Ecosystems and Ecosystem Engineering and Management

Important Issues:

- What limits the production in ecosystems?
- How do nutrients move in the ecosystem?
- How does energy move through the ecosystem?

What is meant by ecological engineering?

- Ecological engineering is defined as the design, restoration, or creation of ecosystems, with a strong emphasis on ecosystem self-design and self-organization.
- Ecological engineering involves the design, construction and management of ecosystems that have value to both humans and the environment. It is a rapidly developing discipline that provides a promising technology to solve environmental problems. It involves interactomics, metabolomics, enzyme engineering, architecture etc.

Which animal called ecosystem engineers?

- Animals like squirrels, beavers and elephants are rightly called engineers of their ecosystems since they have been able to sustain their own kind as well as those of several wild cohabitants. Ecosystem engineers are therefore also included within the list of notable keystone species.

What are the benefits of ecological engineering?

- By understanding systems ecology the ecological engineer can more efficiently design with ecosystem components and processes within the design, utilize renewable energy and resources, and increase sustainability.
- Systems engineering ecology is an approach to ecosystem study based on formal procedures of systems thinking, synthesis, and modeling. Its goals are : develop and test theory of ecosystem organization; detect and manage emergent properties; and predict responses to disturbance.

- The interaction among different ecosystem engineers is an important issue, and introduces new aspects not explicitly found in the single-species systems, and in the biotic interactions that have formed the core of much ecological thinking. Here, especially if several species can and do affect the physical environment in different ways,. new kinds of dynamics and interactions emerge because species are interacting with each other potentially on the longer timescales and broader spatial scales that are typical of ecosystem engineers. As analyzed by Oren et al. (2007), one sees that the complications induced by interactions among ecosystem engineers can lead to much more complex behavior than normal. Here the emphasis is both on active management, and also on the understanding of ecosystem processes. It is clear that the analysis of the ecosystem dynamics would be impossible without explicit inclusion of the biosystem engineering aspects,.

Ecosystem

- All the organisms in a community plus abiotic factors
  - Ecosystems are transformers of energy & processors of matter
- Ecosystems are self-sustaining
  - what is needed?

- capture energy
- transfer energy
- cycle nutrients

- Ecosystem management employs a holistic approach to manage the natural resources and ecological processes that serve our social, economic and cultural values. It relies on science and engineering based approaches to address ecosystem stresses and changing ecosystem components and processes at multiple scales over time.
- Adaptive management, strategic management and landscape and other species based conservation are different methodologies and processes involved in implementing ecosystem engineering and management.

- An ecosystem (or ecological system) is a large community of living organisms (plants, animals and microbes) in a particular area. The living and physical components are linked together through nutrient cycles and energy flows. Ecosystems are of any size, but usually they are in particular places.

Benefits of Ecosystem

- Ecosystem services are the benefits people receive from nature. These include clean drinking water and sustainably harvested forest products to nature-based tourism. They also include the sense of home that communities find in rural landscapes and the values that world places on conserving biodiversity.

- **Ecosystems have a critical role in regulating climate, and soil, water and air quality, but management to change an ecosystem process in support of one regulating ecosystem service can either provide co-benefits to other services or can result in trade-offs.**

Which Indian village lives with snakes?

- Shetpal is a village, where snakes have no restriction in their movement and none of the 2,600 plus villagers ever harm them in any way. However, about 200 km from Pune, Maharashtra, in the Sholapur district, is located a village named Shetpal.

Snakes are no doubt very dangwerous and one should be careful of the snakes. Shetpal

- What ecosystems are most at risk?
- Forests, tundras, and alpine areas are some of the world's most at-risk ecosystems to climate change, according to a new map published in the journal Nature.
- Snakes are friends of farmer but not always?
- Rice field water - Snakes

What are the five threats to the ecosystem?

- Bycatch – useless catch of fishing.
- Deforestation and Forest Degradation.
- Effects of Climate Change.
- Illegal Fishing.
- Illegal Wildlife Trade - Cheetahs
- Oil and Gas Development.
- Overfishing And Pollution.

How does ecosystem disruption affect humans?

- Changes to Earth's natural systems affect the quality of the water we drink and the air we breathe by multiple mechanisms and impact our vulnerability and exposure to natural hazards. We know that these changes are pervasive, affecting nearly every natural system on Earth and that they are accelerating.

Energy

- Ecosystems are stable, but changeable. They react to major changes in the environment, especially climate changes. For example, the major rainforests have lasted for a long time (perhaps 50 million years or more in some cases).
- Global warming – Forest fires, Floods, Stoms, Tsunami, Volcanoes, Cyclones, Epidemics, Draughts, Heat waves.

Why do ecosystems matter to human health?

- Nature provides us with water, clean air and food, and raw materials for medicines, industry and buildings. Our crops rely on insect pollination and the complex biological processes that create soil. Enjoying parks, landscapes and wildlife improves our health and well-being.
- Human biology has a fundamental need for food, water, clean air, shelter and relative climatic constancy.

- As the rainfall and temperature changes, they change. We know that the Amazon rainforest shrank in size during ice ages, and expanded in the warmer periods.
- What drives all ecosystems is the primary production. Primary production is the production of organic matter from inorganic carbon sources.

- This happens through photosynthesis. It drives the carbon cycle, which influences global climate via the greenhouse effect.

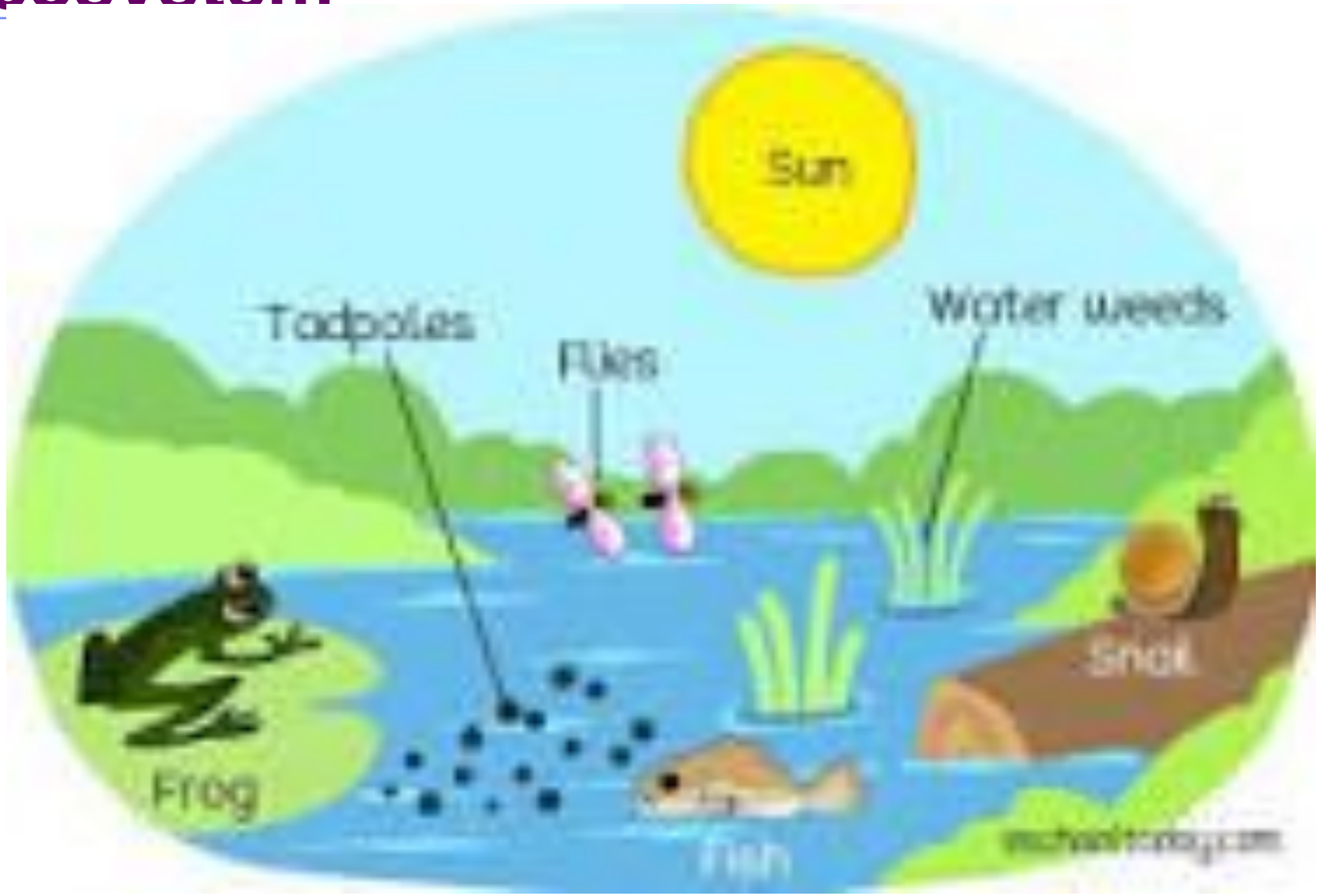
- Through the process of photosynthesis, plants capture energy from sunlight and use it to combine carbon dioxide and water to produce carbohydrates and oxygen.

- The photosynthesis carried out by all the plants in an ecosystem is called the gross primary production (GPP).

- About 48–60% of the GPP is consumed in plant respiration. The rest is known as the net primary production (NPP).

- Total photosynthesis is limited by a range of environmental factors. These include the amount of light available,some light is reflected back, the amount of leaf area a plant has to capture light (shading by other plants limits photosynthesis), the supply of carbon dioxide and water, and suitable temperatures for carrying out photosynthesis. Allelopathy.

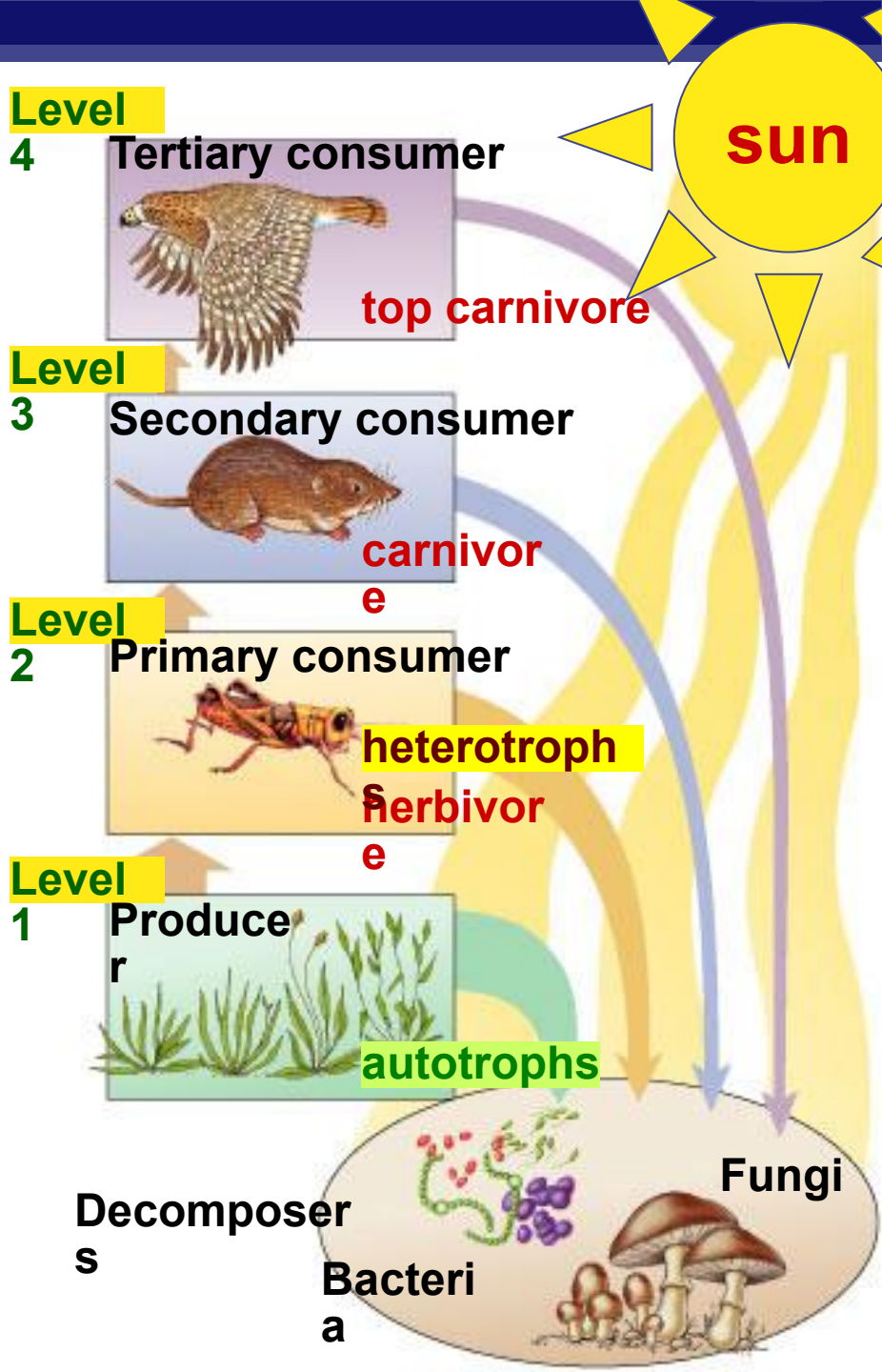
Ecosystem



- Each ecosystem has its own community. An aquarium community, for example, can have small fish and other organisms. A desert community may have cacti, small snakes, lizrds, and scorpions.
- Algal blooms- cyanobacteria, diatoms (Microakgae having Silicon),
- CCM - pyrenoids- chloroplasts tobacco – Arabidopsis- Chlamydomonas – Drosophila - guinea pig- monkey,.

Food chains

- Trophic levels
  - feeding relationships
  - start with **energy from the sun**
  - captured by **plants**
    - 1st level of all food chair
  - food chains usually gc up only 4 or 5 levels
    - inefficiency of energy transfer
  - all levels connect to **decomposers**



Inefficiency of energy transfer

sun

- Loss of energy between levels of food cha
  - To where is the energy lost? The cost of living!

17% growth

only this energy moves ~~on to~~ the next level in the food chain

33% cellular respiration

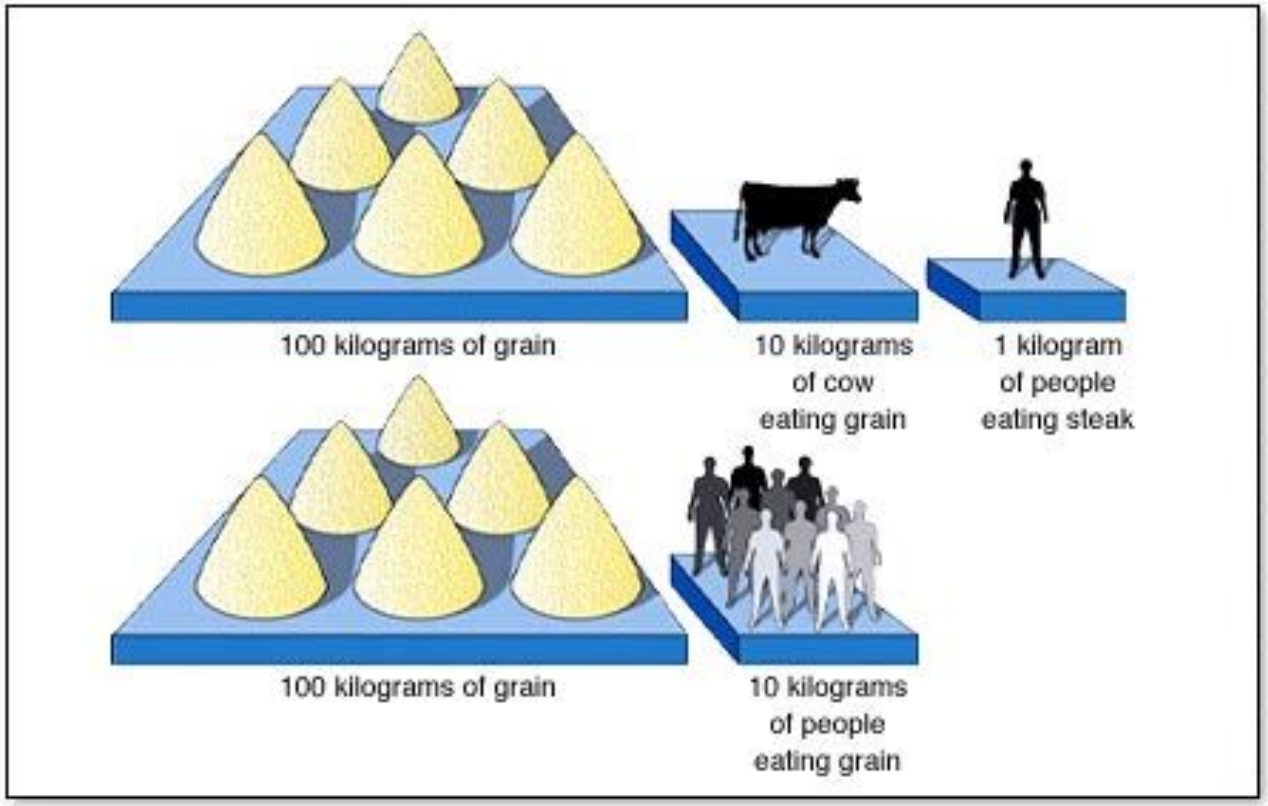
50% waste

energy lost to daily living

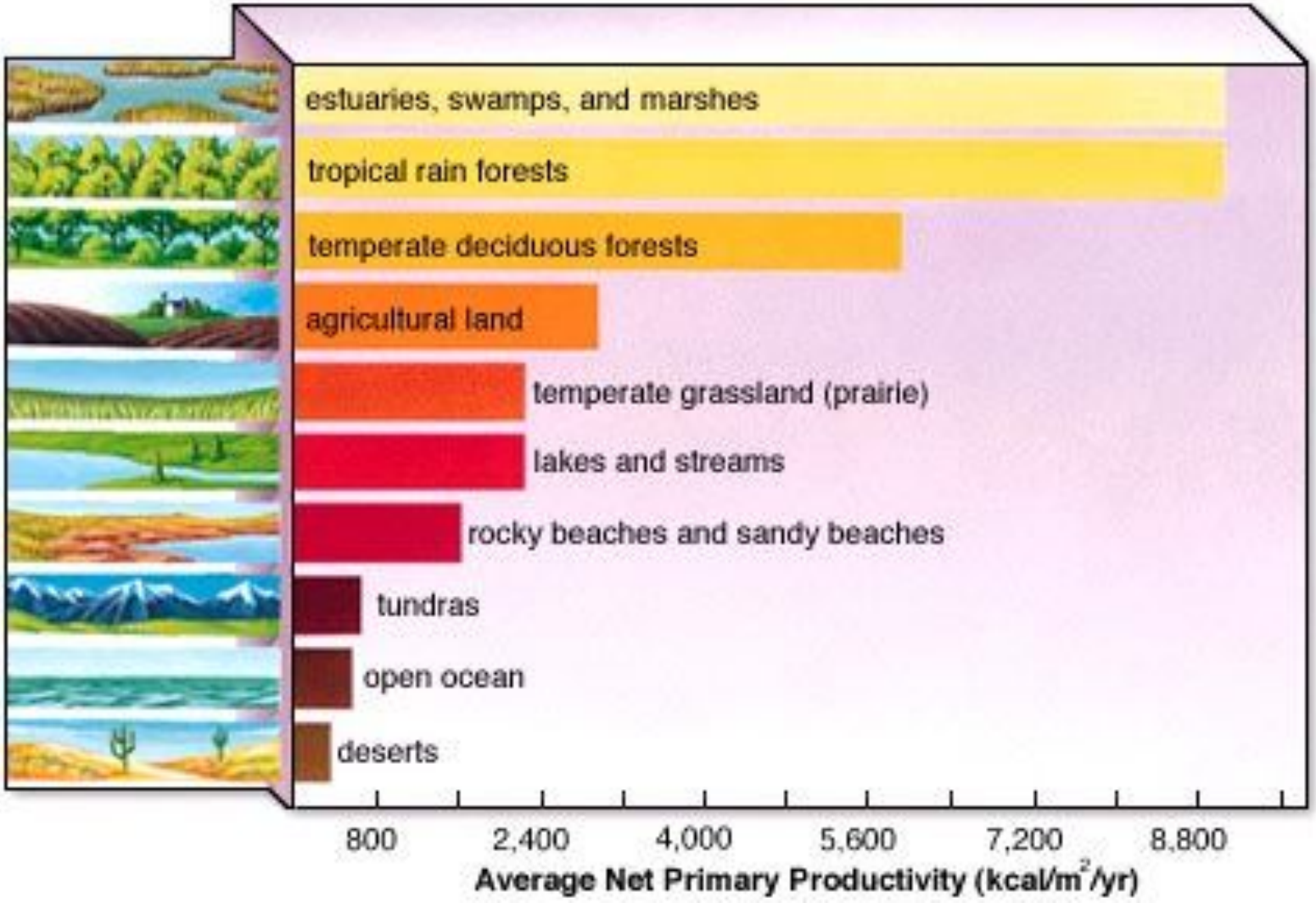
Humans in food chains

- **Energy dynamics of ecosystems have important implications for human populations**
  - **How much energy is available if we are:**
    - **carnivores? vegetarians?**

Seems to be easier/cheaper to support a large population on grain than on beef!



- **Ecosystems with greater productivity have more sunlight, water and nutrients.**



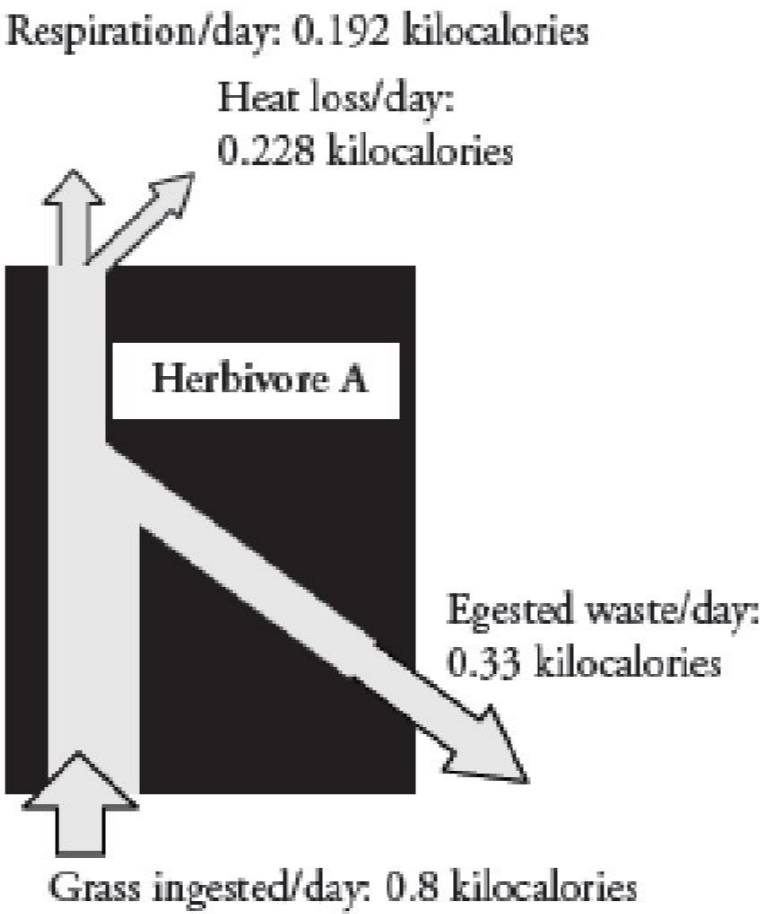
What you need to be able to do:

- Using the laws of conservation of matter and energy to do some basic accounting and determine different aspects of energy and matter usage in a community.

- Remember: Inputs have to equal outputs

Sample problem #1

- Total energy output?
  - .75 kcal
- How much is used to build biomass or *Secondary Production*?
  - .05 kcal
- What % is <u>not</u> being efficiently used for biomass?
  - 93%



Sample problem #2

- A caterpillar consumes 100 kcal of energy. It uses 35 kcal for cell respiration, and loses 50 kcal as waste. ***Determine the trophic efficiency for its creation of new biomass.***
  - Total energy consumed = 100 kcal
  - Lost and Respired: 35 + 50 = 85 kcal
  - Total energy for growth: 15 kcal
- Efficiency (%) = 15/100 = .15 or 15%

Generalized Nutrient cycling

Decomposition connects all trophic levels

consumers

producers

decomposers

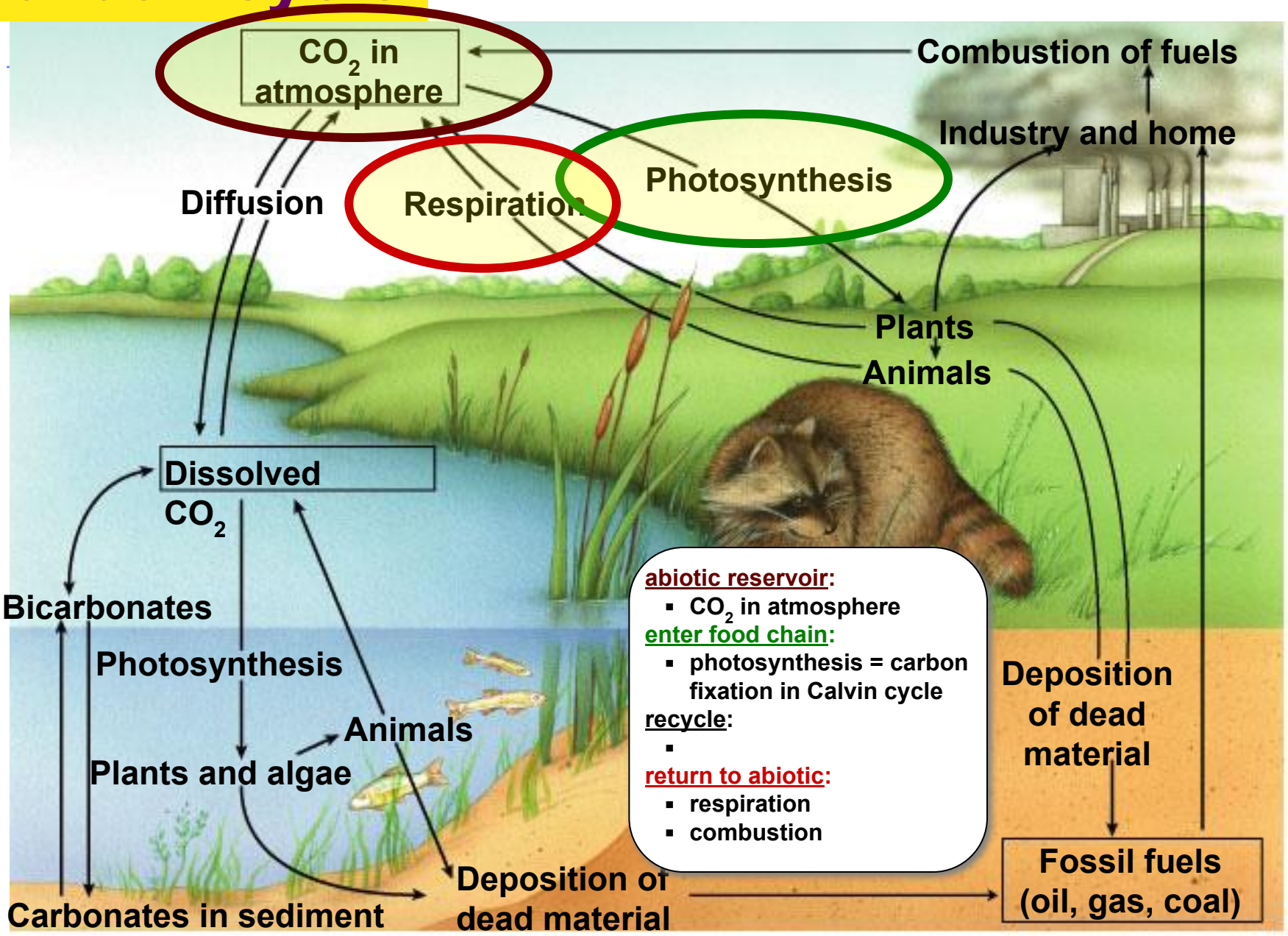
nutrients
ENTER FOOD CHAIN
= made available to producers

return to abiotic reservoir

abiotic reservoir

geologic processes

Carbon cycle



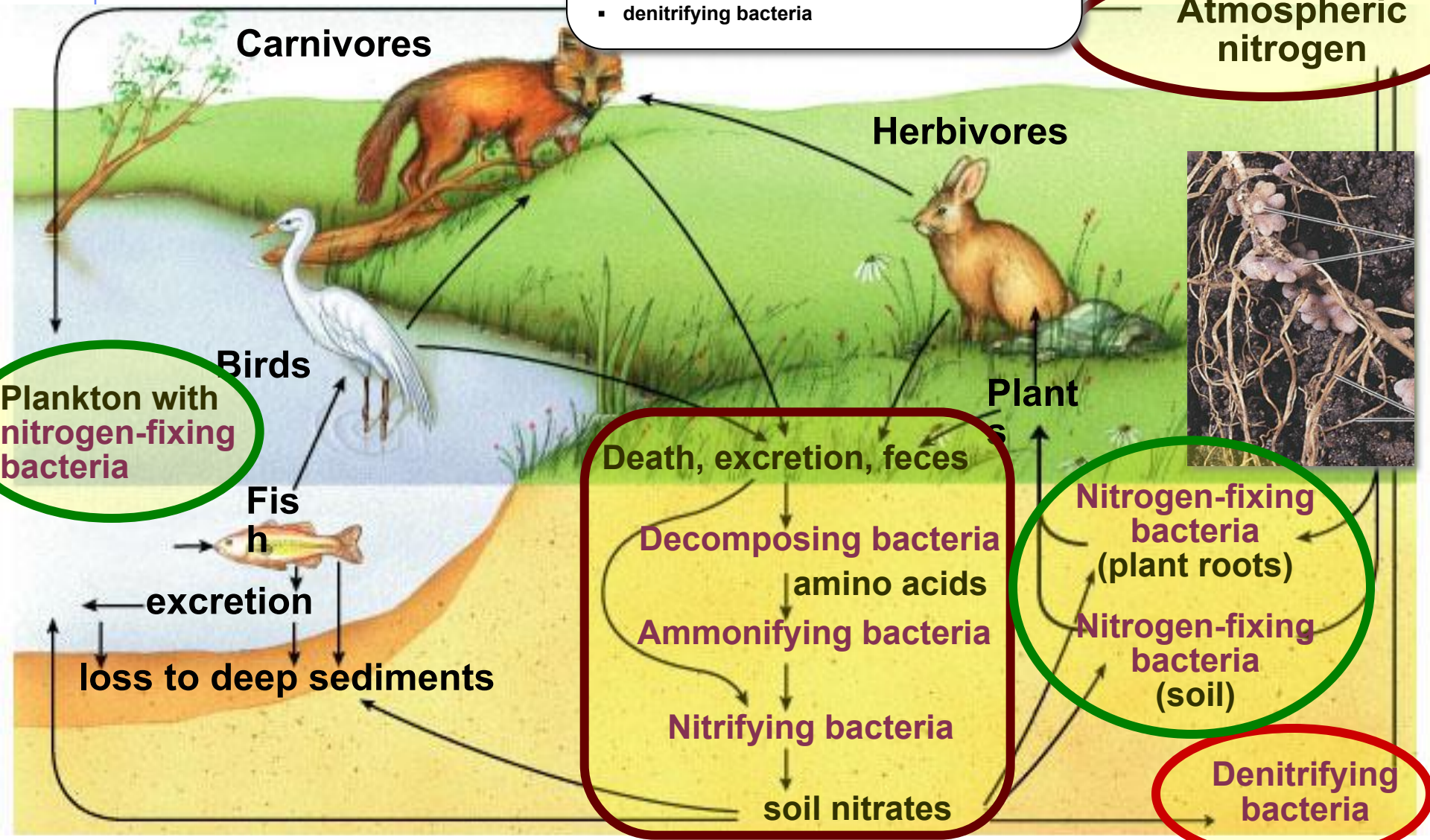
Nitrogen cycle

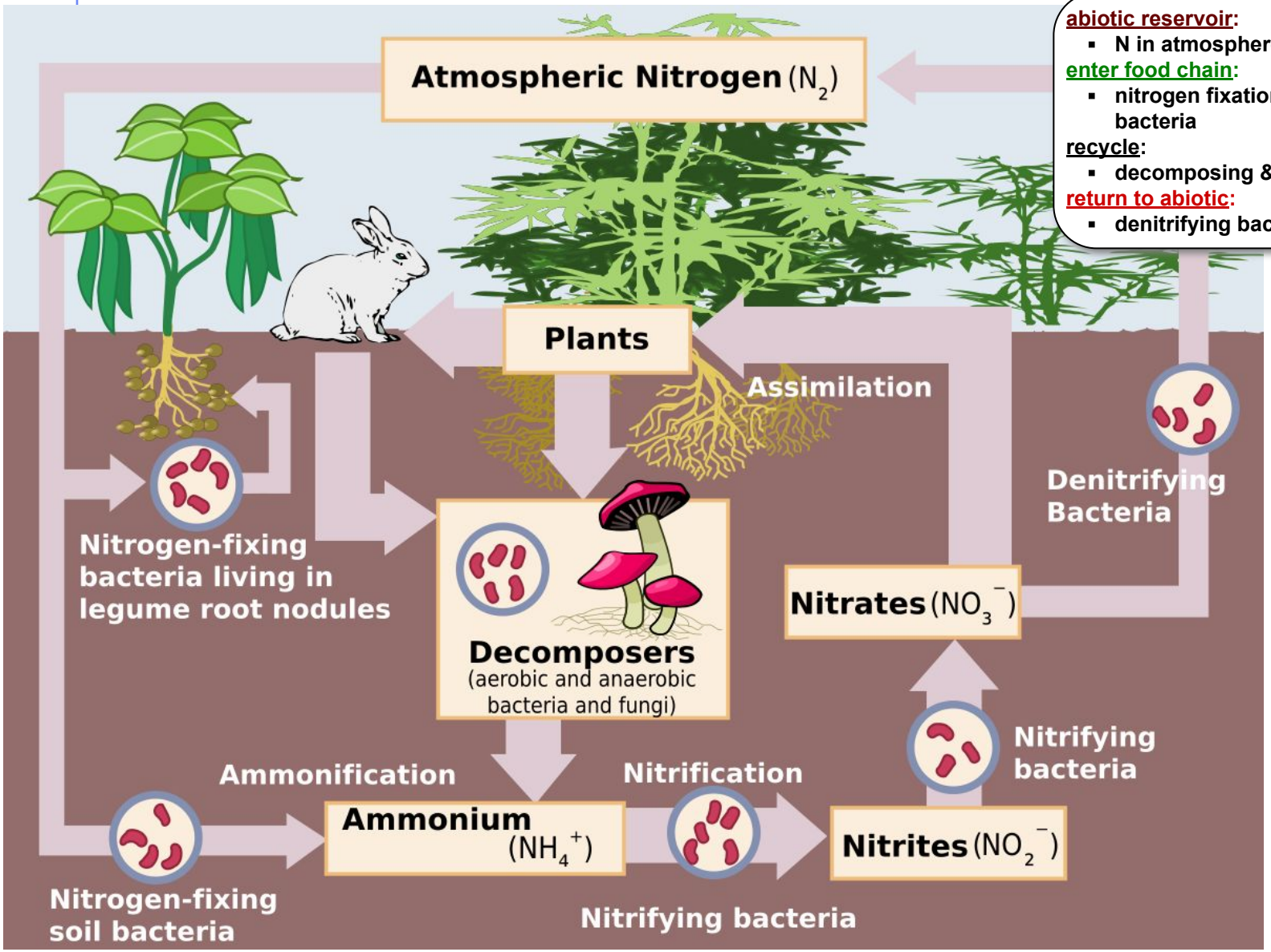
abiotic reservoir:
- N in atmosphere

enter food chain:
- nitrogen fixation by soil & aquatic bacteria

recycle:
- decomposing & nitrifying bacteria

return to abiotic:
- denitrifying bacteria





abiotic reservoir:
- N in atmosphere

enter food chain:
- nitrogen fixation by soil & aquatic bacteria

recycle:
- decomposing & nitrifying bacteria

return to abiotic:
- denitrifying bacteria

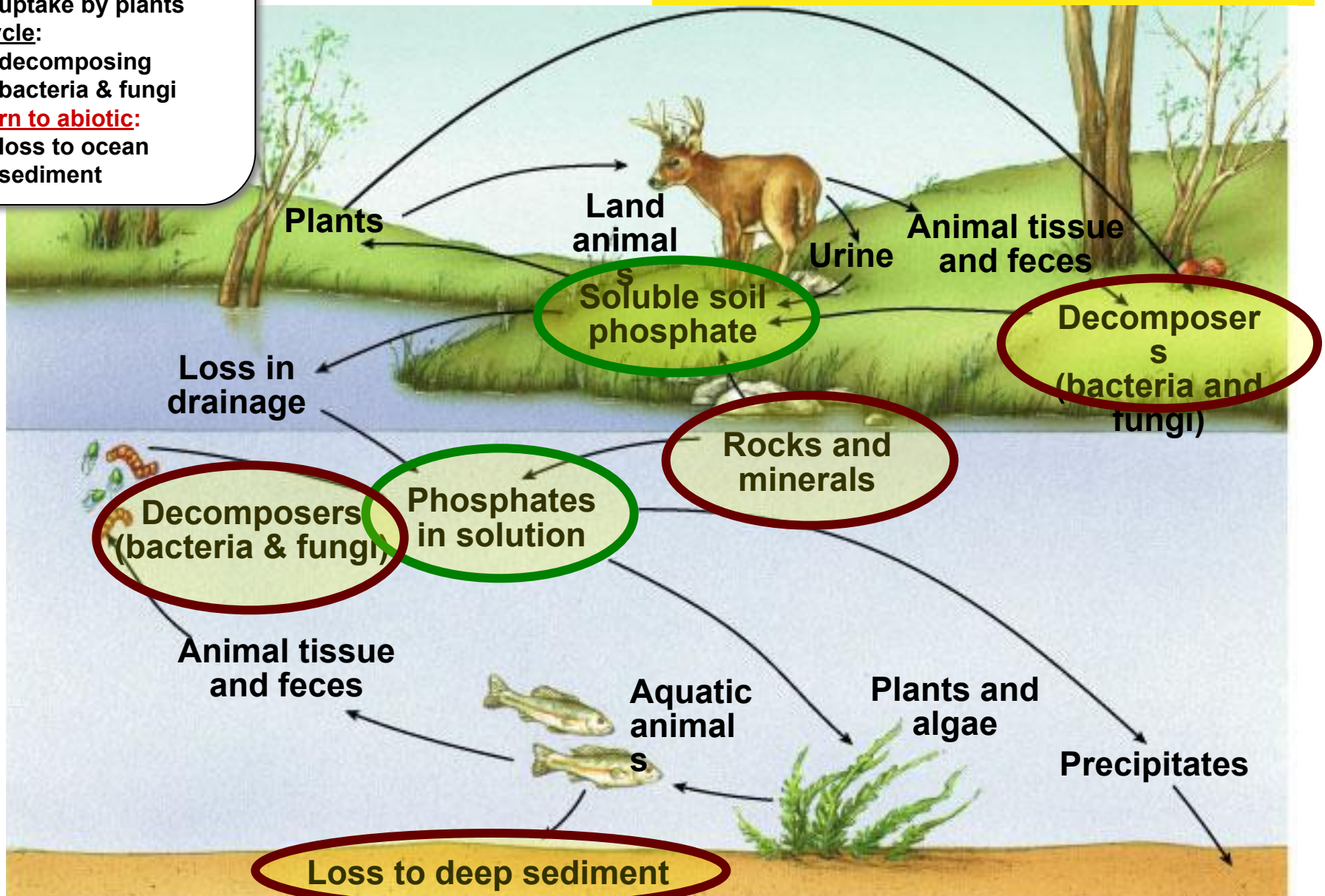
Phosphorus cycle

abiotic reservoir:
- rocks, minerals, soil

enter food chain:
- erosion releases soluble phosphate
- uptake by plants

recycle:
- decomposing bacteria & fungi

return to abiotic:
- loss to ocean sediment



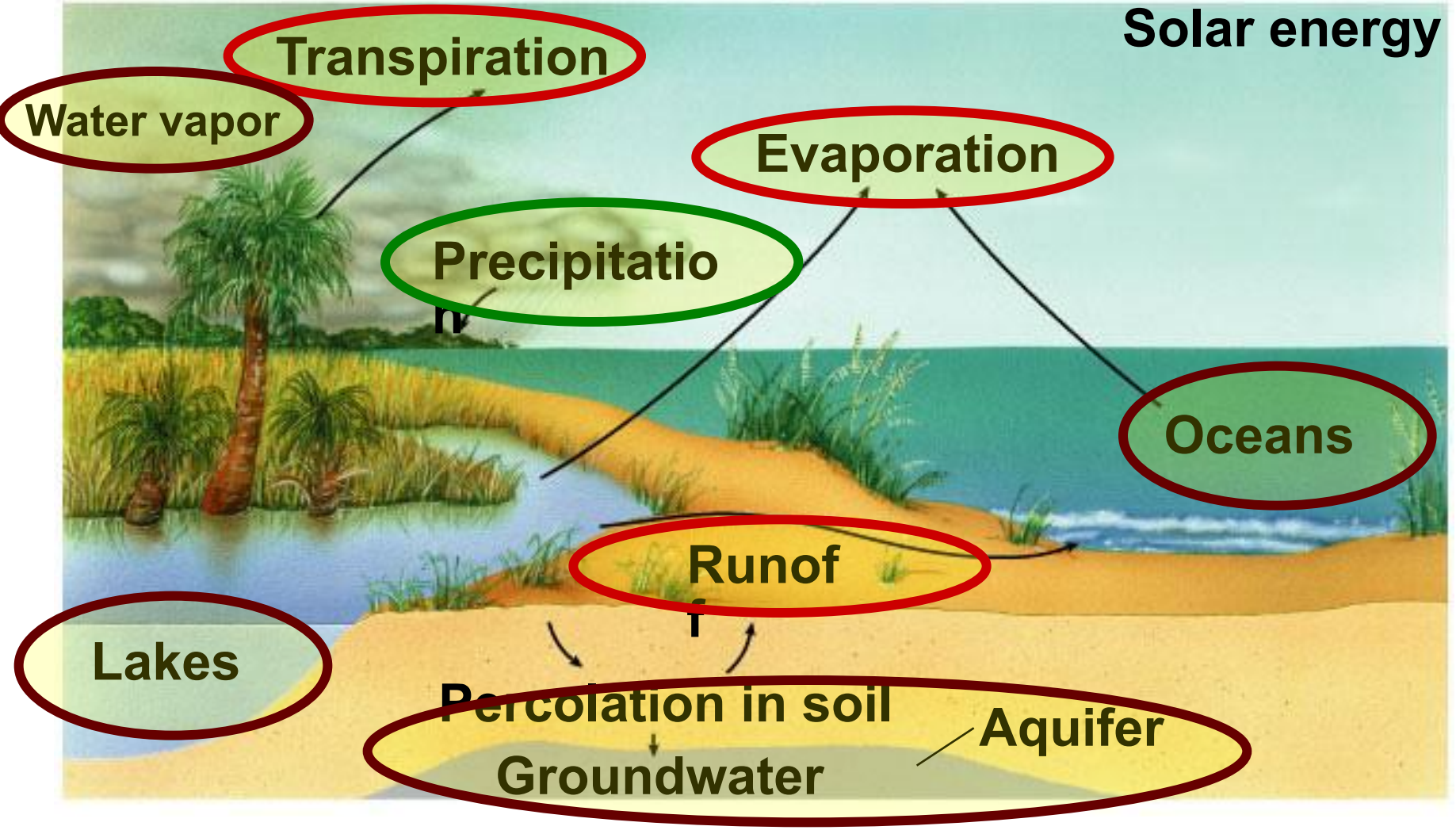
Water cycle

abiotic reservoir:
- surface & atmospheric water

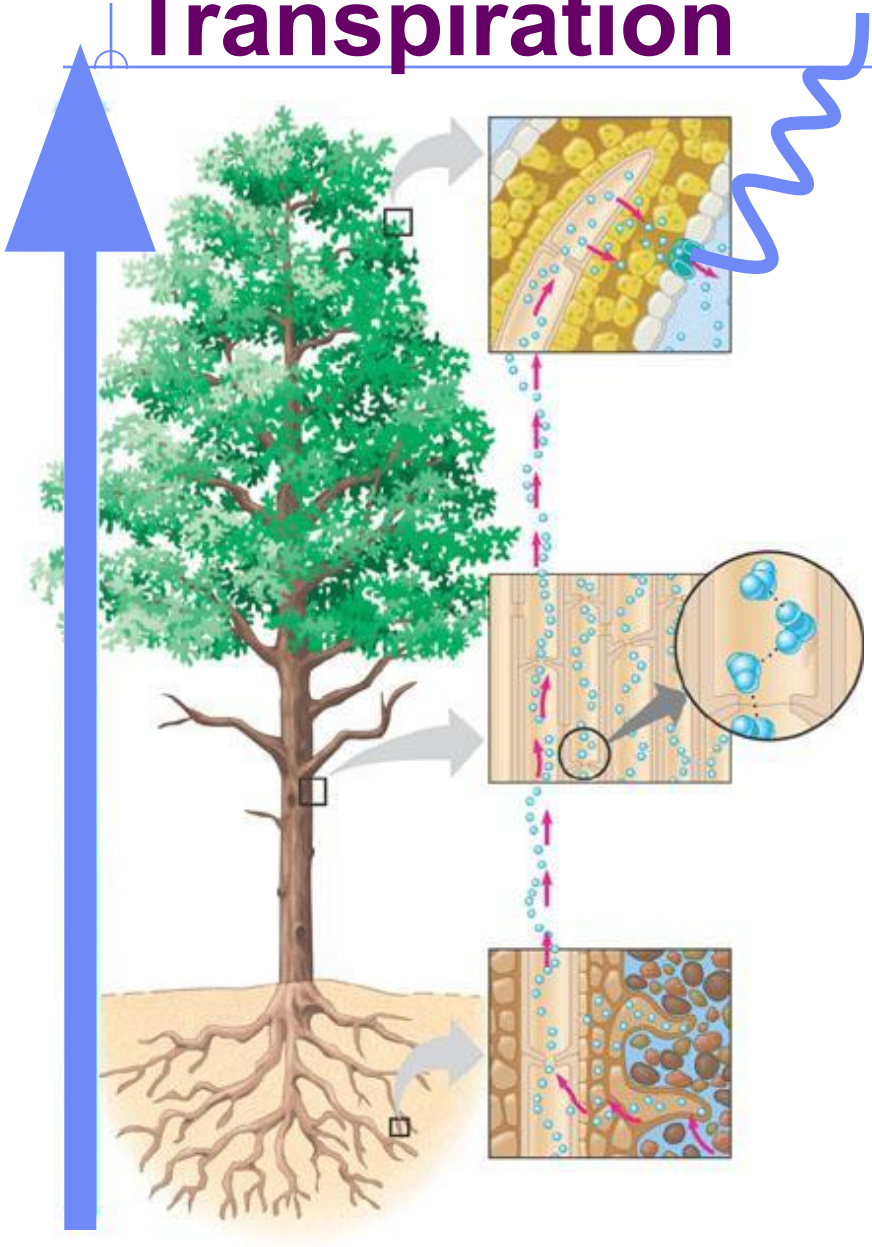
enter food chain:
- precipitation & plant uptake

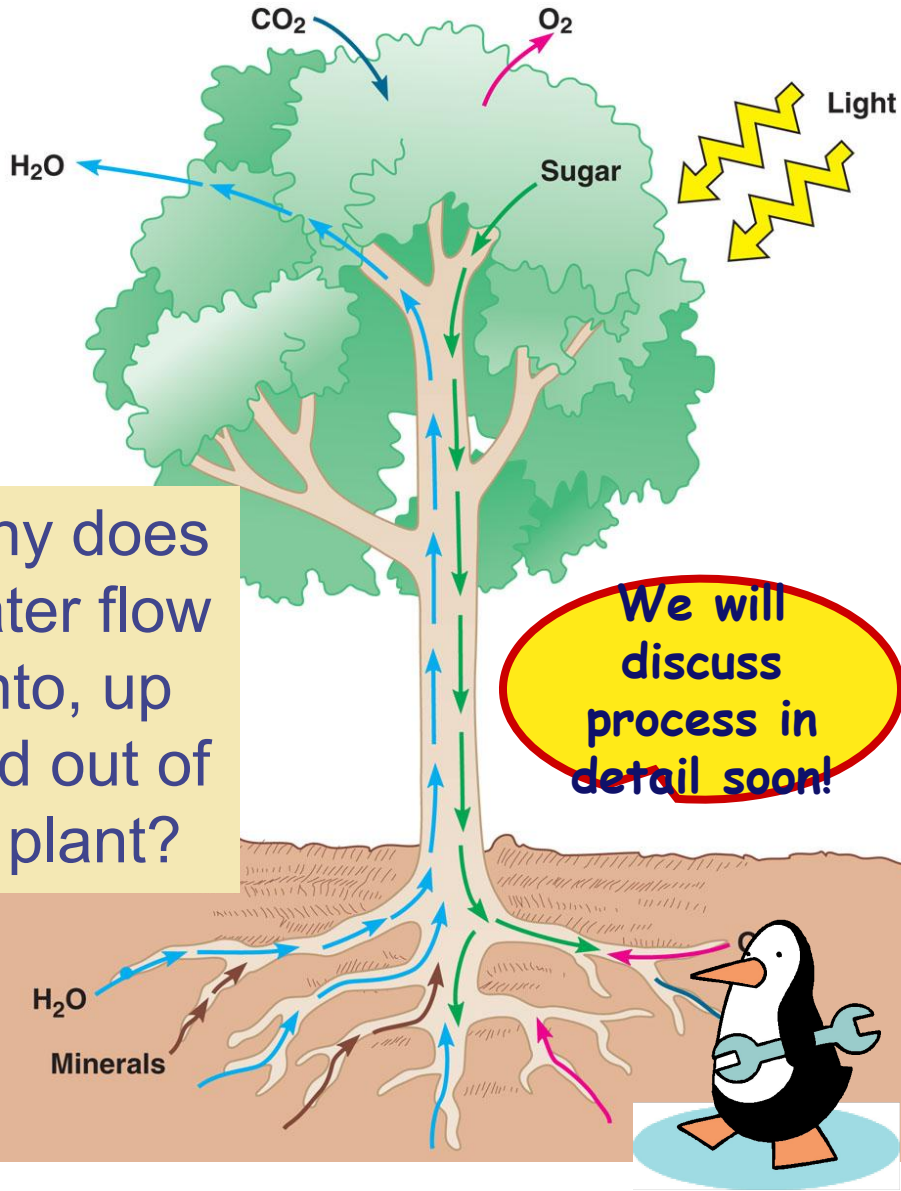
recycle:
- transpiration

return to abiotic:
- evaporation & runoff



Transpiration





Why does water flow into, up and out of a plant?

We will discuss process in detail soon!

Breaking the water cycle

- Deforestation breaks the water cycle
  - groundwater is not transpired to the atmosphere, so precipitation is not created

forest → desert

desertification

Types of Ecosystems

- What are the different types of ecosystems?
- Terrestrial ecosystem. Forest ecosystem. Grassland ecosystem. Desert ecosystem. Tundra ecosystem.
- Aquatic ecosystem. Freshwater ecosystem. Marine ecosystem.
- Artificial or Man made ecosystems
- Disturbed ecosystem
- Aerial ecosystem (eg. trees). Birds, bats, and insects are only a few of the species
- Planetary ecosystem - The various forms of energy and matter that constitute a given planet interact on a continual basis. etc.etc.

Some of the major types of ecosystem:

- Aquatic ecosystem
- Marine ecosystem
- Freshwater ecosystem
- Lake ecosystem
- River ecosystem
- Wetland, Terrestrial ecosystem, Forest

- https://www.google.com/search?q=Ecosystem+video&sca_esv=3792e63440ca6429&biw=1067&bih=449&sxsrf=AHTn8zo8_fdixXUDnrXWN2lQ50y_NTmRFg%3A1742700090544&ei=On7fZ9b6lNuVseMPhJCpsAw&ved=0ahUKEwjW_-Len5-MAxXbSmwGHQRlCsYQ4dUDCBA&uact=5&oq=Ecosystem+video&gs_lp=Egxnd3Mtd2l6LXNlcnAiD0Vjb3N5c3RlbSB2aWRlbzILEAAYgAQYkQIYigUyCxAAGIAEGJECGIoFMgUQABiABDIKEAAYgAQYFBiHAjIFEAAYgAQyBRAAGIAEMgUQABi

- https://www.youtube.com/watch?v=KQF9WdZrH_c
- https://www.youtube.com/watch?v=dTaWsFct32g

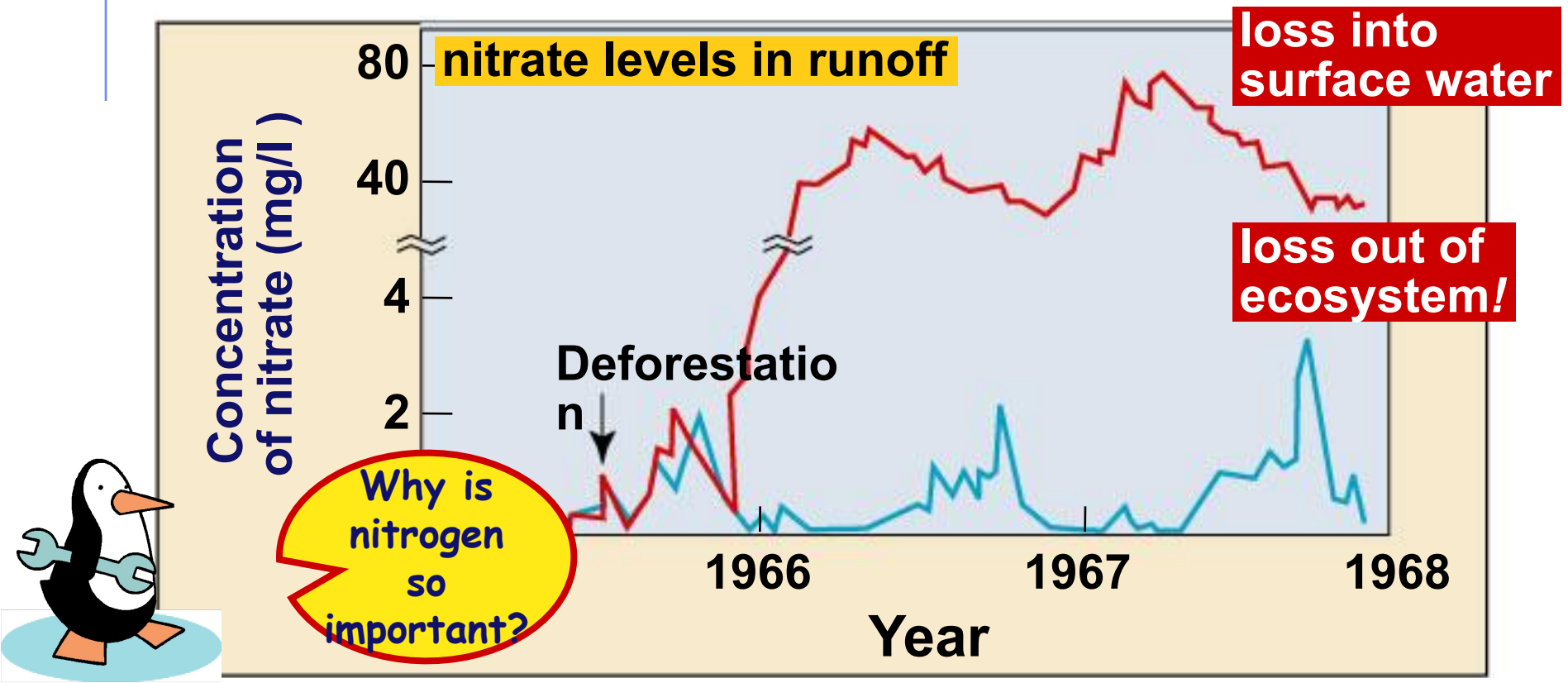
- Rain Forest
- Greater Yellowstone Ecosystem
- Littoral zone
- Riparian zone
- Desert
- Grassland
- Tundra - Treeless
- Taiga – Snow forests

Effects of deforestation

40% increase in runoff

- loss of water

- 60x loss in nitrogen
- 10x loss in calcium



Advanced Ecology

Synecology – Study of many species in an ecosystem.

Autoecology – Study of single organisms or populations of single species and their relationship with environment, e.g., single lion in a bush. Its food, shelter, predators, reproduction, competitors.

However in the field :

Eagles in air

Monkeys/ baboons on trees

Crocodiles and sharks in water .

Hunters in forests

Tigers as challengers

Pythons and cobras.

Auroecology – Examples :
In brief, lizards, crocodiles and several other reptiles can hatch their eggs and sex of the baby is determined by the temperature at the time of hatching. Best and classical example is provided by the Darwin's finches of Galapagos Island.

Humans often introduce new species into areas where their niches are already occupied by native species. This may occur intentionally or by accident..

Consider the example of kudzu. Kudzu is a Japanese vine that was introduced intentionally to the southeastern United States in the 1870s to help control soil erosion. The southeastern United States turned out to be a perfect habitat for kudzu because it has no natural enemies there. As a result, kudzu was able to outcompete native species of vines and take over their niches.

What is an ecosystem in technology management?

Ecosystem management

Ecosystem management is an approach to natural resource management that aims to ensure the long-term sustainability and persistence of an ecosystem's function and services while meeting socioeconomic, political, and cultural needs.

AI based Ecosystem models can be used for understanding general phenomena of evolution, ecology, and ethology (study of human behaviour and social organization).

Such systems can be used for analyzing and predicting the ecological consequences of human activities on specific ecosystems, e.g., the effects of agriculture, forestry, construction, hunting and fishing.

Reference :

Claes Strannegård, Niklas Engsner, Jesper Eisfeldt and John A Endler, Ecosystem Models Based on Artificial Intelligence July 2022,Proc. Conference: Swedish AI Society SAIS-22.https://www.researchgate.net/publication/361925258_Ecosystem_Models_Based_on_Artificial_Intelligence, Accessed on April 02, 2024.

What is complexity in an ecosystem?

“

Ecological complexity refers to the complex interplay between all living systems and their environment, and emergent properties from such an intricate interplay. The concept of ecological complexity stresses the richness of ecological systems and their capacity for adaptation and self-organization.
The tropical rainforest is the most complex ecosystem in the world as it consists of a large number of plant and animal species that vary among each other. They are biodiversity hotspots due to the presence of the suitable environmental conditions for the growth of a large number of primary producers.

Wetlands are highly complex ecosystems due to interacting effects of physical, chemical and biological processes that influence output water quality. From: Environmental Science and Ecotechnology, 2020.

The Ocean is the planet's largest ecosystem, regulating the climate, and providing livelihoods for billions. But its health is in danger.

What is the future of our ecosystem?

Besides drought and sea level rise, there are a variety of other likely changes around the world. There might be intense heat waves, increased incidences of infectious and respiratory diseases, changes in ecosystems particularly at high latitudes, and loss of biodiversity ... just to name a few.

Over 50% of commercially available drugs are based on bioactive compounds extracted (or patterned) from non-human species, including some lifesaving medicines such as cytarabine, derived from a Caribbean sponge, which is reputed as the single most effective agent for inducing remission in acute myelocytic leukemia .

Ecosystem Services are the direct and indirect contributions ecosystems (known as natural capital) provide for human wellbeing and quality of life. This can be in a practical sense, providing food and water and regulating the climate, as well as cultural aspects such as reducing stress and anxiety.