April 1st

Ecosystems

- Consist of communities of organisms that live in an area and their physical and chemical (abiotic) environment

Ecosystem Ecology

- Includes study of how energy flows among ecosystem components
- How carbon and nitrogen and other key elements cycle through organisms, sediments, the oceans, the atmosphere, how humans affect the environment

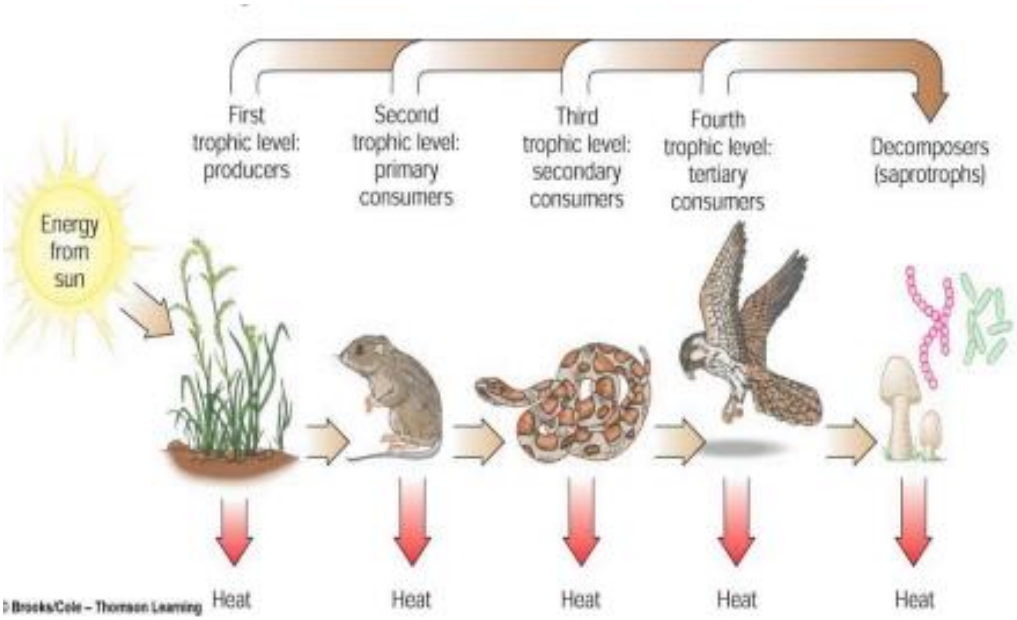
Energy Flow and Trophic Structure

- An ecosystem can be thought of as an economy in which energy is currency
- Links four components:
    - Primary Producers (autotroph) – organism which synthesizes its own food from inorganic material and energy (sun); an autotroph supports an ecosystem by transforming sunlight to chemical energy stored in sugars, used for maintenance, respiration, growth and production
    - Consumers (these become secondary producers)
    - Decomposers
    - Abiotic Environment

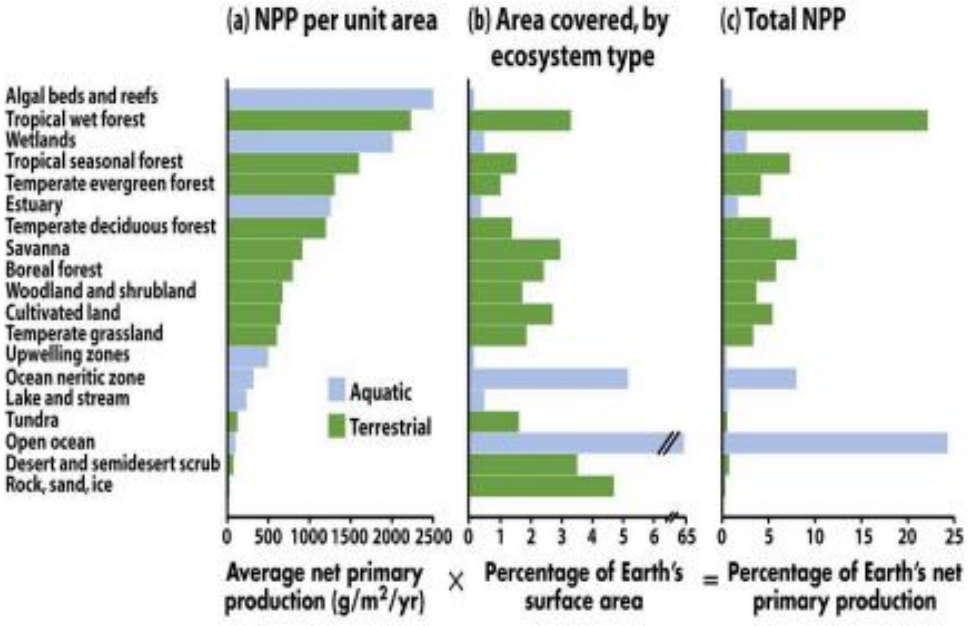
NPP, Consumers and Decomposers

- Gross primary productivity (GPP) is the rate at which photosynthesis captures energy
- After plants and other producers carry out cellular respiration, the energy invested in new tissue is net primary productivity (NPP)
- NPP is the energy available to consumers – organisms that eat other organisms; herbivores eat plants, carnivores eat animals – both lead to net secondary production after metabolism and waste accounted for
- Decomposers or detritivores feed on waste products or the dead remains of other organisms

Energy flow through an ecosystem – only 10% moves to next level



Net Primary Productivity of Ecosystem



What limits the productivity of terrestrial or marine ecosystems?

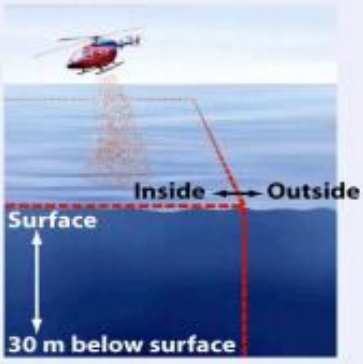
- Terrestrial NPP is the lowest in deserts and arctic regions; their overall productivity is limited by a combination of temperature and the availability of water and sunlight
- Overall productivity of freshwater and marine ecosystems limited by specific nutrients
- **Eutrophication** is caused by an excess of **macronutrients like nitrogen or phosphorus** in lakes, while adding **micronutrients** such as **iron** to oceans could **increase production** and help sequester atmospheric carbon dioxide

Question: Is net primary productivity (NPP) in the open ocean limited by nutrients?

Hypothesis: NPP in the open ocean is limited by availability of iron.

Null hypothesis: NPP in the open ocean is not limited by availability of iron.

Experimental setup:



1. Add 350 kg iron (as $FeSO_4$) to a patch of ocean 8 km × 10 km.

2. Take water samples for a two-week period outside and inside the patch, at surface and a depth of 30 m, and record amount of chlorophyll *a* present (as indicator of NPP).

Prediction: Amount of chlorophyll *a* near the surface inside the patch will increase relative to amounts outside the patch or at 30 m below the surface.
Prediction of null hypothesis: Amount of chlorophyll *a* will be the same in all measurements.

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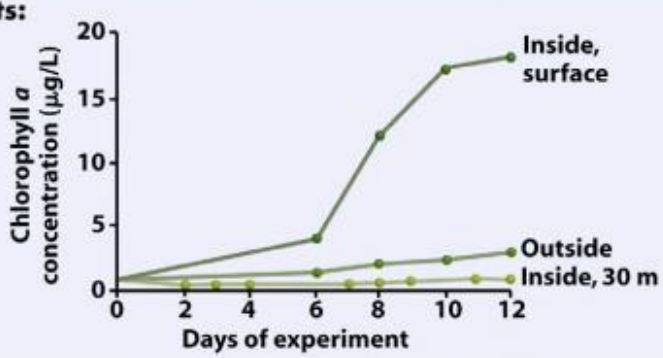
Results:



Conclusion: NPP in the open ocean is limited by the scarcity of nutrients—specifically, iron.

- Suggestion to add iron to open ocean, which would
- Problem: there was a super bloom of a particular microbe, that produced tremendous amounts of methane which caused a spite in global warming which caused extinction of 70% of species

- Pyramids of biomass and energy vary between ecosystems

- Some marine systems have inverted biomass pyramids. Why?
- Reflects fact most oceanic primary producers are microscopic algae which reproduce quickly and are continually consumed so that "standing crop" at any moment is low
- In terrestrial ecosystems, sunlight is fixed; add leaves, fruits which support farmers and consumers helping trophic level
- Biomagnification – one consequence of food chains and the pyramid of biomass and energy that some pollutants (eg. DDT and PBCs: because they have toxicity and they are extremely stable; these are slowly fading away as they get locked up in…) concentrate as they move from lower to higher trophic levels; is seen when dealing with stable toxic molecules

Biogeochemical Cycles in Ecosystems

- Nutrients cycle from organism to organism in an ecosystem
- Humans have impact on many biogeochemical cycles

Factors Controlling rate of nutrient cycling in ecosystems:

- Decomposition of detritus limits rate at which nutrients move through

Boreal Forest: Extensive litter accumulation dead wood and leaves

- 100 foot cores taken from ground and compositions are being measured

Tropical Wet Forest: Almost no litter accumulation

- Usually forests would get nutrients washed out of soil due due all of rain, however tropical rain forests have a very efficient system with rich soil
- Bright red soil means no nutrients (in places like Belize, etc.)

Hubbard Brook, New Hampshire: Excpt' l'ecosystem studied since 1963; six water sheds used to look at process including impact of clear suts on nutrient cycling

- Normal water sheds have spikes on graph; rain and snow contain small amounts of nutrients from car exhaust and other factors; allows soil to erode, and nutrients in soil to erode

Carbon Dioxide – highly tropical

- A key gas which enters plants and forms backbone of organic molecules such as carbohydrates
- Cellular respiration, combustion, and erosion

Carbon cycle – number without circles show size of active carbon pools in 10^15g of carbon

Inject CO2 into sugar solution, it greatly increases acidity

EXAM

Know where big pools of given elements are found (eg. Carbon found in sedimentary rock, inaccessible to most animals and humans)