

**Unit 3 Ecology, Evolution, and Biogeochemical Cycles**

Now that you know what the exams will be like, you can focus on doing what you need to do to do well. Did you spend too long on the multiple choice last time? Were the FRQs your trouble area? Know where you are weak and focus on those places. Our job all year is to focus on your weak areas so by the time the AP exam rolls around in May, your weak areas will be strengths.

There is **almost always at least 1 FRQ on the AP Exam from this material.**  Don’t just learn this material for the exam and then forget it. The material from this exam will be with us for the rest of the year, so learn it well now so you don’t have to go back and reread or relearn parts.

**Biogeochemical Cycles (*Video 3.1 Biogeochemical Cycles due \_\_\_\_\_\_\_\_\_\_\_\_\_\_)* (pages 82 – 90)**

1. **Nutrients needed for life** / CHNOPS (know why each is important to life)
   1. **Carbon** / building block of life due to its four bonding sites bases of carbs, lipids, proteins, DNA and a major greenhouse gas as carbon dioxide (CO2)
   2. **Hydrogen and Oxygen** / makes up water, which transports nutrients/life is mostly made of it
   3. **Nitrogen and Sulfur** / major building blocks of proteins and amino acids
   4. **Phosphorus** / Found in DNA, RNA, ATP, and an essential nutrient in the makeup of bones/teeth
2. **Two limiting nutrients in plant growth** / nitrogen and phosphorus (which are the main components in fertilizer and excess amounts lead to eutrophication-algal blooms)
3. **Nitrogen Cycle** / N2 (gas) cannot readily be absorbed and used by plants and animals, so we rely on electrical discharges (lightening) and **nitrogen fixing bacteria** to make it usable for plants
   1. Animals consume plants or other consumers to obtain their nitrogen
   2. **Reservoir** / the atmosphere (78% nitrogen)
4. **Know each step of the nitrogen cycle & the diagram on the last page, very hard, you must know!)**

**Remember “FNAAD, ANPAN” (*Video 3.2 Nitrogen Cycle DETAILED due \_\_\_\_\_\_\_\_\_\_\_\_\_\_)***

**F**ixation--------------🡪 **A**mmonia (Bacteria and cyanobacteria combine gaseous N2 with hydrogen to

make ammonia (NH3) which they use as

nutrient for themselves. They excrete the rest of the ammonia into

the soil or water)

**N**itrification----------🡪 **N**itrates, Nitrites (Ammonia not taken up by plants is converted by soil bacteria into nitrate ions NO3- which are easily taken up by the roots of plants)

**A**ssimilation----------🡪 **P**roteins (Plants use the ammonia or nitrate ions to produce proteins, nucleic

acids, and vitamins. Consumers will ingest plants or other

consumers and do the same)

*----Organism Death/Decomposition---------------------------------------------------------------------------------------------------------------------------------------------------------------*

**A**mmonification------🡪 **A**mmonia (Decomposer bacteria convert detritus material into ammonia NH3

and ammonia ions (NH4+ this is called Ammonium)

**D**enitrification--------🡪 **N**itrogen Gas (Specialized bacteria in waterlogged soil and the bottoms of lakes, oceans, swamps, and bogs covert ammonia NH3 and ammonia ions NH4+ back into nitrate ions and then into nitrogen gas and nitrous oxide gas. These are released back to the atmosphere to begin the cycle again.)

1. **How Humans Alter the Nitrogen Cycle** / (know at least one of these)
   1. Agricultural runoff of fertilizers, animal manure, and sewage discharge add excess nitrates NO3- to bodies of water. This can lead to eutrophication (algal blooms, which bring in more bacteria as algal decomposes, decreasing the oxygen in aquatic environment, often resulting in fish kills)
   2. We add nitric oxide NO to the atmosphere as we burn fuel at high temperatures (cars, jets). This gas is converted into nitrogen dioxide gas NO2 and nitric acid vapor HNO3 which falls to the earth as acid deposition aka acid rain.
2. **Carbon Cycle** (know each at least 3 of the facts, including reservoirs, and the carbon cycle diagram!)
   1. Found in the atmosphere as a gas (CO2), dissolvable in water making oceans more acidic
   2. Producers pull carbon (CO2) from the atmosphere or water for the process of photosynthesis
   3. Consumers take in carbon by ingesting producers or other consumers
   4. Producers and consumers release carbon (CO2) as a product of respiration
   5. Carbon can be incorporated into marine (shells and corals) and terrestrial sediments
   6. After millions of years carbon can be compressed into fossil fuels
   7. **Reservoirs** / the largest reservoir is calcium carbonate (CO3)2- rocks first (limestone and dolostone) found in shells/corals, fossil fuels, and marine sediments (decomposers release insoluble carbonates from dead marine organisms), second most is dissolved in oceans, then carbon locked in forests
3. **How Humans Alter the Carbon Cycle** / (know at least one of these)
4. The extraction and burning of huge quantities of fossil fuels that have taken millions of years to form have released large amounts of carbon dioxide to the atmosphere
5. The clear-cutting of carbon-absorbing vegetation (especially tropical rain forests) have released large amounts of carbon to the atmosphere
6. The increased concentration of carbon dioxide and other greenhouse gases (methane, water) are warming our planet and projected to change Earth’s climate this century
7. **Photosynthesis** / plants convert CO2 (atmospheric carbon) into complex carbohydrates (sugars) (glucose C6H12O6) (requires sunlight energy converts low energy to high energy and is only 2-3% efficient!
   1. **Chemical Equation for Photosynthesis** / 6CO2 + 6H20 + light energy → C6H12O6 + 6O2
8. **Cellular Respiration** /process of breaking down organic molecules to release energy stored in food like carbs (emits energy; high energy to low energy)
   1. **Chemical Equation for Cellular Respiration** / C6H12O6 + 6O2 → 6CO2 + 6H2O + energy
9. **Anaerobic Respiration** / breaking down glucose in the absence of oxygen – products are methane (CH4), ethyl alcohol, acetic acid, hydrogen sulfide (H2S) Smells bad
10. **Phosphorous Cycle** / no gaseous phase involved; a sedimentary cycle only
    1. **Phosphorous does not circulate as easily as nitrogen because** /it does not exist as a gas, but is released by weathering of phosphate (PO4)-3 rocks which is a SLOW process
       1. Very slow to cycle in comparison to water, carbon, and nitrogen
    2. Water erodes away inorganic compounds, that include phosphates, from rocks
    3. Water carries dissolved phosphates into the soil where they can be absorbed by producers
    4. Consumers take in phosphates by ingesting producers
    5. **Reservoirs** / Phosphate salts containing phosphate ions, terrestrial rock formations, and ocean bottom sediments. Does not include the atmosphere**!**
11. **How Humans Alter the Phosphorus Cycle /** humans mine phosphate salts which are added to fertilizers and applied to agricultural fields. Excess phosphates from runoff can also cause eutrophication (algal blooms, which bring in more bacteria as algal decomposes, decreasing the oxygen in aquatic environment, often resulting in fish kills)
12. **Sulfur Cycle** / (know each at least 3 of the facts, including reservoirs, and the sulfur cycle diagram!)
    1. Volcanoes release sulfur dioxide (a colorless, poisonous gas with a rotten egg smell). Decomposers in flooded swamps, bogs, and tidal flats also release sulfur dioxide.
    2. Sulfate salt particles enter the atmosphere from sea spray, dust storms, and forest fires.
    3. Plants absorb sulfate ions, and incorporate them into proteins.
    4. Marine algae produce large amounts of volatile dimethyl sulfide (DMS – CH3SCH3). DMS is the nuclei/particle around which water droplets condensate (aka cloud seeds)
    5. **Reservoirs** / underground rocks and minerals in the form of sulfate salts SO42**-**

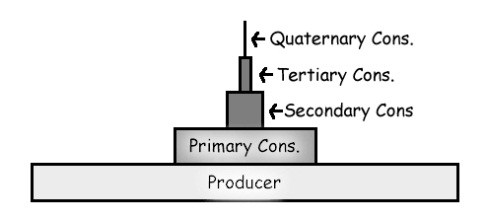
**Energy in Ecosystems (*Video 3.3 Energy in Ecosystems due \_\_\_\_\_\_\_\_\_\_\_\_\_\_)* (pages 43 – 48, 74 – 78)**

1. **Energy** / the ability to do work
   1. **Kinetic** / energy in motion
   2. **Potential** / energy stored within a physical system and has the ability to be converted into different forms of energy
2. **Gross Primary Productivity (GPP)** / total amount of energy produced by all the photosynthetic life (producers) in a particular area
3. **Net Primary Productivity (NPP)** / energy available to the next trophic level (total amount of photosynthetic activity GPP – energy consumed by plants (Respiration))

*Net Primary Productivity = Gross Primary Product. – Cell Respiration* ***(NPP = GPP – R) Know this!***

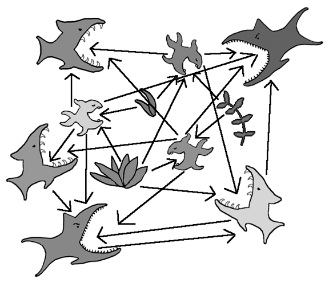
1. **First Law of Thermodynamics**  / in all physical and chemical changes energy can neither be created nor destroyed, but can be converted from on form to another (**Law of Conservation of Energy**)

ENERGY IN = ENERGY OUT (THERE IS NO AWAY)

1. **Second Law of Thermodynamics (entropy)** / when energy is changed from one form to another, some useful energy is ALWAYS degraded into lower quality energy, HEAT LOSS!
2. **Biomass** /total dry mass of all living things on earth; can be estimated at each trophic level
3. **Why are Trophic Levels Always Shaped like Pyramids?** / because most usable energy is lost as heat. (second law of thermodynamics) not all biomass is digested and absorbed; predators expend energy to catch prey (heat) which limits amount of top consumers
4. **Ten Percent Rule (Energy Flow in Food Webs)** / only 10% of the usable energy is transferred to the next trophic level.

REASON: Second Law of Thermodynamics

**Ecosystem Ecology (*Video 3.4 Ecology Basics due \_\_\_\_\_\_\_\_\_\_\_\_\_\_)* (pages 67 –74, 168 – 170, 205 – 215)**

1. **Niche** /role or job an organism play in its environment
2. **Fundamental Niche** / theoretical role that organism can occupy without limiting factors
3. **Realized Niche** / actual niche that organism occupies, usually smaller due to competition
4. **Competitive Exclusion Principle** /two species cannot occupy the same niche, competition will drive one out, but niche overlap is possible
5. **Generalists** / are organism that have very broad niches, giving them the ability to have wide ranges and fit into a variety of habitat (ex. roaches, raccoons)
6. **Specialists** / have a narrow niche, are very successful when condition are favorable, but if condition decline they are more susceptible to extinction (ex. panda)
7. **Producer (autotroph)** / organisms that make their own food—photosynthetic or chemosynthetic life
8. **Chemosynthesizers** / bacteria that have developed the ability to make their own food at deep ocean vents by turning carbon and hydrogen sulfide into organic matter (glucose) using energy
9. **Consumer (heterotroph)** / organisms that cannot make their own organic compounds from inorganic ones and must feed on other living things
   1. **Herbivores** /organism that eats only plants; Are primary consumers; On the 2nd trophic level
   2. **Carnivore** /organism that eats meat; Are secondary Consumers; On the 3rd trophic level
   3. **Omnivore**/ organism that feeds on both autotrophs and heterotrophs
   4. **Detritivore** / organism that eat dead matter ex. termites/earthworms
   5. **Decomposer** / organism that feeds and breaks down remains and wastes of organisms into simpler, inorganic substances ex. mushrooms, bacteria
10. **Food Chain** / sequence of organisms each which is food for the next

Example: grass→ ant→ lizard→ snake

1. **Food Web** / complex arrangement of food chains; all possible feeding relationships in an area
2. **Keystone Species** / species whose role has a greater impact on the environment than other species.

Ex. sea otter controls the sea urchin population which feeds on kelp: beaver building a dam creating a pond, which is the home to many other species; elephant making trails by knocking down trees

1. **Indicator Species** / unique species that provide insight into the health of an ecosystem
2. **Mutualism** / symbiotic relationship where both organisms benefit (+,+) Ex. honeybee and flower
3. **Commensalism /** symbiotic relationship in which one organism benefits and the other organism is unaffected (+,0) Ex. Barnacle on whale
4. **Parasitism /** relationship in which one organism (the parasite) obtains nutrients at the expense of the host (+,-) Ex. tick and coyote
5. **Amensalism** / relationship in which one organism is harmed and the other in unaffected (-,0) Ex. Cattle creating trails in grass
6. **Primary succession** / development of communities in a soil-less area not recently inhabited by life (ex. retreating glacier, lava flows) or those in which the soil profile is completely destroyed: begin with lichen releasing acids that breakdown rock into smaller sediments, they die adding nutrients…*lichen**→ grass → shrub → coniferous tree → hardwood tree → climax ecosystem*
7. **Pioneer species** / 1st community in succession (ex. lichen, mosses, blue-green algae in water)
8. **Secondary succession** / recolonization of an area after a disturbance; must have existing soil (clear cut forest, vacant lot, old farm or fire) *grass → shrub → coniferous tree → hardwoods → climax ecosystem*
9. **Climax Community** / the stable, final community that develops from ecological succession (not all ecosystems achieve climax communities)

**Ecosystem Diversity (*Video 3.5 Ecosystem Diversity due \_\_\_\_\_\_\_\_\_\_\_\_\_\_)* (pages 147 – 167)**

1. **Charles Darwin** / credited with the THEORY of evolution, who believed in God, his father was a minister; he was a geologist on the *SMS Beagle* sailed for two years observed small variations in life on the Galapagos Islands (ex. Darwin’s finches); he did not know about genetics yet
2. **Mutation** / a random *mistake* in the gene sequence caused by environmental, radiation, or just a mistake
3. **Evolution** /change, all life descended from earlier life forms; two types:
   1. **Gradualism** / slow change over a long period of time (old view)
   2. **Punctuated equilibrium** / periods of no change followed by rapid change (newer view)
4. **Natural selection** /the process in which organisms with adaptive characteristics are more likely to survive and pass on their traits to their offspring; a primary mechanism of evolution
5. **Survival of the Fittest** / fit for their niche or role, most people think it means stronger which is incorrect

**Ecology Calculation Practice**

Calculate the missing values in the table “Productivity and Respiration in Three Ecosystems” table on the next page. Then answer the discussion questions.

**EQUATION**

**Net Primary Productivity (NPP) = Gross Primary Productivity (GPP) – Plant Respiration (Rp)**

**Productivity and Respiration in Three Theoretical Ecosystems**

All values in **kilocalories/meter2/year**

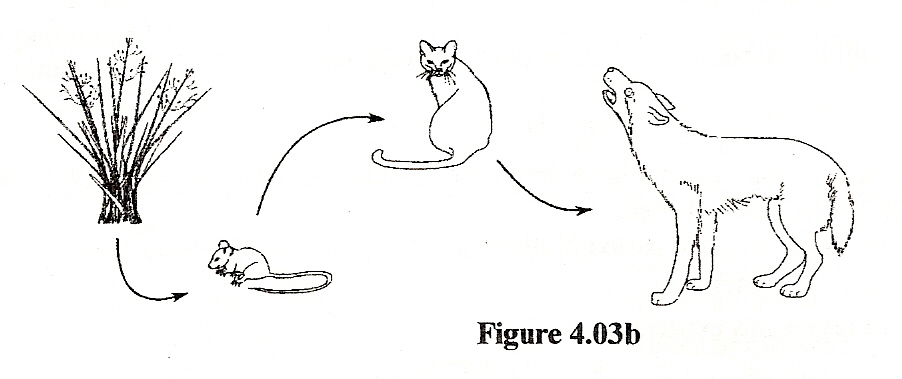
|  |  |  |  |
| --- | --- | --- | --- |
| Productivity and Respiration | Alfalfa Field | Short-Grass Prairie | Deciduous Forest |
| Gross Primary Productivity  (GPP) | 24,000 | 5,230 | 27,976 |
| Plant Respiration (Rp) | 9,200 | 1,778 | 18,200 |
| Net Primary Productivity  (NPP) |  |  |  |

* + - 1. Not based on the above diagram, but in general give an example of an ecosystem that has a high net primary productivity?

…..give an example of an ecosystem that has a low primary productivity?

Using the food chain shown below, answer the following questions.

**BE SURE TO USE COMPLETE UNITS THROUGHOUT YOUR EQUATIONS!!!**



* + - 1. Calculate the net primary productivity if the gross productivity of the grasses is 500,000 kJ/m2/yr and their annual respiration is 340,000 kJ/m2/yr.
      2. What does your answer to the previous question say about the energy in the ecosystem? What’s happening to it?

Grasses: 340,000 kJ/m2/yr

Mice: 80,000 kJ/m2/yr

Cats: 60,000 kJ/m2/yr

Wolves: 40,000 kJ/m2/yr

* + - 1. If there are 300,000 kilocalories (kcal) in the producer level, how many kcal will become incorporated in the tissues of the secondary consumers?



Producer (300,000 kcal)

Consumer (Human)

Consumer (Perch)

Consumer (Zooplankton)

Consumer

* + - 1. How many humans could be supported if every human needs 2.1 kcal to survive? Show work below
      2. In a particular forest ecosystem the vegetation is producing 55,000 kcal/m2/yr of energy in the form of glucose. About 30,000 kcal/m2/yr is left over after the plants perform cellular respiration. What is the net primary productivity (NPP) of the system?

**THE CARBON CYCLE**

*ATMOSPHERE*

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

*UNDERGROUND*

Destinations: Actions:

Animals Burning/Combustion

Atmosphere (CO2) Decomposition

Fossil fuels Diffusion/Absorption

Ocean Photosynthesis

Plants Respiration

Soil (organic matter)

How do humans affect this cycle?

**THE NITROGEN CYCLE**

*ATMOSPHERE*

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

*UNDERGROUND*

Destinations: Actions:

Animals Ammonification

Atmosphere (N2) Assimilation

Decomposers Consuming/Eating

Nitrogen fixing bacteria Decomposition

Plants Denitrification

Soil Lightning

Soil bacteria Nitrification

Nitrogen fixation

How do humans affect this cycle?

**THE PHOSPHORUS CYCLE**

*ATMOSPHERE*

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

*UNDERGROUND*

Destinations: Actions:

Animals Assimilation

Fertilizer Consuming

Plants Mining

Rock Runoff

Sediment Weathering

Soil

How do humans affect this cycle?

**THE SULFUR CYCLE**

*ATMOSPHERE*

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

*UNDERGROUND*

Destinations: Actions:

Atmosphere (SO2) Combustion

Coal Condensation

Soil Decomposition

Volcano Eruption

Mining

Precipitation

How do humans affect this cycle?

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **CYCLE** | **Why Important?** | **Where is it Mostly Found?** | **Time Frame**  **(speed of cycle)** | **How Humans Affect It** |
| Nitrogen |  |  |  |  |
| Carbon |  |  |  |  |
| Phosphorus |  |  |  |  |
| Sulfur |  |  |  |  |