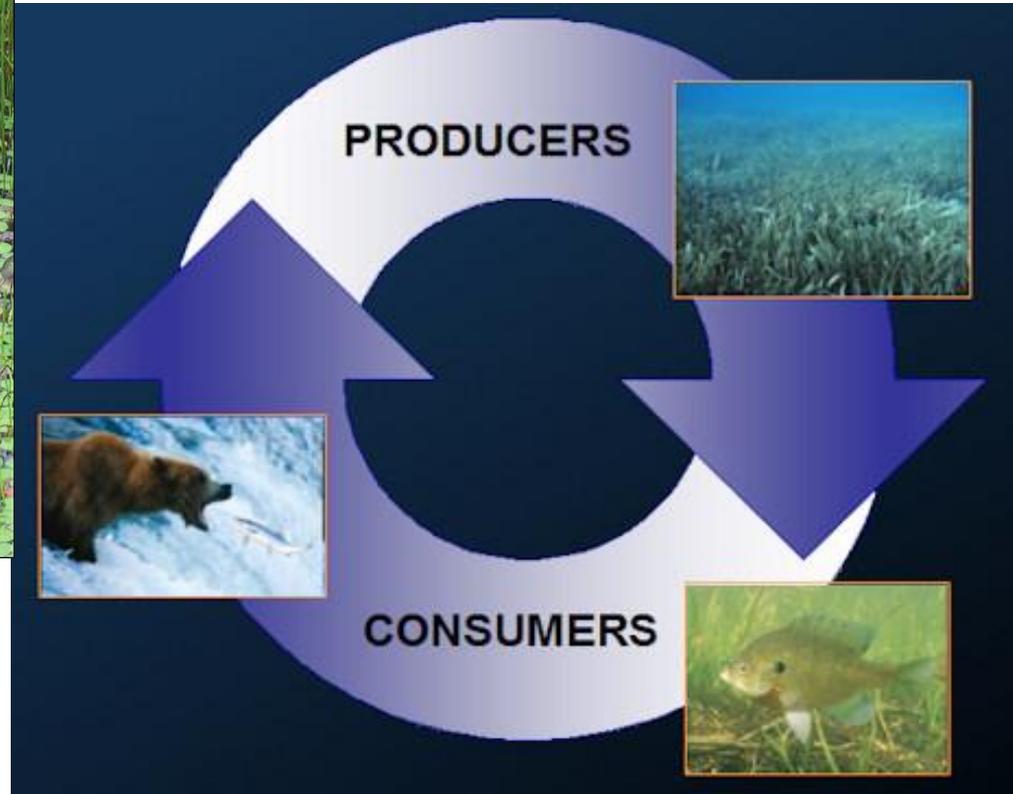




# Ecosystem, Biodiversity



Lecture 4: Introduction to Civil and  
Environmental Engineering

# What are Ecosystems ?

- **Ecosystems** are the biotic and abiotic factors in a specified area that interact with one another.
- Understanding the interaction of the biotic and abiotic factors in an ecosystem can help us to see why particular human activities may be a problem for human survival.
- Example: The loss of ozone in the stratosphere increases the quantity of UV radiation on the surface of the planet. In the same way that humans experience sunburn from too much sun exposure, so do plants. Excessive UV may damage or destroy plant protein and DNA, killing the plant.

# Basic Characteristics of Ecosystems

- Sustained life on Earth is a characteristic of ecosystems, not of individual organisms or populations- no member of a community can carry out the processes of life alone
- 1) Structure: An ecosystem is made up of two major parts:
- Non-Living (Abiotic)- Physical Environment (Soil, Air and Water)
  - Living (Biotic)- Ecological community

# Basic Characteristics of Ecosystems

- 2) Processes: Two basic kinds of processes must occur in an ecosystem: a cycling of chemical elements and a flow of energy
- 3) Change: An ecosystem changes over time and can undergo development through a process called succession

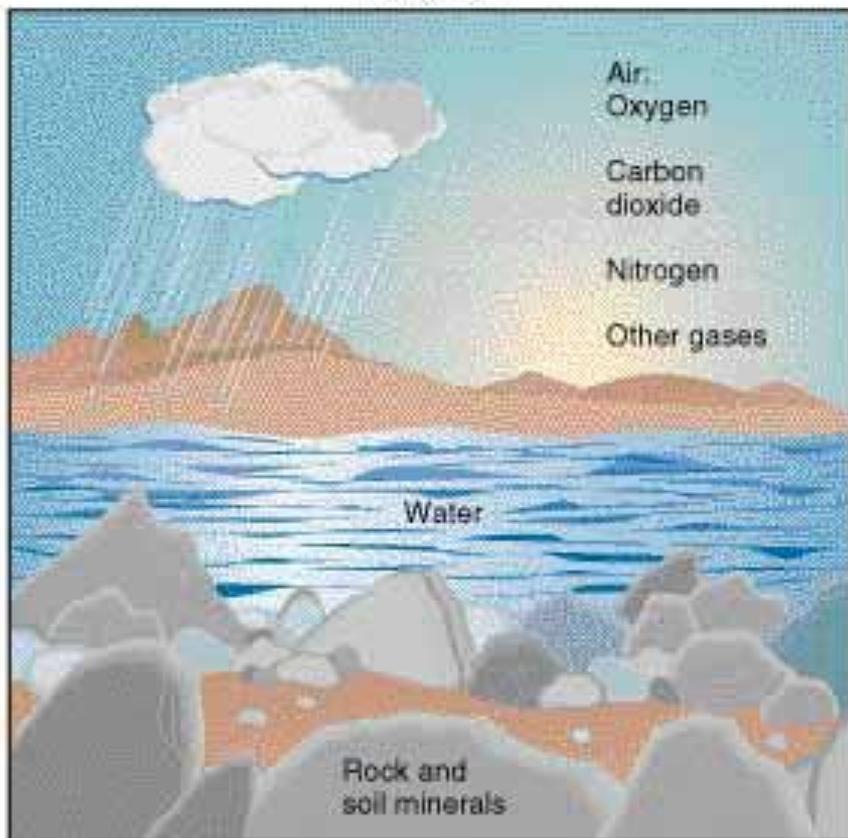
# Ecological Communities and Food Chains

- A set of interacting species that occur in the same place and function together to make possible the persistence of life
- Energy, chemical elements and some compounds are transferred from creature to creature along FOOD CHAINS/FOOD WEBS (Linkage of who feeds on whom)

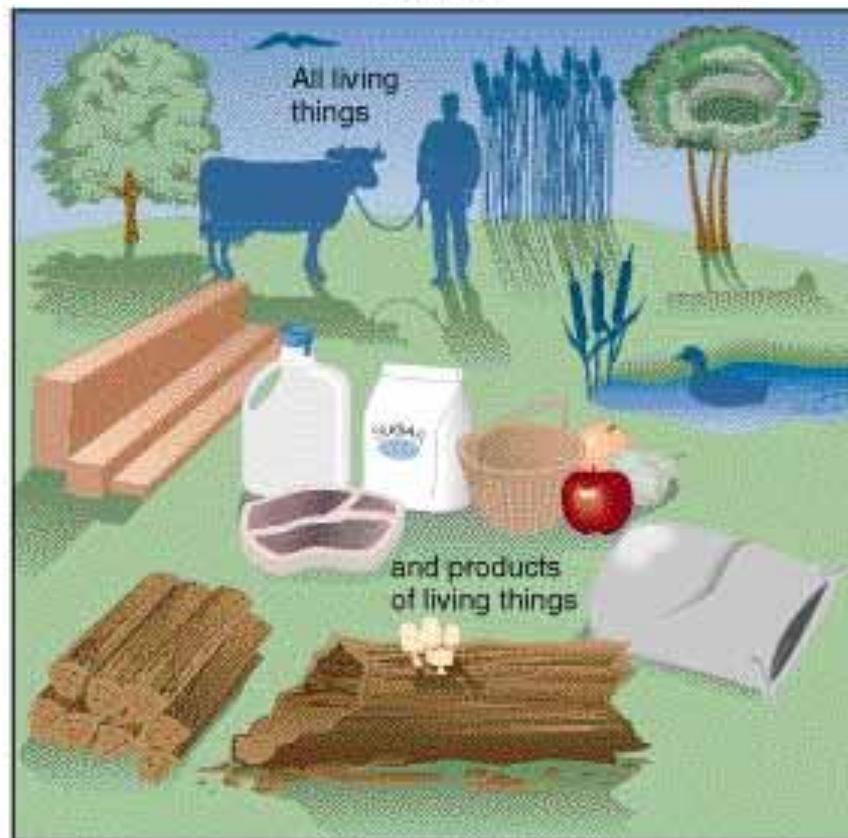
# Trophic Categories: Producers

- **Producers** create organic molecules proteins, lipids and carbohydrates- by
- capturing light energy and combining the captured energy with inorganic molecules.
- · Differentiate between organic and inorganic.
- · Differentiate between natural and synthetic.

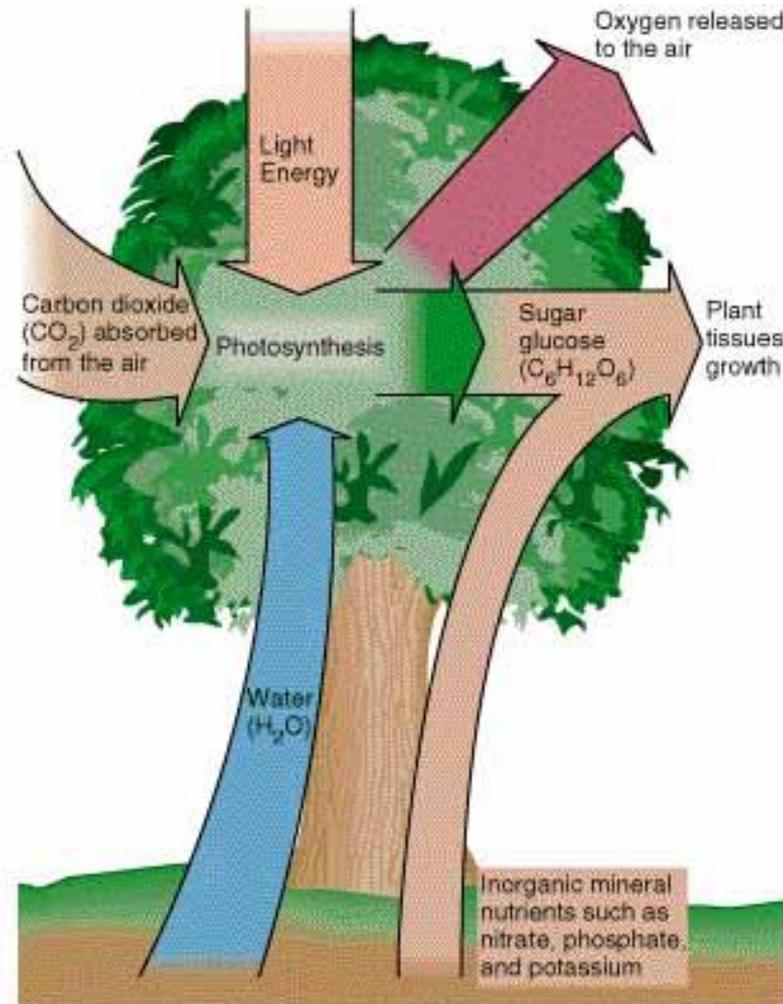
### Inorganic



### Organic



# The Producers in all major ecosystems are Green Plants

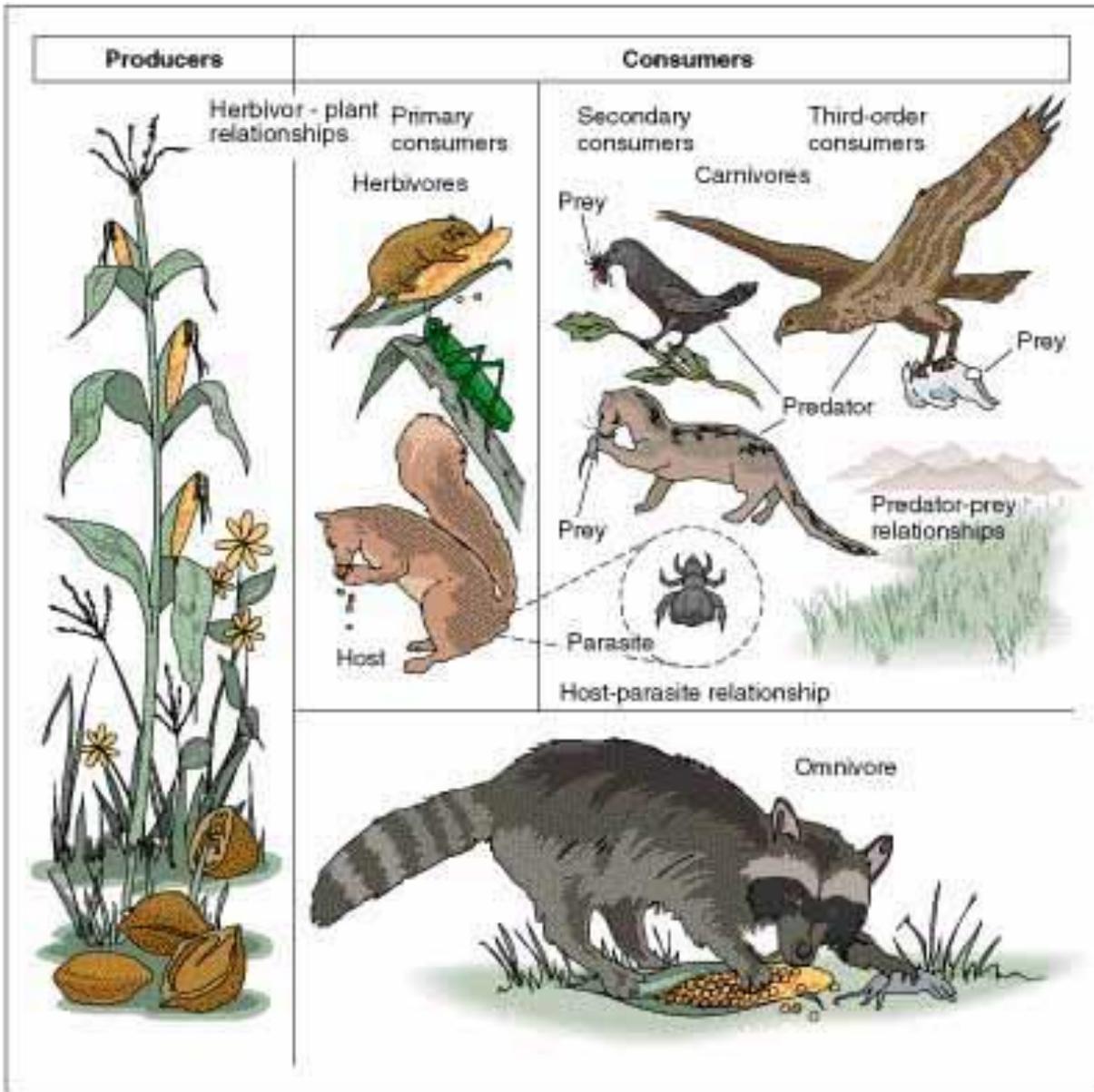


# Trophic Categories: Consumers

- **Consumers** feed on producers and would not exist without producers.
- • Primary consumers (herbivores)
- • Secondary consumers (carnivores)
- • Omnivores are both herbivorous and carnivorous.

# Trophic Categories: Decomposers

- **Detritus feeders and decomposers**
- Detritus feeders can be primary (feed directly on detritus) or secondary (feed on those who eat detritus).
- Generally detritus feeders can be described as those who consume dead plants and animals, feces, etc.
- Decomposers are primary detritus feeders.



# Trophic Relationships

- **a. Food chains:** feeding pathways
- • Food chains are a description of who eats whom.
- • Predator-prey and host-parasite describe specific feeding relationships.
- **b. Food webs:** complexes of feeding relationships.
- **c. Trophic Levels** or Feeding Levels

# Trophic Levels

- A trophic level consists of all those organisms in a food web that are the *same number of feeding levels* away from the original source of energy.
- The original source of energy in *most ecosystems is The Sun*.

# Food Chains and Food web

- A Terrestrial Food Chain

- 4 trophic levels:

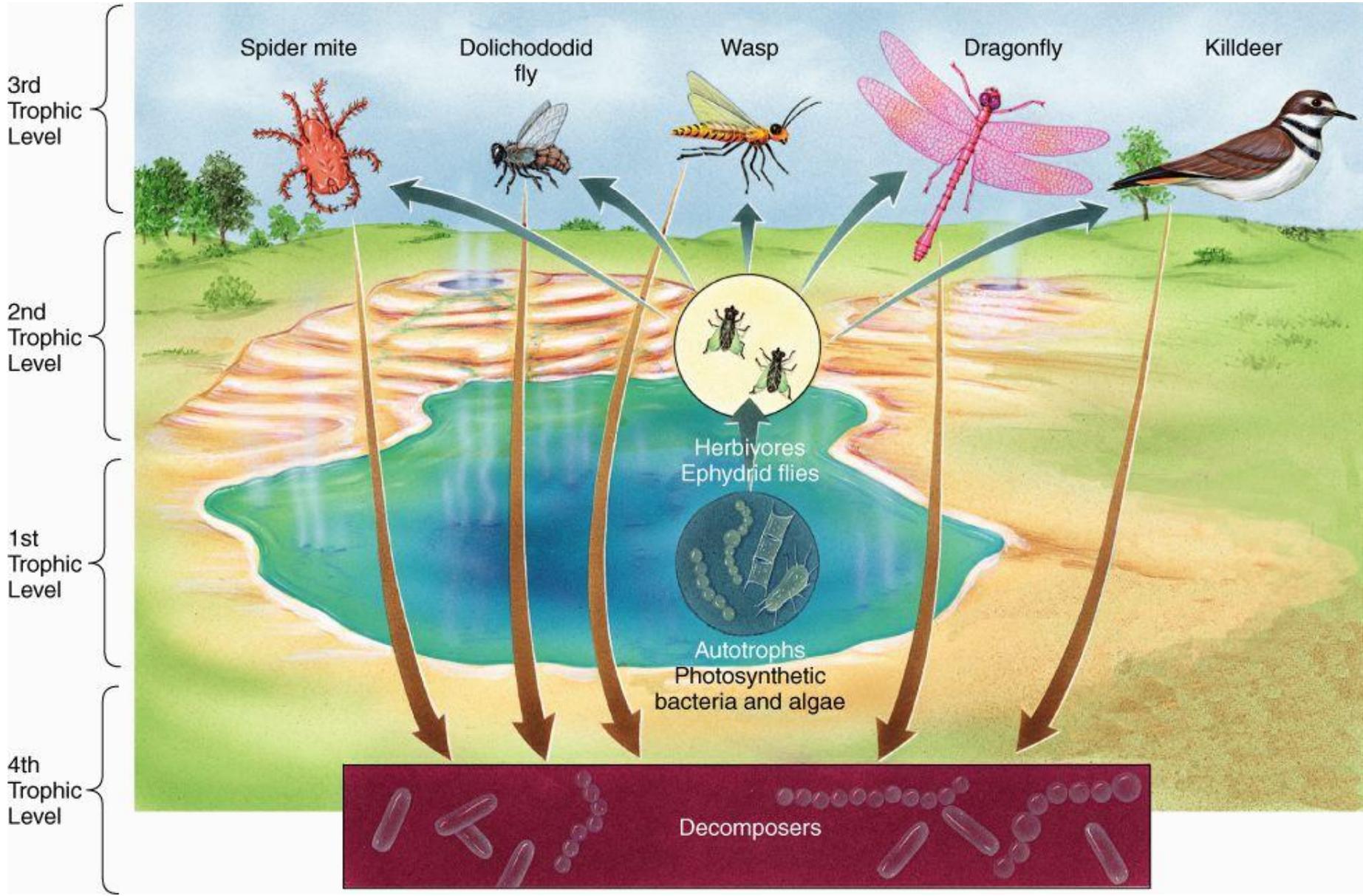
- Autotrophs (Photosynthesizing plants, algae and bacteria)

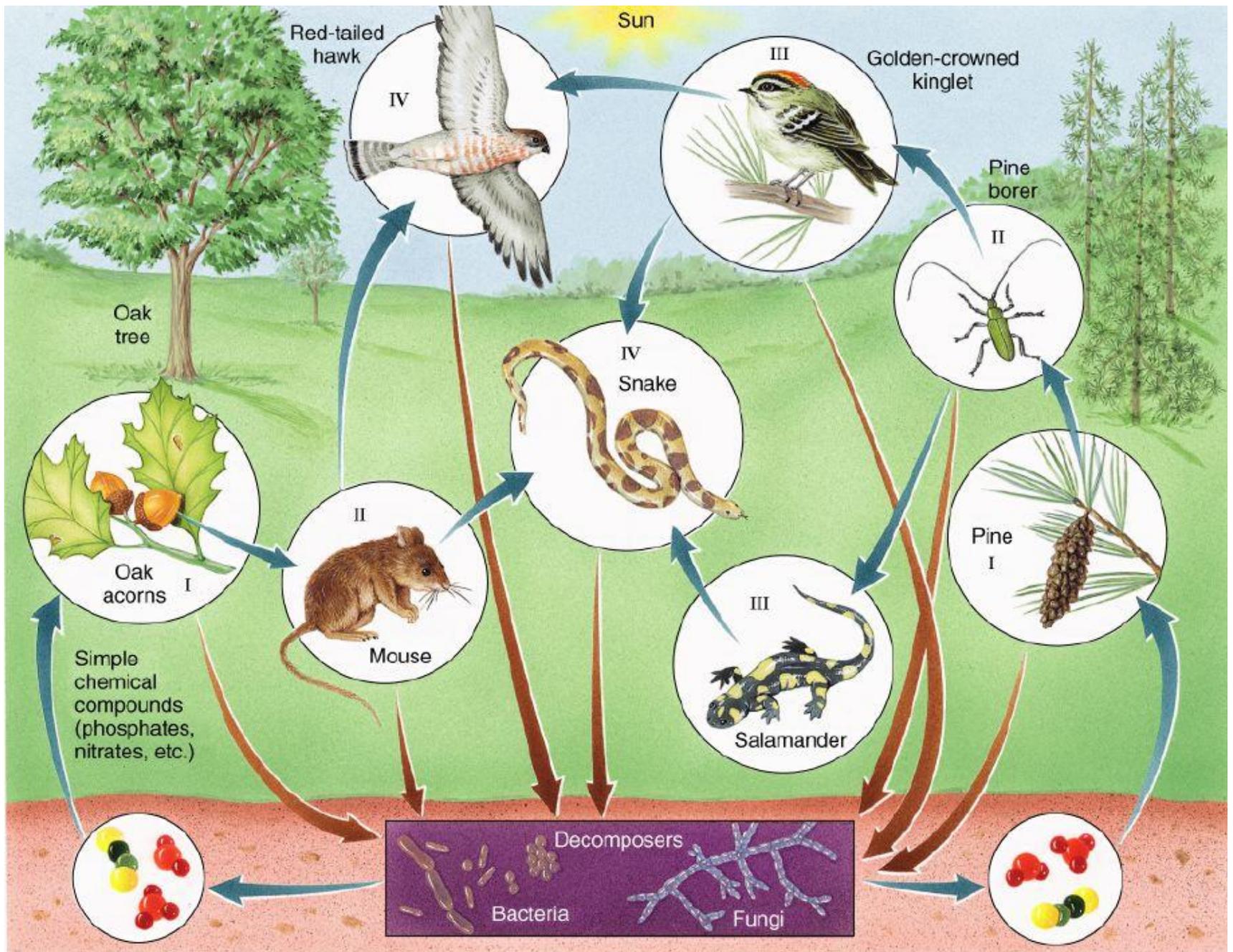
- Herbivores (Plant-Eaters)

- Carnivores (Feed directly on Herbivores)

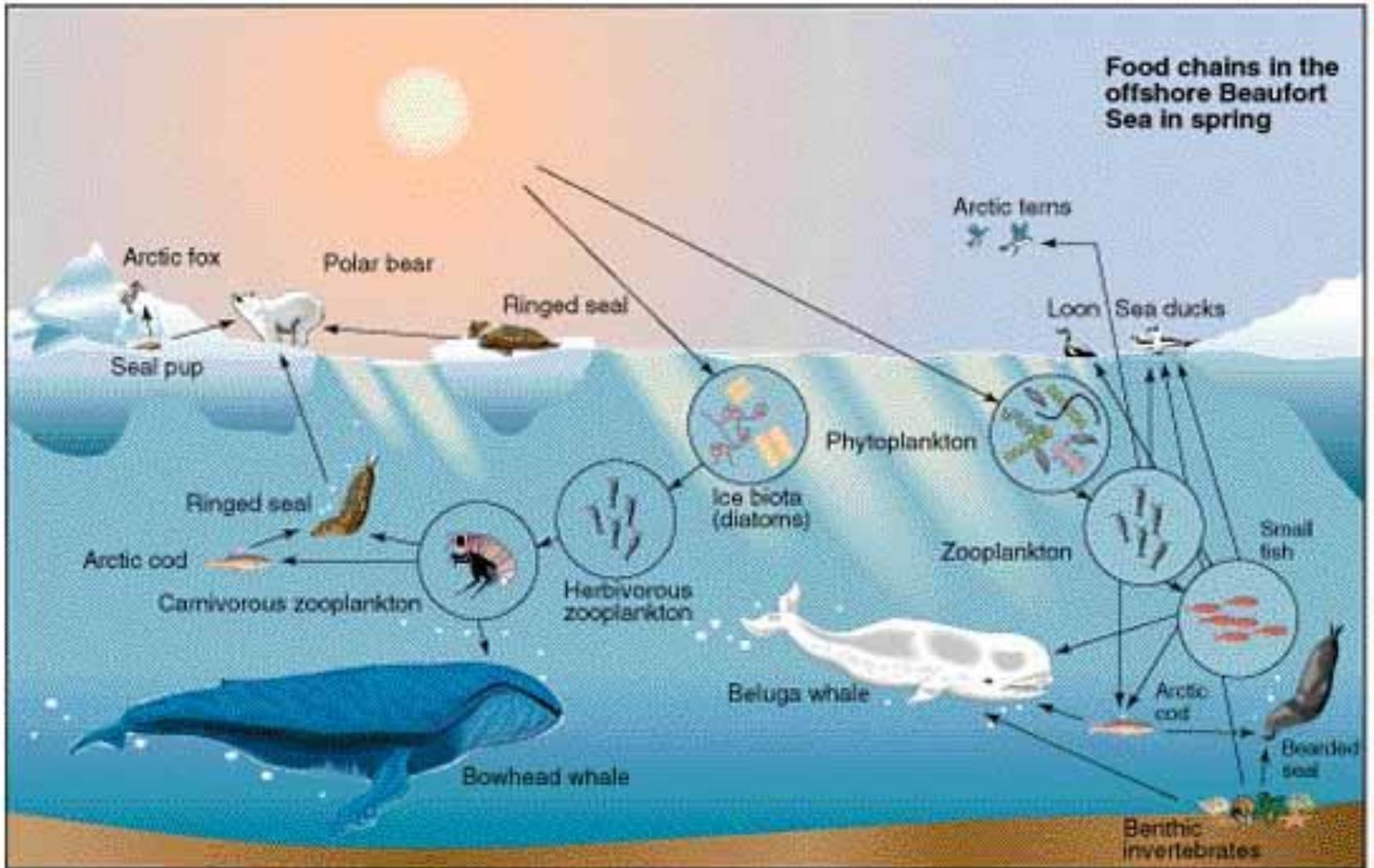
- Carnivores (Feed on other Carnivores) and  
Decomposers (Bacteria and Fungi-Feed on everything)

- People are Omnivores (Herbivore & Carnivore)





Food chains in the offshore Beaufort Sea in spring



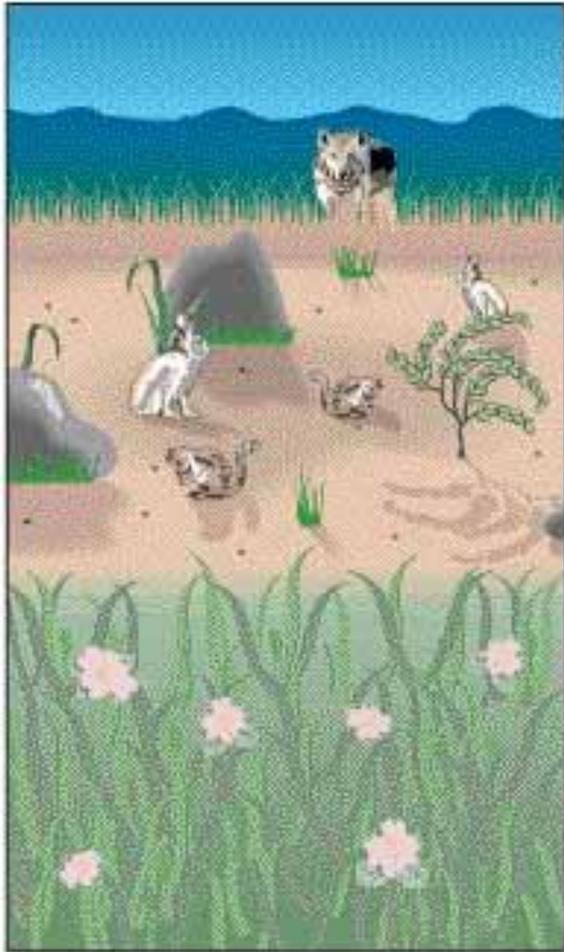
(b)

# Biomass and Biomass Pyramid

- **a.** All organic matter can be defined as **biomass**.
- **b.** All biomass can be arranged into a feeding relationship with the producers on the first trophic level.
- **c.** On average, **10%** of the energy from one trophic level moves to the next trophic level. (This is due partly to the First and Second Laws of thermodynamics.) At each trophic level most of the organisms are not consumed, portions of organisms consumed pass through the consumer undigested, and energy is released to the environment as high potential energy is converted to low potential energy.

# Biomass and Biomass Pyramid

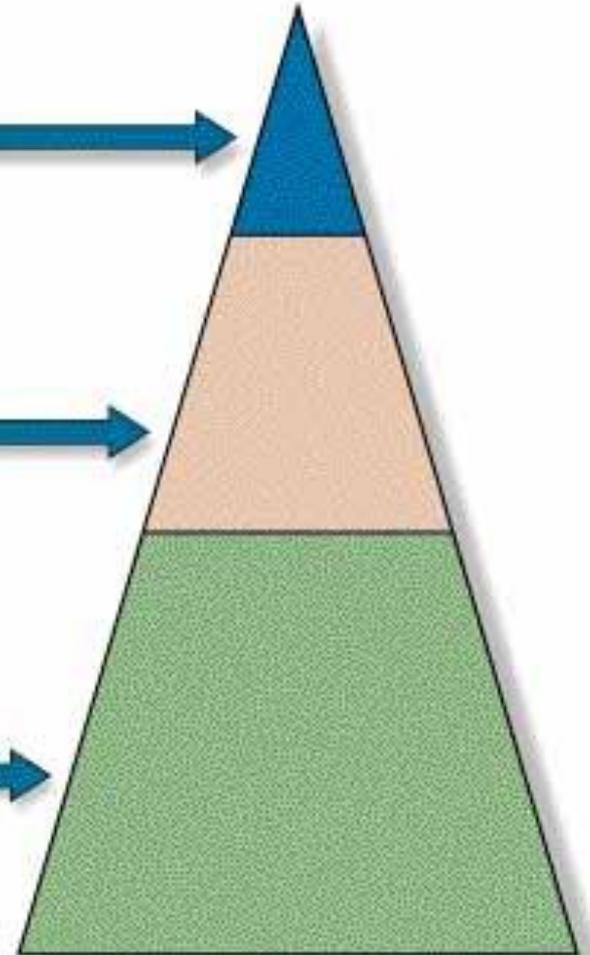
- **d.** Because so little energy can be transferred between trophic levels, it is necessary that the first trophic level contain the greatest number of organisms, and the subsequent trophic levels contain fewer and fewer organisms. Limitations on the transfer of energy between trophic levels creates the biomass pyramid.
- **e.** If organisms (humans) eat high on the biomass pyramid (trophic levels 3, 4, 5, etc.), then fewer organisms can be supported than if organisms eat lower on the biomass pyramid.



→ Total Combined Mass of All Carnivores = Biomass of Third Trophic Level →

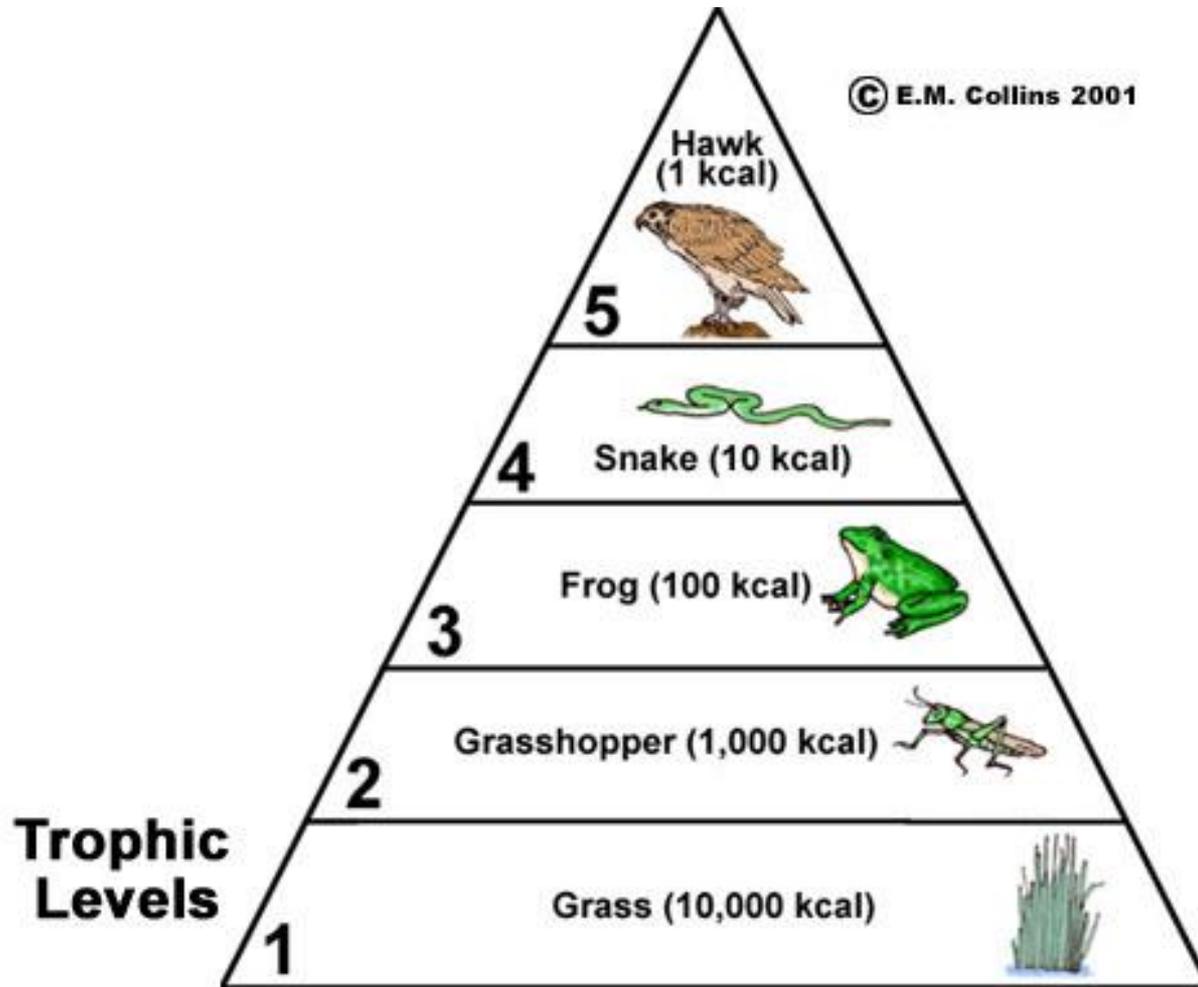
→ Total Combined Mass of All Herbivores = Biomass of Second Trophic Level →

→ Total Combined Mass of All Producers = Biomass of First Trophic Level →

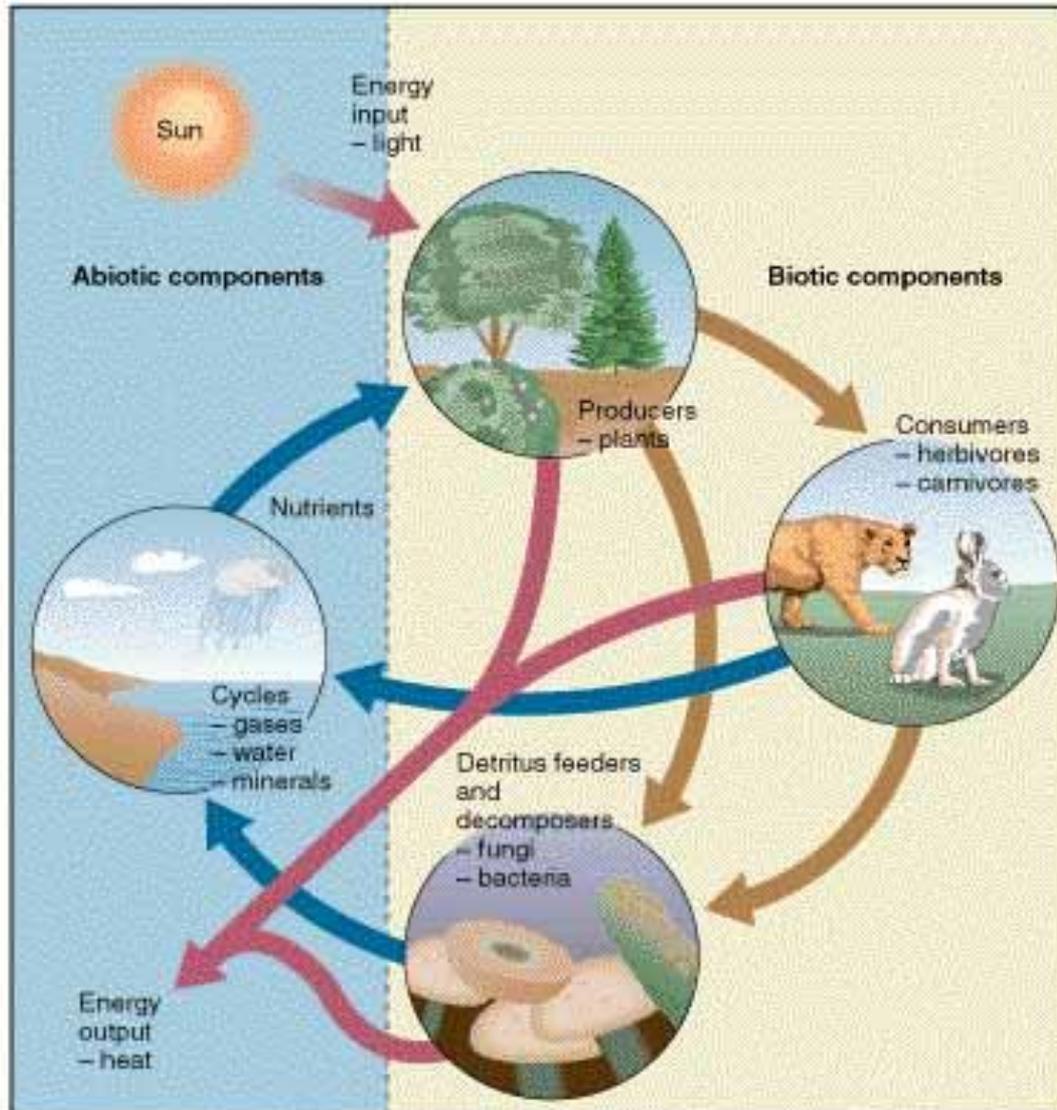


Segments of Pyramid Show Relative Biomass at Each Trophic Level

The mass (weight) and numbers of organisms decreases along a food chain (e.g. grass-grasshoppers-frogs-snakes-hawk). It takes many pounds of grass (or numerous grass plants) to support one hawk at the top of a food chain



# The movement of nutrients (blue arrows) and energy (red arrows) and both (brown arrows) through the ecosystem

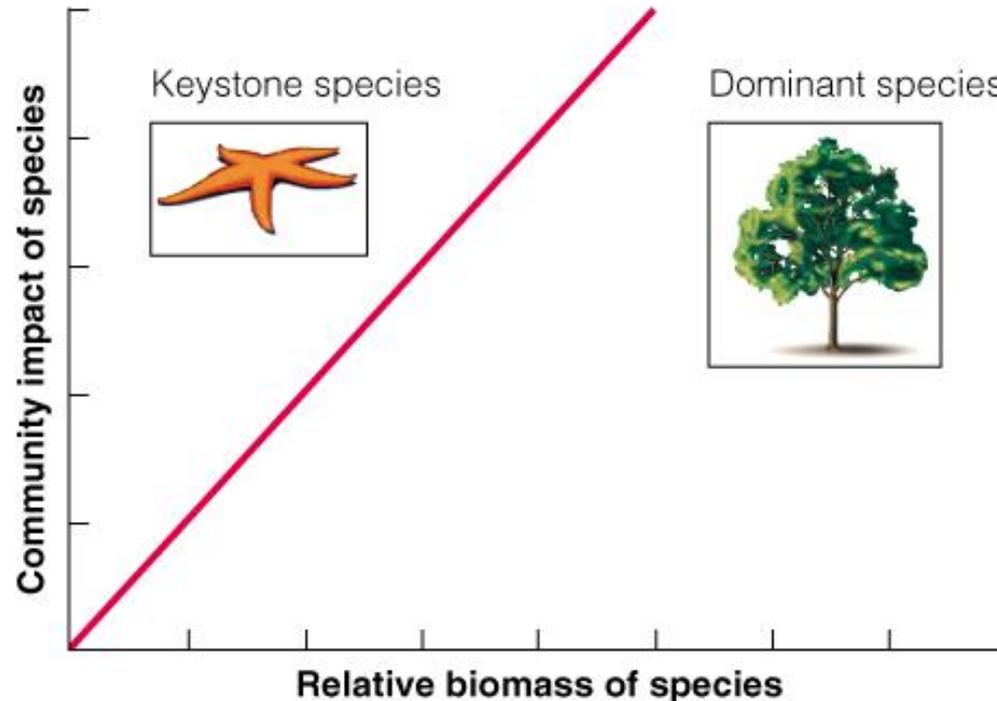


# Species Interactions

- **Competition (-, -)**
  - 2 species using same limited resource to the detriment of both
- **Predation (+, -)**
  - One animal eats another
- **Herbivory (+, -)**
  - An animal eats a plant
- **Parasitism (+, -)**
  - 2 species live in close proximity and one depends on the other
- **Disease (+, -)**
  - A pathogenic microorganism causes damage to its host
- **Mutualism (+, +)**
  - Two species living in a close positive association

# Keystone vs dominant species

- Keystone species: have an impact that is disproportionate to their abundance
- Dominant species: those species that are most common in the community; impact is proportionate to their abundance



# Primary Production

- Gross Primary Productivity

The rate at which an ecosystem's producers convert solar energy into chemical energy as biomass is the ecosystem's gross primary productivity

- Net Primary Productivity

Rate at which producers store chemical energy stored as biomass (produced by photosynthesis) – Rate at which producers use chemical energy stored as biomass (through aerobic respiration)

- The earth's total net primary productivity is the upper limit determining the planet's carrying capacity for all species

# Biological Diversity and Biological Evolution

- Biological Diversity
  - The variety of life-forms commonly expressed as the number of species in an area
- Biological Evolution
  - The change in inherited characteristics of a population from generation to generation
  - One of the features that distinguishes life from everything else in the universe

# Ecological Importance

- trees provide habitat and food for birds, insects, other plants and animals, fungi, and micro-organisms;
- insects, bats, birds, and other animals serve as pollinators;
- parasites and predators act as natural population controls;
- various organisms, such as earthworms and bacteria, are responsible for recycling organic materials and maintaining the productivity of soils;
- green plants remove carbon dioxide from the atmosphere and replenish it with oxygen. Forests, for example, are particularly important "sinks" for the absorption of carbon dioxide and thus are key factors in reducing global climate change;
- wetlands serve as sponges to reduce the impacts of floods and to cleanse streams by filtering sediments, nutrients, and contaminants from inflowing waters.
- The interaction of all these natural processes forms a complex web of life. If any part of this web suffers or breaks down, the future of the other parts is threatened. Humans are in many cases degrading and destroying the ability of biological diversity to perform the services mentioned above.

# Economic Importance

- **food:** species are hunted (e.g. deer, birds), fished (e.g. cod, tuna fish), and gathered (e.g. fruits, berries, mushrooms), as well as cultivated for agriculture (e.g. wheat, corn, rice, vegetables) and aquaculture (e.g. salmon, mussels). It is interesting to know that, of the about 80,000 available comestible plants, humans use less than 30 to satisfy 90% of our planet's alimentary needs;
- **fuel:** timber and coal are only two examples of natural resources used to produce energy;
- **shelter and warmth:** timber and other forest products (e.g. oak, beech, pine) are used as building materials and for shelter. Fibers such as wool and cotton are used to make clothes;
- **medicines:** both traditional medicines and processed drugs are obtained from biodiversity: penicillin is produced by a mould, codeine is obtained from poppies, digitalis from foxglove and quinine from the bark of cinchona trees;
- **other goods** such as paper and pencils come from raw materials provided by the Earth's diversity.

# Four Processes that lead to Evolution

- Mutation
- Natural Selection
- Migration
- Genetic Shift

# Mutation

- A chemical change in a DNA molecule
- Affects the expressed characteristics when cells or individual organisms reproduce

# Natural Selection

## (Survival of the fittest)

- When there is a variation within a species, some individuals may be better suited to the environment than others
- The process of increasing the proportion of offspring
- 4 Characteristics:
  - Genetic Variability
  - Environmental Variability
  - Differential Reproduction
  - Environmental Influence
- Species:
  - a group of individuals that reproduce with each other

# Migration

- Two new species evolve from an original species due to isolation
- The separated portion of the species will try to survive through natural selection.
- Especially, if they are separated geographically for long time, they can be changed significantly.
- Natural selection, combined with migration can produce new species, which can be completely different from their ancestors.

# Genetic Drift



- Changes in the frequency of a gene in a population due to chance rather than mutation, selection or migration
  - Chance may determine which individuals become isolated in a small group from a larger population and thus which genetic characteristics are changed.
  - The individuals may be better, poorly or neutrally adapted to the environment.
- Can be a problem for rare or endangered species
  - For example bighorn sheep live in the mountains of the desert southwest of US.
  - Before human settlement, they can migrate and move freely.
  - With human settlement on that region, many population of bighorn sheep have become isolated and that cause problem to their survival.

# Basic Concepts of Biological Diversity

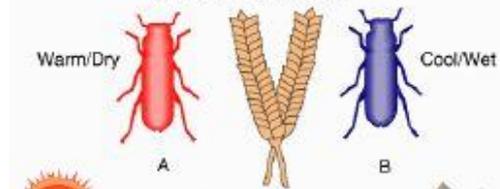
- Genetic Diversity
  - The total number of genetic characteristics of a specific species, a subspecies, or a group of species.
- Habitat Diversity
  - The diversity of habitat in a given unit area
- Species Diversity
  - Species richness: the total number of species
  - Species evenness: the relative abundance of species
  - Species dominance: the most abundant species



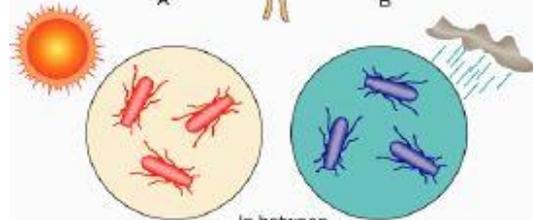
# The Competitive Exclusion Principles

- 2 species that have exactly the same requirements cannot coexist in exactly the same habitat
- Ex) introduction of the gray squirrel into Great Britain

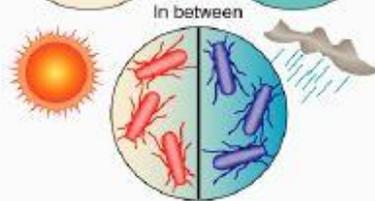
Two species of *Tribolium*



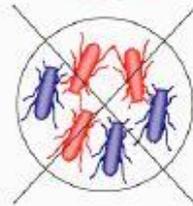
A: Likes warm, dry conditions  
 B: Likes cool, wet conditions  
 Both: Like to eat wheat



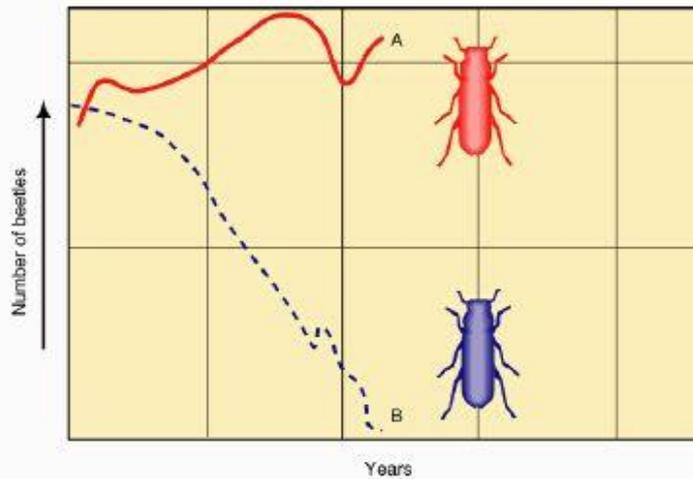
In a uniform environment, one will win out over the other. If the environment is warm and dry, A will win; if it is cool and wet, B will win.



In a mixed environment, the beetles will use separate parts of the habitat.

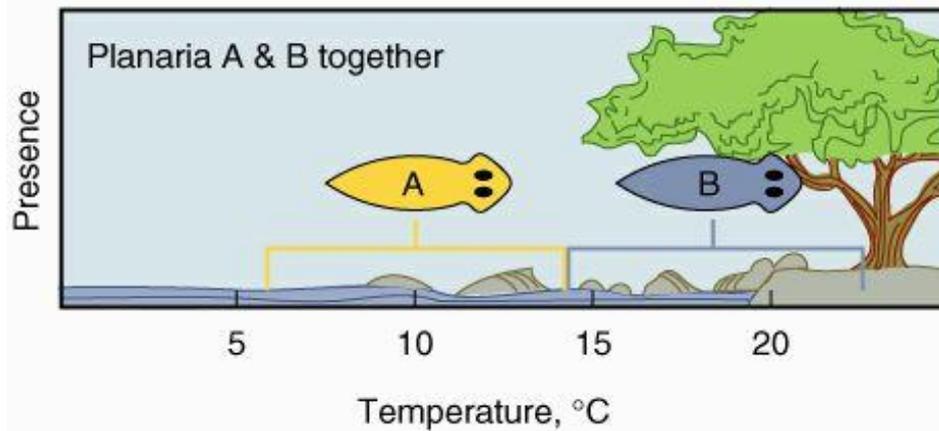
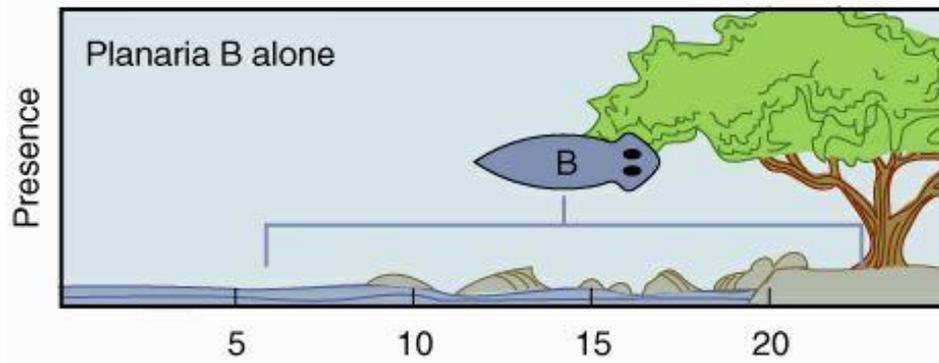
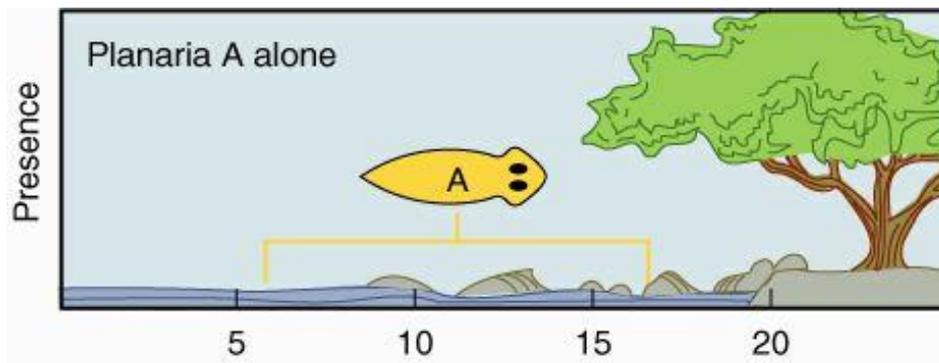


In either case, the beetles do not coexist.



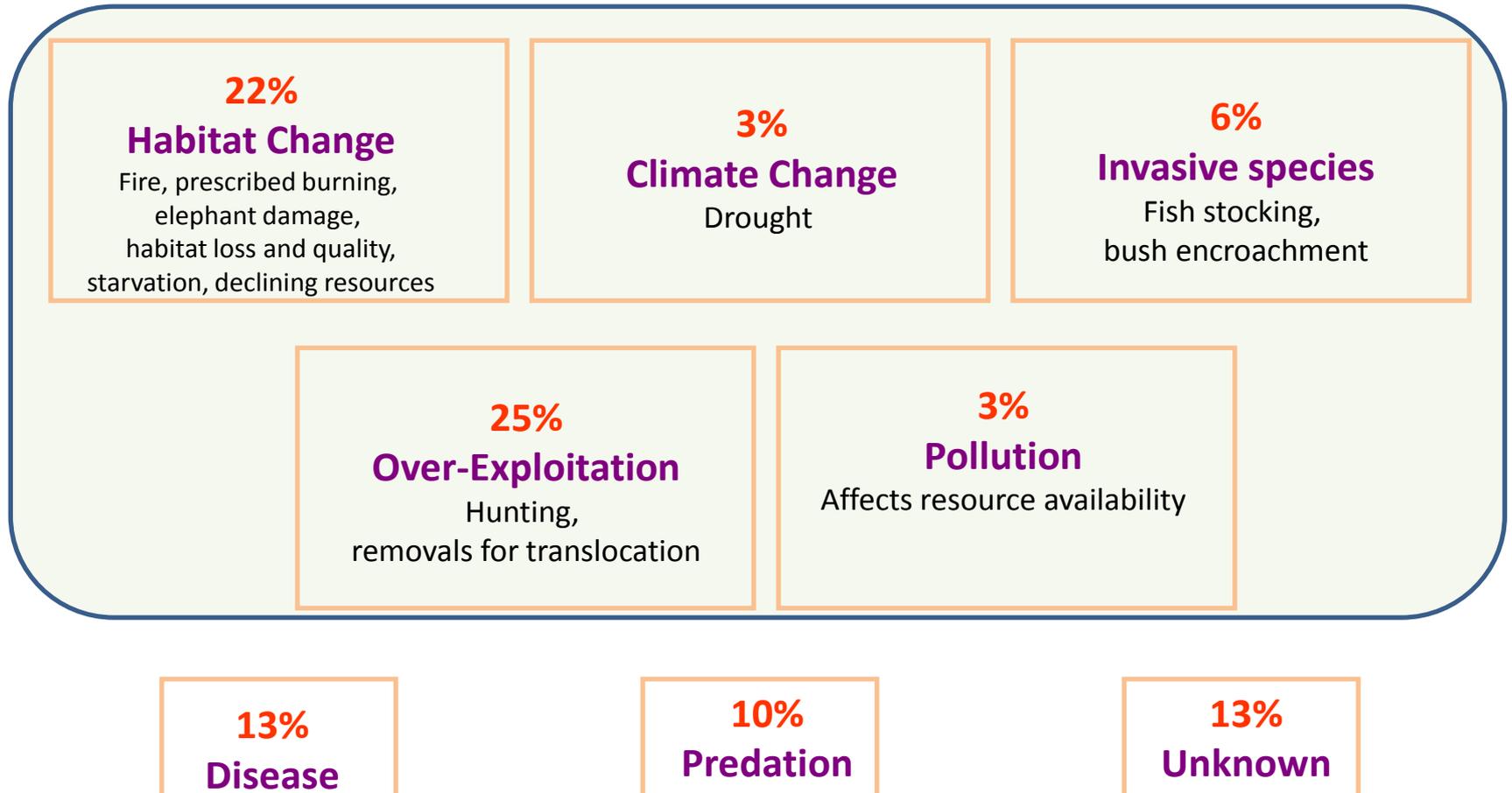
# Professions and Places

- Habitat: where a species lives
- Ecological Niche: a species profession
- The reason more species do not die out from competition is that they have developed a niche, and thus avoid competition



# Threats are Drivers of Global Environmental Change

Reduction or Loss of Species in Protected Areas



54 % of cases involved more than one driver

# Major factors that increase and decrease biodiversity in a nutshell

- Factors that tend to increase diversity
  1. Physically diverse habitat
  2. Moderate amounts of disturbance
  3. A small variation in environmental conditions
  4. High diversity at one trophic level with respect to another
  5. An environment highly modified by life
  6. Middle stages of succession
  7. Evolution

# Major factors that increase and decrease biodiversity in a nutshell

- Factors that tend to decrease diversity
  1. Environmental stress
  2. Extreme environments
  3. A severe limitation in the supply of an essential resource
  4. Extreme amounts of disturbance
  5. Recent introduction of exotic species
  6. Geographic isolation