuals are competing for resources in the environment
    - **Resource Partitioning**
      - Occurs when species can coexist and share resources without any conflict
    - **Predation**
      - Occurs when one species feeds on another
      - Drives changes in population size
        - Eg:
          - Cat & Mouse
          - Polar Bear & Seals
          - Lions & Wildebeests
          - Great White Shark & Elephant Seals
  - **Symbiotic Relationships**

        - Close, prolonged associations between two or more different organisms of different species
    - **Types of Symbiotic Relationships**
        - **Mutualism**
            - Both organisms receive beneficial properties from their relationship
                - Eg: pollinators benefit from feeding on plant nectar, and plants benefit from pollinators moving their pollen from plant to plant
        - **Commensalism**
            - One organism benefits in the relationship and the other are neither harmed nor benefited
                - Eg: Barnacles are sedentary crustaceans that sweep the surrounding water for small, free-floating organisms. They often grow attached to scallop shells, which has almost no effect on the scallop
        - **Parasitism**
            - One organism benefits by harming the other organism
                - Eg: Mistletoe is a flowering plant that grows attached to, and within, the vascular system of a tree or shrub. This helps the mistletoe but harms the tree

- **Types of Ecosystems**
    - **Classifications**
        - **Blending**
            - The biomes blend into each other
            - There are no distinct boundaries
        - **Ecotones**
            - A transitional area where two biomes meet
        - **Ecozones/Ecoregions**
            - Small regions within ecosystems that have similar physical features
        - **Edge Effects**
            - Ecotones have a great amount of species diversity and biological density
            - Some species only live on the edge of certain habitats
- **Energy Flow**
    - **Cell Respiration** - Occurs when autotrophs make ATP (adenosine triphosphate) from carbohydrates and other biomolecules in a complex series of reactions
    - **Bioenergetics -** The study of how energy flows through living organisms
        - All energy on Earth comes from the Sun
        - Photosynthetic organisms use solar energy to turn CO_2 and H_2O into carbohydrates
            - Also releases O_2
        - Biological macromolecules store energy in their chemical bonds

        - Cells use respiration to transfer energy from the chemical bonds of macromolecules to the chemical bonds of smaller molecules like ATP, GTP, NADH, NADPH and $FADH_2$
            - This releases CO_2 and H_2O
        - These small, high-energy molecules power all the reactions and processes the cell needs to perform
    - **Photosynthesis**
        - Plants and algae are producers and perform photosynthesis: they convert solar energy into chemical energy
        - In plants, most photosynthesis occurs in leaves
        - Algae include some bacteria and plant-like protists
        - **Light-Dependent Reactions**
            - Purpose:
                - Convert light energy to chemical energy
                - Reactant(s) = Sunlight + H_2O
                - Products(s) = O_2 + ATP + NADPH
        - **Light-Independent Reactions**
            - Purpose:
                - Use ATP and NADPH to build organic molecules from CO_2
                - Reactant(s) = CO_2 + ATP + NADPH
                - Product(s) = $C_6H_{12}O_6$
    - **Cellular Respiration**
        - All living organisms require a source of energy, and all living organisms use the same metabolic pathways to power life
        - Cell respiration is a series of redox reactions. Glucose is oxidized to CO_2, and this powers the synthesis of ATP, an energy source
        - All living organisms perform cellular respiration
- **Classifying Organisms in Ecosystems**
    - **Autotrophs**
        - Autotrophs produce complex organic compounds from simple substances in the environment
        - Most autotrophs use energy from light (photoautotrophs)
        - Some autotrophs use inorganic chemical reactions instead
        - Autotrophs serve as primary producers in a food chain
        - Example:
            - Producers
            - Saprotrophs
    - **Heterotrophs**
        - Heterotrophs consume other organisms in a food chain
        - A heterotroph is unable to produce organic substances from inorganic ones
        - Heterotrophs depend either directly or indirectly on autotrophs for nutrients and food energy
        - Example:
            - Primary Consumers
            - Secondary Consumers

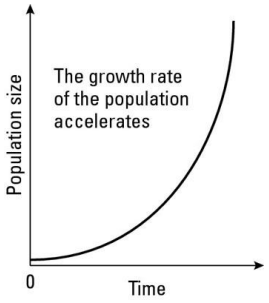
- Tertiary Consumers
- Decomposers
- Detritivores

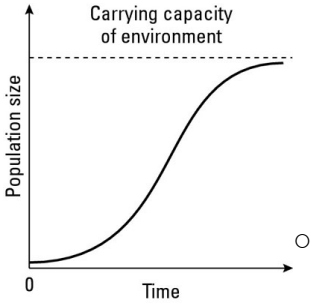
- **Food Chains & Food Webs**
  - **Food Chain** - shows how energy flow step by step from producer to consumers
    - Eg.
      - Rice→Humans→Microorganisms
      - Corn plants→Beef cattle→Humans
      - Phytoplankton→Crustaceans→Fish→Humans
  - **Energy Pyramid** - shows how much energy is available to each successive trophic level
  - **Food Webs** - show the complex interactions between many species
- **Ecosystem Diversity** - describes how variable an ecosystem is within a geographical location
  - **Biodiversity**
    - The number and variety of organisms found in the world or in a particular habitat or ecosystem
    - The variability among living organisms
    - Biodiversity in all forms is the result evolution
    - More biodiversity means a larger and more diverse gene pool, which leads to a greater chance of adaptation and survival
  - **Evolution** - the change in the population's genetic composition over time
    - **Natural Selection**
      - The natural selection of advantageous traits changes the makeup of a population
        - **Charles Darwin (Father of Evolution) Theory**
          - Certain organisms live and reproduce, and other die
          - Beneficial inherited characteristics are passed down to the next generation
          - Unfavorable heritable characteristics become less common in the population
          - This process acts upon a whole population over time, not on one individual organism
    - **Genetic Drift**
      - Chance events change the makeup of a population with no regard to traits
    - **Phylogenetic Tree** - a diagram that shows how organisms are related based on evolutionary relationships.
  - **Species** - a group of organisms that are capable of breeding with one another but incapable of breeding with other species
    - **Speciation** - the formation of new species from preexisting species
  - **Extinction** - occurs when a species cannot adapt quickly enough to environmental change and all members of the species die
    - **Biological Extinction**
      - Extermination of a species
      - No individuals of this species left on the planet

        - Eg: Dodo birds, Passenger pigeon, Mammoth, Dinosaurs
    - **Ecological Extinction**
        - So few individuals of a species that this species can no longer perform its ecological function
            - Eg: Alligators in the Everglades in 1960; Wolves in Yellowstone before reintroduction in the 1990s
    - **Commercial or Economic Extinction**
        - A few individuals exist, but the effort needed to locate and harvest them is not worth the expense
            - Eg: Groundfish population of the Grand Banks
- **Ecosystem Services**
    - Humans gain many benefits from the natural environment and from properly functioning ecosystems
    - Ecosystems are essential to life
    - Land, water, and air must be used responsibly if they are to benefit future generations
    - **Provisioning Services**
        - Physical items we obtain from our environment
        - Example:
            - Food
            - Raw materials
            - Water
            - Energy
            - Medicinal resources
        - **Cultural Services**
            - Non-material benefits people obtain from the ecosystem
            - Example:
                - Recreation
                - Science & education
                - Tourism
                - Inspiration for culture & art
                - Spiritual experience
        - **Regulating Services**
            - Benefits obtained from the regulating of ecosystems. These are often hard to see and are taken for granted
            - Example:
                - Pest & disease control
                - Water & air purification
                - Climate regulation
                - Waste decomposition & detoxification
                - Pollination
        - **Support Services**
            - Allow for other ecosystems services to be present
                - Example:
                    - Nutrient recycling and soil formation
- **Natural Ecosystem Change**

- **Types of Species**
  - **Keystone**
    - Maintain the biotic balance in a community
    - Their presence contributes to an ecosystem's diversity
    - Their extinction would lead to a large change in the ecosystem
      - Eg: Fig trees in a tropical forest; Wolves in western North America
  - **Indicator**
    - Used as a standard to evaluate the health of an ecosystem
    - More sensitive to biological changes within their ecosystems than others species
    - Used as an early warning system to detect dangerous changes to a community
      - Eg: Trout in freshwater biomes
- **Ecological Succession**
  - **Primary Succession**
    - Begins in a virtually lifeless area, such as the area below a retreating glacier
  - **Secondary Succession**
    - Takes place where an existing community has been cleared, but the soil has been left intact
  - **Pioneer Species**
    - Organisms present in the first stages of either type of succession
    - Have wide ranges of environmental tolerance
  - **Climax Community**
    - Formed in the final stage of succession
    - Have a dynamic balance between abiotic and biotic components of the community
  - **Habitat Fragmentation**
    - When a natural habitat is reduced or fragmented
    - When a regular and balanced ecosystem is damaged

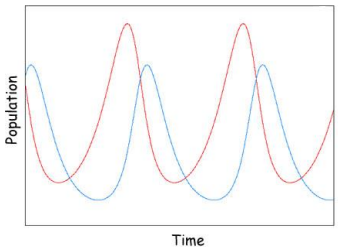
Unit 3: Populations

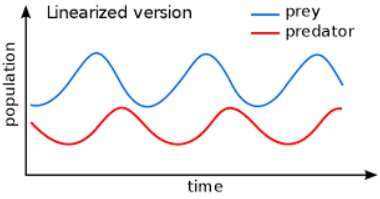
- **Population Ecology**
  - **Population -** a group of organisms of the same species
    - **Population Density -** the number of individuals of a population that inhabit a certain unit of land or water area
    - **Population Dispersion -** how individuals of a population are spaced within a region
      - **Clumped Dispersion**
        - The most common dispersion pattern for populations
        - Adheres to the "those of a feather flock together" idea
        - Eg: Plants & fish
      - **Uniform Dispersion**
        - Members of a population are uniformly spaced throughout their geographic region; usually a result of competition for an ecosystem's resources
        - Eg: Trees
      - **Random Dispersion**
        - A relatively uncommon pattern of dispersion
        - Occurs when the position of each member of a population is not determined or influenced by other members of the population
  - **Population Growth & Carrying Capacity**
    - **Biotic Potential**
      - How much a population would grow if there were unlimited resources in the environment
      - Not a practical model for population growth because resources in an environment are limited
    - **Carrying Capacity**
      - The maximum population size that can be supported by the available resources in the region
      - Differ by species, as different species have different requirements for life
    - **Graphing Population Growth**
      - **J-Curve Model -** Exponential Growth
        - 

      - **Logistic Population Growth (S-Curve) -** Initial burst then growth rate drops
        - 

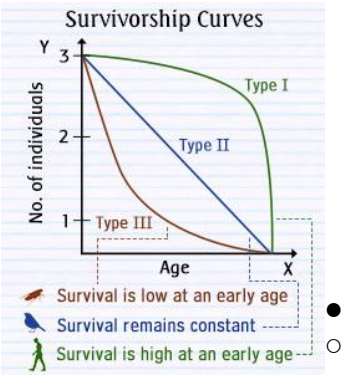
    - **Rule of 70 -** the time it takes for a population to double can be approximated by dividing 70 by the current growth rate of the population
      - Eg: $\frac{70}{25\%}$= 2.8 years
  - **Reproductive Strategies**
    - **R-selected Organisms**
      - Reproduces early in life

        - Usually have a high capacity for reproductive growth
        - Little to no care given to offspring
            - Eg; Bacteria, algae, protozoa
    - **K-selected Organisms**
        - Reproduces later in life
        - Produces fewer organisms
        - Devote significant time and energy to nurturing of offspring
        - Parents are invested in each individual offspring
            - Eg: Humans, lions, cows
- **Survivorship and Population Cycles**
    - **Boom-and-Bust Cycle**
        - Very common among r-strategists
        - Rapid increase→Equally rapid drop-off
    - **Predator-Prey Cycle**





- **Factors Influencing Population Growth**
    - **Density-dependent Factors**
        - Increased predation
        - Competition for food or living space
        - Disease
        - Buildup of toxic materials
    - **Density-independent Factors**
        - Fires
        - Storms
        - Earthquakes
- **Survivorship Curve**
    - **Type I**
        - The majority of offspring will live for a long period of time; eventually they will start to die off
    - **Type II**
        - Offspring have a 50-50 chance of surviving to old age
    - **Type III**
        - Most offspring die young, but if they live to a certain age, they will live a longer life
            -



- **Human Population**
- **World Population**
    - **Birth rate =** the number of live births per 1,000 members of the population in a year
    - **Death rate =** the number of deaths per 1,000 members
    - **Growth Rate =** $\frac{(Birth\ rate+immigration)-(death\ rate+emigration)}{1{,}000}$
- **Population Changes**
    - **Emigration -** the movement of people *out* of a population
    - **Immigration -** the movement of people *into* a population
    - **Total Fertility Rate**
        - The number of children a woman in a given population will bear during her lifetime

        - Based on an analysis of data from preceding years
        - TFRs cannot be depended on because they assume the conditions of the past will be the conditions of the future
    - **Replacement Birth Rate**
        - The number of children a couple must have in order to replace themselves in a population
        - Worldwide, the replacement birth rate is slightly higher than 2
        - In developing countries, this number is as high as 3.4 due to higher mortality rates
    - **Factors that Affect TFRs of a Population**
        - Availability of birth control
        - Demand for children in the labor force
        - Base level of education for women
        - Existence of public and/or private retirement systems
        - The population's religious beliefs, culture, and traditions
    - **Factors that Affect the Growth Rate of a Population**
        - Base level of education for women
        - Dominant religion
        - Existence of public and/or private retirement systems
        - The population's religious beliefs, culture, and traditions
- **Human Impact on Earth**
    - **Ecological Footprint**
        - Used to describe the environmental impact of a population
    - **IPAT Model**
        - ***I=P*A*T***
            - I - The total impact
            - P - Population size
            - A - Affluence
            - T - Level of technology
    - **Environmental Problems**
        - **Overgrazing & Desertification**
            - **Green Revolution -** the technological innovation and an increased use of pesticides and fertilizers, which allowed farmer to increase crop production throughout the world
            - **Extensive Pastoralism -** the shifting of animal herds between grazing pastures has remained popular in several arid parts of the world
            - **Population Pressure -** too many people and too many animals on too little lands
            - **Overgrazing -** led to significant amounts of dry grassland being denuded, eroded, and desertified
            - **Desertification -** any human process that turns a vegetated environment into a desert-like landscape
            - **Soil Salinization -** the salt content in soil increasing due to non-anthropogenic and/or anthropogenic influences
        - **Irrigation Agriculture**

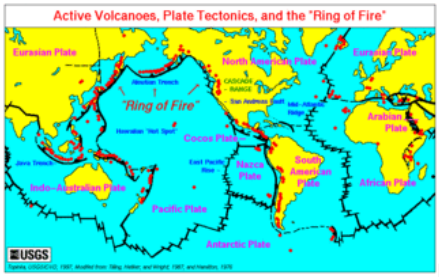
- **Irrigation -** the application of controlled amounts of water to plants at needed intervals
- **Aquifers -** underground water tables
    - Aquifer supplies are being depleted at a rapid rate in large-scale countries such as India, China and the United States

- **Deforestation**
    - **Deforestation -** the act of clearing a forested area of trees and other vegetation without the intention of replanting

- **Threatened & Endangered Species**
    - **Vulnerable Species**
        - The species is likely to become endangered if no action is taken
    - **Endangered Species**
        - The species is likely to become extinct
    - **Critically Endangered**
        - The species is at a very high risk of extinction
    - **Background Extinction Rate**
        - Species that are the most endangered have several factors in common
            - They:
                - Require large ranges of habitat to survive
                - Have low reproductive rates
                - Have specialized feeding habits
                - Have some sort of value for humans
                - Have low population numbers
        - **Fragmentation -** habitats are broken into smaller pieces by, for example, building of roads and cities
        - **Degradation -** pollutants are added to the environment
        - **Overexploitation -** contribution to extinction
        - **Biodiversity Hotspot -**
- **HIPPCO** - an acronym to memorize the cause of extinction
    - **H -** Habitat Destruction/Fragmentation
    - **I -** Invasives
    - **P -** Population
    - **P -** Pollution
    - **C -** Climate Change
    - **O -** Overharvesting/Overexploitation

Unit 4: Earth Systems and Resources

- **The Lithosphere**
  - **Tectonic Plates** - parts of the lithosphere that float on the asthenosphere
    - Earth's Tectonic Plates

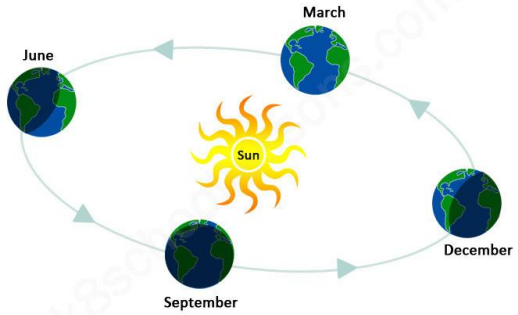


    - **Plate Boundaries** - the edges of tectonic plates
      - Types of Plate Boundaries
        - **Convergent Boundary** - two plates are pushed toward and into each other
        - **Divergent Boundary** - two plates move away from each other
        - **Transform Fault Boundary** - two plates slide against each other in opposite directions
    - **Subduction** - an older and denser plate sinks beneath the younger and lighter plate
    - **Ocean-continent convergence** - the oceanic plate is subducted beneath the less dense continental plate, forming a deep ocean trench
      - Eg: Cascade Range is an example of ocean-continent convergence
  - **Earthquakes** - geological events resulting from vibrations deep in the Earth that release energy
    - **Epicenter** - Initial surface location of the earthquake
    - **Seismograph** - an instrument that measures size or magnitude
    - **Richter Scale** - measures amplitude of the highest S-wave
  - **Volcanoes** - geological events resulting from plate movement
    - **Volcano Classification**
      - **Active** - Erupted within the last 10,000 years
      - **Dormant** - Has not erupted within the last 10,000 years but is expected to erupt again
      - **Extinct** - Is not expected to erupt again
        - **Recharging** - build up of pressure between eruptions
    - **Volcano Creation**
      - **Subduction Zone** - Occurs at convergent boundaries between oceanic and continental plates
        - Eg: Ring of Fire
      - **Rift Valley** - Occurs at divergent boundaries usually between oceanic plates. New ocean floor is formed as magma fills in the gap between separating plates.
        - Eg: East African Rift
      - **Hotspots** - Found in the middle of tectonic plates. Columns of unusually hot magma rise from deep in the mantle, partially melting and weakening the mantle in the lower lithosphere.
        - Eg: Hawaiian Islands
    - **Types of Volcanoes**
      - **Shield Volcanoes** - Tall, Broad base, Gentle slope
        - Eg: Kohala

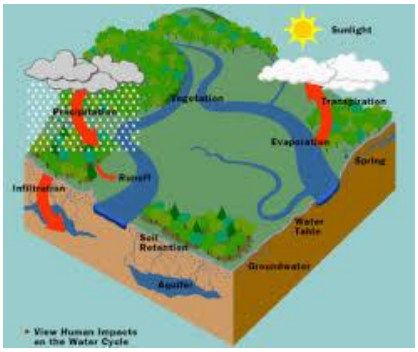
- **Composite Volcanoes** - Tall, Broad base, Steep slope
  - Eg: Mount Fuji
- **Cinder Cones** - Small, Short, Steep slope, Symmetrical cone, Bowl-like crater,
  - Eg: Sunset Crater
- **Lava Domes** - Small, Short, Steep slope, Dome
  - Eg: Mount St. Helens

- **The Atmosphere**
  - **Layer of the Atmosphere**
    - **Exosphere**
      - Gases are thinnest
    - **Thermosphere**
      - Gases are very thin
      - Auroras occur
    - **Ionosphere**
      - Absorbs X-rays and ultraviolet radiation from Sun
    - **Mesosphere**
      - Air pressure extremely low
      - Temperature decreases with altitude
      - Where meteors usually burn up before striking Earth
    - **Stratosphere**
      - Includes the ozone layer
      - Gases are not well mixed
      - Gradually warmer with altitude
    - **Tropopause**
      - Between the troposphere and the stratosphere
    - **Troposphere**
      - Where weather takes place
      - Usually well-mixed
      - Gradually colder with altitude
      - Contains 99% of water vapor and clouds
  - **Greenhouse Gases**
    - **Types of Greenhouse Gases**
      - Water Vapor - H_2O - 0-4% of troposphere
      - Carbon Dioxide - CO_2 - 0.033% of the troposphere
      - Methane - CH_4 - 0.0002% of the troposphere
  - **Weather & Climate**
    - **Weather**
      - Day-to-Day properties
      - Wind Speed + Directions
      - Temperature
      - Amount of Sunlight
      - Pressure
      - Humidity
    - **Climate**
      - Patterns that are constant over many years

        - Average Temperature
        - Average Precipitation Amounts
    - **Seasons -** the motion of the Earth around the Sun that results in a variation in insolation, the amount of solar radiation that reaches a given area



        - Northern Hemisphere Tilted Towards the Sun
            - North = Summer
            - South = Winter
        - Southern Hemisphere Tilted Towards the Sun
            - North = Winter
            - South = Summer
- **The Hydrosphere**
    - Includes Earth's oceans and freshwater bodies
    - Covers about 75% of planet Earth
    - **Freshwater**
        - Contains minimal quantities of dissolved salts
        - Usually comes from precipitation from atmospheric water vapor
        - **Watershed -** an area of land that collects rainwater and drains it into a particular stream or river



        - **Freshwater Biomes**
            - **Deltas**
                - Landforms that forms at the juncture of a river and ocean
                - Made of deposited sediment
            - **Estuaries**
                - Sites where the "arm" of the sea extends inland to meet the mouth of a river
                - Often rich with many different types of plant and animal species
                - Water usually has a high concentration of nutrients and sediments
            - **Wetlands**
                - Ecologically diverse ecosystems
                - Found along the shores of fresh bodies of water
                    - Eg: Marshes, swamps, bogs, prairie potholes, and floodplains
    - **Saltwater**
        - **Saltwater Biomes (Examples)**

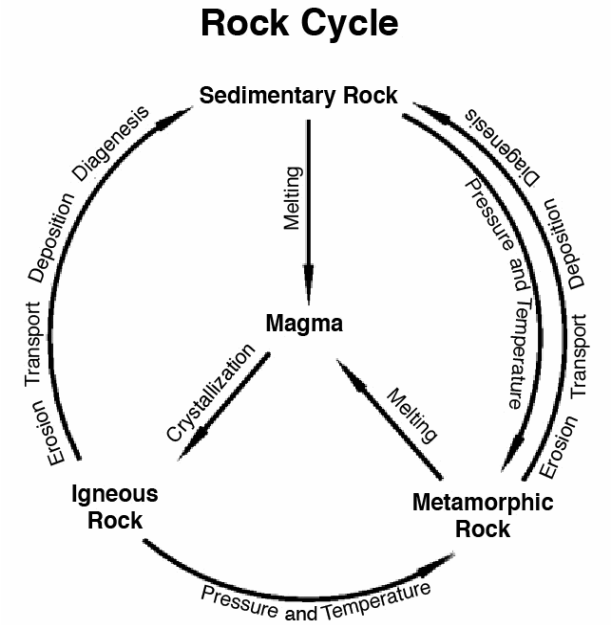
- **Barrier Islands**
  - Landforms that lie off coastal shores
  - Spits of land
  - Created by buildup of deposited sediments
  - Boundaries constantly shifting as water moves around them
  - Function to buffer the shoreline behind them
- **Coral Reef**
  - A type of barrier island
  - Formed by a community of living things
  - Home to a large diversity of species
  - Extremely delicate
  - Vulnerable to physical stresses, changes in light intensity, changes in water temperature, and ocean depth and pH

- **Water Problem & Issues**
  - **Water Risk**
    - The possibility of an area experiencing a water-related challenge such as *water scarcity, water stress,* flooding or drought
  - **Water Stress**
    - Occurs when demand for water exceeds the available amount during a certain period, or when poor quality restricts water use. Water-stressed countries have a renewable annual water supply of about 1,000-2,000 m^3 per person.
  - **Water Scarcity**
    - A lack of sufficient available water resources to meet demand for water in a region. It affects every continent and around 2.8 billion people around the world at least one month out of every year. Water-scarce countries have a renewable annual water supply of less than 1,000 m^3 per person
- **Water Conservation**
    - Includes Policies, strategies, and activities to sustainably manage the natural resource of fresh water, to protect the hydrosphere, and to meet the current and future human demand for water.

Soil & Soil Dynamics

- **The Pedosphere**
  - **What is Soil?**
    - A complex, ancient material teeming with living organisms
    - Consists of
      - Finely broken-down or weathered rock (45%)
      - Living and dead organic matter (~5%)
      - Air (~25%)
      - Water (~25%)
  - **The Chemistry of Soil: pH**
    - pH substances ranges from 0-14
    - pH is the measure of the concentration of hydrogen ions
    - Most soils have a pH between 4 to 8
    - Soil can be acidic (<7) or alkaline/basic (>7)

        - **The Importance of Soil**
            - Links the abiotic and biotic components of the world
            - Plays an active role in nutrient cycling
            - Supports plant life by supplying a physical foundation for growth, water, and nutrients
            - Nonrenewable resource
- **Rocks**
    - **Rock Cycle**



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    - **Types of Rocks**
        - **Igneous**
            - Rock is melted by heat and pressure below the crust
                - Eg: Basalt, Granite
        - **Sedimentary**
            - Forms as a sediment; builds up and is compressed
                - Eg: Limestone, shale, coal, chert
        - **Metamorphic**
            - Formed by transforming an existing rock via a large amount of pressure and heat
                - Eg: Slate, marble
    - **Rock Weathering**
        - **Types of Weathering**
            - **Physical**
                - Rock is weakened and worn down by physical forces, usually wind or water
                - No change in the chemistry of the rock
                - Dominates in cold or dry environments
            - **Chemical**

        - Rock is subjected to chemical alteration through reactions with water, oxygen, or dissolved minerals
        - Breakdown and reorganization of rock minerals
        - Dominates in warm or moist environments
    - **Biological**
        - Weathering that takes place as the result of the activities of living organisms
        - Organisms can weather rock by physical or chemical means
- **Types of Soil**
    - **Sand**
        - Large particles
        - Don't easily adhere together
        - Large pores
        - More space for water but it drains away quickly
    - **Clay**
        - Small particles
        - Easily adhere to each other
        - Small pores
        - Less space for water but is held in soil and doesn't drain
- **Soil Problems**
    - Enough arable soil is needed to meet our agricultural needs
    - Soil fertility is a must
- **Erosion**
    - The removal of soil, rock, or dissolved material from one location on the Earth's crust and transportation to another location

Problems w. Modern Agriculture

- **Monoculture vs. Polyculture**
    - **Monoculture**
        - Planting just one type of crop in a large area
        - Common in modern agriculture
        - Leeches soil of specific nutrients
        - Decreases crop genetic diversity, making crops more susceptible to pests and diseases
    - **Polyculture**
        - Planting many types of crops in a large area
        - Increases sustainability
        - Limits nutrient depletion in soil
        - Increases genetic diversity
        - Crop rotation another good solution
- **Other Problems**
    - Damaged soil due to large machinery
    - Repeated plowing breaks down soil aggregates; this leaves *plow pan*, or *hard pan*, which is hard, infertile soil
    - Large energy consumption, including burning fossil fuels
    - Pollution in the form of pesticides and fertilizers
- **Green Revolution**

        - **What is it?**
            - A huge increase in worldwide agricultural productivity over the past 50 years
            - Due to mechanization of farming that resulted from the Industrial Revolution
        - **Cons**
            - Many detrimental effects on the environment
            - Use of chemical pesticides lead to new pesticide-resistance insects
            - Over-irrigation has caused salinization of soil and land degradation
        - **Solutions**
            - Genetically modified plants decrease the need for pesticide use
            - Drip irrigation adds only the water required and delivers water directly to plants' roots
    - **Soil Conservation**
        - **Practices to Conserve Soil Properties**
            - Using manure, compost, and the residue of plants to increase the amount of organic matter in the soil
            - Organic agriculture, a method of farming that uses compost, manure, crop rotation, and non-chemical methods to manage soil fertility and pest control
            - Changing tillage practices to reduce soil breakup and erosion, including contour plowing and strip planting
            - Using trees and other winds barriers to reduce wind force

Unit 5: Land and Water Use

- **Resource Utilization**
  - **"The Tragedy of the Commons"**
    - Serves as a foundation for modern conservation
      - **Conservation** - the management or regulation of a resource
        - Different from preservation
      - **Preservation -** the maintenance of a species or ecosystem in order to ensure its perpetuation
  - **Renewable & Non-renewable Resources**
    - **Renewable Resources**
      - Resources that can be regenerated quickly
        - Eg: Hardwood trees take 50 years to mature; It's widely considered the crossover point of nonrenewable and renewable resources.
    - **Nonrenewable Resource**
      - Things like minerals and fossil fuels
      - Typically formed by very slow geologic processes
    - **Main Sources of Energy**
      - **Fossil Fuels**
        - Provide 65% of the world's electricity
        - Formed from the fossilized remains of once-living organisms; over time, this organic matter was exposed to intense heat & pressure, eventually breaking the organic molecules down into oil, coal, and natural gas
      - **Nuclear Energy**
        - The world's primary non-fossil fuel, nonrenewable energy source
        - In the U.S., 20% of electrical energy is provided by nuclear power plants
        - Worldwide, more than 400 nuclear power plants produce approximately 13% of the world's electrical energy
        - China and India lead the world in the creation of new nuclear facilities
      - **Renewable Energy**
        - Bottomless energy source = advantage
        - Examples include biomass, solar, wind, geothermal, and hydropower energy
        - Globally, only 15% of our energy needs are currently met using renewable energy sources
        - Energy storage limitations hinder the expansion of renewable storage

- **Agriculture**
  - **Agricultural Innovations**

- **Neolithic Agricultural Revolution -** the period of time during which people transitioned from hunting and gathering for food to an organized system of farming
    - **Vegetative planting -** where shoot, stems, and roots of existing wild plants are collected and grown together ↓
    - **Seed agriculture -** fertilized seed grains and fruits of plants are collected and planted together ↓
    - **Horticulture -** the domestication of plants by rejecting poorly growing crops and taking seeds from productive, heartier crops to grow future generations ↓
    - **Animal domestication -** the process in which selected animal populations become accustomed to human provision and control; was established as an alternative to hunting & fishing ↓
    - **Animal husbandry -** productive breeds were purposely interbred or hybridized for reproduction
- **Second Agricultural Revolution -** technological innovations in agriculture and manufacturing that drastically reduced labor requirements and increased the scale of farm production
    - **Green Revolution -** the time after the Industrial Revolution when farming became mechanized and crop yields in industrialized nations booms
        - **Positive Effects**
            - Mechanization, fertilizers, and pesticides that led to improved crop production on small plots of land and a reduction in world hunger
            - Decreased food costs
            - Affordable irrigation pumps that move water to farming regions
            - Genetic engineering allowing farmers to modify crops with beneficial traits and create high-yield seeds
            - Biotechnology research resulting in the development of vaccines, antibiotics, and growth hormones
        - **Negative Effects**
            - Suffering small farms due to their inability to capitalize on economies of scale
            - Detrimental environmental impact caused by the increased use of energy, materials, and machinery
            - Chemical use leading to eutrophication and causes explosive algae growth and water pollution
            - Use of fertilizers and pesticides resulting in pesticide resistance
            - Genetic engineering resulting in distrust

- **Agricultural Activity & the Environment**
  - **Irrigation**
    - **Problem**
      - Repeated irrigation can cause serious problem , including a significant buildup of salts on the soil's surface, which makes the lands unusable for crops
    - **How the Problem is Being Addressed**
      - To combat this salinization of the land, farmers have begun flooding fields with massive amounts of water in order to move the salt deeper into the soil
    - **Drawbacks**
      - The large amounts of water can waterlog plant roots, which will kill the crops; this process also causes the water table of the region to rise
      - The water for these irrigation farms comes from underground aquifers which are being depleted at a rapid rate
  - **Prevention of Soil Degradation**
    - **Intercropping**
      - Also called strip cropping
      - The practice of planting bands of different crops across a hillside
      - Can also prevent some erosion by creating an extensive network of roots
    - **Contour Plowing**
      - Rows of crops are plowed across the hillside; prevents the erosion that can occur when rows are cut up and down on a slope
    - **Terracing**
      - Aids in preventing in soil erosion on steep slopes
      - Terraces are flat platforms that are cut into the hillside to provide a level planting surface; this reduces the soil runoff from the slope
    - **No-Hill Method**
      - Farmers plant seeds without using a plow to turn the soil, reduces the levels of CO_2 let into the environment by plowing
    - **Crop Rotation**
      - Can provide soils with nutrients when legumes are part of the cycle of crops in an area
  - **Types of Pesticides**
    - **Biological**
      - Living organisms are used to control pests
        - Eg: Bacteria, ladybugs, milky spore disease, parasitic wasps, and certain viruses
    - **Carbamates**
      - Affect the nervous systems of pests
    - **Chlorinated Hydrocarbons & Other Persistent Organic Compounds (POPs)**
      - Chlorinated Hydrocarbons are synthetic organic compounds belonging to the group of persistent organic pollutants

        - Eg: DDT pesticide
      - POPS are organic compounds that are resistant to environmental degradation through chemical, biological, and photolytic processes.
  - **Fumigants**
    - Used to sterilize soil and prevent pest infestation of stored grain
  - **Inorganic**
    - Broad-based pesticides
    - Includes arsenic, copper, lead, and mercury.
    - Highly toxic and accumulate in the environment
  - **Organic/Natural**
    - Natural poisons derived from plants such as tobacco or chrysanthemum
  - **Organophosphates**
    - Extremely toxic but remain in the environment for only a brief time
      - Eg: Malathium

- **Livestock & Overgrazing**
  - **Livestock Grazing**
    - The shifting of animal herds between grazing pastures in area where dry grassland is common
    - A sustainable practice, as long as the grazing area is sufficient for the number of animals
  - **Overgrazing**
    - Occurs when too many people and too many animals are placing population pressure on too little land
    - Has led to significant amounts to dry grasslands being denuded, eroded, and desertified
    - Harmful to the soil because it leads to erosion and soil compaction
    - Solutions include rotating animals from site to site and away from their source of water, and overall control of herd numbers
  - **Animal Waste**
    - Manure not used as fertilizer due to difficulty with transport
    - Has become the most widespread source of water pollution in the United States
- **Forestry**
  - **Deforestation**
    - The removal of trees for agricultural purposes or purposes of exportation
    - **Slash & Burn -** severely reduces the amount of available forest and contributes to deforestation; an area of vegetation is cut down and burned before being planted with crops
  - **Tree Plantations and Old Growth Forests**
    - **Old Growth Forests**
      - Have never been cut or seriously disturbed for several hundred years

        - Contains incredible biodiversity, with nyriad habitats and highly evolved intricate niches for a multitude of organisms
    - **Second Growth Forests**
        - Areas where cutting has occurred and a new, younger forest has arisen naturally
    - **Plantations & Tree Farms**
        - Planted and managed tracts of trees of the same age that are harvested for commercial use
- **Forest Management**
    - **Silviculture -** the management of forest plantations for the purpose of harvesting timber
    - **Clear-Cutting -** the removal of all of the trees in an area
    - **Selective Cutting -** the removal of select trees in an area

Natural Events & Forest Fires

- Humans control the areas that affect the quality of food and the number of trees that are available to use by:
    - Removing infected trees
    - Removing select trees
    - Using chemical and natural pest controls
    - Carefully inspecting imported trees and tree products
    - Developing pest and disease-resistant species of trees

Rangelands

- Are diverse in nature, consisting of desert, wet and dry grasslands, and mountainous meadows
- Approximately 770 million acres are rangelands; 46% of it is governed

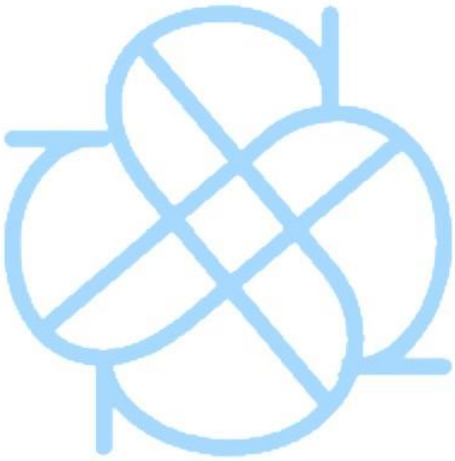
Types of Mining

- **Strip Mining**
    - Controversial type of mining
    - Strips the surface layer of soil and rock in order to expose a seam of mineral ore
    - Least expensive and least dangerous method of mining for coal
    - Has a detrimental effect on the environment
- **Mountaintop Removal**
    - Most extreme form of strip mining
    - Mostly associated with coal mining in the Appalachian Mountains
    - Transforms the summits of mountains and destroys ecosystems
- **Shaft Mining**
    - Vertical tunnels are built to access
    - Excavate minerals that are unreachable

Fishing

- **Fishing Techniques**
    - **Drift Nets**
        - Nets float through the water and catch everything in their path
    - **Long-Lining**
        - The use of long lines with baited hooks that are taken by numerous aquatic organisms

        - **Bottom Trawling**
            - The ocean floor is scraped by heavy nets that smash everything in their path
    - **Overfishing & Aquaculture**
        - About 69% of major fish stocks of the world are either overexploited or fully exploited
        - About 20% of the stocks are moderately overexploited
        - About 8% are either recovering from depletion or depleted
        - **Aquaculture -** raising aquatic species in captivity for harvesting



Unit 6: Energy Resources and Consumption

- **Energy Concepts**
  - **Forms of Energy**
    - **Potential** = energy at rest, or stored energy
    - **Kinetic** = energy in motion
    - **Radiant** = sunlight, or electromagnetic energy
    - **Thermal** = heat, or the internal energy in substances
    - **Chemical** = energy stored in chemical bonds between atoms
    - **Electrical** = energy from the motion of electrons
    - **Nuclear** = stored in the nuclei of atoms
  - **Laws of Thermodynamics**
    - **First Law of Thermodynamics**
      - Energy can neither be created nor destroyed
      - It can only be transferred and transformed
        - Eg: Photosynthesis
    - **Second Law of Thermodynamics**
      - Entropy (disorder) of the universe is increasing
      - In most energy transformations, a significant fraction of energy is lost to the universe as heat
        - Eg: Food chains
- **Sources of Energy**
  - **Nonrenewable**
    - Electricity
    - Nuclear
    - Fossil Fuels
      - Oil
      - Coal
      - Natural gas
      - Synfuels
  - **Renewable**
    - Hydroelectric
    - Solar
    - Wind
    - Biomass
    - Geothermal
    - Ocean Waves and Tides
    - Hydrogen fuel cells
- **Fossil Fuels**
  - **What Are Fossil Fuels?**
    - **Oil**
      - Long chains of hydrocarbons
    - **Coal**
      - Mixture of carbon, hydrogen, oxygen, and other atoms
      - Types of Coals

        - Anthracite = Purest Form
        - Bituminous
        - Subbituminous
        - Lignite = Least Pure
    - **Natural Gas**
        - Mostly methane gas (CH_4) with a mixture of other gases such as Pentane (C_5H_{12}) and Butane (C_4H_{10})
- **Where Are Fossil Fuels Found?**
    - **Oil & Natural Gas**
        - **Source =** Ancient marine organisms such as zooplankton; Organisms in ancient swamps, especially plants
        - **Locations**
            - Deep in the Earth
            - Under both land and ocean floor
            - Stored in spaces between rocks
            - Long continuous deposits called seams
            - At various depths underground
    - **Coal**
        - **Source =** Living organisms found in landfills, swamps, wetlands, and the intestines of various animals
        - **Location =** Many locations around the world
- **Extraction & Use of Fossil Fuels**
    - **Crude Oil**
        - Raw or fresh oil when it is pumped up from a reserve
        - **Methods of Extracting Oil:**
            - Primary Extraction
                - Oil well is tapped and pumped to the surface
                - Easiest way to extract oil
            - Pressure Extraction
                - This method is used when oil is harder to extract
                - Mus, saltwater, or CO_2 is used to push oil out from the reserve
            - Heat Extraction
                - Steam, hot water, or hot gases are used to partially melt very thick crude oil
                - This makes the oil easier to extract
    - **Coal**
        - **Coal mining** occurs through two processes
            - Strip Mining
                - Removal of the Earth's surface, all the way down to the level of coal seam
                - Removed earth is called the overburden
                - Coal is removed; overburden is replaced with and topped with soil
                - Area contoured and re-vegetated
            - Underground Mining

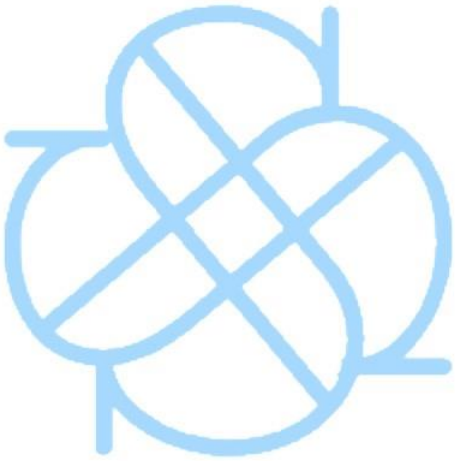
        - Sink shafts to reach underground deposits
        - Networks of tunnels are dug or blasted
        - Humans enter these tunnels to manually retrieve coal
    - **Natural Gas**
        - **Uses**
            - Heating homes
            - Cooking
            - Burned to generate electricity
            - Can be used in some cars and trucks
        - **Pros**
            - Produces only CO_2 and H_2O when it burns
            - Cleaner than burning oil or coal
        - **Cons**
            - A leak can cause a violent explosion
            - More difficult to transport than oil or coal
            - Liquified before transportation, which requires energy
            - Can be transported via pipes, but these can leak and explode, as well as damage habitats when they're installed
- **Synfuels**
    - **Characteristics**
        - Synthetic fuel
        - Obtained from non-petroleum sources such as coal, natural gas, or biomass
        - Can also be derived from waste such as plastic or rubber
        - Can be liquid or gas
        - A mixture of carbon monoxide and hydrogen
    - **Pros**
        - Large potential supply
        - Lower air pollution than coal
        - Can replace oil or natural gas in some cases
        - Used in transportation and industry
        - Holds promise to be a more sustainable or renewable energy source in the future
    - **Cons**
        - Low to moderate net energy yield
        - More costly than fossil fuels
        - Currently still requires coal
        - High water use
        - Higher CO_2 emissions than coal
- **Environmental Considerations of Fossil Fuels**
    - **Oil Drilling**
        - **Pros**
            - Drilling for oil is only moderately damaging to the environment
            - Little land is needed to drill

        - **Cons**
            - Oil is transported thousands of miles by tankers, pipelines, and trucks
            - A lot of environmental damage can occur during transportation
    - **Burning Coal**
        - Burning coal produces:
            - Air pollutants such as CO_2, NO_x, Hg, and SO_2
            - Fly ash - small dark flecks that are carried into the air
            - Boiler residue - solid waste left at the bottom of the boiler
- **Nuclear Energy**
    - **Fusion & Fission**
        - **Fusion**
            - Combining two small atoms to produce heavier atoms and energy
            - Can release more energy than fission without producing as many radioactive by-products
            - Reactions occur in the Sun
            - Practice is still being developed
        - **Fission**
            - Discovered first
            - Energetic splitting of large atoms into two smaller atoms
            - To split an atom, you have to hit in with a neutron
            - Several neutrons are released, which continue the chain reaction
            - Used by all commercial nuclear power plants
    - **Nuclear Reactors**
        - Steam is piped directly to the turbines
        - Steam spins turbines to generate electricity
        - Water is cooled back into a liquid then pumped back to the core to be turned into steam again
- **Renewable Energy**

Energy Source	**Definition/Examples**	**Pros**	**Cons**
Hydroelectric	Electricity generated as moving water turns a turbine	Doesn't produce chemical pollutants	Produces thermal pollution Affects river flow and nearby habitats
Solar	Solar panels convert solar energy into heat or electricity	Doesn't produce pollutants No moving parts Requires little maintenance Silent	Producing PV cells requires fossil fuels Not every location receives enough light to

		Pays off in the long term	make solar panels worthwhile Initially expensive Limited by Sun exposure and energy storage potential
Biomass	Wood Charcoal Animal waste products	Carbon neutral Widely available Still being optimized	Expensive Can lead to deforestation
Wind	Wind is used to rotate blades	Fastest growing alternative energy source Safe Doesn't produce pollutants	Expensive Loud Unattractive to some Need an alternative for when there is no wind
Geothermal	Energy that is obtained from within the Earth Harness Earth's internal heat	Cost effective Reliable Doesn't produce pollutants during typical operation Minimal harm to land and habitats Virtually infinite supply	Only possible in some locations Affects and is limited by groundwater Salts in the water corrode machinery Gases or trace toxic chemicals trapped in the water may be released as the water is used
Ocean Waves & Tides	Incoming and/or outgoing tides pass through the dam, turning turbines and generating electricity	Doesn't produce pollutants Predictable Long life span	Expensive Limited locations Environmental impact is still being determined
Hydrogen Fuel Cells	Hydrogen is obtained from	Use is clean and safe	Expensive Making the fuel

	water or organic matter, stored, and used to generate electricity		can release pollutants



Unit 7-8: Atmospheric, Terrestrial and Aquatic Pollution

- **Types of Pollution**
  - Noise
  - Light
  - Thermal
  - Air
  - Water
  - Solid Waste
  - Hazardous
- **Biggest source of pollution**
  - Burning fossil fuels
  - Mining
  - Industrial processes
  - Deforestation
  - Hazardous waste
- **Anthropogenic Uses of Water**
  - **Agriculture**
    - Water footprint - the total daily per capita use of freshwater
  - Agriculture is one of the most common uses of water. (70%)
  - Industry (20%)
  - Household Use (10%)
  - The United States is the country that uses the most water globally.
  - Different scenarios regarding geological differences
    - Eg. West v. East
  - China uses the least amount of water globally
- **Irrigation** - technological advances have made water use for crops more efficient.
  - Furrow - a trench that is flooded with water
  - Flood - the entire field is flooded with water
  - Spray - an apparatus sprays water across the field
  - Drip - a slow dripping hose is laid on or buried beneath the soil
- **Hydroponic Agriculture**
    - The cultivation of plants in greenhouse conditions by immersing roots in a nutrient-rich solution
  - An alternative to irrigation, hydroponic agriculture is more expensive but has several advantages
    - Requires little to no pesticide use
    - Uses up to 95% less water than traditional irrigation
    - Crops can be grown year-round
  - Water is also used for industrial processes and household use
    - After agriculture, the most common use of water is in industry
- **Industry**
  - Water is used mainly for:
    - Generating electricity
    - Cooling down systems

- **Household Use (Anthropogenic Uses)**
    - About 10% of water use in the U.S
        - Eg. Normal activities, recreational activities.
    - U.S is the leading user of water for households.
        - Advocacy for reduction in household use of water
    - Gray Water - wastewater from bath, showers, bathrooms and washing machine
    - Contaminated Water - wastewater from toilets, kitchen sinks and dishwashers.
- **Wastewater From Humans + Livestock Could Pose Multiple Problems**
    - Water Pollution - the contamination of streams, rivers, lakes, oceans or groundwater with substances produced through anthropogenic activities. Wastewater produced by livestock operations and human activities, including human sewage from toilets and gray water from bathing and washing laundry.
- **Problems w. Wastewater**
    - Oxygen depletion
    - Lack of nutrients
    - Disease-causing organisms + contaminants
- **Oxygen Problems**
    - Biochemical oxygen demand (BOD) - the amount of oxygen a quantity of water uses over a period of time at specific temperatures
    - Dead zone - an area w. Extremely low oxygen concentration + very little life
    - Anoxic - no oxygen present in an area.
- **Excessive Nutrient Release**
    - Eutrophication - a phenomenon which a body of water becomes rich in nutrients
    - Cultural eutrophication - an increase in fertility in a body of water; the result of anthropogenic inputs of nutrients
    - Eutrophication caused by an increase in nutrients
        - Eg. fertilizers
    - Eutrophication can cause rapid growth of algae which eventually dies causing the microbes to increase the BOD
- **Disease-Causing Organisms**
    - Wastewater can carry a variety of pathogens
        - Example of Diseases
            - Cholera
            - Typhoid
            - Stomach Flu
            - Diarrhea
            - Hepatitis
    - **Indicator species** - a species that indicates whether or not disease-causing pathogens are likely to be tested
    - **Fecal coliform bacteria** - a group of generally harmless microorganisms in human intestines that can serve as an indicator species for potentially harmful microorganisms associated w. contaminated sewage.
- **Wastewater Treatment**
    - **Septic Systems**
        - Septic systems

        - Septic tank
        - Sludge
        - Septage
        - Leach field
    - **Sewage Treatment Plants**
        - In developed countries, municipalities use centralized sewage treatment plant that receive wastewater from hundreds or even thousands of households
        - In traditional waste treatment plants, there are two phases of treatment; primary and secondary
- **Animal Feedlots and Manure Lagoons**
    - Manure from concentrated animal feeding operations is a problem because of volume. It can also contain hormones and antibiotics that are given to the animals
        - Manure lagoons - human-made ponds lined with rubber built to handle large quantities of manure produced by livestock.
    - After the manure is broken down by bacteria\, it is spread onto fields as fertilizers
- **Heavy Metals and Other Chemicals**
    - Three Heavy Metals are of particular concern
        - **Lead** - found in pipes and other materials in older construction
        - **Arsenic** - occurs naturally and through human activity such as mining and industry
        - **Mercury** - occurs naturally and through human activity; primarily burning coal
- **Deposition** - acids deposited on Earth as rain or snow or as gases and particles that attach to the surface of plants, soil and water
    - Acid deposition occurs when burning coal releases sulfur dioxide and nitrogen dioxide into the air.
        - In the atmosphere, these chemicals are converted to sulfuric acid and nitric acid, which falls back to Earth as acid deposition
        - Acid deposition reduces the pH of water bodies to levels that are lethal to many organisms.
        - Many coal-burning facilities have installed coal scrubbers to combat this problem.
- **Synthetic Organic Compounds and Human-Produced Chemicals**
        - Synthetic compounds can enter the water supply from industrial point sources or from nonpoint sources when they are applied over large areas.
    - Compounds include pesticides, pharmaceuticals, military compounds and industrial compounds.
    - Synthetic organic compounds can be toxic, cause genetic effects and interfere with growth and sexual development.
- **Military Compounds**
    - Perchlorates - a group of harmful chemicals used for rocket fuel
        - Sometimes contaminates the soil in regions of the world where military rockets are manufactured, tested or dismantled.
- **Industrial Compounds**

- Industrial compounds - chemicals used in manufacturing
    - It use to be common for manufacturers in the United States to dump industrial compounds directly into bodies of water
- Polychlorinated biphenyls (PCBs) - a group of industrial compounds used to manufacture plastics and insulate electrical transformers and responsible for many environmental problems

Oil Pollution

- Petroleum products are highly toxic to many marine organisms, including birds, mammals and fish, as well as to the algae and microorganisms that form the base of the aquatic food chain
- One source of oil in the water comes from drilling from undersea oil using offshore platforms
- Oil and other petroleum products can also enter the oceans as spills from oil tankers

Ways to Remediate Oil

- Containment: Booms keep the floating oil from spreading, then boats equipped with giant oil vacuums suck up as much oil as possible
- Chemicals: Chemicals break up the oil on the surface, making it disperse before it hits the shoreline
- Bacteria: A particular bacterium consumes oil; scientists are currently trying to genetically engineer the bacterium to consume oil even faster.

Non-chemical Water Pollution

- **Solid Waste Pollution**
    - **Solid Waste** = Garbage + Sludge produced by sewage treatment plants
    - Garbage on beaches and in the ocean is dangerous to both marine organisms and people
    - In the United States the practice of dumping garbage in the ocean was curtailed in the early 1980s
    - The problem remains in many developing countries.
- **Sediment Pollution**
    - 30% of all sediments in our waterways come from natural sources while 70% comes from human activities
    - Problems with sedimentation
    - Suspension of soil particles cause waterways to become brown and cloudy
    - Reduced infiltration of sunlight lowers productivity of aquatic plants and algae
    - Sediments clog gills and prevent aquatic organisms from obtaining oxygen
- **Thermal Pollution**
    - **Thermal Pollution** - non-chemical water pollution that occurs when human activities cause a substantial change in the temperature of water
    - **Thermal Shock** - a dramatic change in water temperature that can kill organisms
    - One common solution is cooling towers that release the excess heat into the atmosphere instead of into the water.
- **Noise Pollution**

        - Sounds emitted by ships and submarines can interfere with animal communication
        - Especially loud sonar can negatively affect species such as whales that rely on low-frequency, long distance communication.
        - An increased awareness of noise pollution in the ocean has inspired some shipbuilders to design ships equipped with quieter propellers
- Developed countries have addressed the problems of pollution by clearing up polluted areas and by passing legislation to prevent pollution in the future.
- Developing countries are still in the process of industrializing and are less able to afford water-quality improvements
- Developing countries suffer from the additional pollution but also benefit economically from the additional jobs and industrial spending,
- **Air Pollution** - the introduction of chemicals, particulate matter, or microorganisms into the atmosphere at concentrations high enough to harm plants, animals, and materials such as buildings, or to alter an ecosystem
    - Has many inputs and outputs
- **Classifying Pollutants**
    - **Primary Pollutants** = A polluting compound that comes directly out from its source (smokestack, exhaust pipe or natural emission sources)
        - Examples - CO, CO2, SO2, NO2 and most suspended particulate matter
    - **Secondary Pollutants** = A primary pollutant that has undergone transformation in the presence of sunlight, water, oxygen or other compounds
        - Examples - O2, sulfate and nitrate
        - **Sulfur Dioxide (SO2)**
            - A corrosive gas that comes primarily from combustion of fuels such as coal and oil
            - A respiratory irritant and can adversely affect plant tissue
            - Releases in large quantities during volcanic eruptions and in much similar quantities during forest fires.
        - **Nitrogen Oxides (NOx)**
            - Motor vehicles and stationary fossil fuel combustion are the primary anthropogenic sources of nitrogen oxides
            - Respiratory irritant, increases susceptibility to respiratory infections
            - An ozone precursor, leads to formation of photochemical smog
            - Converts to nitric acid in atmosphere which is harmful to aquatic life and some vegetation
            - Contributes to over-fertilizing terrestrial and aquatic systems
        - **Carbon Oxides**
            - Carbon monoxide (CO) is a common emission in vehicle exhaust and most other combustion processes
            - CO can be a significant component of air pollution in urban areas
            - Carbon dioxide (CO2) released by burning fossil fuels has led to its becoming a major pollutant

            - CO_2 recently exceeded a concentration of 400 parts per million in the atmosphere and appears to be steadily increasing each year.
        - **Particulate Matter** - Solid or liquid particles suspended in air
            - The sources of particulate matter and is affects
                - Particulate matter can be natural or anthropogenic
                - Particulate matter in the atmosphere ranges considerably in size and can absorb our scatter light, which creates a haze and reduces the amount of light
        - **Haze** - Reduces visibility
        - **Photochemical oxidant** - A class of air pollutants formed as a result of sunlight acting as compounds such as nitrogen oxides
        - **Ozone** - A secondary pollutant made up of three oxygen atoms bound together
        - **Smog** - A type of air pollution that is a mixture of oxidants and particulate matter
        - **Photochemical Smog** - A smog that is dominated by oxidants
        - **Sulfurous smog** - Smog dominated by sulfur dioxide and sulfate compounds
        - **Lead**
            - A gasoline additive, also found in coal, oil, and old paint
            - Impairs central nervous system
            - All low concentrations can have measurable effects on learning and ability to concentrate
    - **Volatile Organic Compounds** (VOCS) - an organic compound that evaporates at typical atmospheric temperatures.
        - Formed by evaporation of fuels, solvents, paints and improper combustion of fuels such as gasoline.
        - A precursor to ozone formation.
    - **Sources of Air Pollution**
        - Natural emissions of pollution includes volcanoes, lightning, forest fires, and plants both living and dead; all releases compounds that can be classified as pollutants
        - Anthropogenic sources include on-road vehicles, power plants, industrial processes, and waste disposal (incinerator)
    - **Anthropogenic Emissions**
        - In the U.S, emissions from human activity are monitored, regulated and in many cases controlled.
        - Some anthropogenic sources are on-road vehicles, power plants, industrial processes, and incineration
        - The Clean Air Act and its various amendments require that EPA establish standards to control pollutants that are harmful to human health
        - Through the National Ambient Air Quality Standards the EPA periodically specifies concentration limits for each air pollutant.
- **Photochemical Smog and Acid Rain**
    - Photochemical smog in the United States

        - The formation of photochemical smog is complex and still not well understood.
        - A number of pollutants are involved and they undergo a series of of complex transformations in the atmosphere
        - Prevalent in Los Angeles, California, United States
- **Pollution Control**
    - **Ways to address air pollution**
        - Avoid emissions in the first place
        - Use cleaner fuel
        - Increase efficiency
        - Control pollutants after emissions
        - Management of waste pollution
    - **Ways of Controlling Emissions**
        - Remove sulfur dioxide from coal by fluidized bed combustion
        - Install catalytic converter on cars
        - Use baghouse filters
        - Use electrostatic precipitators
        - Install scrubbers in smokestacks
    - **How People are Implementing Innovative Pollution Control Measures**
        - Municipalities have tried a number of strategies
            - Reduce gasoline spilled at the pump, restrict evaporation of dry-cleaning fluids, and the use of lighter fluid
            - Reduce use of wood-burning stove and fireplace
            - Limit automobiles to every other day uses or charge user fees for roads during heavy commute times.
- **Breakdown of Stratospheric Ozone**
    - When chlorine is present (from CFCs), it can attach to an oxygen atom in an ozone molecule to form chlorine monoxide (ClO) and O_2
        - $O_3+Cl=ClO+O_2$
    - The chlorine monoxide molecule reacts with a free oxygen atom which pull the oxygen from the CIO to produce free chlorine again
        - $ClO+O=Cl+O_2$
    - A single chlorine atom can catalyze the breakdown of as many as 100,000 ozone molecules until finally one chlorine atom finds another and the process is stopped
    - In the process, the ozone molecules are no longer available to absorb incoming UV-B radiation
    - As a result, the UV-B can reach Earth's surface and cause harm to biological organisms

Unit 9: Global Change

- ## Global Warming
  - **Greenhouse Gas Concentration**

Greenhouse Gas	Pre-Industrial Level	In 2016
Carbon Dioxide, CO_2	280 ppm	400 ppm
Methane, CH_4	715 ppb	1,840 ppb
Nitrous Oxides, N_2O	270 ppb	328 ppb

- ## Effects of Climate Change: What's Coming?
  - **Physical Changes**
    - Decrease of glaciers and ice sheets
    - Continued rising of average ocean levels
    - Changes in precipitation
    - Increase in frequency and duration of storms
    - Increase in number of hot days
    - Decrease in number of cold days
  - **Changes in Biota**
    - Increased crop yields in cold environments
    - Loss of croplands due to drought and higher temperatures
    - Cold-tolerant species will need to migrate to cooler climates
    - Heat-tolerant species may spread and invade new habitats
    - Additional deaths from water and insect-borne diseases
    - Commerce, transport, and coastal settlements may be disrupted by changes in ocean levels and storms
    - Change in marine ecosystems and fishery productivity
  - **Adaptations to the Warmer Climate**
    - Must occur at many levels of society
    - Develop new technology
    - Continue to reduce emissions from engines
    - Legislative and behavioral changes needed
    - Promote sustainable growth
- ## Reducing Climate Change
  - **Technological**
    - Carbon sequestration
    - Reduction of emissions from engines
  - **Behavioral**
    - Turning off the lights to conserve electricity
  - **Policy**
    - Enacting new treaties and legislation