Environmental Science Study Guide – EXAM TWO

CHAPTER 3 – ECOSYSTEMS AND FLOW OF ENERGY pg. 25

1. Ecosystem – a biotic (living) community and its abiotic (non-living) environment functioning together as a system
    a. The size is arbitrarily defined by the investigator (as small as a patch of reef or as large as a barrier reef)
    b. Community does not consider abiotic factors
2. Photosynthesis pg. 28 – $6CO_2 + 12H_2O$ + light energy $\rightarrow$ $C_6H_{12}O_6$ (sugar) + $6H_2O + 6O_2$
    a. Light energy is absorbed → light energy converted to chemical energy → chemical energy stored in sugars
    b. Sugar transported throughout the plant body
    c. Products of p/s serve as food for all of life
        i. Exception – chemosynthesis (hydrothermal vents → hydrogen sulfide)
3. Light dependent reactions – enzymes split apart water molecules and liberate molecular oxygen, creating the supply of all atmospheric oxygen
4. Light independent factors – high energy molecules ATP and NADPH take carbon atoms from CO_2 and use them to make simple sugars like glucose

Chloroplast – the green pigment chlorophyll harvests light energy → light energy harvested and converted into ATP in the thylakoid membranes → ATP converts CO2 to glucose in the stroma

5. Second law of thermodynamics – all energy transfers release or degrade energy
6. Cellular respiration pg. 29 – reverse of p/s. energy used for growth, reproduction, and maintenance
7. Production – energy stored by organisms (p/s)
    a. Productive ecosystems – coral reefs, marshes, rain forests, estuaries
        i. Low productive ecosystems – deserts (no moisture), open oceans (no nutrients)
8. Primary productivity – (plants) rate of production of organic tissue during p/s (energy storage)
    a. Requirements - high moisture, long growing season, warm temps, abundant nutrients
9. Secondary production – (consumers) accumulation of energy by consumers (converts plant matter to animal matter)
10. Food chain pg. 26 – a series of connecting links in the food relationship of living organisms
    a. Producers – autotrophs, use compounds in their environment to produce their own food (green plants, algae thru p/s)
    b. Consumers – heterotrophs, require their food prefabricated. Mostly feed on living tissue or fresh kill (herbivores, omnivores, carnivores, etc)
    c. Decomposers – feed on dead matter and break it down into inorganic compounds (bacteria and fungi)
    d. Trophic levels – organisms of one level operate on a common feeding plan
    e. Ecological efficiency pg. 29 – measures the percentage of energy transferred form one trophic level to the next
        i. Energy reduced by factor of 10 from one level to the next.
        ii. 90% of energy in any one trophic level is unavailable to the next trophic level (why few large mammals and numerous small organisms)
11. Food web – network or web of interconnecting food chains
    a. Detrital food web – dominant over grazing
    b. Grazing food web – only a small percentage of production (herbivores)
12. Detritus – dead organic matter
    a. Detritovores – organisms that eat detritus (maggots, worms, mites, snail, millipedes, mollusks, crabs)
13. Pyramid of numbers – constructed by census of each trophic level – number of organisms in each level
14. Pyramid of biomass – functional basis of ecosystem structure
15. Energy pyramid pg. 27 – the flow of chemical energy thru an ecosystem

CHAPTER 4 – THE CYCLING OF MATTER

1. Positive feedback loop – nutrient availability increases → flow of energy increases → rate of nutrient cycling increases
2. Negative feedback loop – nutrient availability declines → flow of energy declines → nutrient cycling declines
3. Biogeochemical cycle pg. 35 – recycling of materials thru ecosystems or the biosphere. Involves biotic and abiotic components. Two compartments which they cycle thru:
    a. Gaseous compartment – air/atmosphere and the oceans.
    b. Sedimentary compartment – rocks and soils
4. Metabolism – the sum of chemical changes that provide energy and assimilate materials in living organisms.
5. The Carbon Cycle pg. 35 (CO_2) pg. 35
    a. .03% CO_2 in atmosphere
        i. Assimilated from air by photosynthesis → fixed into the organic compounds of the plant's tissues
        ii. C is passed from trophic level to the next (plants → herbivores → carnivores → decomposers)
        iii. Organisms respire which puts CO_2 back into the atmosphere (dissimilatory process – C is oxidized)
    b. Oceans, lakes, streams a major reservoir for C storage

i. High atmospheric CO_2 → high levels CO_2 dissolved by water. Atmospheric CO_2 declines → water releases more CO_2 into atmosphere (reversible process)
ii. Oceans an important buffering system for high concentrations of atmospheric CO_2.
1. Oceans have assimilated 1/3 or 48% excess CO_2 released by anthropogenic activities.

c. Ocean acidification pg. 35 - high CO_2 content; pH declining toward neutral (pH 7), not below 7. Reduces $CaCO_3$ production, decline in coral reefs.
i. Harmful effects on coral reef ecosystems. Forms $CaCO_3$, which is not very soluble.
ii. Forms limestone deposits for shells and coral skeletons.

6. The Nitrogen Cycle pg. 37 (N_2) pg. 37
   a. 79% of atmosphere consists of N_2 – exists in a form unusable to organisms
      i. Organisms require N for the synthesis of proteins and nucleic acids
   b. Nitrogen fixation - N_2 (gas) is converted to ammonia NH_3which plants can assimilate. Physical or biological (main) processes.
      i. 90% of N-fixation is from N-fixing bacteria. Azotobacter bacteria (soil) or cyanobacteria / anabaena (water)
         1. Rhizobium bacteria have a mutualistic symbiotic relationship with legumes. Plants provide Rhizobium a home in root nodules and energy from sugars produced during p/s; Rhizobium provides plants with useable N fixed from the atmosphere.
         2. Root nodules are anoxic – good environ for nitrogenase enzymes to function and form NH_3
         3. Cyanobacteria use heterocysts for anoxic conditions to accomplish N-fixation.
         4. Cyanobacteria have a symbiotic relationship with fungi which forms lichens
      ii. 10% from natural processes – lightning, volcanoes, and industrial processes
   c. Ammonification pg. 38 – conversion of amino acids to NH_3 by decomposer organisms. Ammonifying bacteria convert the N in waste products (urine) into NH_3 and then are absorbed by plant roots.
   d. Nitrification pg. 38 – conversion of NH_3 (ammonia) to NO_2 (nitrite) then to NO_3 (nitrate)
      i. Nitrite bacteria convert NH3 to NO2 → nitrate bacteria convert NO2 to NO3 (assimilated by plants)
   e. Denitrification pg. 38– dissimilation of organic forms of N into inorganic N2.
      i. Reverses N-fixation and nitrification
      ii. Denitrifying bacteria consume nitrates for oxygen. They are anaerobic (live in soil near water table where there is little oxygen)
7. The Phosphorus Cycle pg. 38 (P) (Phosphate ions – PO_4)
   a. P not in atmosphere – no gaseous phase
      i. Found in rock and released by weathering and erosion
   b. Organism require P to synthesize nucleic acids and form bones/teeth
   c. Plants assimilate PO_4 from soil or water.
      i. Passes thru communities in plant and animal organic matter
      ii. Returns to soil from excretion/death/decay
      iii. PO_4 reused by plants from soil
   d. P is the limiting nutrient in aquatic ecosystems
      i. P in streams and lakes from runoff of farmland/fertilized lawns/urban sewage
      ii. Aquatic plants and algae absorb dissolved P and pass it thru the food web
      iii. Fish eating birds return nutrient to land as guano
      iv. P not assimilated by organisms becomes sediment and re-circulated by geological uplift

CHAPTER 6 – SOILS AND GEOLOGICAL PROCESSES

1. Study of soils – pedology
2. Soil formed by breakdown of parent rock thru physical and chemical weathering and the actions of organisms
   a. Lichens and mosses can split rocks apart by their large roots
3. Soil texture pg. 51 – determined by size of mineral particles and the proportion of different sized particles
   a. Clay < 0.002 mm
   b. Silt = 0.002 - 0.02 mm
   c. Sand = 0.02 – 2 mm
4. Soil color – classification uses color charts
   a. Temperate forests – gray/brown
   b. Tropics – red (very nutrient poor from so much rainfall)
   c. Red/yellow - iron oxide
   d. Dark – high in organic matter
   e. Yellow-brown, gray – poor drainage

5. Chemical properties – mineral content determined by local bedrock (Mineral and organic matter, H_2O and O_2 availability, pH)
    a. pH affects the solubility of mineral nutrients – different minerals soluble at different pH levels
    b. Calcicoles – lime-loving soils (high in Ca) (wildflower, prairie blazing star, alfalfa)
    c. Calcifuges – lime-hating soils (low in Ca) (Azaleas, rhododendrons)
    d.
6. Soil properties - Serves as home and food for microorganisms, soaks up moisture
    a. Organic matter – dead leaves, roots, stems, insect remains, animal droppings, worm secretions
        i. Accumulates in upper part of soil
    b. Humus pg. 51-52 – partially decomposed organic matter in top layers
        i. Mor Humus – found in coniferous forests, acidic and low in Ca, chief decomposers are fungi
        ii. Mull Humus – deciduous forests, alkaline/neutral, high Ca content, chief decomposers are bacteria
7. Pore space – space between mineral particles, 50% soil volume is pore space
    a. Porosity pg. 52 – measure of amnt of pores in soil
        i. Too porous – sand, wont hold H_2O
        ii. Not porous – clay, retains H_2O, can be water logged
    b. Field capacity – amnt of H_2O soil can hold after excess has drained off
        i. Influenced by soil texture, by the relative proportions of clay, silt, and sand.
        ii. Water logged soil – defective soil, pore space occupied by soil, air, and water. 0_2 needed for respiration of roots and organisms
8. Living organisms – comprise 0.1% of soil. Contribute to soil fertility and porosity.
9. Nutrients and charge pg. 52
    a. Soil particles bond with nutrients (esp clay particles)
    b. Clay – negative charge, important in holding nutrients
        i. Nutrients – positively charged cations: K, Ca, NH_4, Mg
        ii. Nitrates not attracted to clay (-), ammonium attracted to clay (+)
    c. Cation Exchange capacity – number of (-) exchange sites on clay particle. High CEC contributes to soil fertility
10. Soil profile – a cross-section of the soil. Exhibit distinct layers called soil horizons.
    a. O-horizon – top layer, plant litter
    b. A-horizon – down 10", topsoil, tends to be deficient in nutrients which are leached to lower layers
    c. E-horizon – separates A and B, zone of leaching, minerals have been removed by percolation of water
    d. B-horizon – under E, subsoil, illuvation (leaching of materials above like clay, Al, and Fe)
    e. C-horizon – below B, broken/weathered parent bedrock, saturated with groundwater, out of reach for most roots
    f. R-horizon – lowest layer, consolidated bedrock
11. Rock cycle – each of the three rock types crushed, melted, or reformed into the others.
    a. Igneous rock – formed from magma/lava that has cooled either below ground or on the earth's surface.
        i. Basalt and granite
    b. Sedimentary rock – formed from the sediments of weathered rock or tiny shells and other $CaCO_3$ precipitates.
        i. Limestone and sandstone
    c. Metamorphic rock – has been subjected to heat and pressure and thus reformed thru partial melting or reshaped by intense pressure
        i. Marble
12. Reserves – high grade deposits that have been identifies and can be mined profitably
13. Resources – deposits that are too expensive to extract or yet to be identified

CHAPTER 15 – INTERACTIONS OF ORGANISMS

1. Predator-prey system – study of how predators interact with their prey. The abundance of one affects the population of the other.
    a. Coevolution – prey species stimulates thru natural selection, the development of a countermeasure by the predator. The two continue to evolve together.
2. Symbiosis – a close association between two species
    a. Mutualistic – when both species benefit from the interaction
    b. Mutualistic coevolution – Hawaiian honeycreeper and the lobelia flower. The flower blossom and the bird beak have coevolved to facilitate one another.
    c. Commensalism – where one symbiont benefits and the other is neither helped nor harmed
        i. The clownfish and the sea anemone. Epiphytes and their host trees.
    d. Parasitism – parasites gain while the host is harmed
        i. Black-legged tick and host

3. Competition pg. – Negative interaction that harms all contestants. Results from competing for a scarce resource or while procuring a relatively abundant resource
    a. Intraspecific competition – members of the same species compete.
    b. Interspecific competition – members of different species compete.
    c. Allelopathy – plants produce secondary compounds to prevent the growth of other plants nearby (black walnut tree)
4. Lotka-Volterra competition model pg. 138 – uses math equations to predict the outcome of competition. Predicts the annihilation of one species.
5. Competitive exclusion – two species cannot persist together while making simultaneous demands on a limited resource.
6. MacArthur's Warblers pg. 139– noted that 5 different species of warblers all seemed to share the same resource. Warblers ate certain size caterpillars that suit that species size.
    a. Resource partitioning – meticulous division of community resources
7. Ecological differentiation – species need to become different to avoid competition.
    a. Avoidance of competition is key, promotes differences among populations (speciation)
8. Ecological niche pg. 139 – niche in terms of space, essentially meaning the species habitat.
    a. Niche concept – idea that each species requires a bundle of resources
    b. N-dimensional hypervolume – a package of resources needed by the organism. Describes niche space available for that particular species.
        i. Niche space – may be described in terms of width or range of resources used.
            1. Cockroach – broad niche width (survive on any food source), Karner blue butterfly – narrow niche width (endangered, feed only on wild lupine)
        ii. Niche compression – increased specialization due to competition.
        iii. Niche expansion – due to removal of a competitor.
    c. Fundamental niche – absence of competitors. Includes all the environmental variables that a species needs to survive.
    d. Realized niche - The niche space actually occupied because the organism is limited by competitor species for the same resource.

CHAPTER 20 – PESTICIDES AND ENVIRONMENTAL TOXICOLOGY

1. Rachel Carson pg.178 – became interested in DDT pesticide in mid-1940s when working for US Fish and Wildlife Service
    a. Silent Spring 1962 - wrote book about a fictitious town stricken by a blight that had caused massive sickness and death among towns people and animals as a result of their liberal use of chemical pesticides.
        i. She argued that chemical pesticides often caused severe consequences for wildlife and also produced long-term effects on human health.
        ii. She argued that the complete extermination of pest-insects was imprudent – aim should be to reduce pest damage through the safest and most practical means. Minimize chemical applications and employ biological and cultural controls whenever possible.
        iii. Finished work did not represent original scientific research but rather a literary survey or current research.
    b. DDT – a chlorinated hydrocarbon (organochlorine), a synthetic organic insecticide, characterized by high toxicity to a wide variety of insects and by its persistence (doesn't degrade quickly) – compounds now referred to as a persistent organic pollutants (POP)
2. Pesticide treadmill – when the 'fittest' insects build up tolerances to these chemicals, forcing the development of increasingly lethal chemicals to kill the super races. Farmers had to use greater applications of the same pesticide or switch to new ones.
3. Bioaccumulated – when the chemicals accumulate in the tissues of the consumer
4. Biomagnification- the increase in concentration of chemicals in successively higher trophic levels.

CHAPTER 21 – RENEWABLE ENERGY

1. Fossil fuels – nonrenewable resources – the earth has a finite supply, their formation takes millions of years (coal, oil, natural gas)
    a. Reserves – high grade deposits that have been identified and mined profitably
    b. Resources – deposits that are too expensive to extract profitably
2. Coal pg. 189 – used primarily for electricity, over half of electricity in US from coal combustion, most abundant resource
    a. How coal was formed – undecomposed vegetation in swamps became buried in deep layers of sediments/mud → earth's heat and pressure converted plant matter to coal → geological uplift moved veins of coal to surface
    b. Mined in two ways
        i. Subsurface mining – extract coal from deep within the earth's crust, dangerous for miners
        ii. Surface mining – used on shallow deposits, disturbs large areas of landscape
    c. Lignite – lowest grade, most abundant
    d. Subbituminous – black, western coal, little higher heat content than lignite
    e. Bituminous – soft coal, higher heat content than subbituminous, high percentage of sulfur

      f. Anthracite – highest grade, least abundant, low sulfur content, highest heat content
3. Oil and Natural Gas pg. 189 – clean burning, energy-rich fuels.
    a. How oil was formed – single-celled aquatic organisms in oceans died → accumulated in ocean sediments (limited oxygen prevented decomposition) → burial, heat, and pressure from earth converted the organisms into oil → migrated upward thru porous rock until they reached cap rocks (prevent seepage to the surface)
    b. How natural gas was formed – same as oil process except 'cooked' at higher temps and longer duration to produce methane
    c. Oil transportation extremely hazardous – Exxon Valdez spill 1989
    d. Air pollution is a problem associated with oil – forms CO_2 and acid deposition from emissions of nitrogen oxides
4. Nuclear Power pg.191 – 7% of worlds commercial energy, nothing is burned
    a. Uranium – fuel source, 99% U-238 (not fissionable), 0.71% U-235 (used by nuclear power plants), 0.01% U-234
    b. Unstable isotopes are radioactive – during radioactive decay, the nucleus changes into a different, more stable element
    c. Nuclear fission – splitting the nucleus of an atom → energy is released in the form of heat → free neutrons split other nuclei, which releases more heat and more neutrons.
    d. One enriched U-235 fuel pellet consists of energy equivalent to one ton of coal → fuel pellets put into fuel rods → 200 fuel rods make up one fuel assembly → a nuclear reactor consists of 250 fuel assemblies
    e. Control rods (absorb neutrons) are intermingled with fuel assemblies → control rods can be drawn up out or reinserted into reactor core.
        i. In the core – absorb neutrons → slow down chain reaction → reduce heat generated
        ii. Drawn out of the core – chain reaction speeds up → more heat generated.
    f. Heat generated: boils water → produces steam → turns turbine → spins a generator → generates electricity
    g. Risks – plant accident (release of radioactivity), radioactive wastes (finding safe disposal locations), transporting nuclear wastes, nuclear power plants eventually must be decommissioned (high cost, technical difficulty, plutonium-239 weapon fuel)
5. Renewable energy
    a. Direct solar energy – passive and active
        i. Passive solar power – direct gain systems and isolated gain systems
            1. Direct – south-facing double/triple glazed windows permit entry of low winter sun rays, reduce heat loss at night, walls inside building placed to absorb and retain heat
            2. Isolated – isolated or attached structure like a greenhouse or sun porch on south side, heats masonry inside which stores heat, warm air directed into house by high vents, cold air returned vents near floor (passive air circulation system)
        ii. Active solar power Pg.193-194 – employs a collector pointed south (collect max amount of solar energy possible.
        iii. Photovoltaics – semiconducting materials fabricated to convert sunlight directly into electricity (watches, calculators, yard lights, traffic signs, shingles)
    b. Indirect solar power – biomass conversion, hydroelectric, and wind power
        i. Biomass fuels – result from conversion of solar energy into chemical energy (photosynthesis → burn plants)
            1. (Solid) Wood, charcoal, crop/animal wastes, peat, (liquid) ethanol, methanol, (gas) methane
        ii. Hydroelectric power – sun's energy drives water cycle in hydroelectric dams, clean source of energy, dams block migratory routes and change water levels
        iii. Wind energy – wind currents are generated by differential heating of the planet by the sun
    c. Energy conservation – most cost-effective solution to our energy problem
        i. Cutting back on energy demands or increasing the efficiency of current energy use

CHAPTER 23 – BIODIVERSITY AND CONSERVATION BIOLOGY pg. 207

1. Conservation biologists – study biodiversity and the impact of humans on the natural world.
2. Endangered Species Act of 1973 – protects species and populations at risk of extinction and their habitat.
    a. Endangered species – those in imminent danger of extinction throughout all or much of their range
    b. Threatened species – those likely to become endangered soon
    c. Indicator species – listed species, protecting entire biological communities
3. Stochasticity – random events affecting growth or decline of populations
    a. Demographic stochasticity – random variation in birth rates, death rates, and sex ratios
    b. Environmental stochasticity – unpredictable variation in environmental factors such as rainfall, storm events, temp.
4. Inbreeding depression – as the size of the population declines, viable breeding adults can experience difficulty locating suitable mates (leads to mating among close relatives)
5. Minimal Viable Population (MVP) – the smallest population that has a good chance of persisting for the foreseeable future
6. Minimum Dynamic Area (MDA) – the amount of suitable habitat necessary for maintaining the MVP

7. Population Viability Analysis (PVA) – assesses a species needs and compares them to available environmental resources and attempts to identify potential problems
    a. Augmentation programs – involve releasing individuals into an existing population to boost its size and genetic diversity
    b. Reintroduction programs – involve releasing captive-bred or wild-collected individuals back into their historic range
    c. Introduction programs – involve releasing captive-bred or wild-collected individuals into suitable habitats outside of their historic range.
    d. Soft release – appropriate for large mammals where they are caged, fed, or sheltered until they are familiar.
    e. Hard release – abrupt release of animals, usually smaller species like fish
8. Restoration ecology – the modification of a degraded habitat with the aim of making it resemble a historic ecosystem
9. Biogeography pg. 216 – the study of geographical distribution of organisms and their habitats, past and present
    a. Sea lamprey – likely entered great lakes thru Erie canal, depleted populations of lake trout and other species, we use TFM chemical on the larvae to reduce lamprey populations by 10%
    b. Alewife – entered great lakes from lake Ontario thru the Welland canal, popular food source for game fish, and reduced populations of whitefish thru competitive exclusion.
    c. Chinook salmon – stocked annually in Lake Michigan and Huron for sport fishing and eats alewives.
    d. Coho Salmon – stocked successfully by Michigan and Ohio annually for sport fishing and to eat alewives as forage.
    e. Carp – US Fish Commission imported several hundred carp from Germany and stocked them in the great lakes. Unfavorable fish who disrupt the habitat and vegetation.
    f. Zebra mussel – European mussel arrived by cargo ships, impact freshwater ecosystems thru biofouling and filter-feeding, reproduce fast and have few predators.
    g. Bythotrephes (spiny water flea) – originated in Great Lakes from ship traffic in port of Leningrad, high capacity to reproduce rapidly, monopolize food supply (less food for juvenile fish)
    h. Ruffe – arrived by grain ships picking up cargo in great lakes, grow fast, high reproductive output, adapt to a wide variety of habitats, may cause decline in other desirable species.
    i. Round goby – transported to great lakes in ballast water of ships, feed on zebra mussels, may crowd out native fishes and dominate prime spawning sites.