

Ch. 41 Warm-Up

1. Draw an energy pyramid and label the following trophic levels:
 - Primary producer
 - Primary consumer
 - Secondary consumer
 - Tertiary consumer
2. What is an example of an organism at each level of the pyramid in #1?
3. If 5000 J of energy is available in producers, how much of that energy would be available to tertiary consumers?

Define the following terms:

- Autotroph
- Heterotroph
- Detritivore
- Gross primary production (GPP)
- Net primary production (NPP)
- Biogeochemical cycle
- Nitrogen fixation

Chapter 42: Ecosystems and Energy



You Must Know:

- How energy flows through the ecosystem (food chains and food webs)
- The difference between gross primary productivity and net primary productivity.
- The carbon and nitrogen biogeochemical cycles.

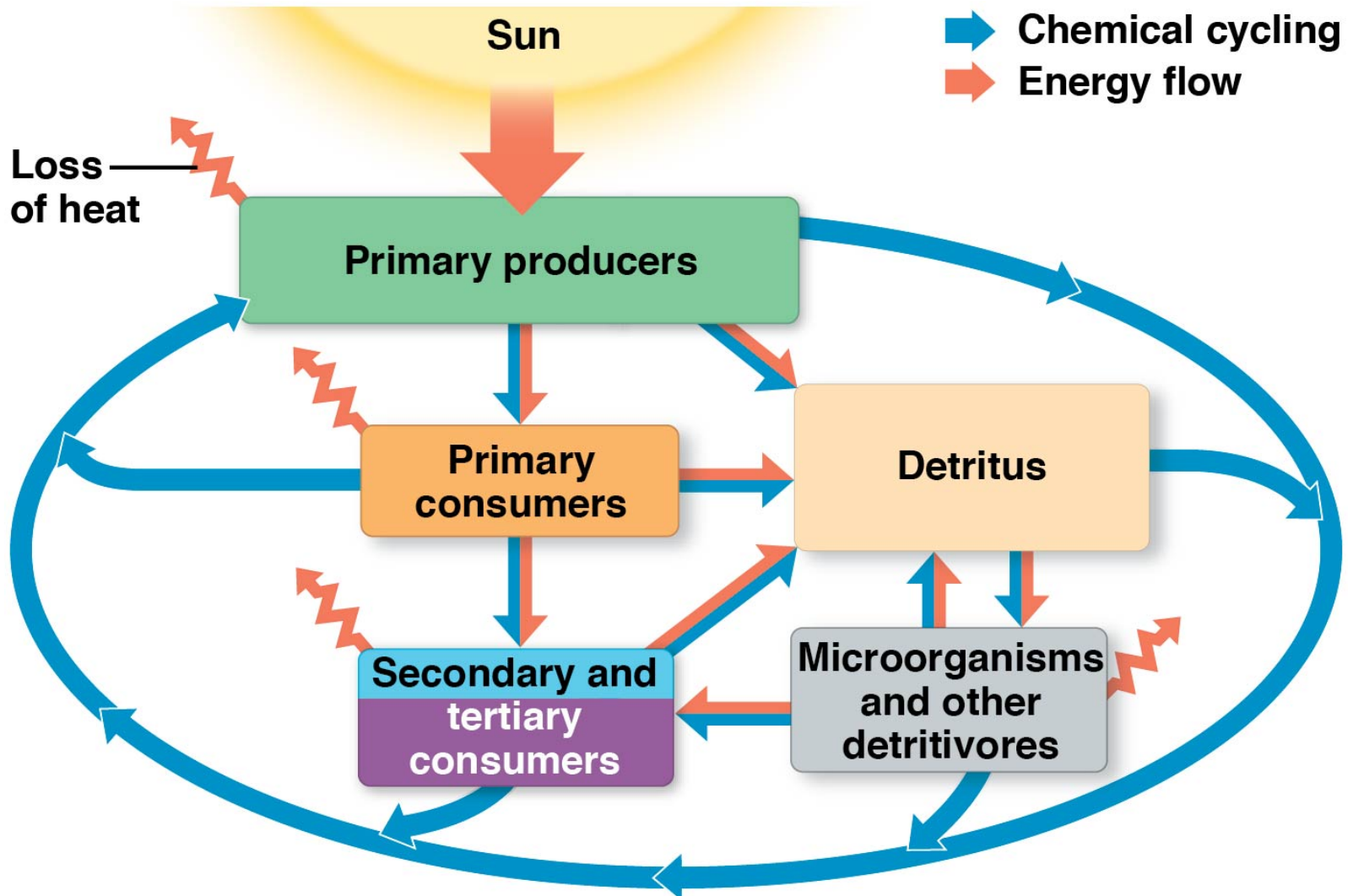
Ecosystems

Ecosystem = sum of all the organisms living within its boundaries (biotic community) + abiotic factors with which they interact

Involves two unique processes:

1. Energy flow
2. Chemical cycling

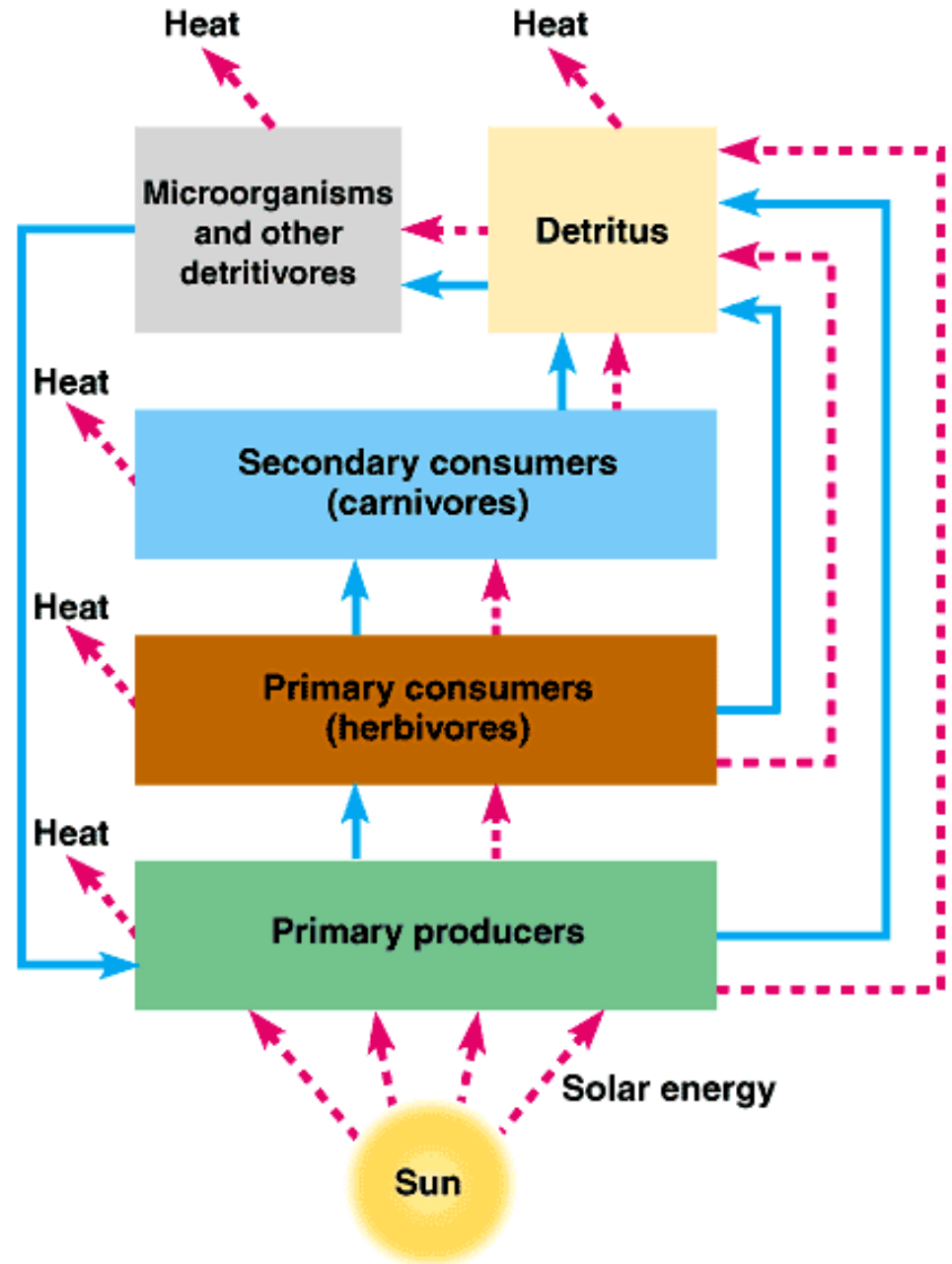
Overview of energy & nutrient dynamics



Energy Flow in an Ecosystem

- **Energy cannot be recycled** → must be constantly supplied to an ecosystem (mostly by **SUN**)
- The **autotrophs** (“self feeders”) are the **primary producers**, and are usually photosynthetic (plants or algae).
 - They use light energy to synthesize sugars and other organic compounds.
- **Heterotrophs** (“other feeders”) – can’t make own food

- **Heterotrophs** are at trophic levels above the primary producers and depend on their photosynthetic output.



- Herbivores that eat primary producers are called **primary consumers**.
- Carnivores that eat herbivores are called **secondary consumers**.
- Carnivores that eat secondary consumers are called **tertiary consumers**.
- Another important group of heterotrophs is the **detritivores**, or **decomposers**.
 - They get energy from detritus, nonliving organic material, and play an important role in material cycling.

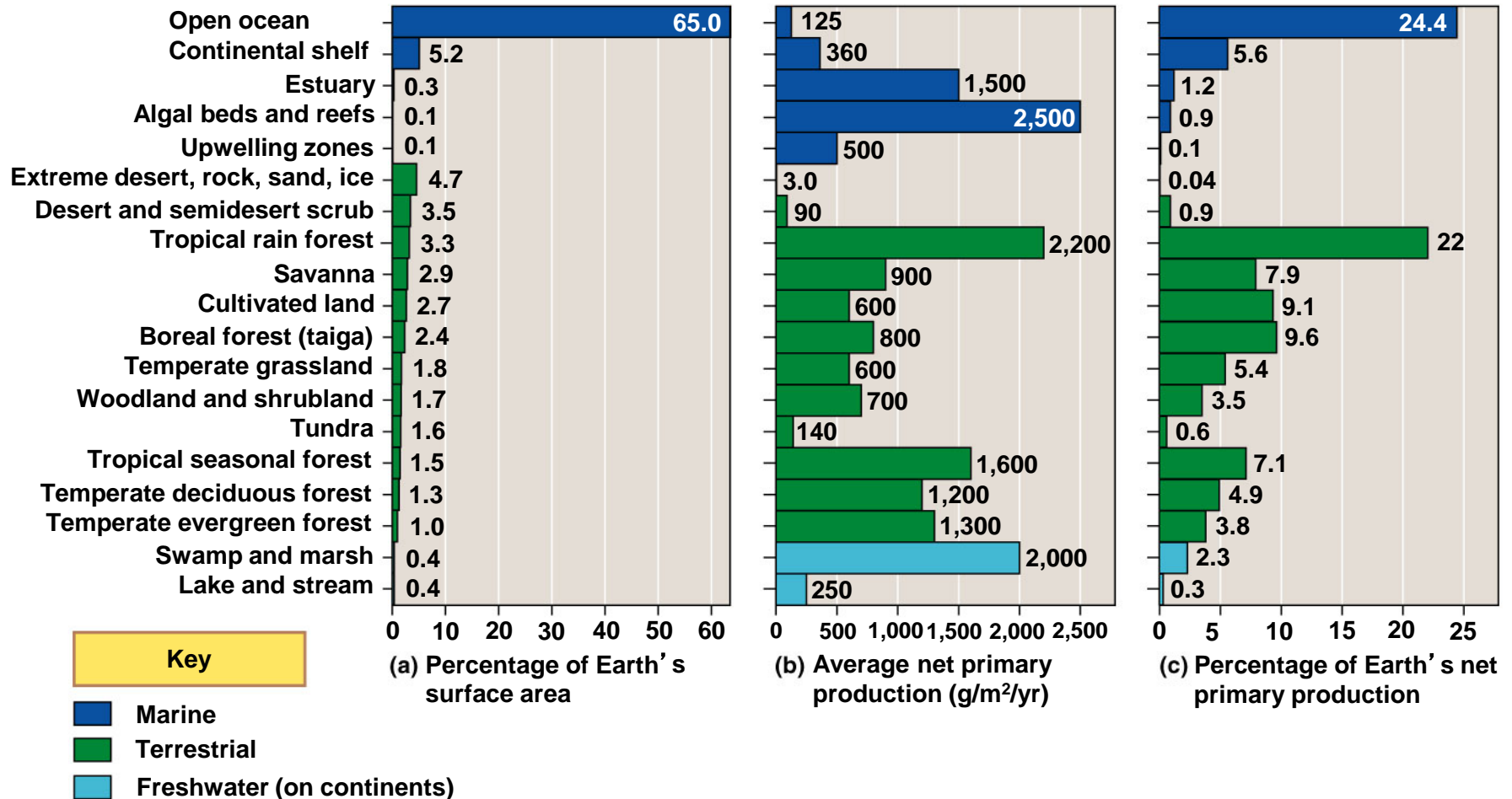
Main decomposers =
fungi & prokaryotes



Primary Production

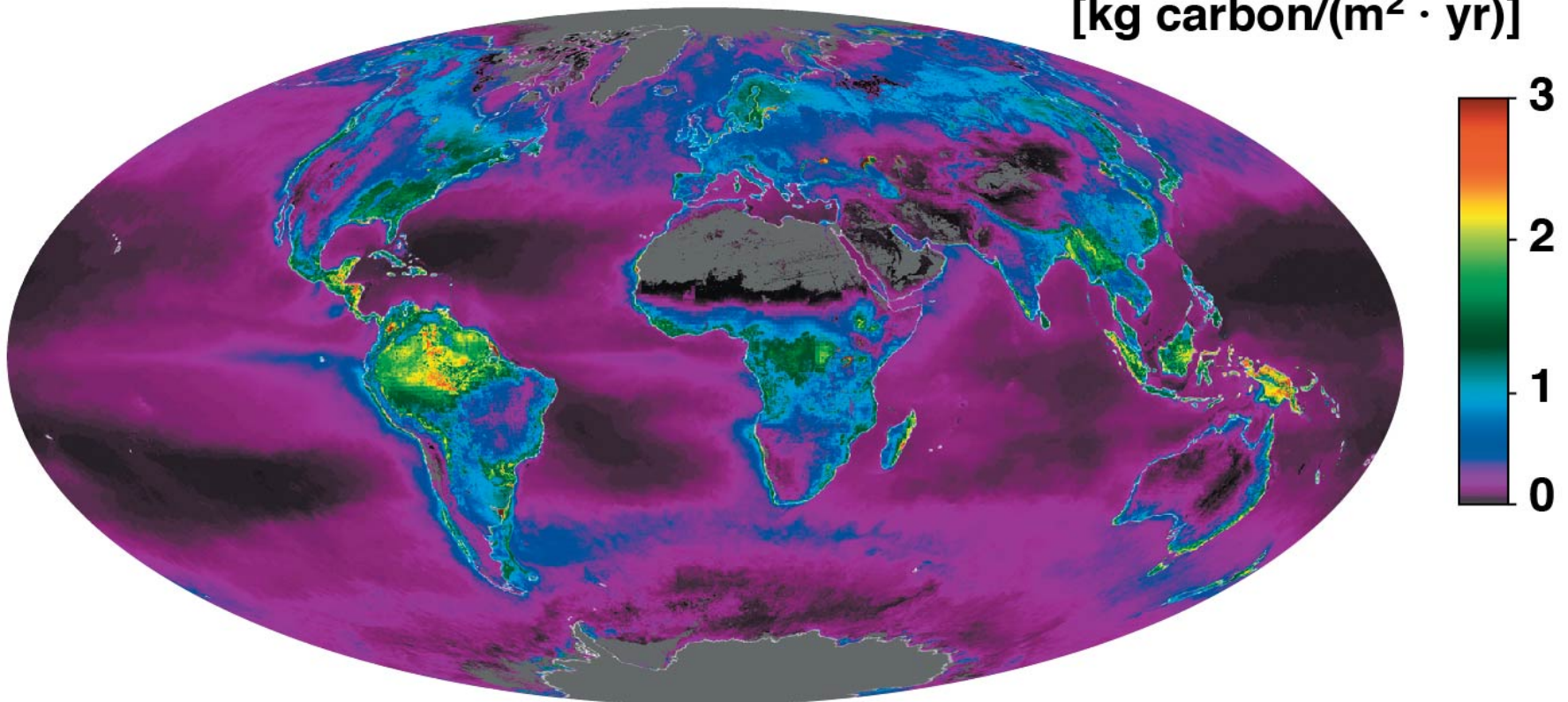
- **Primary production** = amt. of light energy that is converted to chemical energy
- **Gross primary production (GPP)**: total primary production in an ecosystem
- **Net primary production (NPP)** = gross primary production minus the energy used by the primary producers for **respiration (R)**:
 - $NPP = GPP - R$
- NPP = storage of chemical energy available to consumers in an ecosystem

Net primary production of different ecosystems



Net Primary Production

Net primary production
[kg carbon/(m² · yr)]



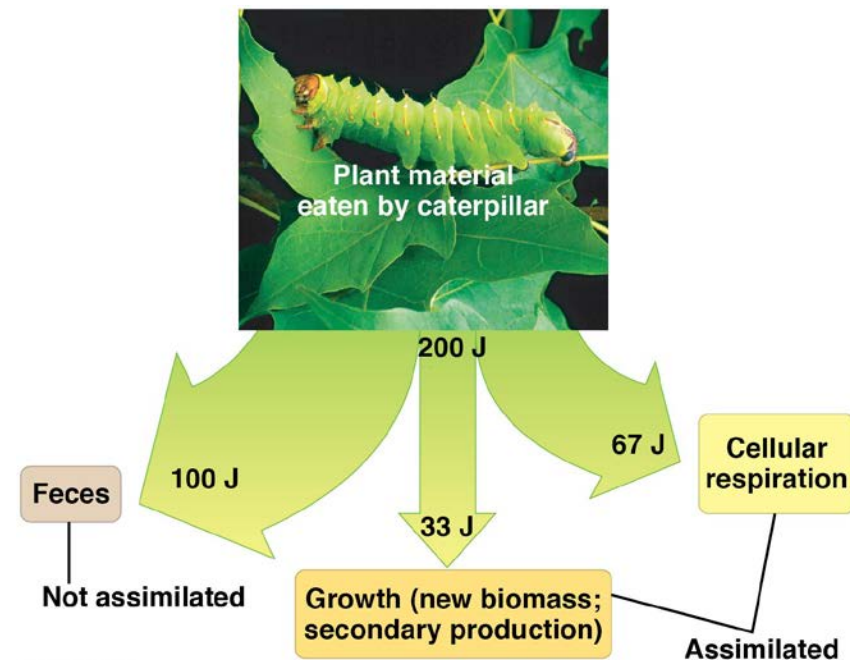
Primary production factors in:

- Aquatic ecosystems:
 - Light availability (\uparrow depth, \downarrow photosynthesis)
 - Nutrient availability (N, P in marine env.)
- Terrestrial ecosystems:
 - Temperature & moisture
- A nutrient-rich lake that supports algae growth is **eutrophic**.



Energy transfer between trophic levels is typically only 10% efficient

- Production efficiency: only fraction of E stored in food
- Energy used in respiration is lost as heat
- Energy flows (not cycle!) within ecosystems



Tertiary consumers



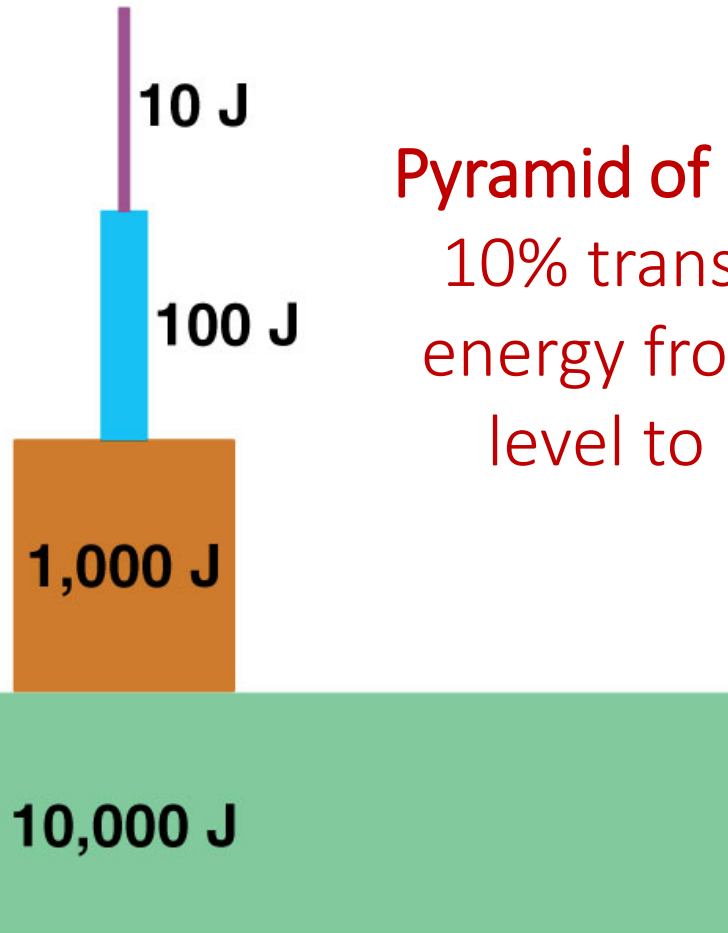
Secondary consumers



Primary consumers



Primary producers

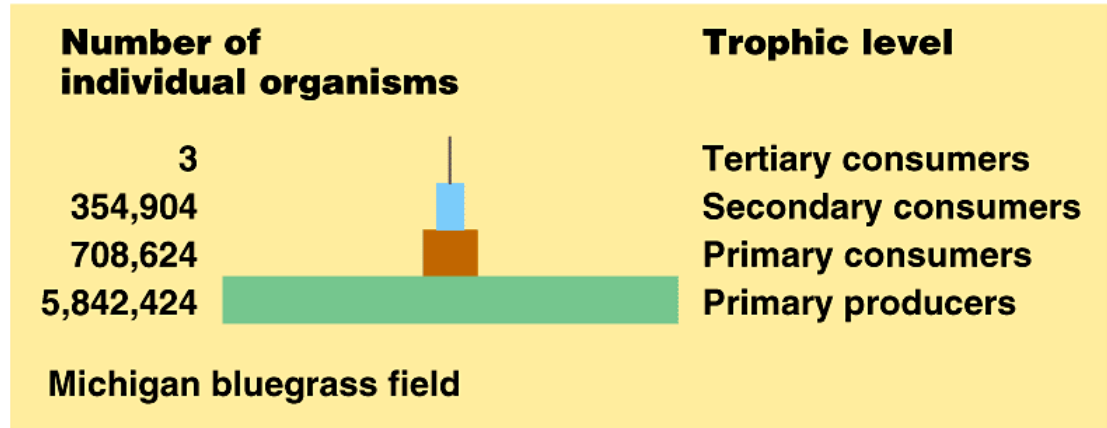


Pyramid of Energy:
10% transfer of energy from one level to next

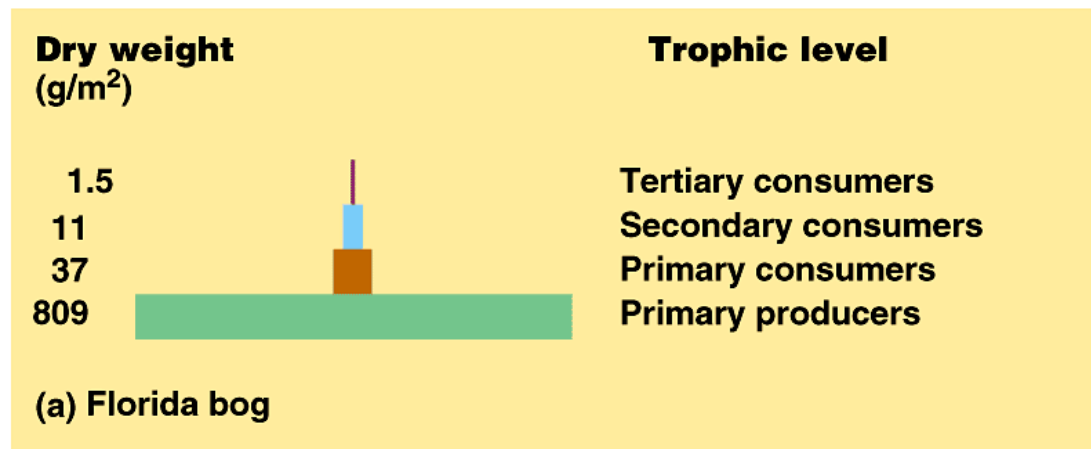
1,000,000 J of sunlight

Ecological pyramids give insight to food chains

- Loss of energy limits # of top-level carnivores
- Most food webs only have 4 or 5 trophic levels



Pyramid of Numbers



Pyramid of Biomass

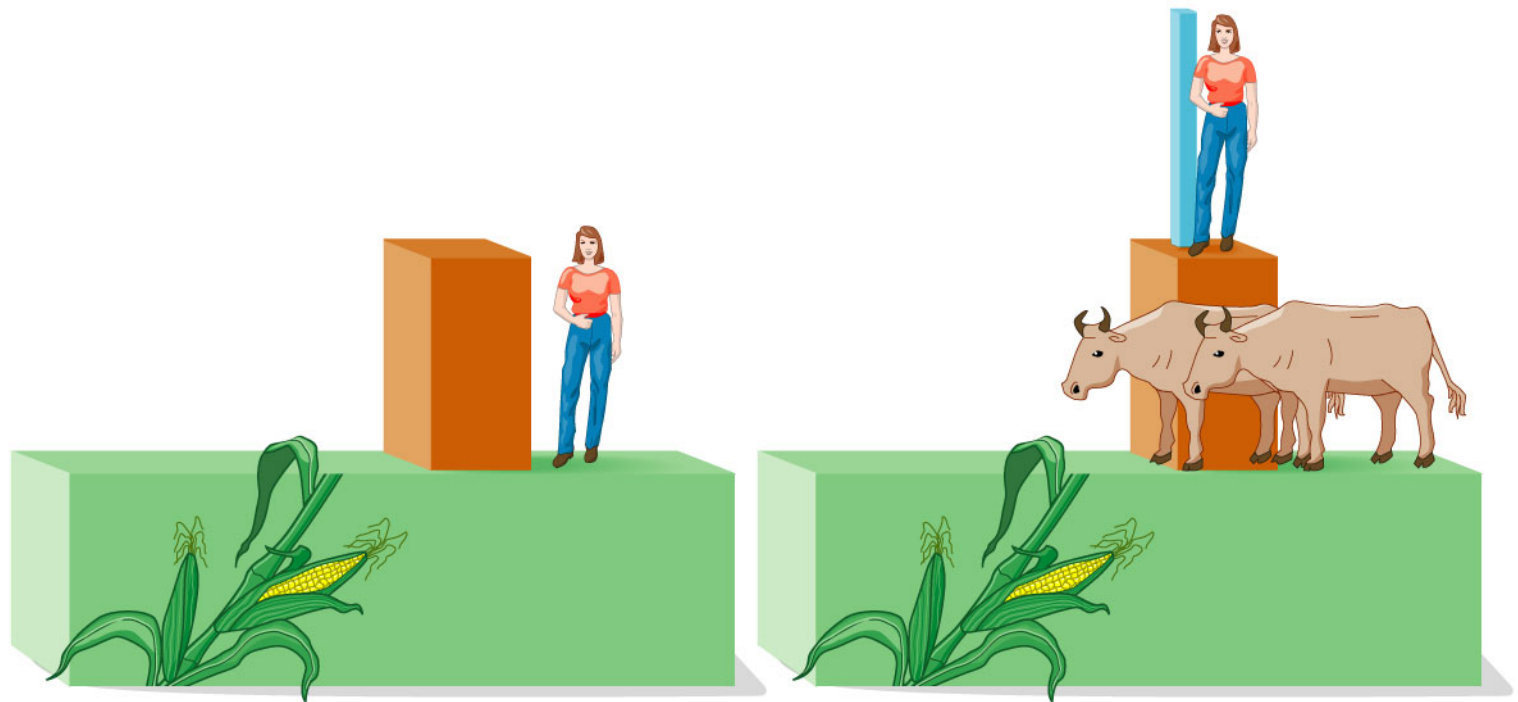
The dynamics of energy through ecosystems have important implications for the human population

Trophic level

Secondary consumers

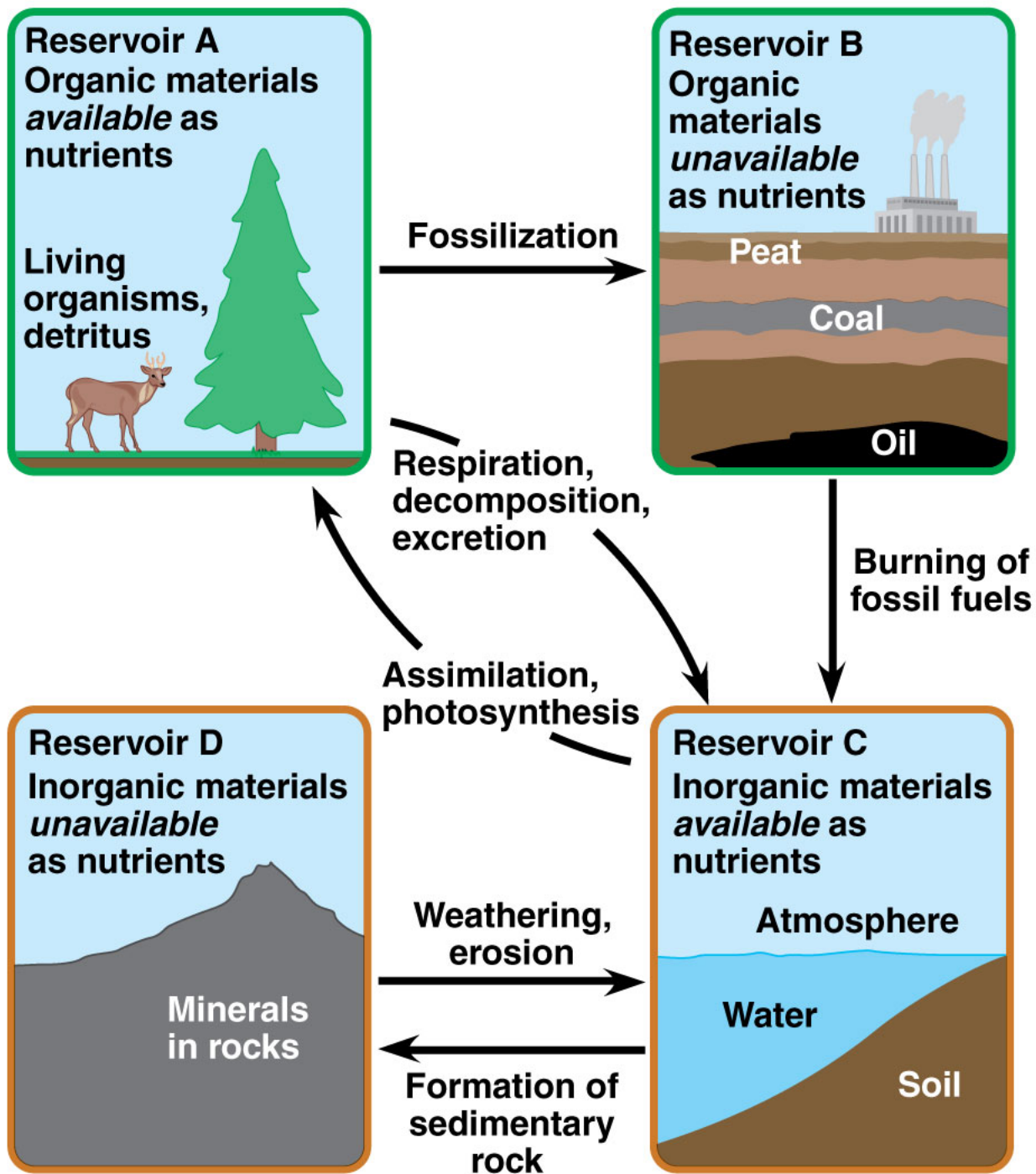
Primary consumers

Primary producers

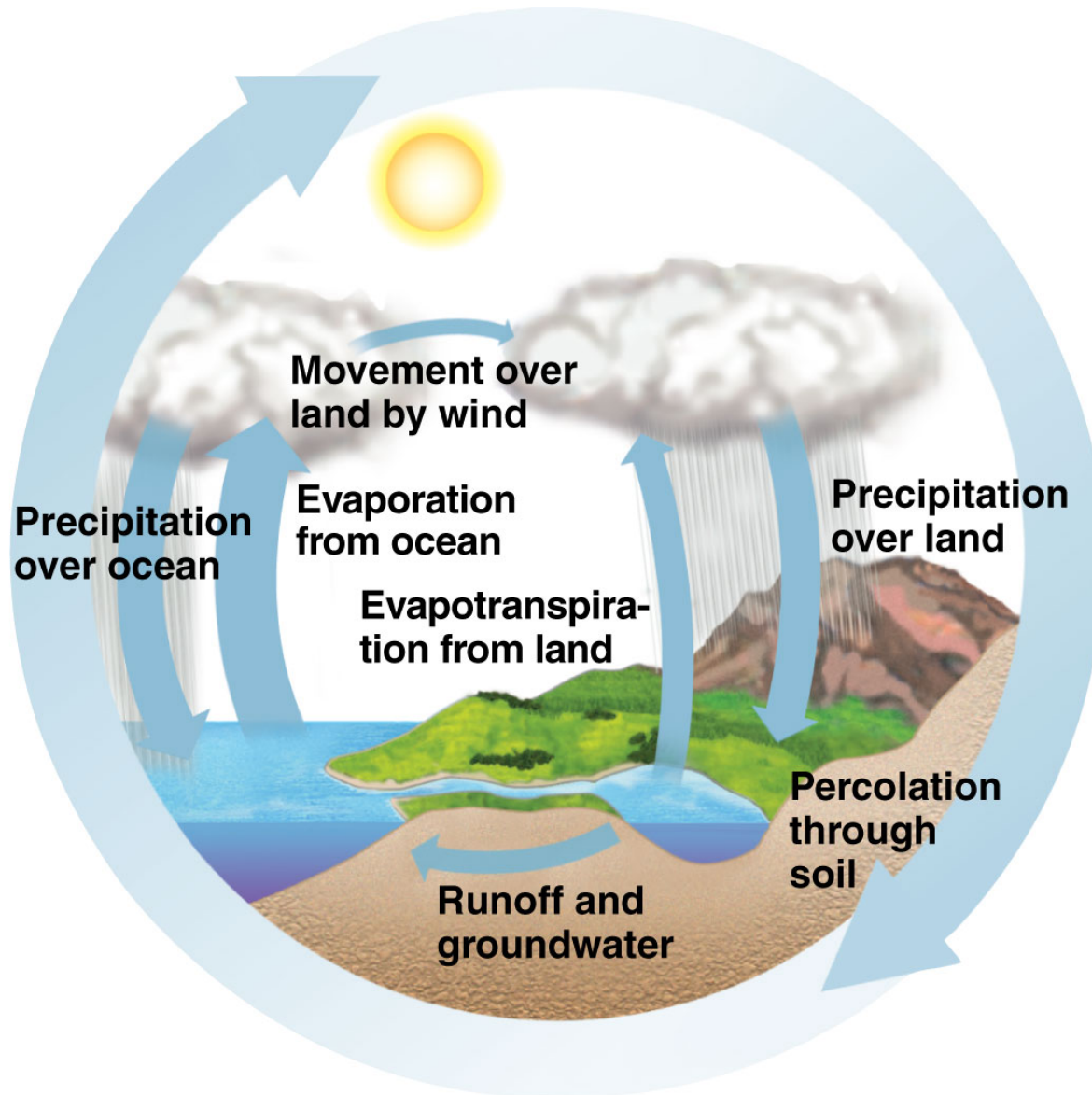


Matter Cycles in Ecosystem

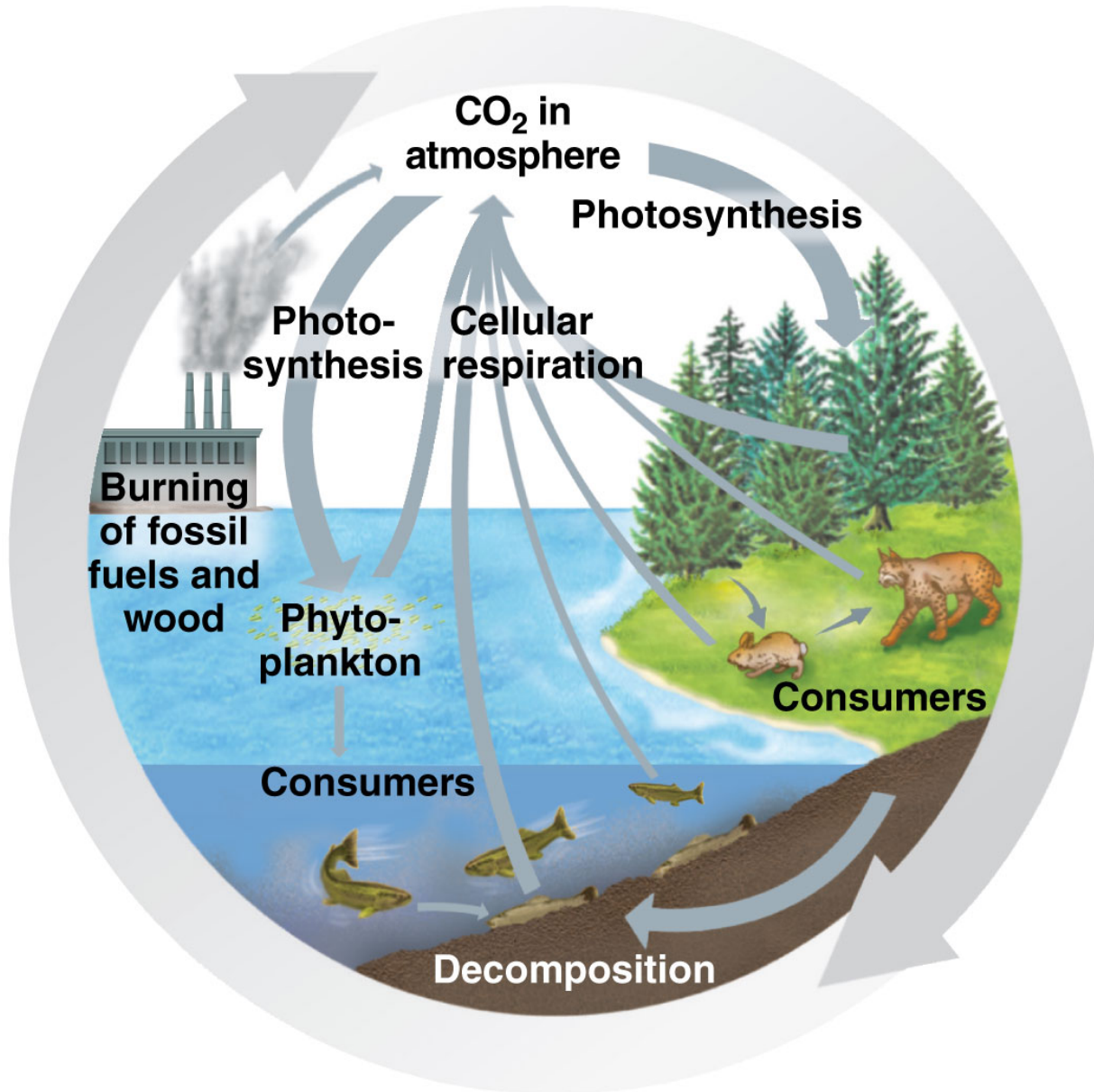
- **Biogeochemical cycles**: nutrient cycles that contain both biotic and abiotic components
- organic \leftrightarrow inorganic parts of an ecosystem
- Nutrient Cycles: water, carbon, nitrogen, phosphorus



Water Cycle



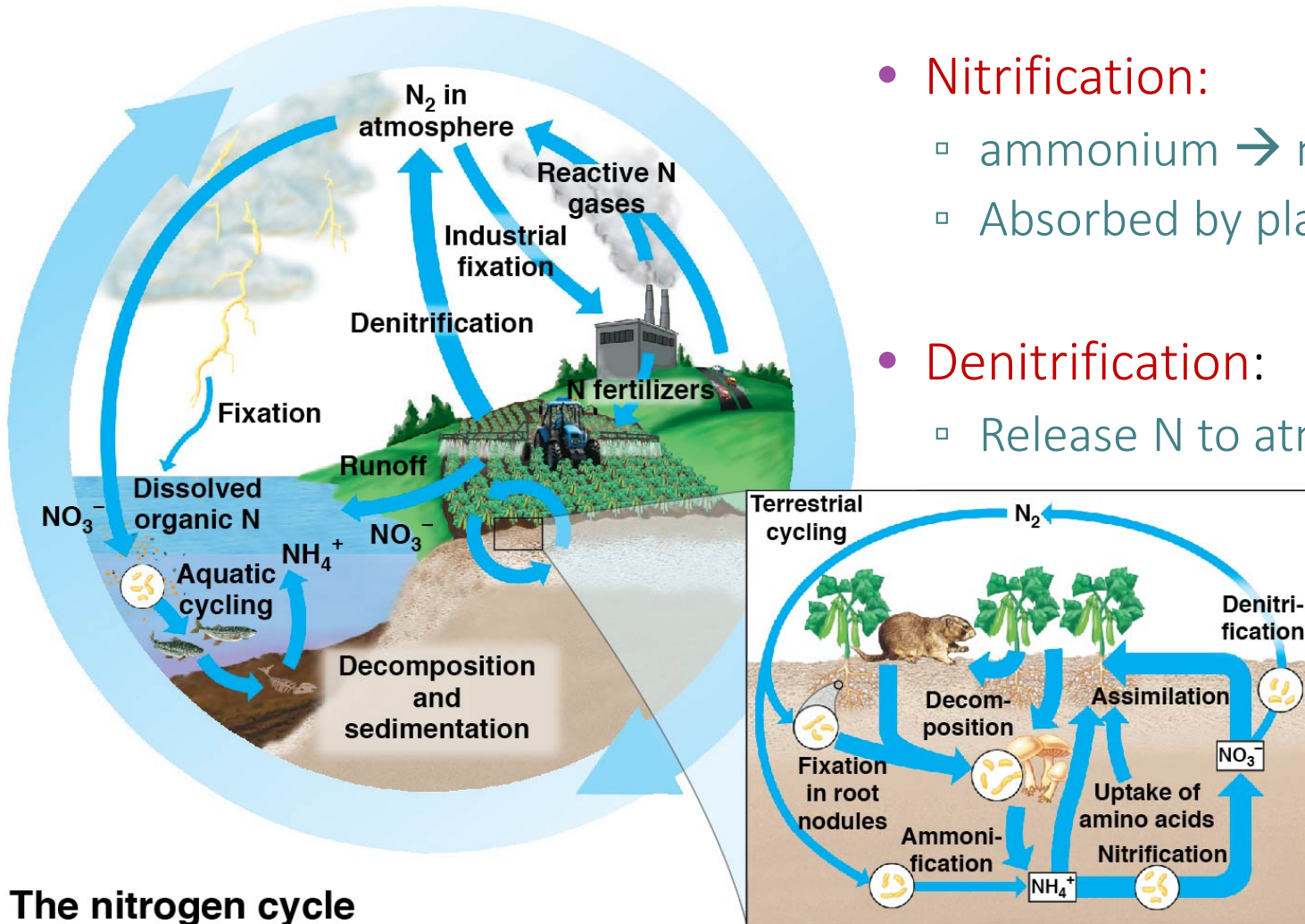
Carbon Cycle



- CO₂ removed by photosynthesis, added by burning fossil fuels

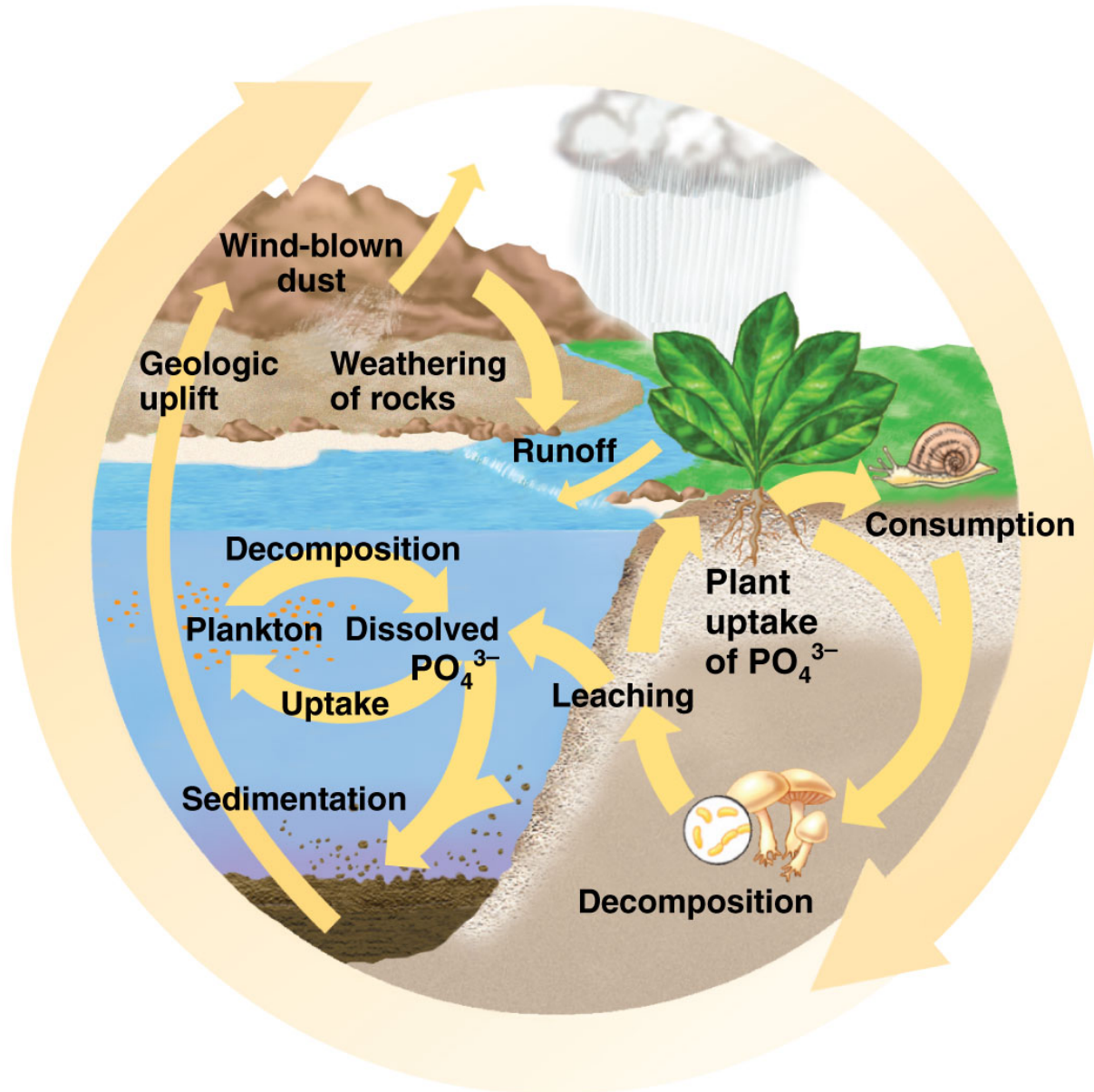
Nitrogen Cycle

- Nitrogen fixation:
 - $N_2 \rightarrow$ plants by bacteria
- Nitrification:
 - ammonium \rightarrow nitrite \rightarrow nitrate
 - Absorbed by plants
- Denitrification:
 - Release N to atmosphere



The nitrogen cycle

Phosphorus Cycle



Restoration Ecology

- **Bioremediation**: use of organisms (prokaryotes, fungi, plants) to detoxify polluted ecosystems
- **Bioaugmentation**: introduce desirable species (eg. nitrogen-fixers) to add essential nutrients



(a) In 1991, before restoration



(b) In 2000, near the completion of restoration

Bioremediation of groundwater contaminated with uranium



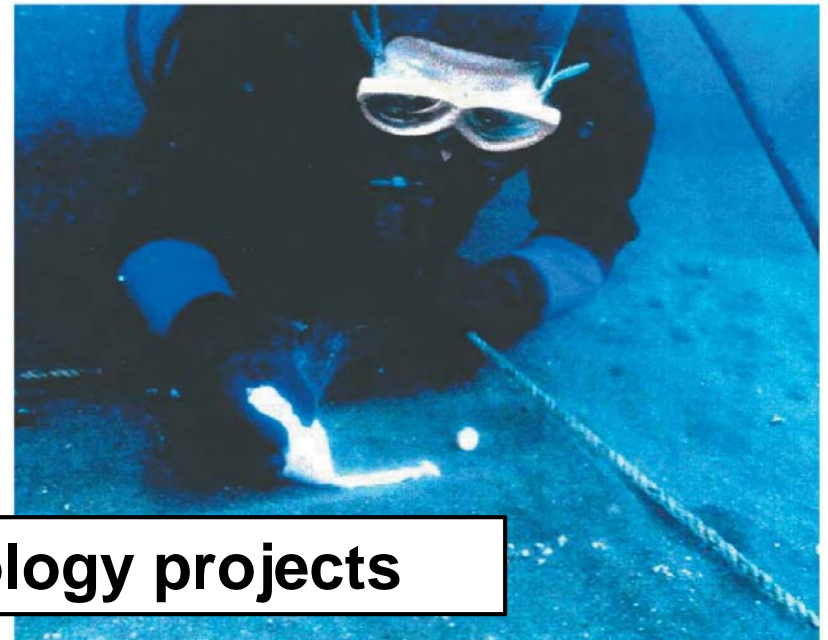
(a) Wastes containing uranium, Oak Ridge National Laboratory

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Kissimmee River, Florida

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Coastal Japan

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Restoration ecology projects