ECOSYSTEM ECOLOGY
Energy flow throuth ecosystem

Chapter 3

OUTLINE

Ecologicla pronciples related to success of an organism:

1. Adoptation
2. Shelford's Low of tolerance
3. Liebig Low of minimum

- Energy Flows Through Ecosystems
- Nutrient Cycles Through Food Webs

- Organism have a variety of characteristics that allow them to live in certain environment obtain sufficient quantities scare resources and adapt the change in environmental conditions
- Ecological principles related to success of organism are adaptation, tolerance and

Adoptation

Process by which an organism changes to become better suited to survive in their environment. It can also refer to a physical or genetic trait that helps an organism to be better suited to survive in their environment.

Adaptation is powered by natural selection. When a trait arises that allows an organism to better adapt to their environment, it will be

EXAMPLE

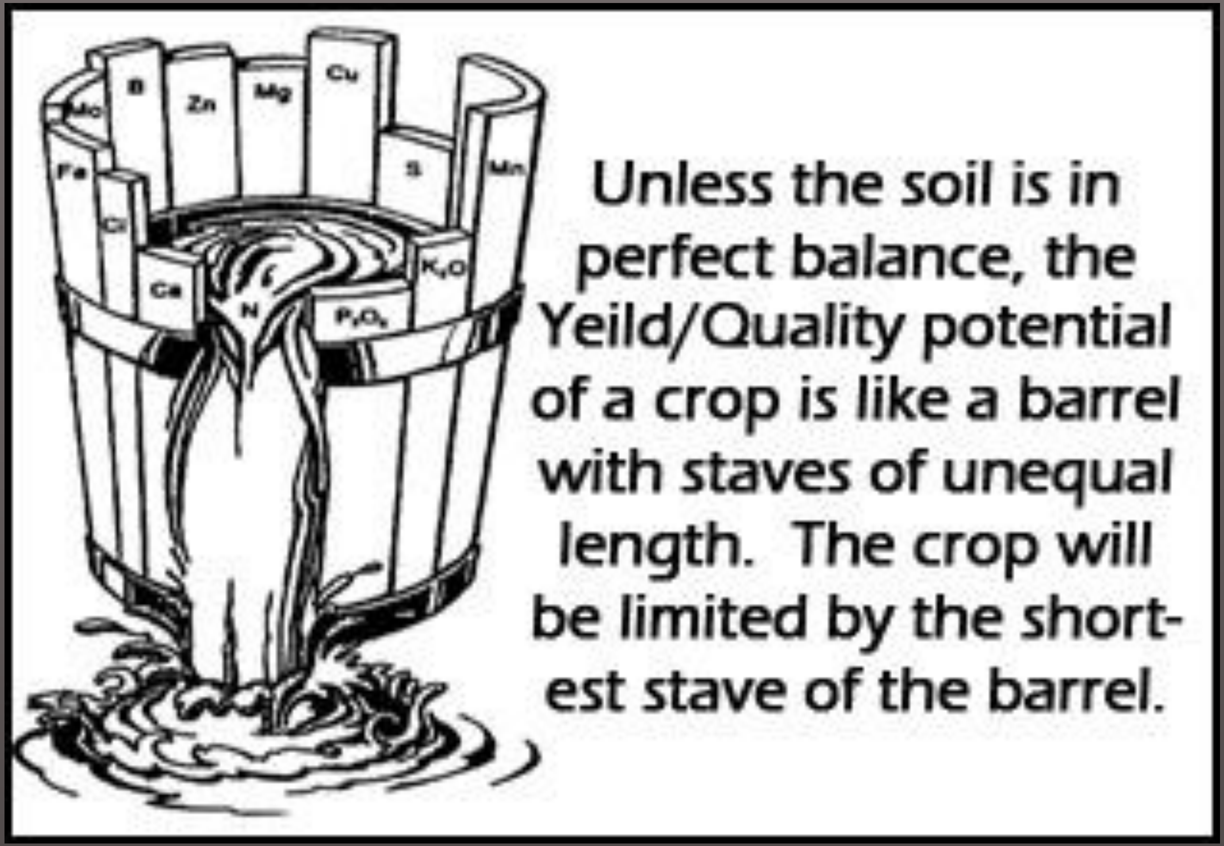
For example, polar bears are adapted to living in the cold because they grow thick fur that keeps them warm, and thus allows them to survive in their frigid environment.

The color of their fur is also an adaptation. Because the environment they live in is mostly white, they have produced white fur to blend in, so they are not seen by the prey they hunt

Liebig's Law of the Minimum - 1840

- The distribution of a species will be controlled by that environmental factor for which the organism has the narrowest range of adaptability or control

Liebig's Law of the Minimum - 1840



Or – the nutrient in lowest supply will set the limit to plant growth

Shelford's Low of tolerance

- distribution of a species will be limited by its range of tolerance for local

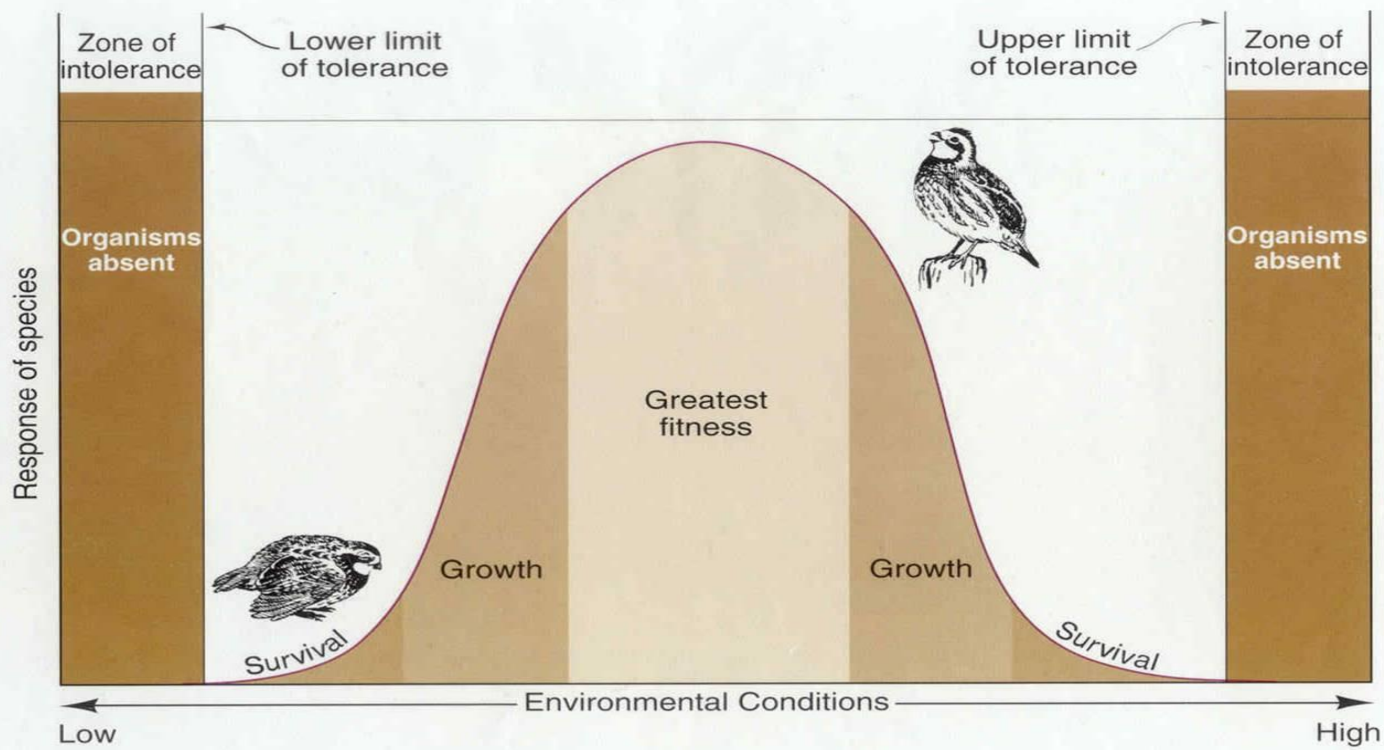


Figure 3.1 The law of tolerance.

Ecology and Field Biology, 5/e by Smith

How organisms obtain energy

- The ultimate source of the energy for life is the sun.
- **The producers:** **Autotrophs**~ An organism that uses light energy or energy stored in chemical compounds to make energy-rich compounds *(Plants, photosynthes*

PHOTOSYNTHESIS

- Organisms able to manufacture complex organic molecules from simple inorganic compounds (water, CO_2, nutrients) include plants, some protists, and some bacteria.
- The process by which they do this usually is
- **6 CO_2 + 6 H_2O à sunlight à $C_6H_{12}O_6$ + 6 O_2**

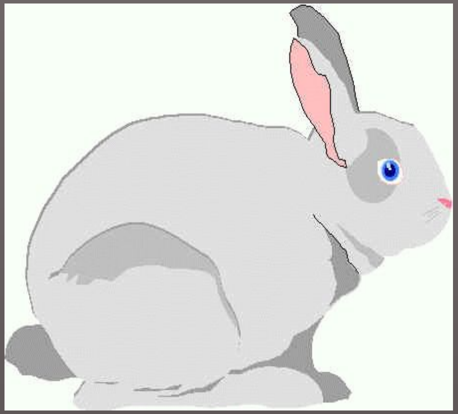
How organisms obtain energy II

The consumers:

Heterotrophs ~ An organism that cannot make its own food and feeds on other organisms

depend on autotrophs for nutrients and energy.

Energy flow



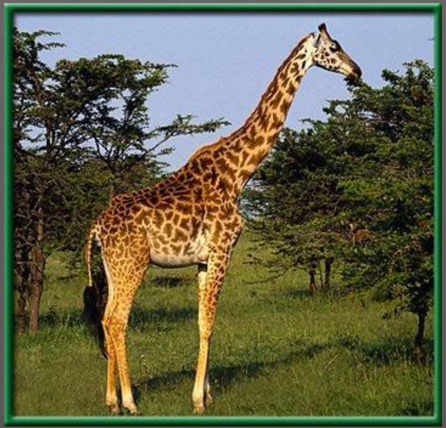
Today we will explore some of the multiple topics related to the flow of energy in ecosystems.

Heterotrophs display a variety of feeding relationships.

- Herbivore ~ feeds only on plants

Carnivores ~ kill and eat only other animals

- Omnivores ~eat both plants & animals



Heterotrophs display a variety of feeding relationships. II

- Scavengers eat animals that have already died

- Decomposers break down the complex compounds of dead and decaying plants

The Process of Primary Production

- The general term **"Production"** is the creation of new organic matter

The plant requires sunlight, carbon dioxide, water, and nutrients, and through photosynthesis the plant produces reduced carbon compounds and oxygen.

- Whether one measures the rate at which photosynthesis occurs, or the rate at which the individual plant increases in mass, one is concerned with **primary production**

- **Primary Production-** the synthesis and storage of organic molecules during the growth and reproduction of photosynthetic organisms).

- The core idea is that new chemical compounds and new plant tissue are produced.
- Over time, primary production results in the addition of new plant biomass to the system.

So far we have not been very precise about our definitions of "production", and we need to make the terms associated with production very clear.

- ***Gross Primary Production*, *GPP*,** is the total amount of CO_2 that is fixed by the plant in photosynthesis.
- ***Respiration*, *R*,** is the amount of CO_2 that is lost from an organism or system from metabolic activity. Respiration can be further divided into components that reflect the source of the CO_2.

$\mathbf{R_p}$ =Respiration by Plants

$\mathbf{R_h}$ = Respiration by Heterotrophs

$\mathbf{R_d}$ = Respiration by Decomposers (the microbes)

- ***Net Primary Production, NPP,*** is the net amount of primary production after the costs of plant respiration are included. Therefore, **NPP = GPP - R**
  Net Ecosystem Production, NEP, is the net amount of primary production after the costs of respiration by plants, hetertrophs, and decomposers are all included. Therefore, **NEP = GPP - (Rp + Rh + Rd)**

- The distinction between gross primary production (GPP), net primary production (NPP), and net ecosystem production (NEP)

- The distinction between gross primary production (GPP), net primary production (NPP), and net ecosystem production (NEP) is critical for understanding the energy balance in plants and in whole ecosystems.

- Production varies among ecosystems, as well as over time within ecosystems. Rates of production are determined by such factors as climate and nutrient supply.

  Precipitation is the dominant control worldwide, but nutrient availability often limits primary production in any particular, local system.

Production and biomass vary greatly across different ecosystems

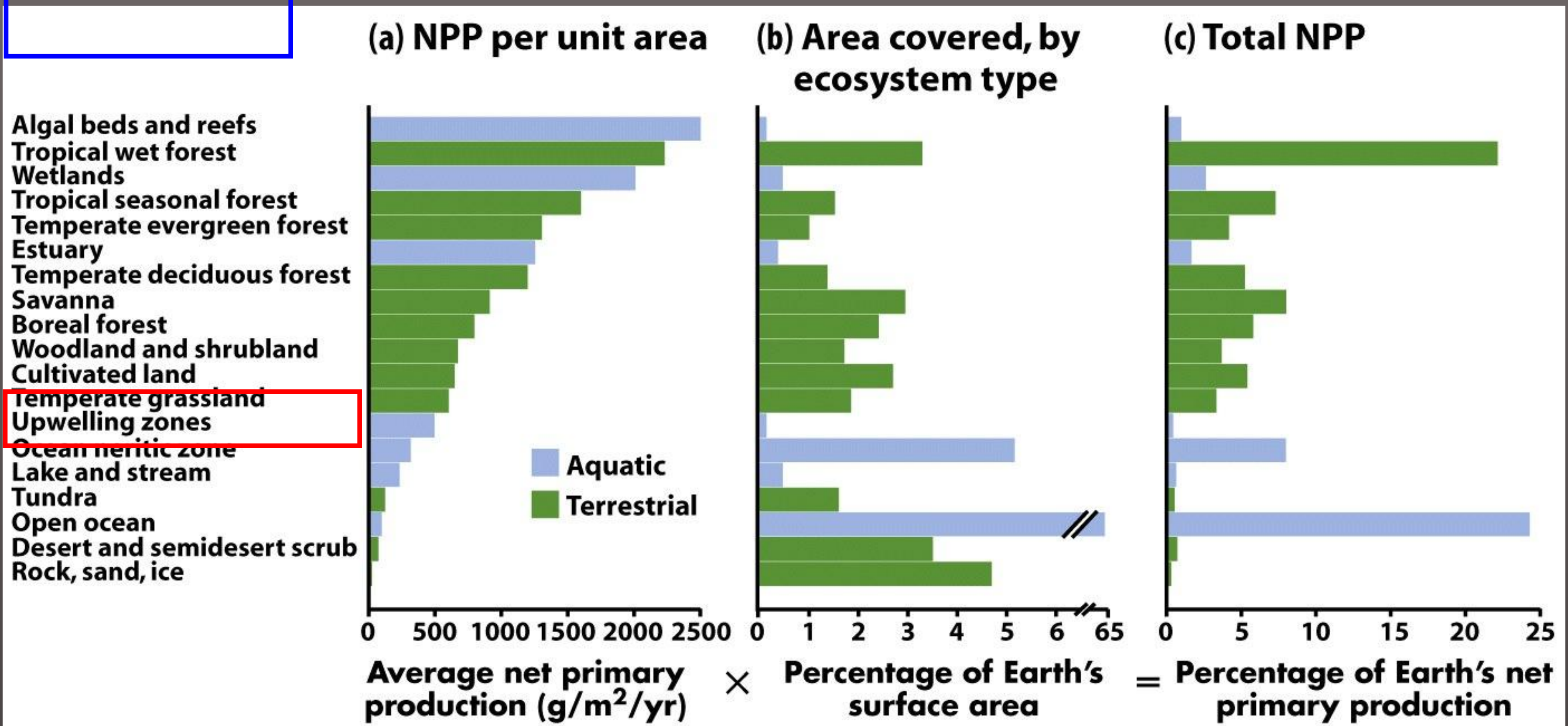
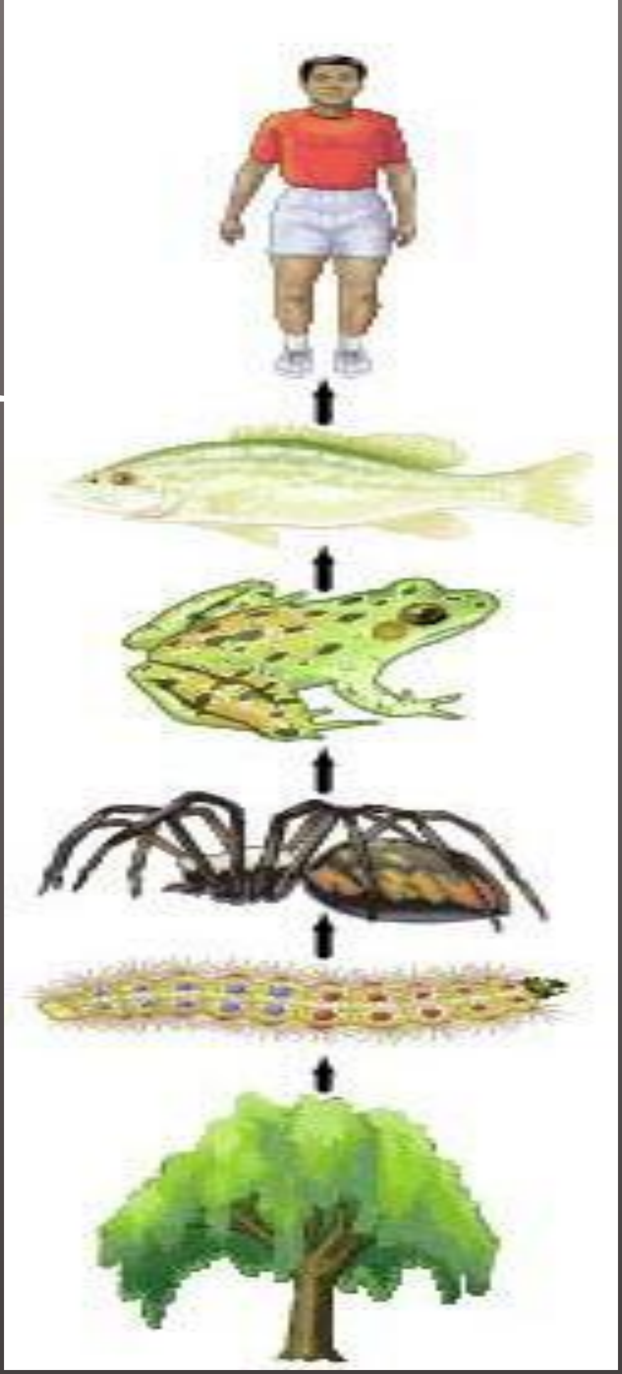


Figure 54-3 Biological Science, 2/e

(Freeman, 3rd ed.)

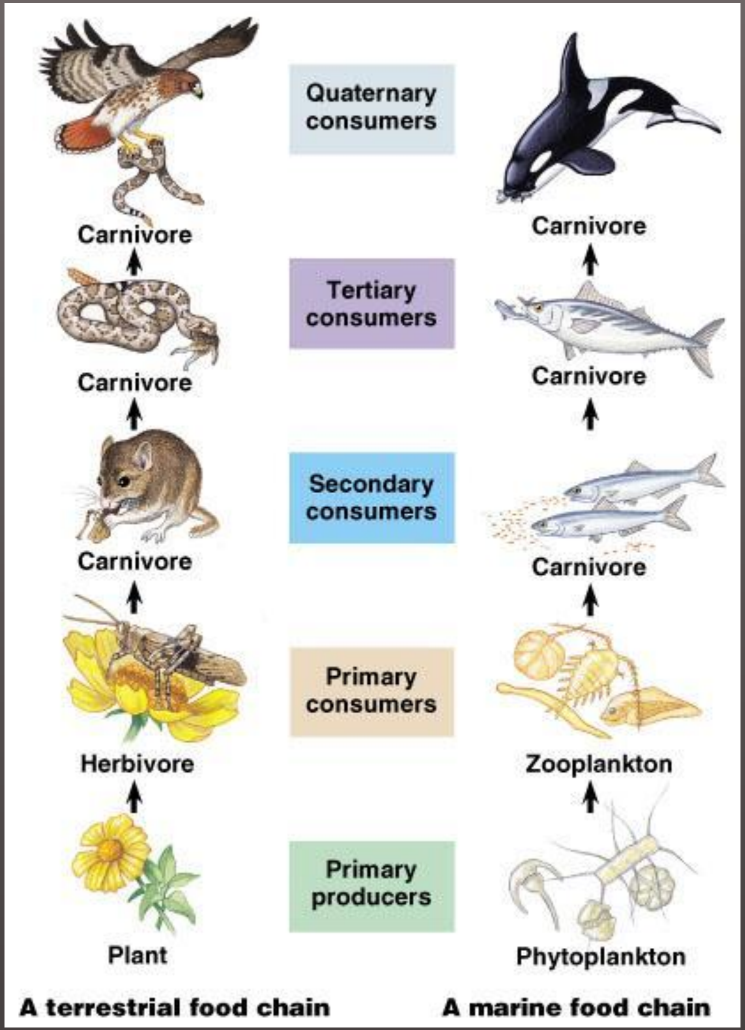
- **Who eats Wh**



Flow of Matter and Energy in Ecosystems

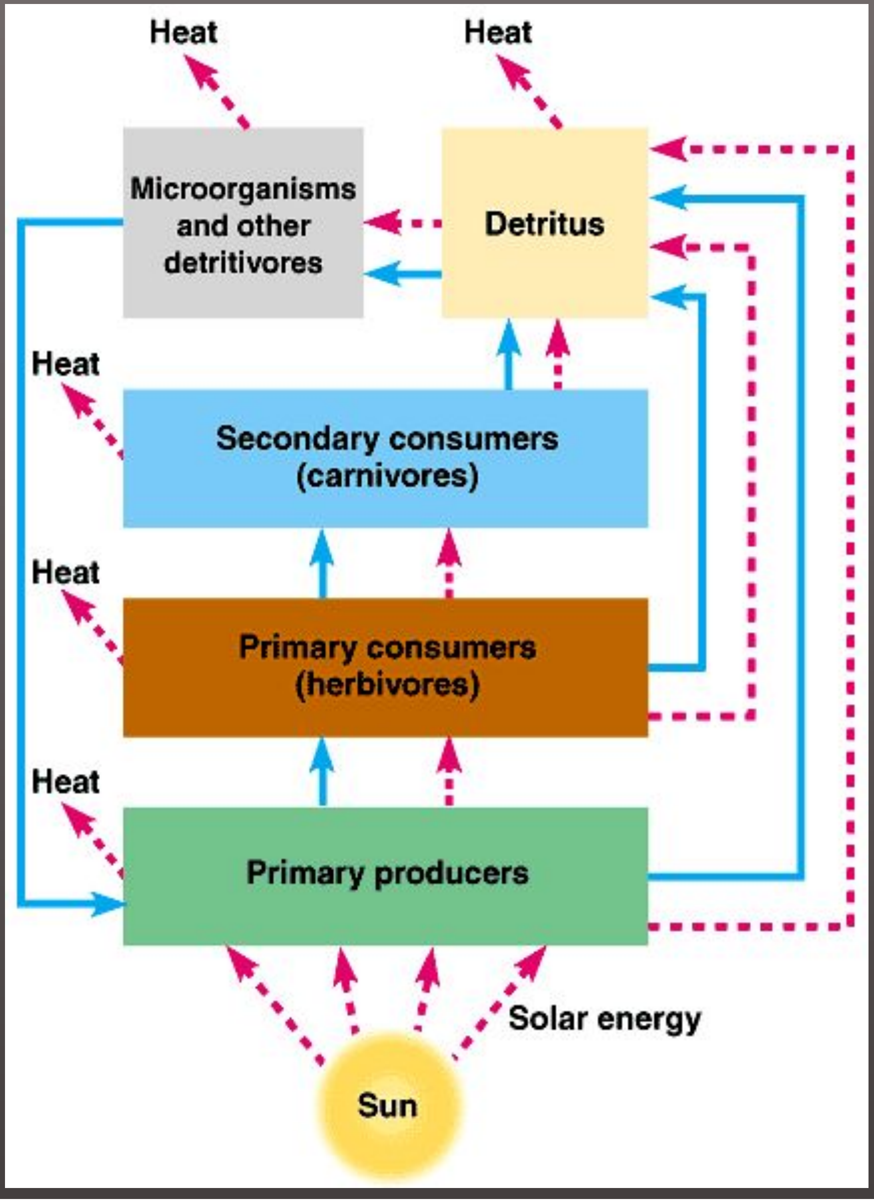
- **Food chains**: the stepwise flow of energy and nutrients through an ecosystem.

  from plants (producers)
  - to herbivores (primary consumers)
  - to carnivores (secondary and higher-level consumers



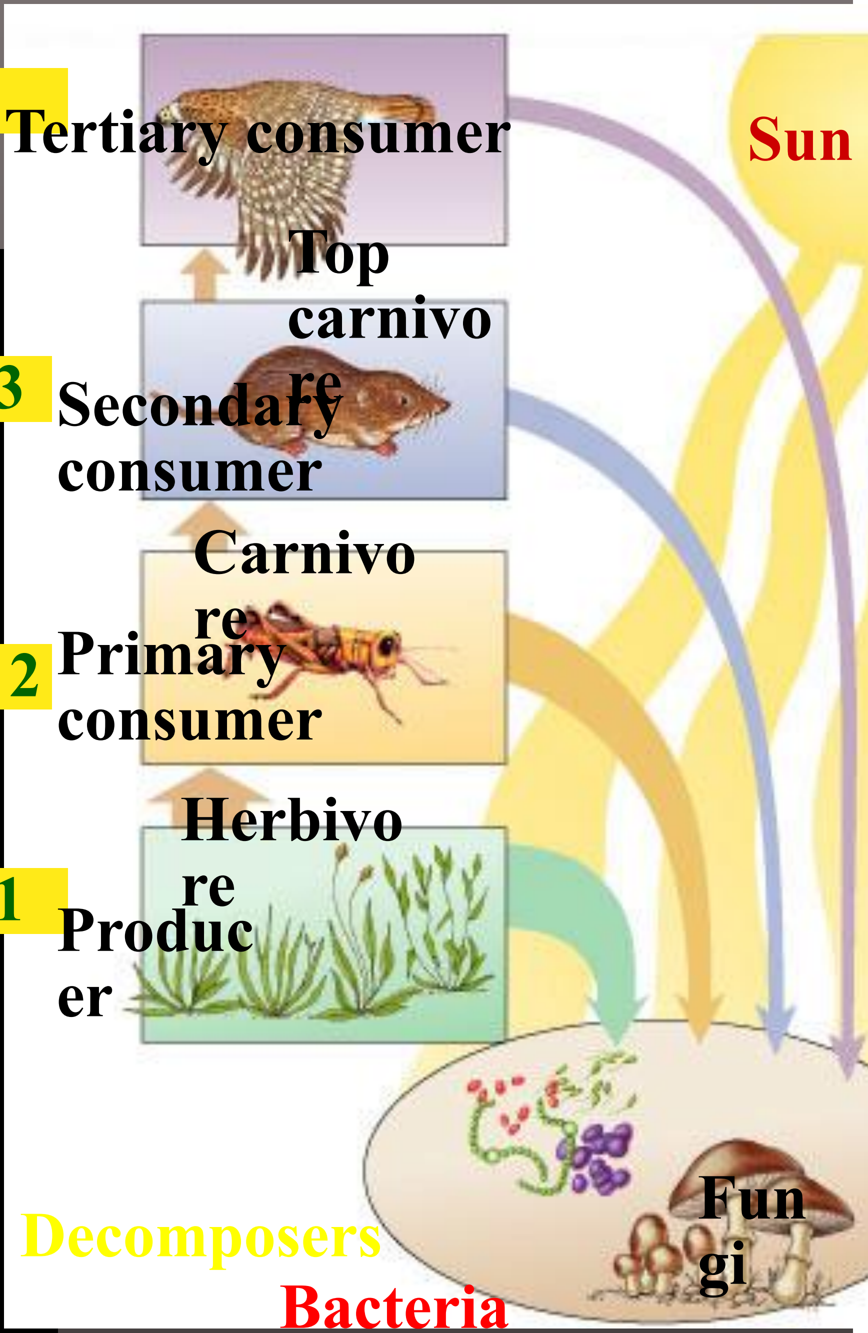
Trophic levels represent links in the chain

- Each organism in a food chain represents a feeding step, or trophic level, in the passage of energy and materials.



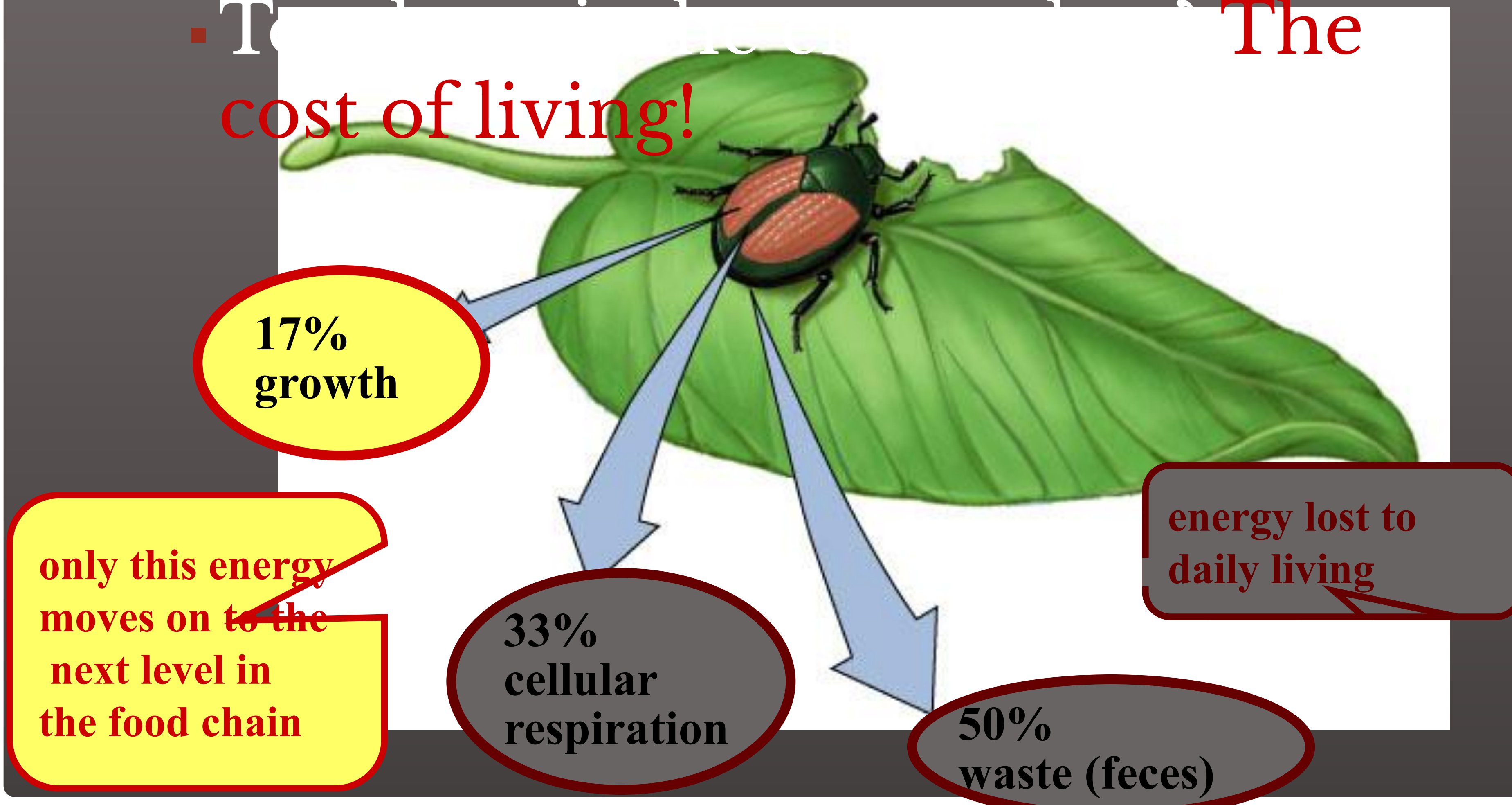
Food chains

- Feeding relationships
  - <u>all food chains start with energy from the sun</u>
  - <u>first level of all food chains is plants</u>
  - most food chains usually go up only 4 or 5 levels
  - <u>all levels connect to</u>
  - <u> decomposers</u>



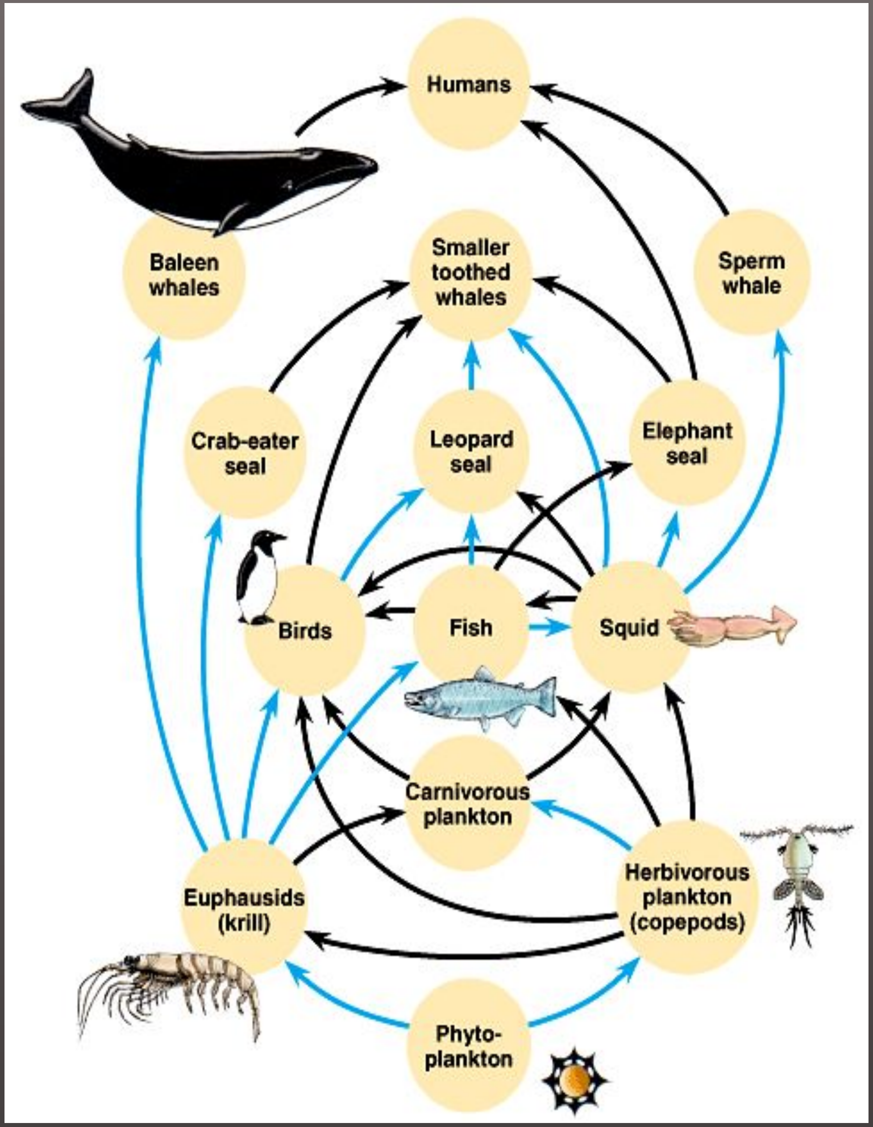
Loss of energy

- Loss of energy between levels of food chain
  - T[illegible] The cost of living!



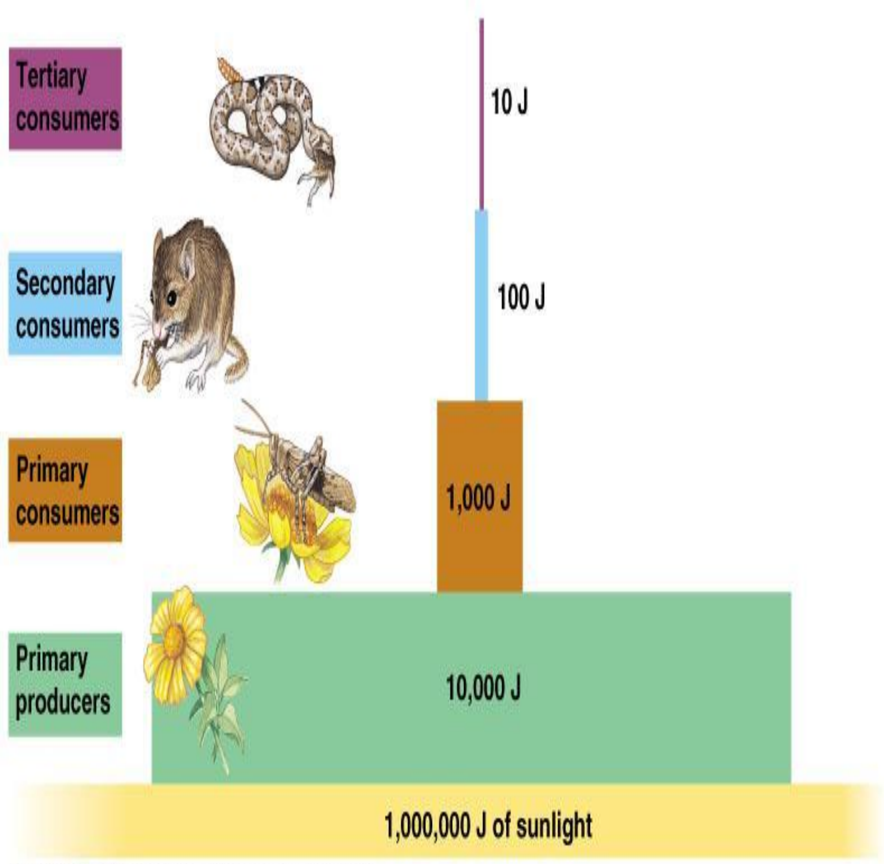
Food webs

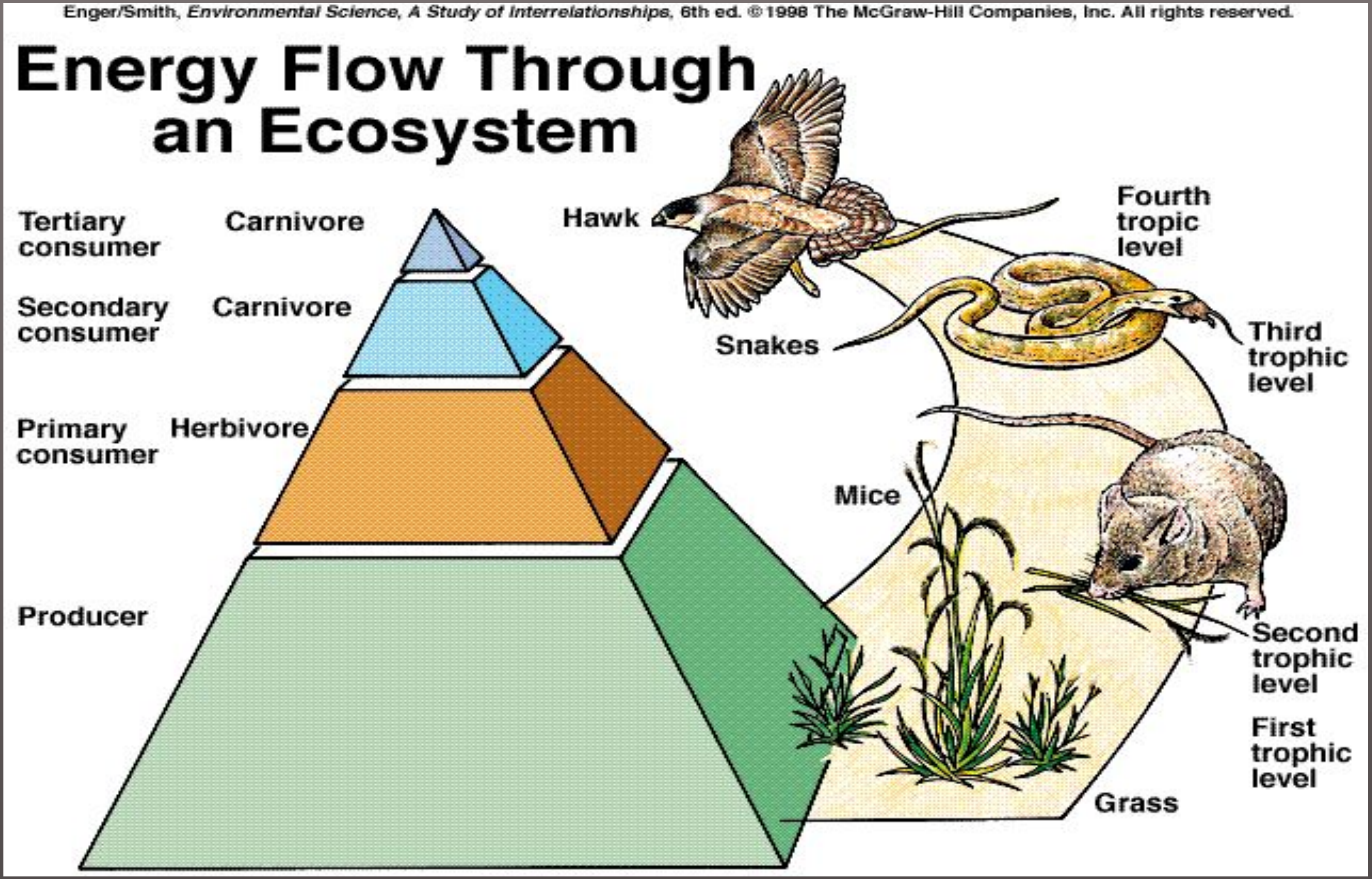
- network of interconnecting food chains
  - It is a more realistic view of the trophic structure of an ecosystem than a food chain



Energy and trophic levels: Ecological pyramids

- show how energy flows through an ecosystem.
- illustrates that the amount of available energy decreases at each succeeding trophic level.
- The total energy transfer from one trophic level to the next is only about ten percent because organisms fail to capture and eat all the food energy available at the trophic level below them.

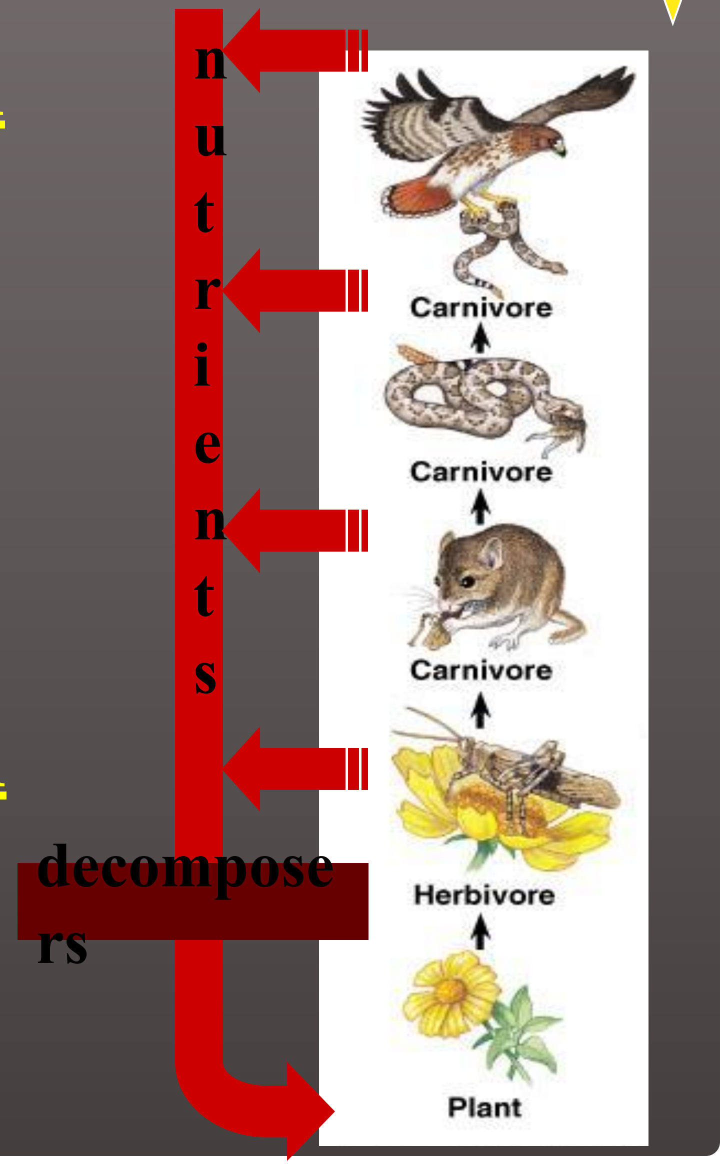




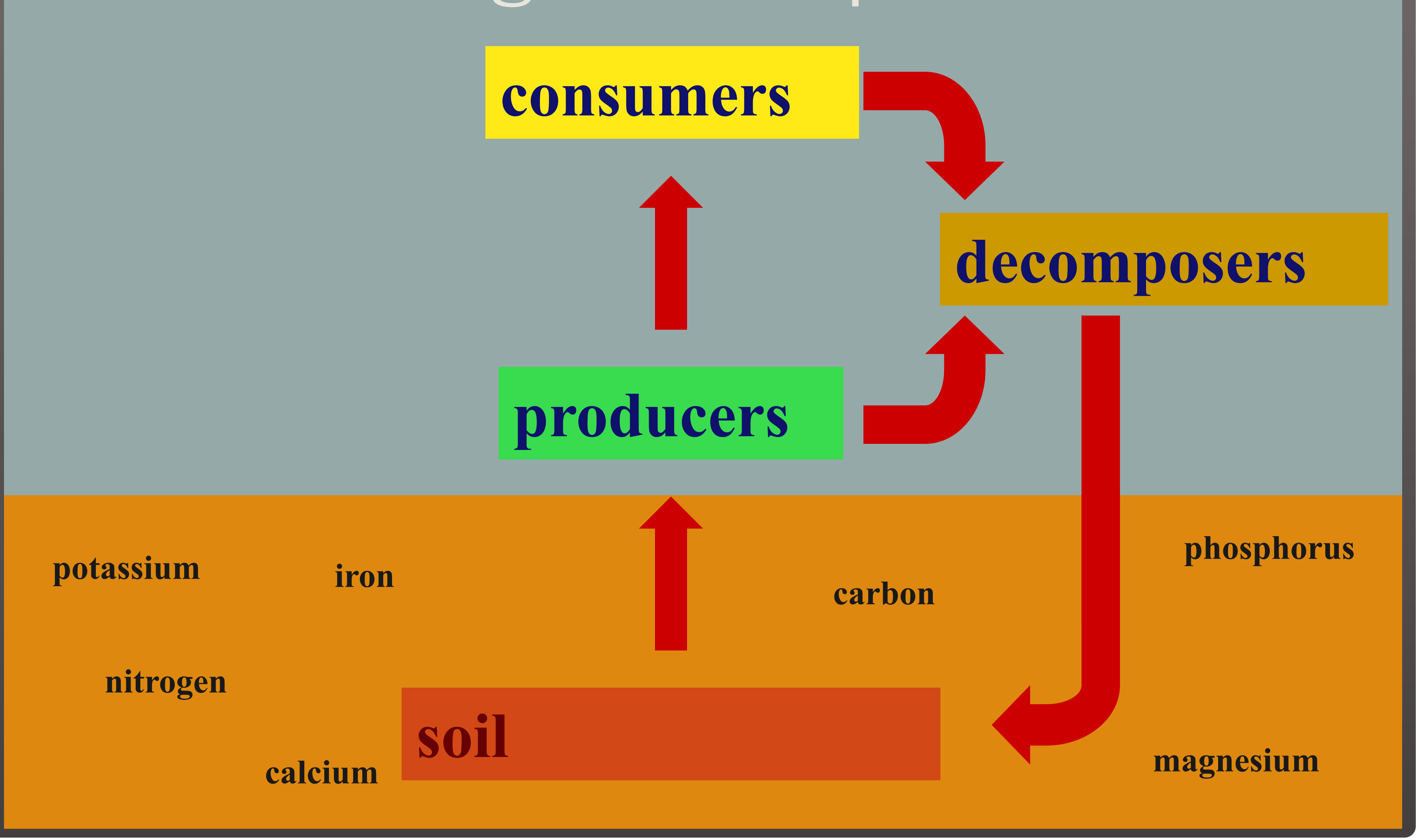
As energy flows from one level to the next throphic level , approximately 90% of energy lost

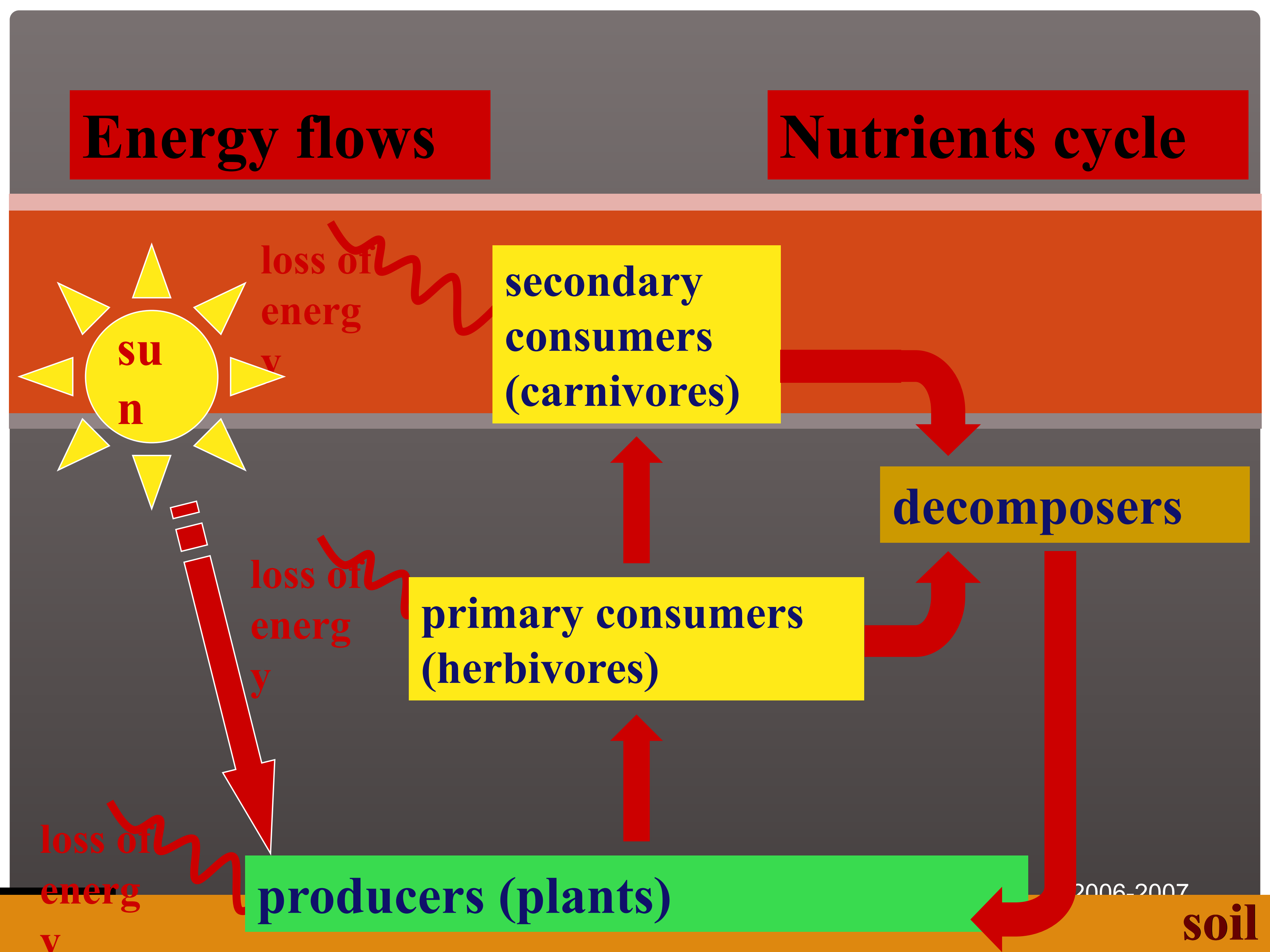
But what about nutrients?

- <u>Energy flows through but nutrients cycle</u>
  - nutrients must be <u>recycled</u> to be available for the next generation
  - <u>decomposers return nutrients to the soil after creatures die</u>
    - fungi

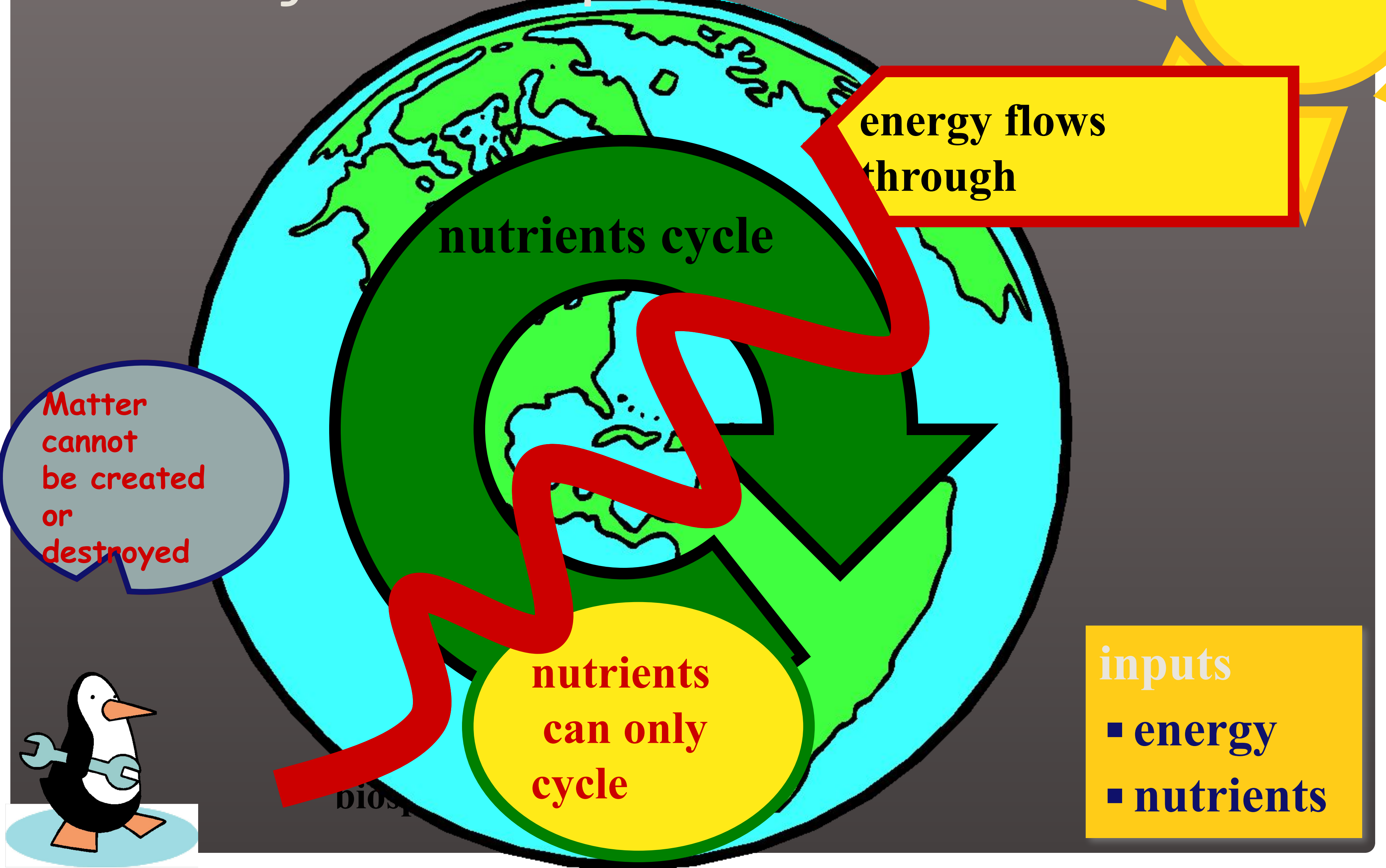


Nutrients cycle around… through decomposers




Energy flows
Nutrients cycle
su
n
loss of
energ
y
secondary
consumers
(carnivores)
decomposers
loss of
energ
y
primary consumers
(herbivores)
loss of
energ
y
producers (plants)
2006-2007
soil

Ecosystem inputs



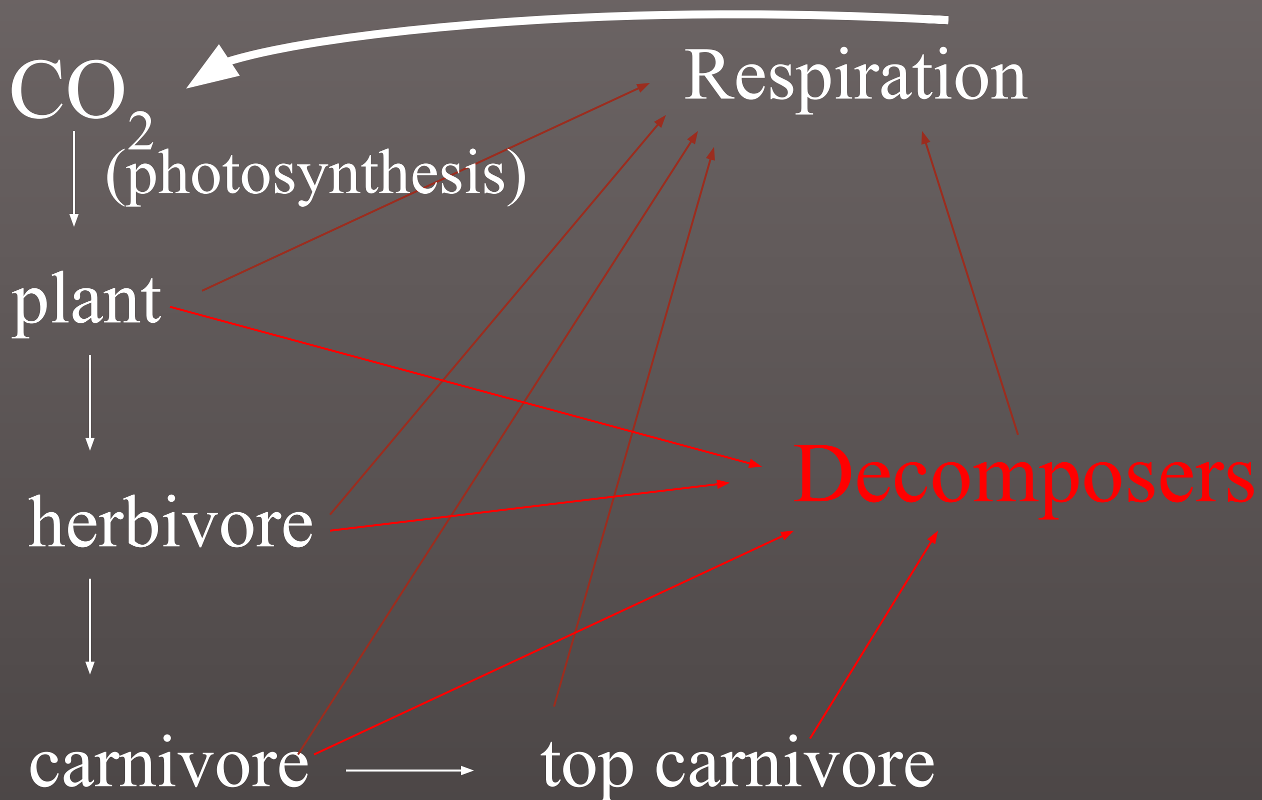
Nutrient Cycling

- There are two major types of nutrient cycles
  - Gaseous – Most of the nutrient is stored in the atmosphere
  - Sedimentary – Most of the nutrient is stored in the sediments or soils

So what nutrients do we need?

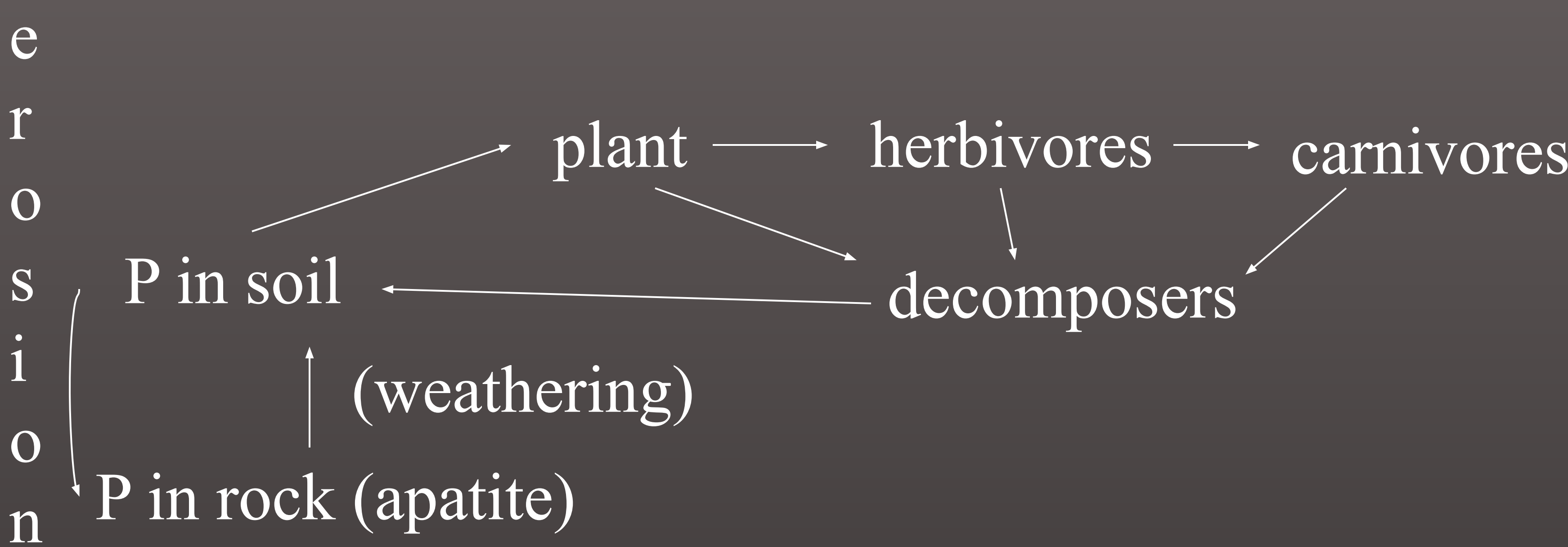
- Macro-nutrients are needed in large quantities
- Na,Cl, C, H, O, P, K, I, N, S, Ca, Fe, Mg
- Micro-nutrients are also essential, but are needed in only small amounts
- Mo, B, Cl, Mn, Cu, Zn

Gaseous Nutrient Cycle
The carbon cycle



Sedimentary Nutrient Cycle

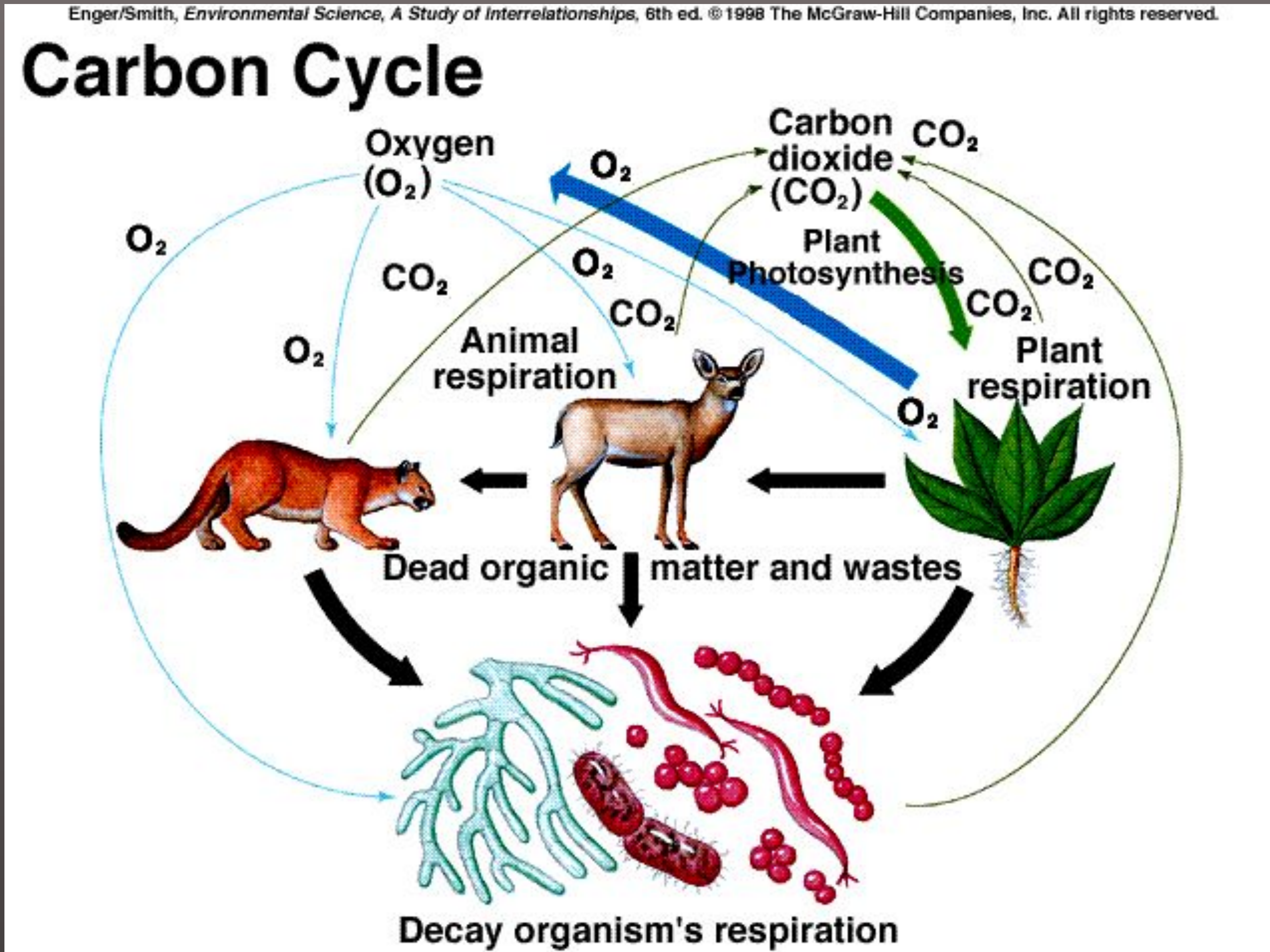
Example: The Phosphorus Cycle



Carbon Cycle

- Carbon and Oxygen combine to form Carbon Dioxide.
- Plants use Carbon Dioxide during photosynthesis to produce sugars.
- Plants use sugars for plant growth.
- Herbivores eat plants, and incorporate molecules into their structure.

- Respiration breaks down sugars releasing CO_2 and water back into the atmosphere.



- Inputs to atmosphere currently exceed outputs because of
- Small pool of C in air (<1%), so even small changes in inputs can have large effects
- • Inputs to atmosphere currently exceed outputs because of human activity

Natural Sources of Carbon	Sources of Carbon from Human Activity
• Death of plants and animals • Animal waste • Atmospheric CO2 • Weathering • Methane gas from cows (and other ruminants) • Aerobic respiration from terrestrial and aquatic life	• Burning wood or forests • Cars, trucks, planes • Burning fossil fuels such as coal, oil and natural gas to produce heat and energy.

So what nutrients do we need?

- Macro-nutrients are needed in large quantities
- Na,Cl, C, H, O, P, K, I, N, S, Ca, Fe, Mg
- Micro-nutrients are also essential, but are needed in only small amounts
- Mo, B, Cl, Mn, Cu, Zn
- The elements in yellow have gaseous cycles