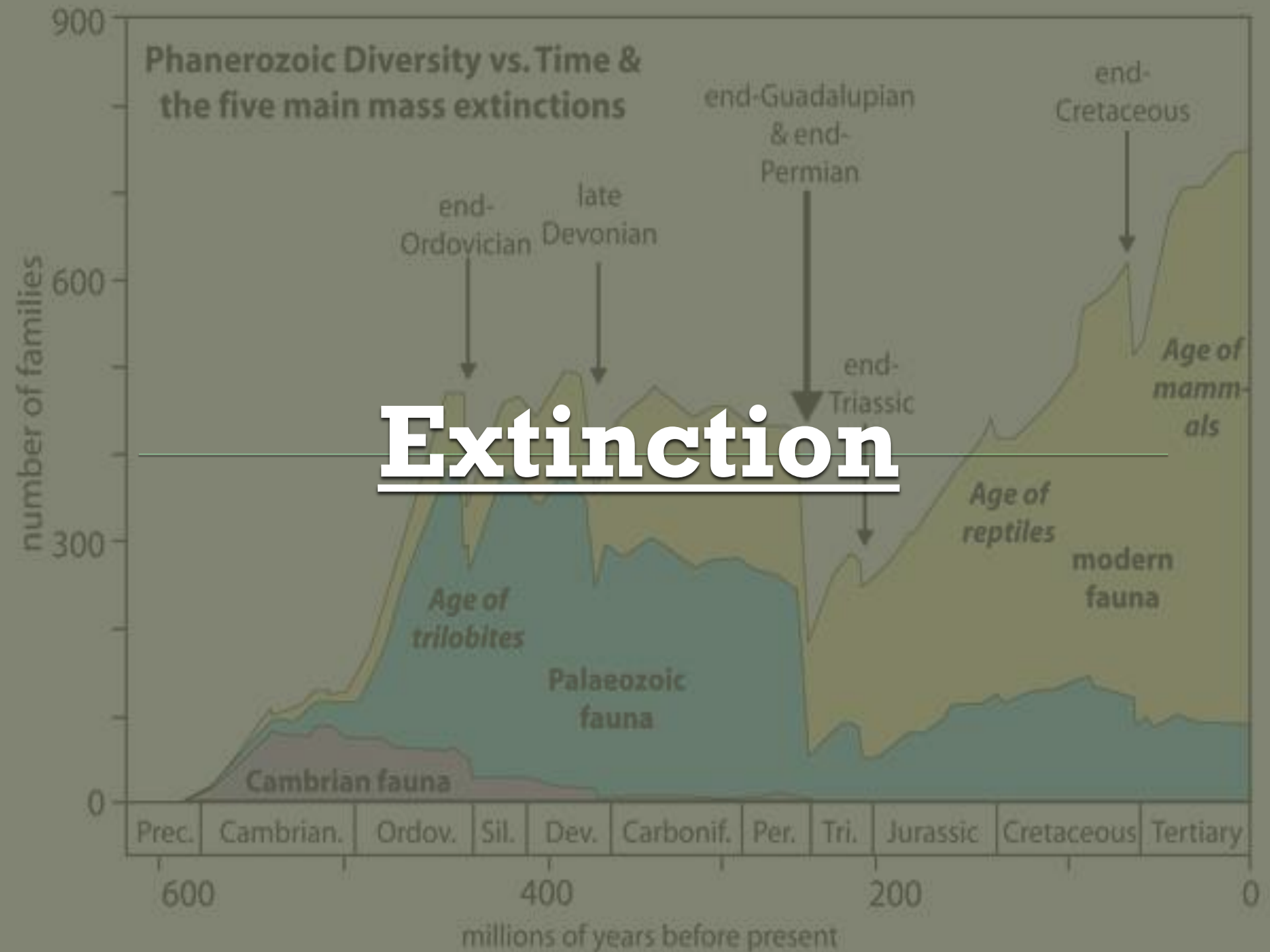

Phanerozoic Diversity vs. Time &
the five main mass extinctions
end-Guadalupian & end-Permian
end-Cretaceous
end-Ordovician
late Devonian
end-Triassic
Age of mamm-als
Age of reptiles
modern fauna
Age of trilobites
Palaeozoic fauna
Cambrian fauna
number of families
900
600
300
0
Prec.
Cambrian.
Ordov.
Sil.
Dev.
Carbonif.
Per.
Tri.
Jurassic
Cretaceous
Tertiary
600
400
200
0
millions of years before present

Extinction

EXTINCTION

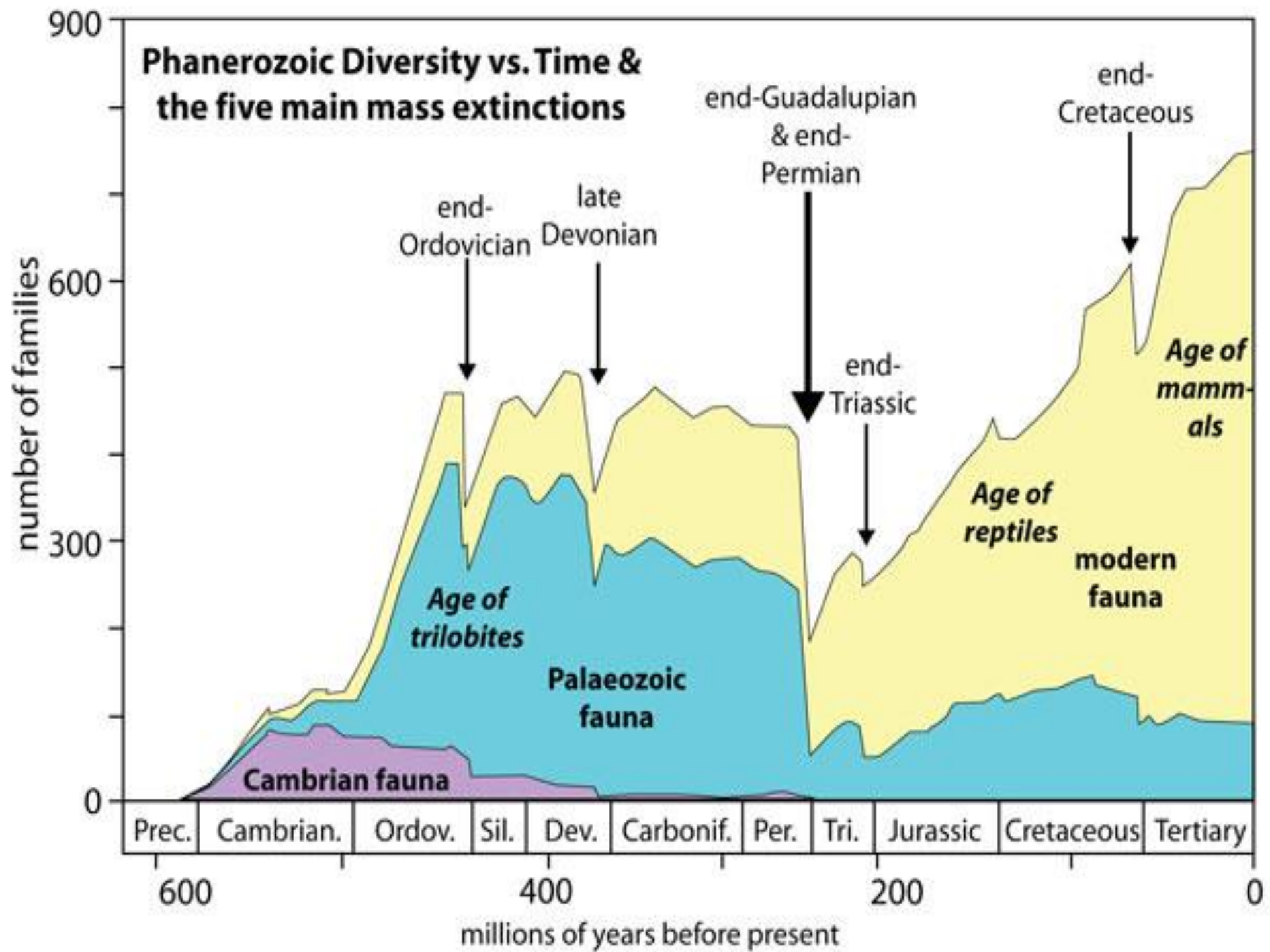
- Speciation is only part of the story; species also disappear.
- **Extinction**: the disappearance of a species from Earth
  - Extinction is a natural process that has taken place for millions of years
  - The fossil record shows many organisms that arose, thrived, and then went extinct long before humans existed
  - Extinction occurs when the environment changes too rapidly for natural selection to work
  - Average time a species spends on earth: 1–10 million years

CAUSES FOR EXTINCTION

- Many factors can contribute to extinction:
  - Climate change, Arrival of new or harmful species, Severe weather (i.e., droughts), Habitat change, Specialized species and small populations etc . . .
- Some species are more vulnerable to extinction:
  - Endemic species are species that only exist in a certain area
  - Endemic species are very susceptible to extinction, because they usually have small populations (i.e., golden toad) and/or sometimes only a single population!
  - Those with specialized niches do not adapt well to changes in their environments.

MASS EXTINCTIONS

- **Background extinction rate**: the normal extinction rate – usually only 1 species goes extinct at a time
- **Mass extinction events**: 5 events in Earth's history that killed off massive numbers of species at once
  - 50-95% of all species went extinct at one time


Phanerozoic Diversity vs. Time &
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late
Devonian
end-Guadalupian
& end-
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end-
Triassic
end-
Cretaceous
Age of
mamm-
als
Age of
reptiles
modern
fauna
Age of
trilobites
Palaeozoic
fauna
Cambrian fauna
Prec.
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Dev.
Carbonif.
Per.
Tri.
Jurassic
Cretaceous
Tertiary
600
400
200
0
millions of years before present

THE 6TH MASS EXTINCTION?

- The rate of extinctions we are experiencing now is much greater than any extinction rate in the past AND most of these extinctions can be traced directly or indirectly to human activities!!!

1. Population growth
2. Development
3. Resource depletion

- Stewardship says we need to try and **reduce** the extinction rate, **not stop it**.
- We can't stop all species from going extinct, and we shouldn't.

OUR BIGGEST ENVIRONMENTAL PROBLEM

Species extinction due to human activities may be the single biggest environmental problem we face, because extinction is irreversible.

Species interactions

INTERACTIONS BETWEEN SPECIES

- Organisms within an ecosystem interact with one another in various ways - we will look at two general categories of interactions:
  - Feeding relationships
  - Non-feeding relationships

FEEDING RELATIONSHIPS: PREDATION

- Predation is one organism preying/eating another.
  - A predator cannot survive unless it can encounter and capture it's prey - this factors into the predator's overall niche (role)
  - Predation also influences the composition of the community
  - For example, a mountain lion must inhabit an area where it can capture food (such as rabbits and deer) and it also keeps the number of rabbits and deer in it's territory from growing to excessive population sizes

HERBIVORY

Here is one our local herbivores, the Desert Tortoise

- Herbivory is a form of predation in which animals feed on the tissues of plants
  - May not kill the plant, but affects its growth and survival
  - Widely seen in insects
- Defenses against herbivory include:
  - Toxic or distasteful chemicals
  - Thorns, spines, or irritating hairs

FEEDING RELATIONSHIPS: COMPETITION

- Competition between organisms can be either
  - *Interspecific*: meaning between *different* species, or
  - *Intraspecific*: meaning between organisms of the *same species*

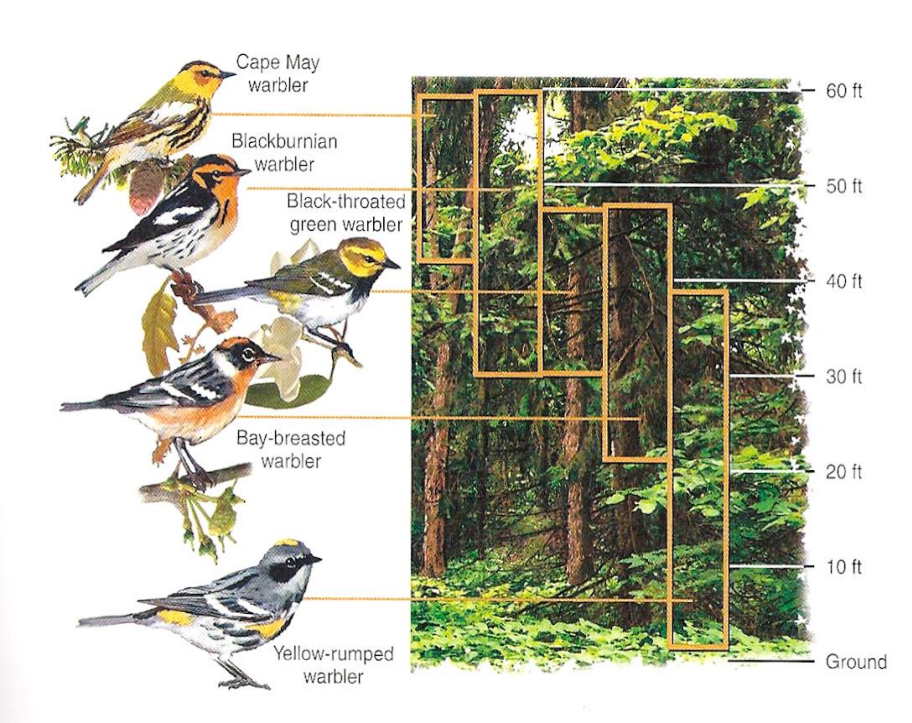
INTERSPECIFIC COMPETITION

- When 2 organisms of different species have a large niche overlap (share a lot in common), they must figure out a way to share, or partition, their resources
- If they do not, one of the species will out-compete the other for resources, and this can lead to extinction.

RESOURCE PARTITIONING

- When 2 (or more) species compete for the same resource (like food), one eventually gains the upper hand and uses the larger share of the resource, while the other species experiences a change in its behavior or physiology (its niche) so that competition is minimized.
- So, the "loser" species undergoes a bit of niche evolution, allowing it to survive.
- The end result is that several species are able to make use of the same resource by using it slightly differently, like:
  - Feeding at different times of day
  - Feeding on slightly different types of food
  - Feeding on the same food source in different areas, etc.

EXAMPLE OF RESOURCE PARTITIONING



(Cunningham et al. 2008)

Break-down of the Resource Partitioning by the Warblers

- Cape May warbler is a gleaner (eats bugs right off tree) - but feeds in the P.M.
- Blackburnian warbler eats aerial insects
- Black-throated green warbler is also a gleaner, but feeds in the A.M.
- Bay-breasted warbler eats bugs in the interior of the tree, in the bark
- Yellow-rumped warbler eats bugs in the ground and leaf littler

INTRASPECIFIC COMPETITION

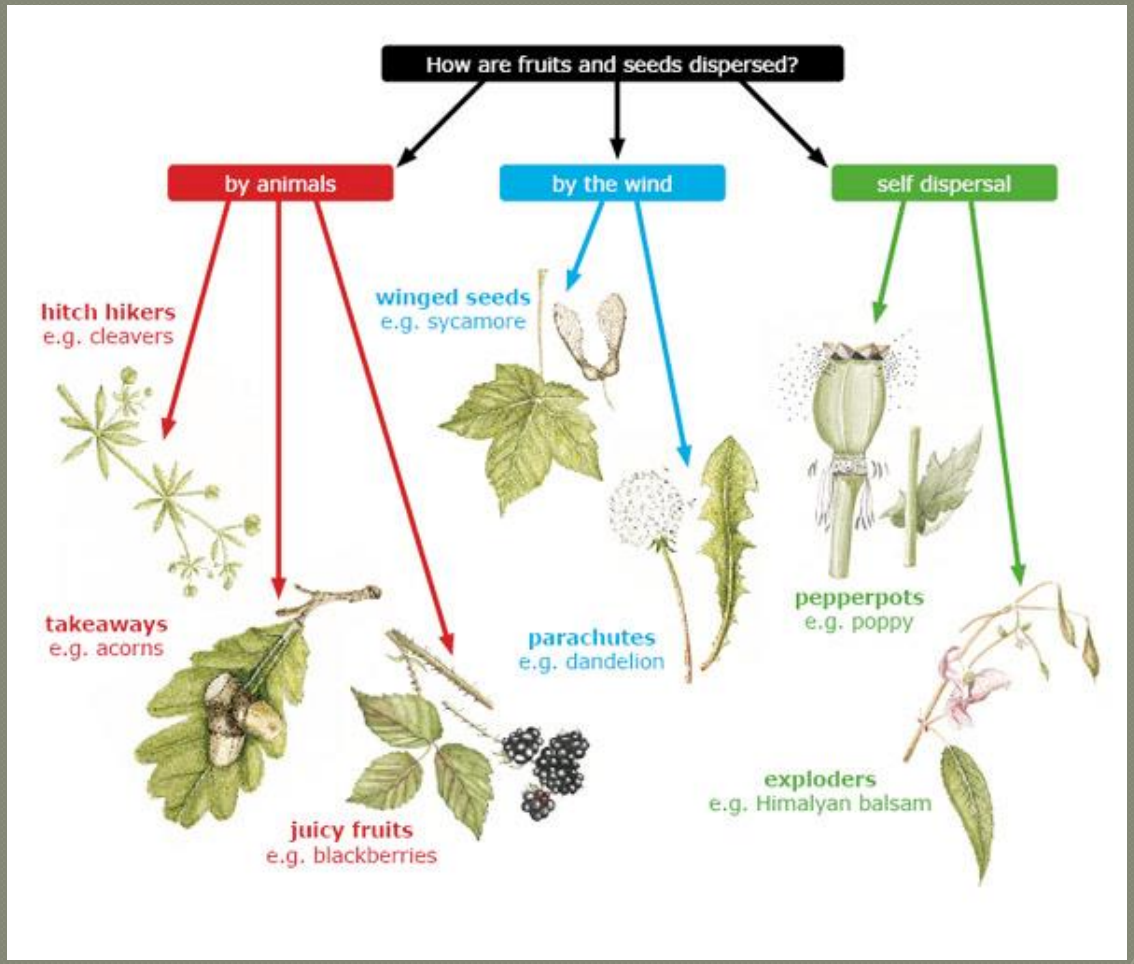
- This type of competition occurs between organisms of the same species

- Some of the methods organisms use to decrease this competition are:

  - Dispersal of young
  - Territoriality
  - And resource partitioning between generations

DISPERSAL OF YOUNG

- Young of the year disperse away from their parents
- Plants do this with seeds, making use if wind, water, and animals to disperse the seeds away from the parent plants
- Animals often "run off" the young of the year once they are able to fend for themselves



TERRITORIALITY

- Animals make use of territories - forcing their offspring and other trespassing adults to move out of their area, thereby reducing the competition for resources
- Hummingbirds are extremely territorial and will defend a feeding territory quite rigorously

RESOURCE PARTITIONING BETWEEN GENERATIONS

- Animals also make use of resource partitioning between generations
  - Adults and juveniles of the same species occupy different niches

For example: Monarch caterpillars eat milkweed leaves and adults drink nectar from the milkweed flowers

SYMBIOTIC RELATIONSHIPS

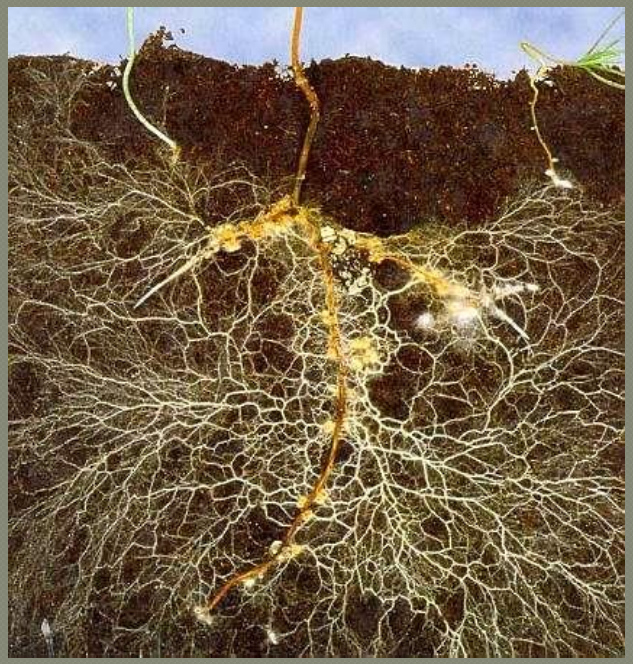
- Symbiosis is a non-feeding relationship between organisms - it is when two or more species live together.
  - Sym=together, biotic=living
- 3 Types of Symbiotic Relationships:

1. Mutualism: relationship in which both organisms benefit.

2. Commensalism: one organism benefits while the other neither benefits nor is harmed.

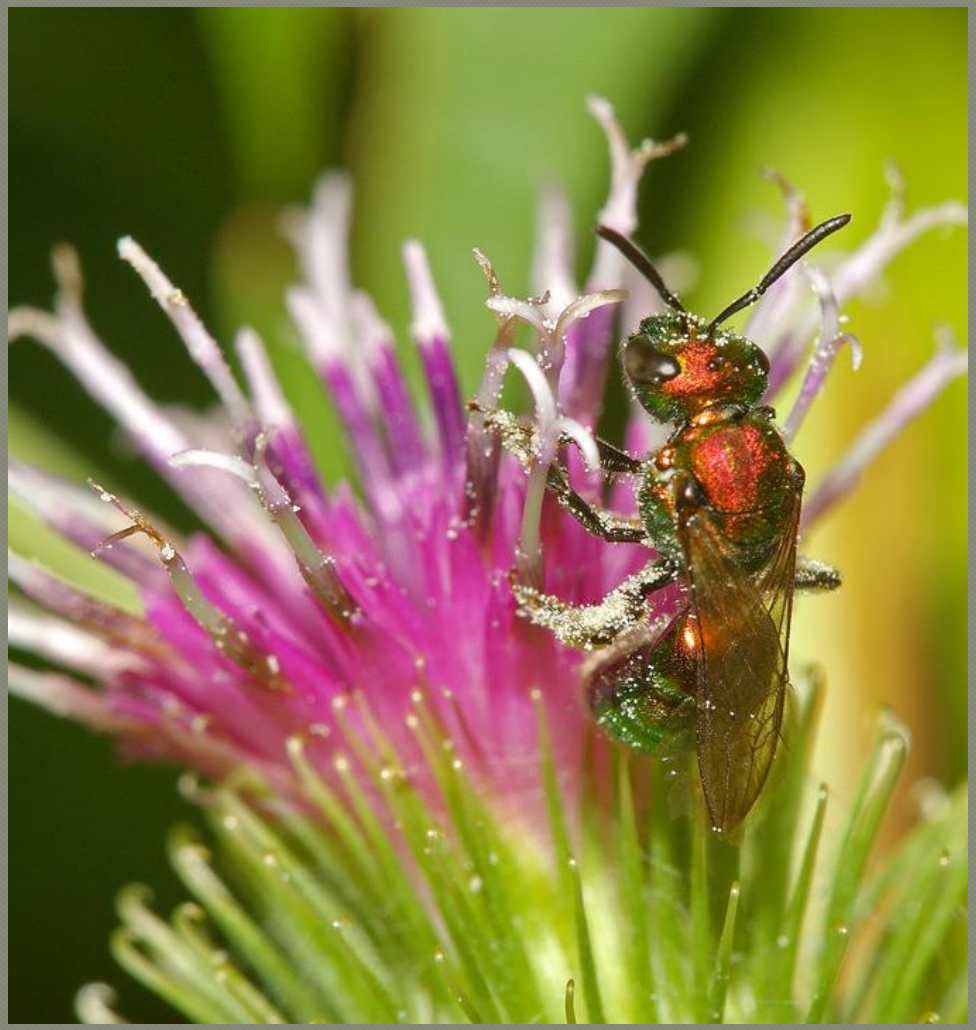
3. Parasitism: one benefits while the other is harmed.

EXAMPLES OF MUTUALISM



Mycorrhizal fungi envelops the roots of the tree which aids the tree in water absorption, stability and protects roots from drying out and from heavy metals. The tree provides sugars and starches to the fungi.

Anemones protect the clownfish from predatory fish and the clownfish protect the anemones by chasing away butterfly fish that eat the anemones.



Pollination is mutualism Bats, bees and butterflies all assist in pollination and, in return, the plants provide food for them.

EXAMPLES OF COMMENSALISM

Barnacles are small filter feeders that hitch rides on large objects, such as a whale. They do not feed off of the host.

Epiphytes are plants that live on trees high in the canopy. They gather water from rain and nutrients from the surface of the host (from leaf litter and falling dust). They do not feed from the host.

EXAMPLES OF PARASITISM

Fleas are parasites that feed from larger hosts such as dogs and cats.

Brown-headed cowbirds are nest parasites. They lay their eggs in nests of smaller birds. The host parents raise the cowbird chick. The chick out-competes the smaller birds' chicks and often kicks them out of the nest.

Cuckoo's do the same thing!

Keystone species

KEYSTONE SPECIES

A keystone species is a species that plays a critical role in maintaining the structure of an ecological community, and whose impact on the community is greater than would be expected based on its relative abundance, or total biomass.

Simply put . . . a keystone species supports or impacts a large number of organisms in the ecosystem.

EXAMPLE OF KEYSTONE SPECIES

It is important to note that a keystone species does not always have to be a top predator

THE AFRICAN BAOBAB

To give you an idea on the size these trees can reach. . . The creatures at the base of the tree are elephants!

The flowers and fruit of the baobab tree that provide food for many species.

The African Baobab is a keystone species of the African plain

This baobab has several weaver bird nests in it, just one of the many species that depend on the trees for their survival.


“If the honeybee goes extinct,
we have four more years on Earth.”
~ Albert Einstein

ONE-WAY ROAD

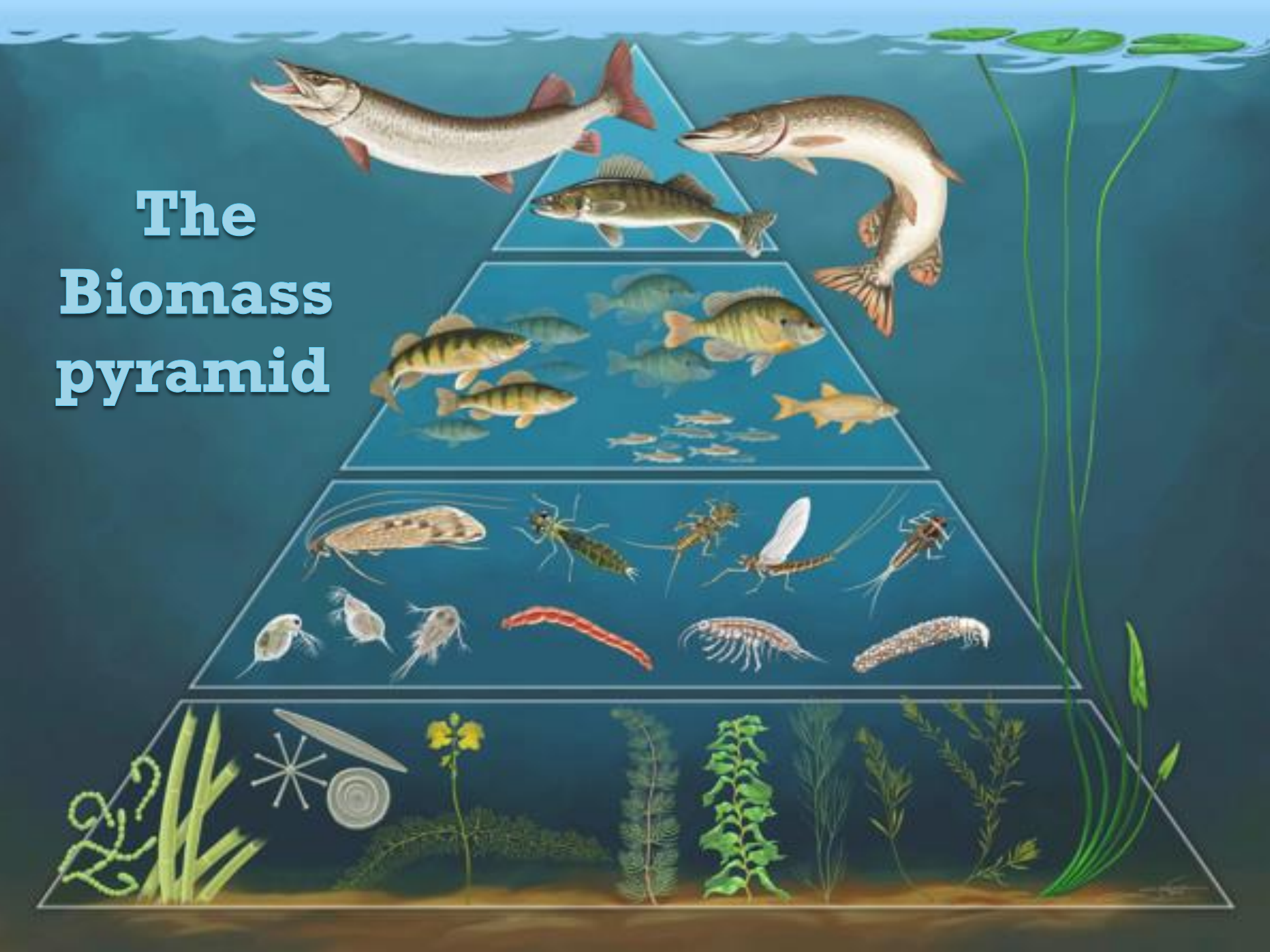
- Energy flows in a one-way path

- It can be temporarily stored and used multiple times as it flows through a system

- But in the end - all energy is eventually released and dissipates as non-useful heat energy

- Therefore, we need a constant supply of potential energy . . . and what is that energy source???

The Biomass pyramid



TERMS

- Trophic level - trophic means food or feeding - so trophic levels are feeding levels in an ecosystem

- There are 2 categories of trophic levels:
  - Producers/Autotrophs (self-feeding)
    - green plants
    - Capture energy from sun and use photosynthesis to make food/sugar
  - Consumers/Heterotrophs (feeding on others)
    - Everything other than green plants are consumers - they must consume other organisms to get energy because they can't photosynthesize and make their own food!
    - Consumers can be further divided as you'll see in the next slide

TROPHIC LEVELS

- **Producers/Autotrophs** ("self-feeders"): organisms that capture solar energy for photosynthesis to produce sugars
  - Green plants, cyanobacteria, algae

- **Primary consumers**: organisms that consume producers and comprise the second trophic level. Also known as:
  - **Herbivores** such as deer and grasshoppers

- **Secondary consumers**: these are omnivores (feed on plants and animals) and smaller carnivores.
  - **Omnivores:** coyotes, skunks, some reptiles, many non-raptor birds.

- **Tertiary consumers**: predators that feed at higher trophic levels
  - **Carnivores:** hawks, owls, bears, snakes, alligators, wolves

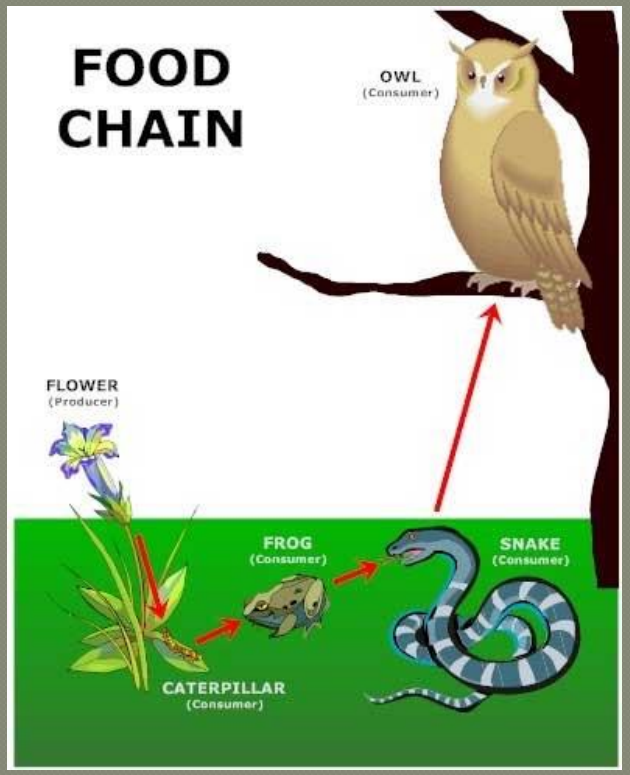
DETRITIVORES AND DECOMPOSERS

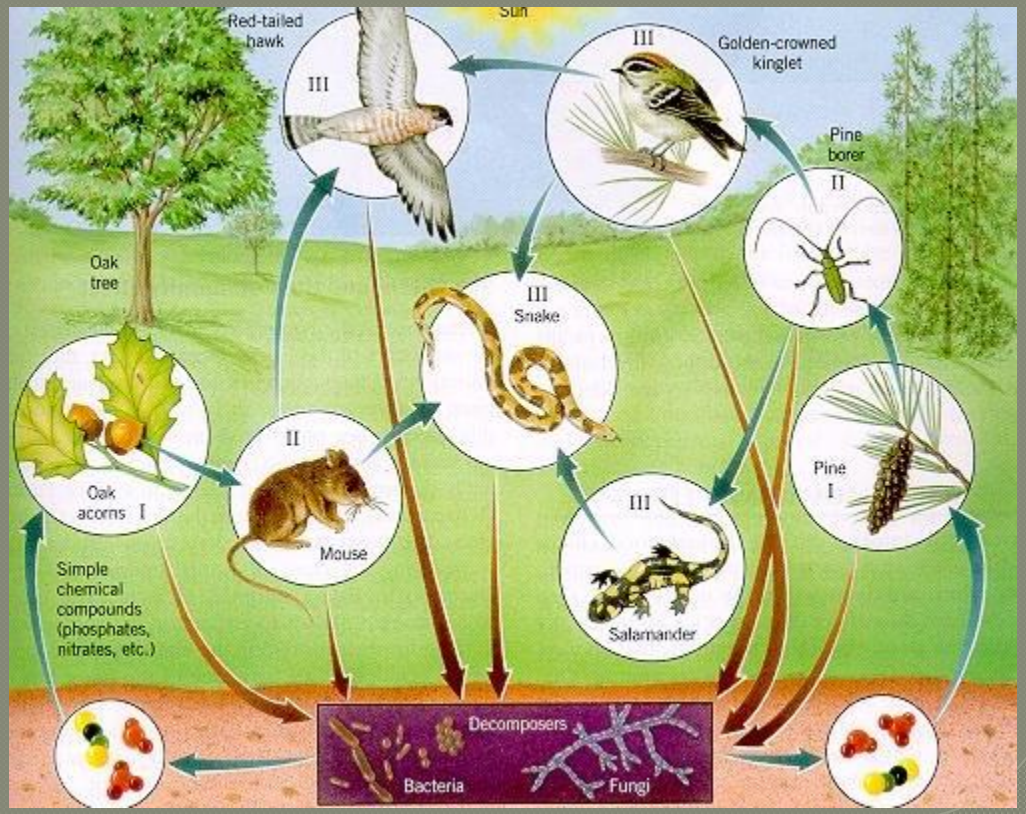
- Organisms that consume non-living organic matter
- These organisms are still consumers – it's just that what they feed on is no longer living
- **Detritivores**: scavenge waste products or dead bodies
  - Millipedes
- **Decomposers**: break down leaf litter and other non-living material
  - Fungi, bacteria
  - Enhance topsoil and recycle nutrients

FOOD CHAIN OR FOOD WEB?

A food chain represents the basic relationship between the trophic levels.

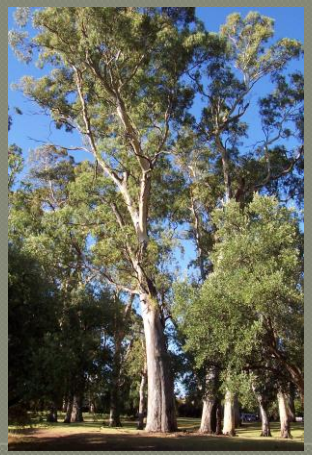
A food web is a more accurate representation (shows the food chains as interconnected).



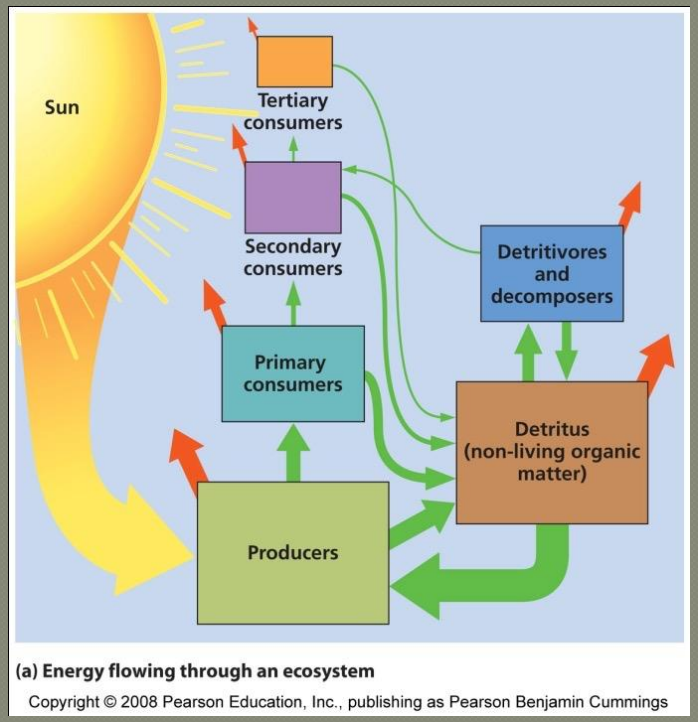


THE MOVEMENT OF ENERGY & MASS

- All energy cycles start with the sun
- Photosynthesis stores the energy from the sun in the C-H bonds of glucose as potential energy
- Respiration (by organisms) breaks the C-H bonds when they eat and digest the glucose stored in the green plants and put that potential energy to use (transforming it to kinetic energy)



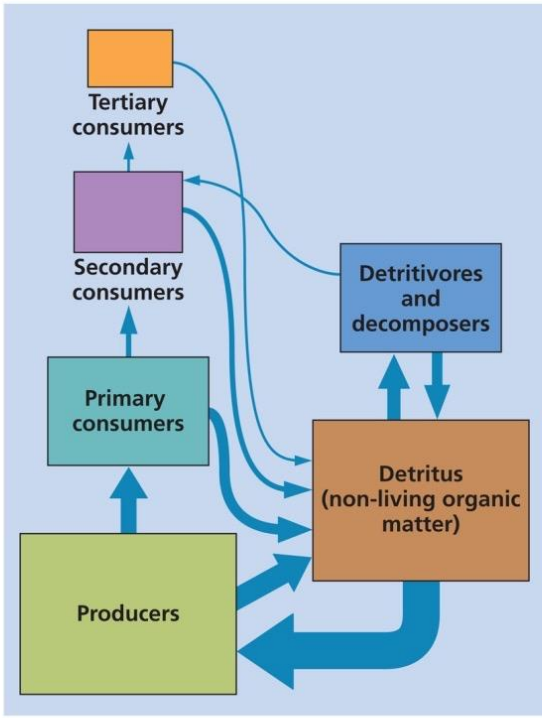
ENERGY AND MATTER IN ECOSYSTEMS



(a) Energy flowing through an ecosystem

- **Ecosystem**: all organisms and non-living entities occurring and interacting in a particular area
  - Animals, plants, water, soil, nutrients, etc.

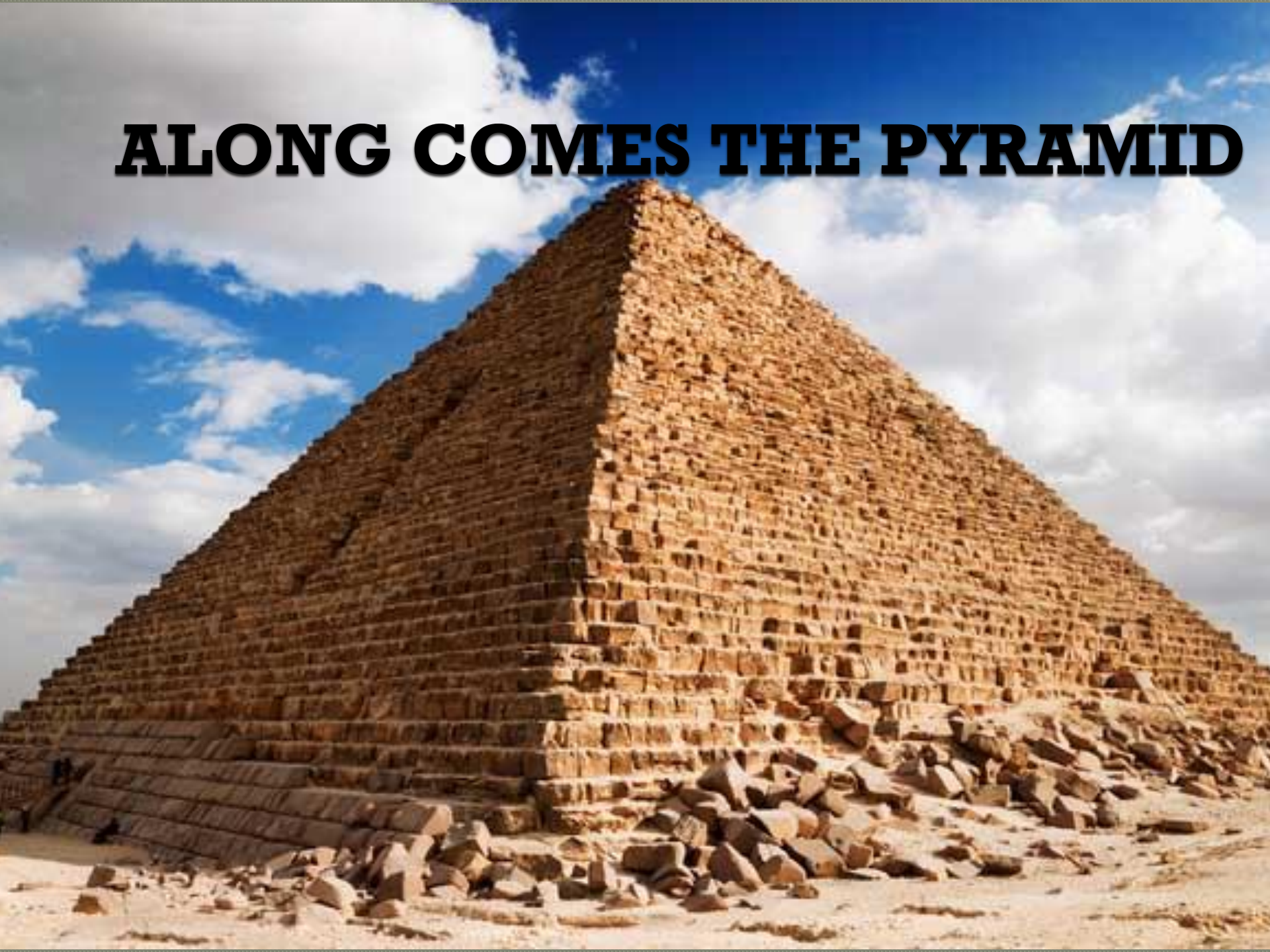
- Energy from the sun flows in one direction (linear) through ecosystems.
  - Energy is processed and transformed (it is not recycled) –requires continuous energy input from the sun
- Matter is recycled within ecosystems.



(b) Matter cycling within an ecosystem

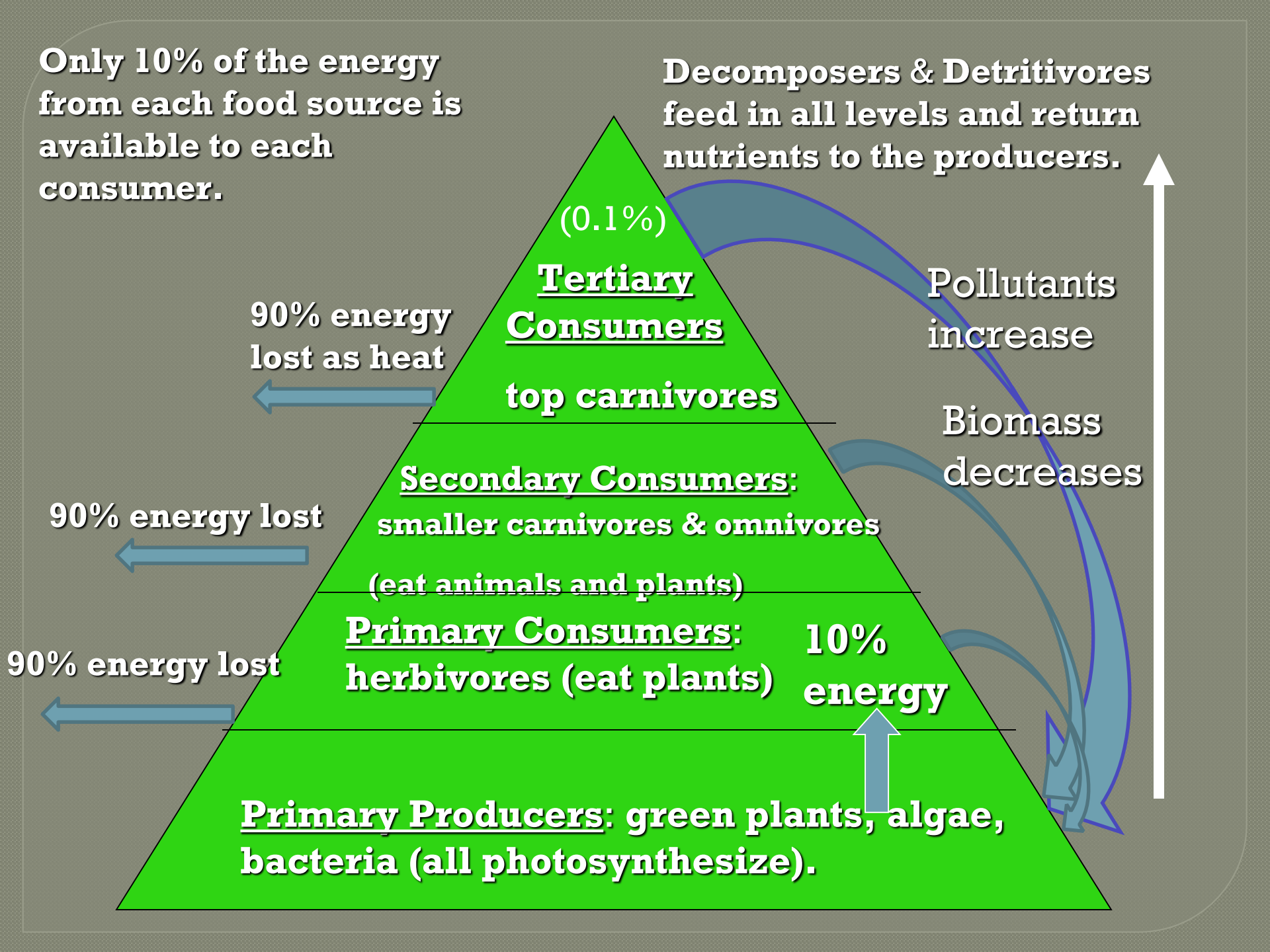
WHAT DOES IT ALL MEAN?

- It takes a whole lot of plants to feed 1 primary consumer because of this inefficient energy transfer (major loss of energy as heat)
- It also takes a whole lot of primary consumers to feed 1 secondary consumer. . . and so on and so forth
- Therefore, as you move up through the trophic levels of an ecosystem, the biomass (the amount of the living things) must decrease.

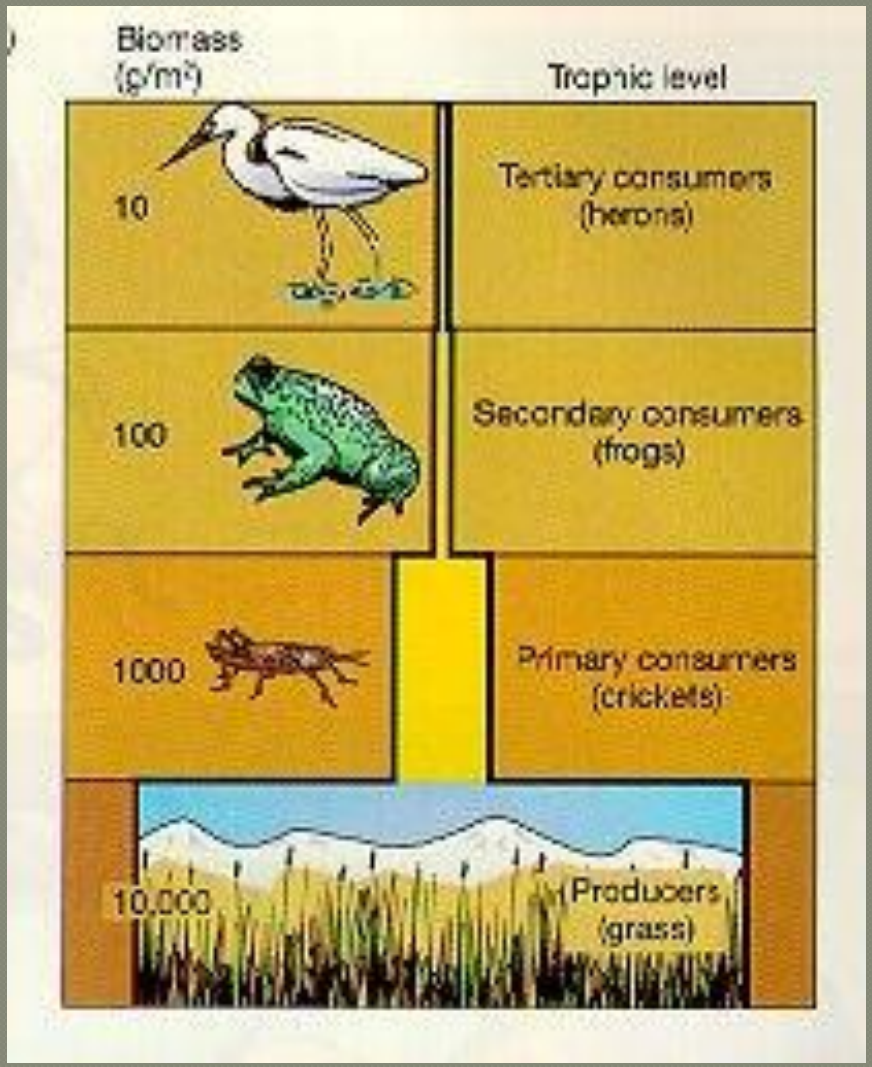

ALONG COMES THE PYRAMID

BIOMASS PYRAMID

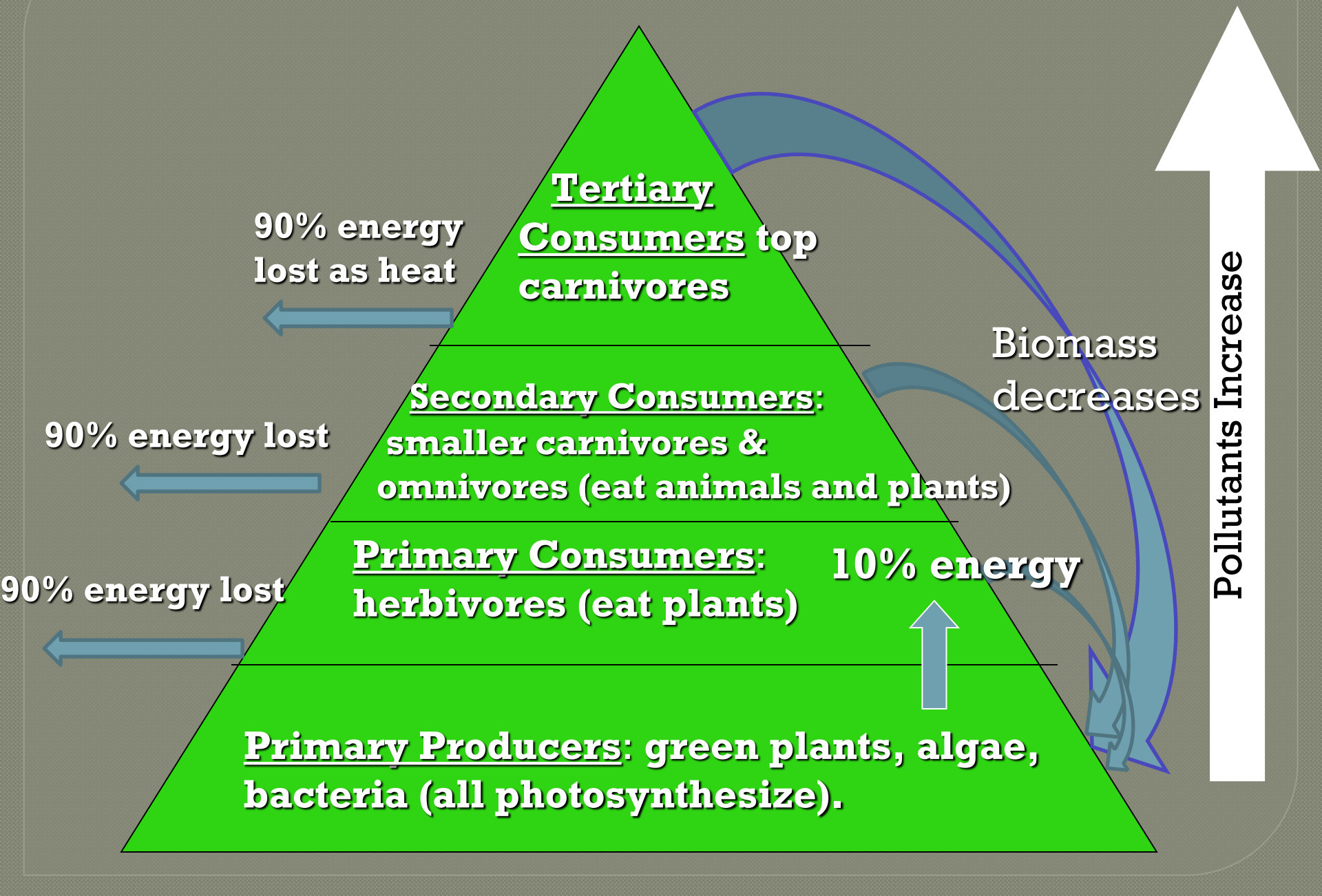
- Organisms in any food web can be arranged in a *trophic pyramid*, also known as a *biomass pyramid*.
- The shape of the pyramid is used to depict how biomass (energy) is passed up through a food web.
- Due to the massive loss of energy every time energy transfers from one organism to the next, the organisms in higher levels must eat more to compensate.


Only 10% of the energy from each food source is available to each consumer.
Decomposers & Detritivores feed in all levels and return nutrients to the producers.
(0.1%)
Tertiary Consumers
top carnivores
90% energy lost as heat
Pollutants increase
Biomass decreases
Secondary Consumers:
smaller carnivores & omnivores
(eat animals and plants)
90% energy lost
Primary Consumers:
herbivores (eat plants)
10% energy
90% energy lost
Primary Producers: green plants, algae, bacteria (all photosynthesize).

- When energy (biomass) is consumed, only 10% of the total available energy is able to be used by the consumer.
- The other 90% is "lost" (transformed into useless energy) as heat and waste.
- The pyramid shows that there are fewer individuals in each succeeding level of the food web. Those higher up must eat more of those in the lower levels.



Bioaccumulation/Biomagnification



EXAMPLE OF BIOACCUMULATION

- DDT offers an example of bioaccumulation.
- Bald eagles ate lots of fish that contained DDT from the insects and plants they ate in the water.
- While one insect might not have much DDT in it - the fish ended up with quite a bit of DDT because it ate hundreds of insects; and the eagles ate hundreds of fish, which led to a heavily poisoned eagle.

BIOGEOCHEMICAL CYCLES