What is an ecosystem?

Ecosystem = an ecological system;

= a community and its physical environment treated together as a functional system

OR, MORE SIMPLY

an ecosystem is composed of the organisms and physical environment of a specified area.

SIZE: micro to MACRO

THE RULES OF ECOLOGY

1. Everything is connected to everything else.

2. Everything must go somewhere.

Attributes of Ecosystems

Order

Development

Metabolism (energy flow)

Material cycles

Response to the environment

Porous boundaries

Emphasis on function, not species

ENERGY FLOW IN ECOSYSTEMS

All organisms require energy,

for growth, maintenance, reproduction, locomotion, etc.

Hence, for all organisms there must be:

A source of energy

A loss of usable energy

Types of energy

heat energy

mechanical energy (+gravitational energy, etc.)

chemical energy = energy stored in molecular bonds

Transformations of energy

How is solar energy converted to chemical energy?

How does this process influence life as we see it on earth?

The transformations of energy from solar radiation to chemical energy and mechanical energy and finally back to heat are a traditional topic of **Ecosystem Ecology.**

An ecosystem has abiotic and biotic components:

ABIOTIC components:

Solar energy provides practically all the energy for ecosystems.

Inorganic substances, e.g., sulfur, boron, tend to cycle through ecosystems.

Organic compounds, such as proteins, carbohydrates, lipids, and other complex molecules, form a link between biotic and abiotic components of the system.

BIOTIC components:

The biotic components of an ecosystem can be classified according to their mode of energy acquisition.

In this type of classification, there are:

Autotrophs

and

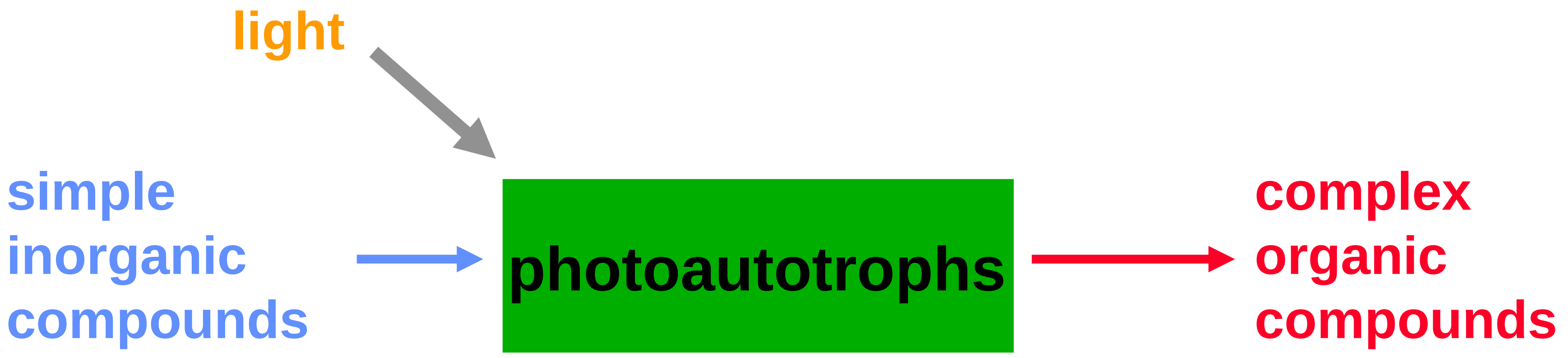
Heterotrophs

Autotrophs

Autotrophs (=self-nourishing) are called primary producers.

Photoautotrophs fix energy from the sun and store it in complex organic compounds

(= green plants, algae, some bacteria)



Chemoautotrophs (chemosynthesizers) are bacteria

that oxidize reduced inorganic substances

(typically sulfur and ammonia compounds)

and produce complex organic compounds.

Chemosynthesis near hydrothermal vents

Other chemoautotrophs:

Nitrifying bacteria in the soil under our feet!

Heterotrophs

Heterotrophs (=other-nourishing) cannot produce their own food directly from sunlight+ inorganic compounds. They require energy previously stored in complex molecules.

(this may include several steps, with several different types of organisms)

Heterotrophs can be grouped as:

consumers

decomposers

Consumers feed on organisms or particulate organic matter.

Decomposers utilize complex compounds in dead protoplasm.

Bacteria and fungi are the main groups of decomposers.

Bacteria are the main feeders on animal material.

Fungi feed primarily on plants, although bacteria also are important in some plant decomposition processes.

The Laws of Thermodynamics

Energy flow is a one-directional process.

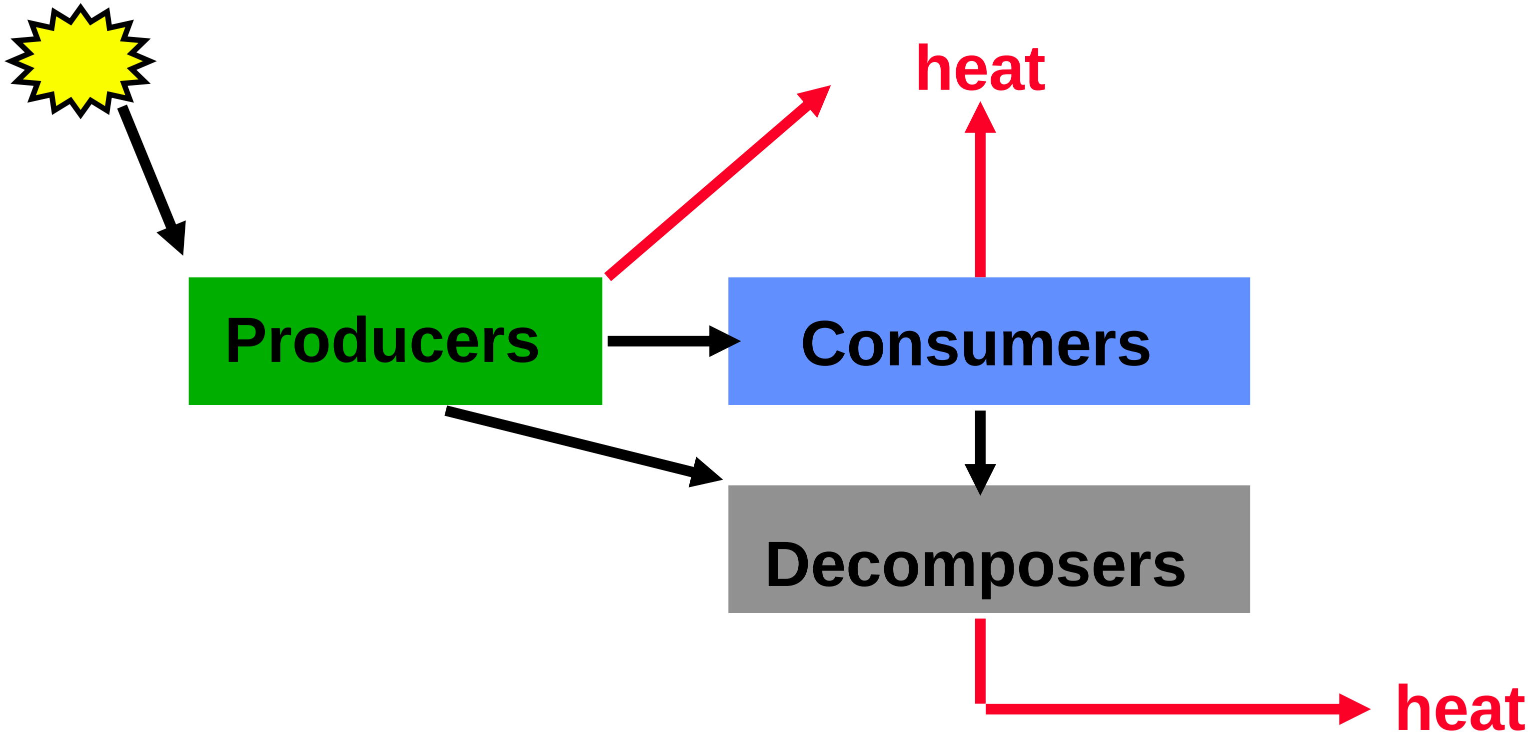
sun---> heat (longer wavelengths)

FIRST LAW of THERMODYNAMICS:

Energy can be converted from one form to another, but cannot be created or destroyed.

Energy flow

Simplistically:



This pattern of energy flow among different organisms is the TROPHIC STRUCTURE of an ecosystem.

It is useful to distinguish different types of organisms within these major groups, particularly within the consumer group.

Terminology of trophic levels

We can further separate the TROPHIC LEVELS, particularly the Consumers:

Producers (Plants, algae, cyanobacteria; some chemotrophs)--capture energy, produce complex organic compounds

Primary consumers--feed on producers

Secondary consumers--feed on primary consumers

Tertiary consumers--feed on secondary consumers

More trophic levels:

Detritivores--invertebrates that feed on organic wastes and dead organisms (detritus) from all trophic levels

Decomposers--bacteria and fungi that break down dead material into inorganic materials

Alternate Terminology

Producers = plants etc. that capture energy from the sun

Herbivores = plant-eaters

Carnivores = animal-eaters

Omnivores--eat both animals and plants

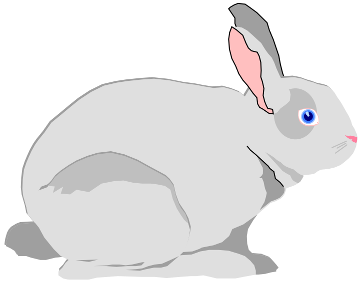
Specialized herbivores:

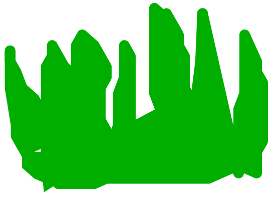
Granivores--seed-eaters

Frugivores--fruit-eaters

Together, these groups make up a FOOD CHAIN

E.g., grass, rabbit, eagle





Carnivore Herbivore Producer

Carnivores

Carnivores can be further divided into groups:

quaternary carnivore (to

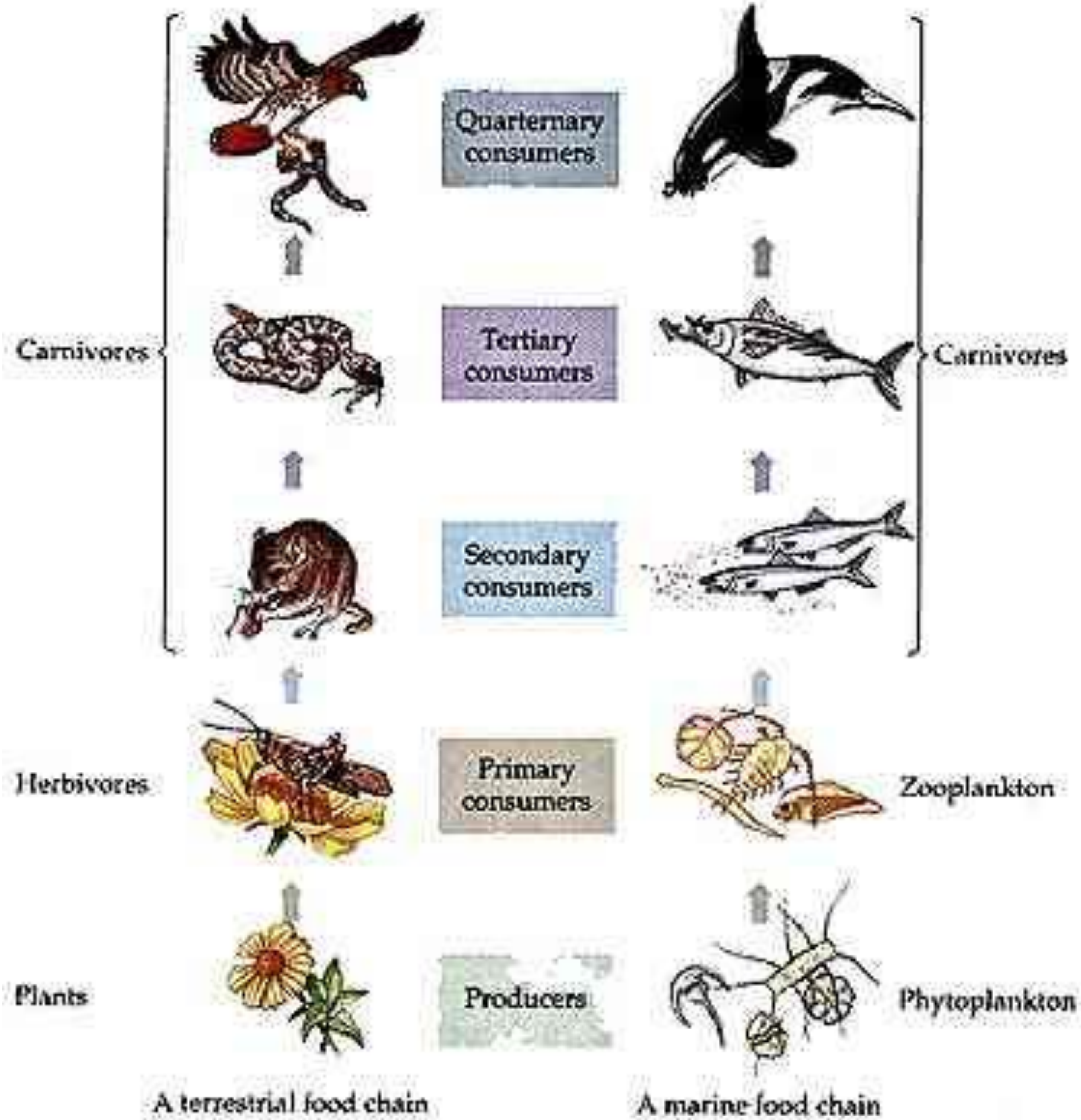
tertiary carnivore

secondary carnivore

primary carnivore

The last carnivore in a chain, which is not usually eaten by any other carnivore, is often referred to as the top carnivore.

Food chains



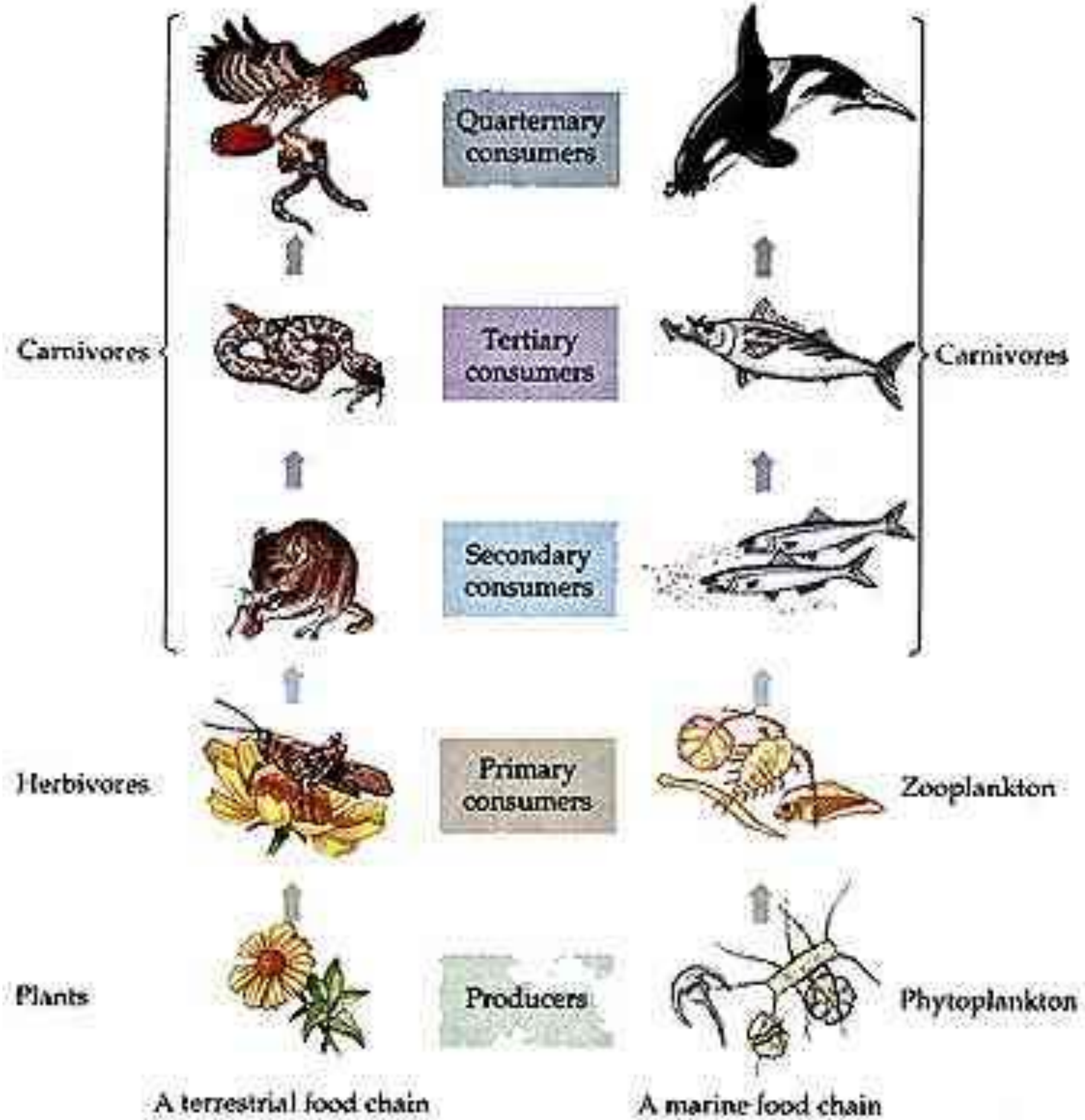
Carnivores
Herbivores
Plants
Quarternary consumers
Tertiary consumers
Secondary consumers
Primary consumers
Producers
Carnivores
Zooplankton
Phytoplankton
A terrestrial food chain
A marine food chain

Problems

Too simplistic

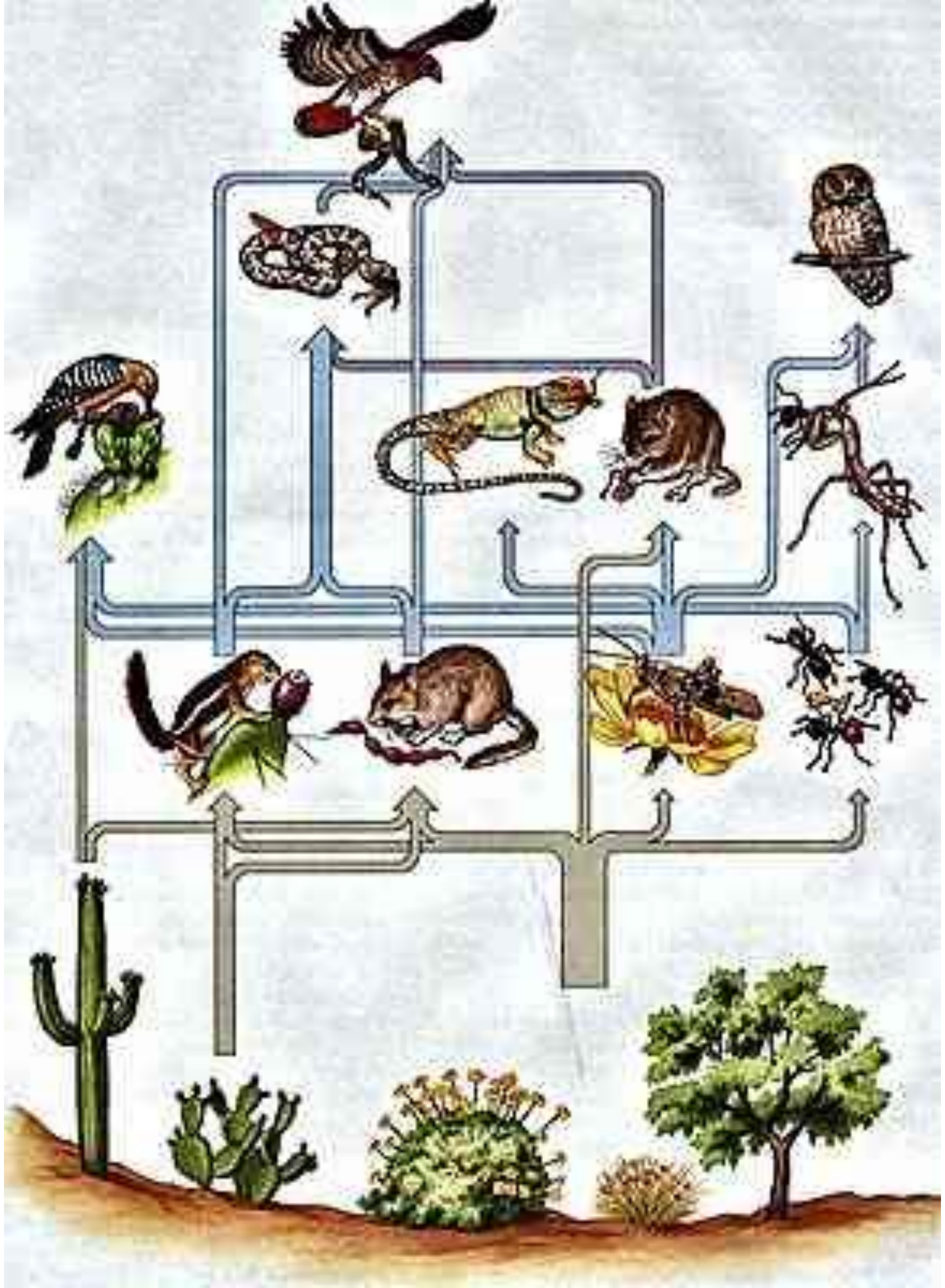
No detritivores

Chains too long



Rarely are things as simple as grass, rabbit, hawk, or indeed any simple linear sequence of organisms.

More typically, there are multiple interactions, so that we end up with a **FOOD WEB**.



Energy transfers among trophic levels

How much energy is passed from one trophic level to the next?

How efficient are such transfers?

Biomass--the dry mass of organic material in the organism(s).

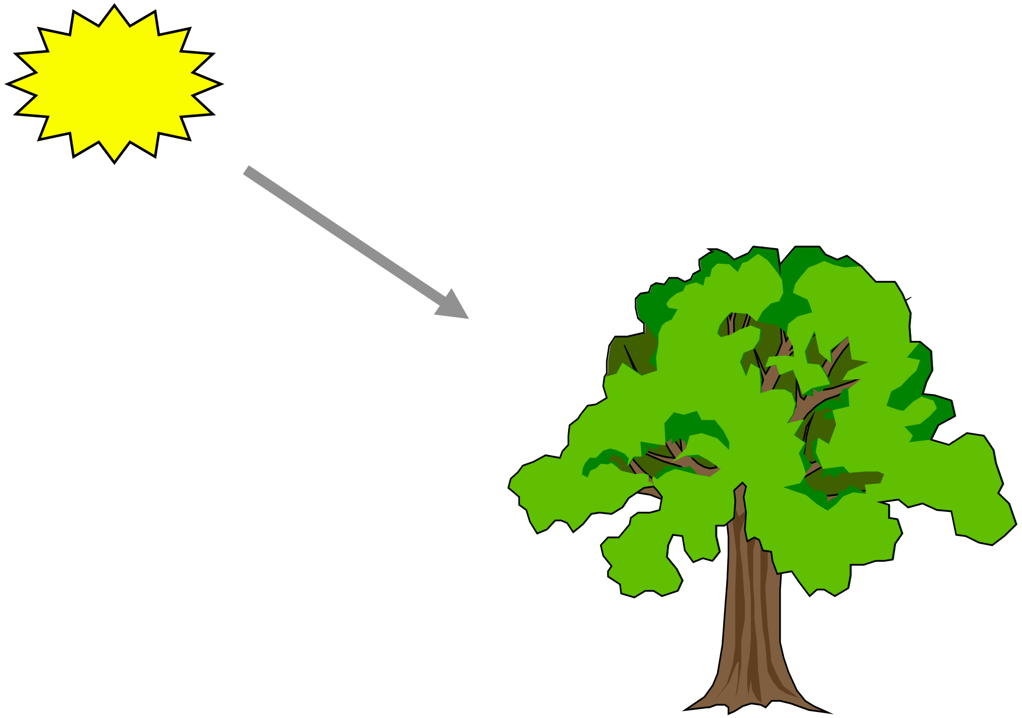
(the mass of water is not usually included, since water content is variable and contains no usable energy)

Standing crop--the amount of biomass present at any point in time.

Primary productivity

Primary productivity is the rate of energy capture by producers.

= the amount of new biomass of producers, per unit time and space



Gross primary production (GPP)

= total amount of energy captured

Net primary production (NPP)

= GPP - respiration

Net primary production is thus the amount of energy stored by the producers and potentially available to consumers and decomposers.

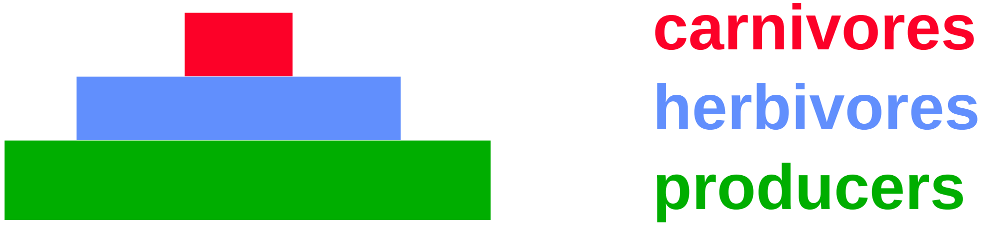
Secondary productivity is the rate of production of new biomass by consumers, i.e., the rate at which consumers convert organic material into new biomass of consumers.

Note that secondary production simply involves the repackaging of energy previously captured by producers--no additional energy is introduced into the food chain.

And, since there are multiple levels of consumers and no new energy is being captured and introduced into the system, the modifiers gross and net are not very appropriate and are not usually used.

Ecological pyramids

The standing crop, productivity, number of organisms, etc. of an ecosystem can be conveniently depicted using “pyramids”, where the size of each compartment represents the amount of the item in each trophic level of a food chain.



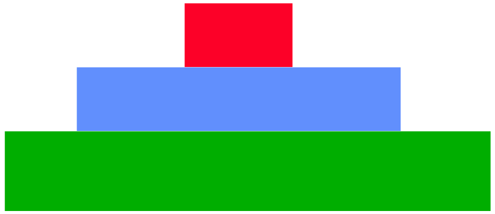
Note that the complexities of the interactions in a food web are not shown in a pyramid; but, pyramids are often useful conceptual devices--they give one a sense of the overall form of the trophic structure of an ecosystem.

Pyramid of energy

A pyramid of energy depicts the energy flow, or productivity, of each trophic level.

Due to the Laws of Thermodynamics, each higher level must be smaller than lower levels, due to loss of some energy as heat (via respiration) within each level.

Energy flow in :

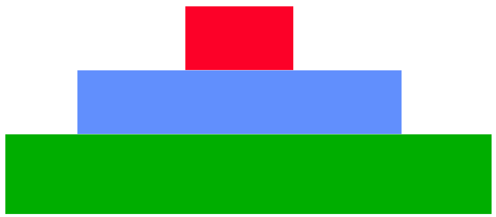


carnivores
herbivores
producers

Pyramid of numbers

A pyramid of numbers indicates the number of individuals in each trophic level.

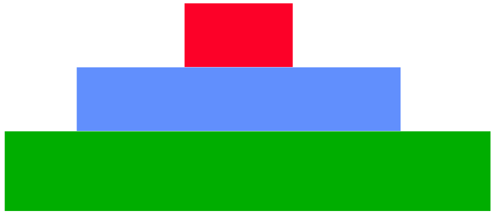
Since the size of individuals may vary widely and may not indicate the productivity of that individual, pyramids of numbers say little or nothing about the amount of energy moving through the ecosystem.



Pyramid of standing crop

A pyramid of standing crop indicates how much biomass is present in each trophic level at any one time.

As for pyramids of numbers, a pyramid of standing crop may not well reflect the flow of energy through the system, due to different sizes and growth rates of organisms.



biomass of carnivores

biomass of herbivores

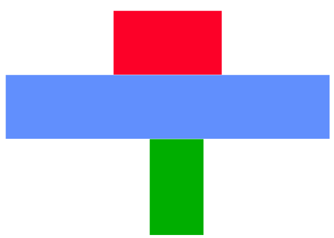
biomass of producers

(at one point in time)

Inverted pyramids

A pyramid of standing crop (or of numbers) may be inverted, i.e., a higher trophic level may have a larger standing crop than a lower trophic level.

This can occur if the lower trophic level has a high rate of turnover of small individuals (and high rate of productivity), such that the First and Second Laws of Thermodynamics are not violated.

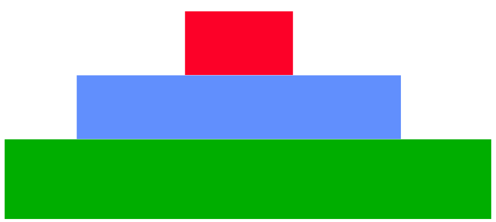


biomass of carnivores
biomass of herbivores
biomass of producers

(at one point in time)

Pyramid of yearly biomass production

If the biomass produced by a trophic level is summed over a year (or the appropriate complete cycle period), then the pyramid of total biomass produced must resemble the pyramid of energy flow, since biomass can be equated to energy.



Yearly biomass production (or energy flow) of:

carnivores
herbivores
producers

Note that pyramids of energy and yearly biomass production can never be inverted, since this would violate the laws of thermodynamics.

Pyramids of standing crop and numbers can be inverted, since the amount of organisms at any one time does not indicate the amount of energy flowing through the system.

E.g., consider the amount of food you eat in a year compared to the amount on hand in your pantry.

Examples of food webs

the North Sea

a hypothetical web--effects on species diversity

Examples of pyramids

Terrestrial and fresh-water communities

Ocean communities--English Channel