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Chapter 34:
Ecology
Introduction

WARM-UP

What are the levels of organization for an individual organism?

What living factors are involved with an individual person?

What NON-living factors are involved with an individual person?

WARM-UP

What are the levels of organization for an individual organism?

atom → molecule → Cell → Tissue → Organ → Organ System → **Organism**

What living factors are involved with an individual person?

other people, animals, plants, etc.

What NON-living factors are involved with an individual person?

Environment, climate, etc.

Lesson Objectives

By the end of this lesson, you should be able to:

- Define ecology and levels of organization within an individual and outside the organism.
- Identify two major variables that affect all organisms.
- Understand interactions in an ecosystem.
  - Distinguish habitat from niche.
  - Food chains, food webs, food pyramids
  - Food relationships, cycles of materials in nature
- Explain how energy flows between trophic levels of a food chain (pyramid).
- Describe how energy supply limits the length of food chains

- **Science Practice: Creating an Antarctic Food Web**

WHAT IS ECOLOGY?

Ecology is the scientific study of **interactions** between **organisms** and their **environment.**

Oikos – house

-*logy* – study of

Up to this point emphasis has been placed upon the organisms. The term itself implies an organization.

WHAT IS ECOLOGY?

Levels of ORGANIZATION include the following:

Example Using the Cell

Atom →

Molecule →

Cell →

Tissue →

Organ →

Organ System →

Organism

Organism Boundaries

Organisms experience Levels of ORGANIZATION:

Organism → **atom … individual**

population → organisms of the same species living together in a given location.

community → populations of different species in a given location interacting with each other.

ecosystem → Interactions of the living community & the Abiotic (non-living) environment.

Biome → That portion of the planet where life is possible or ecosystems operate.

ORGANISM

Any unicellular or multicellular form exhibiting all of the characteristics of life, an individual.

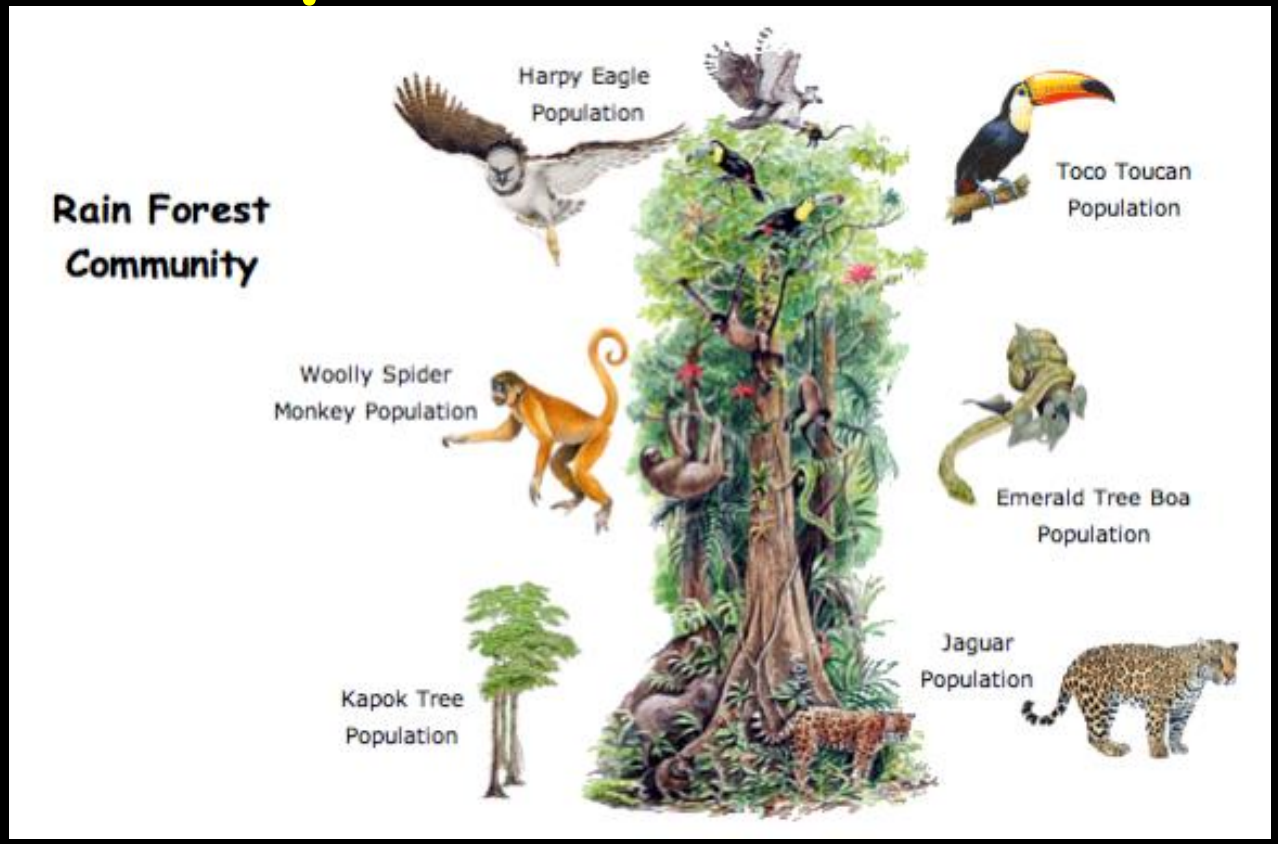
POPULATION

A group of organisms of the **same species** living in the same area at the same time.

- They **interbreed** and produce fertile offspring.
- **Compete** with each other **for resources** (food, mates, shelter, etc.).

COMMUNITY

Several **interacting populations** that inhabit a common environment and are **interdependent**.

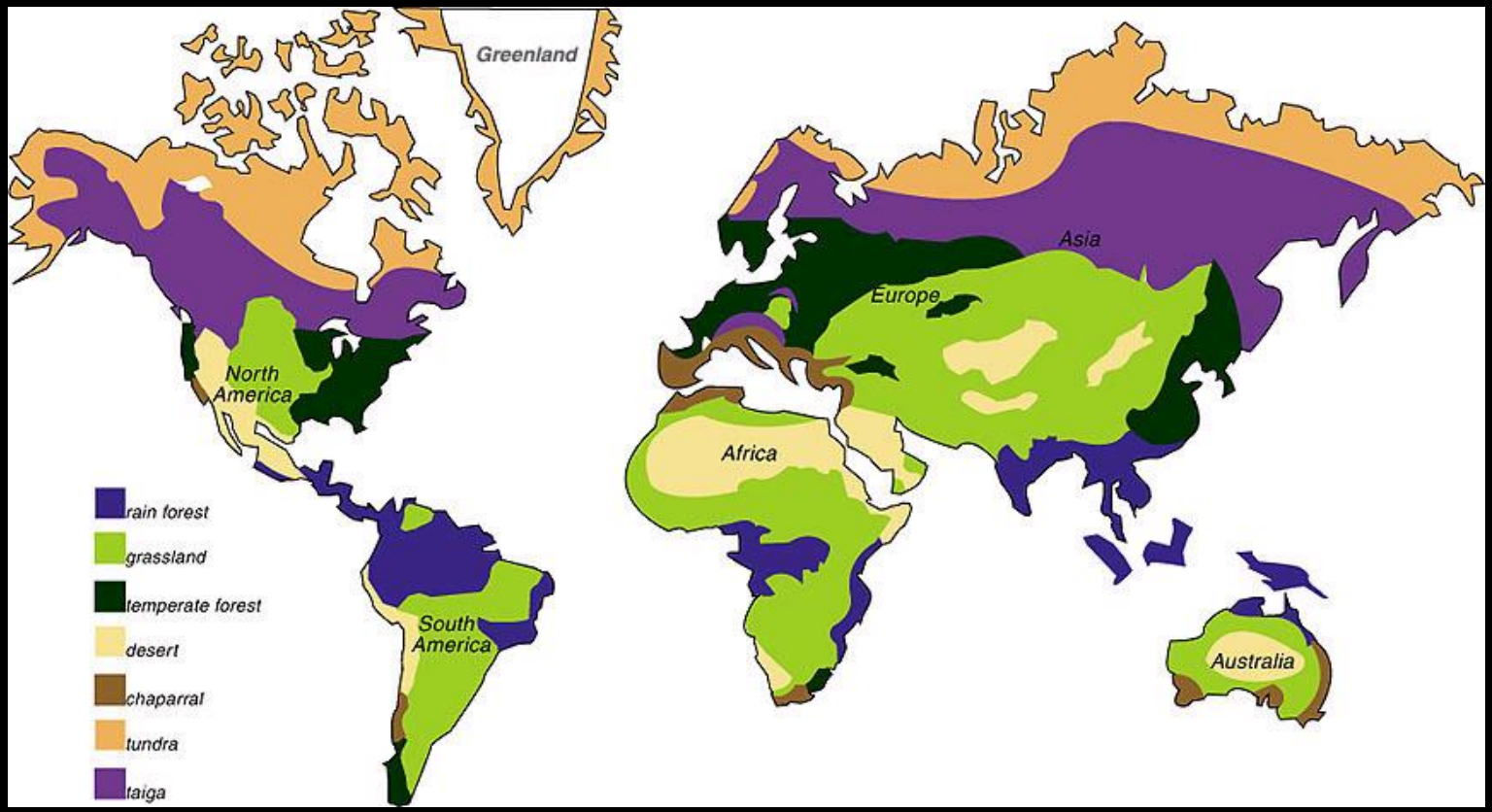


ECOSYSTEM

Both the biotic and abiotic factors of the environment.

BIOMES

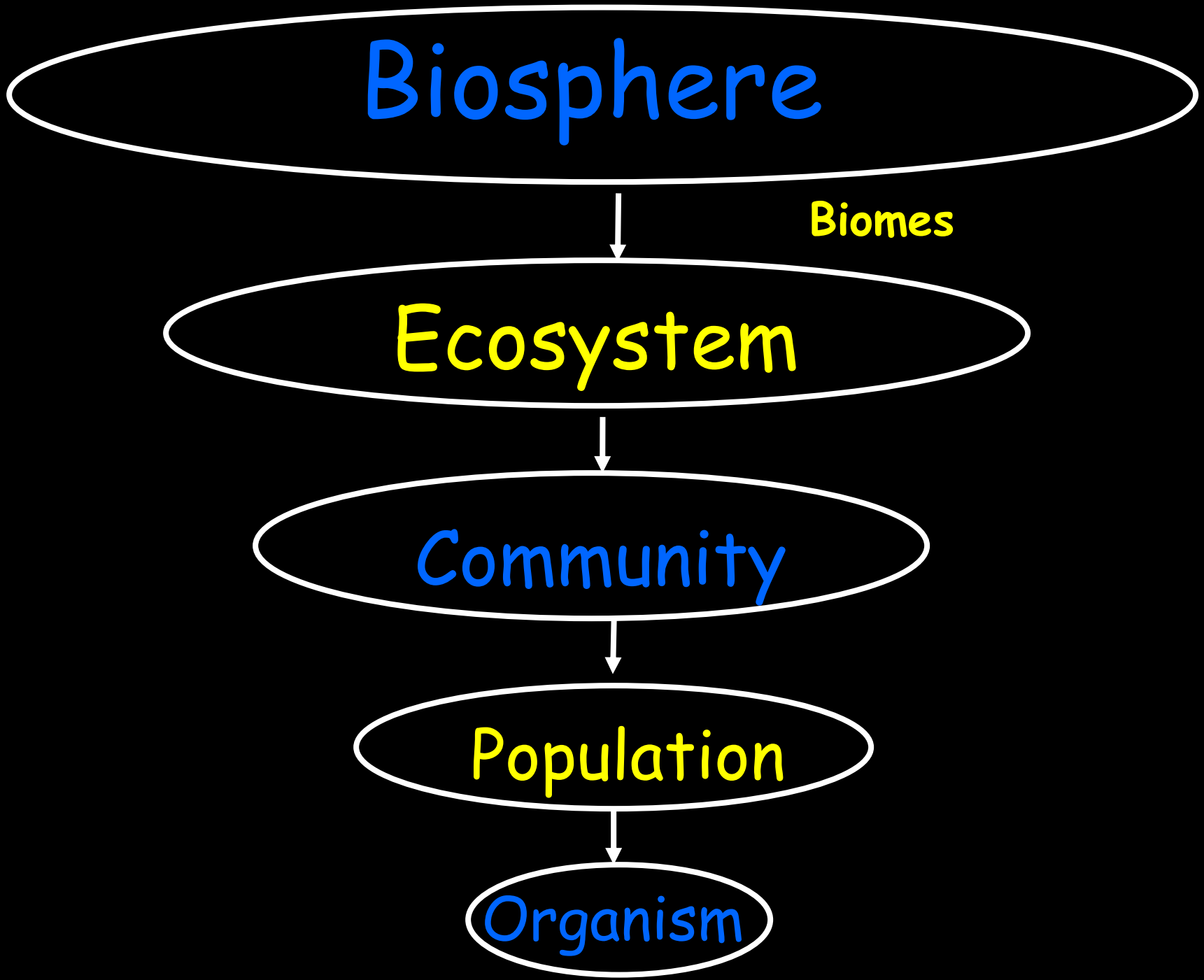
A group of ecosystems with similar climates (temperature + rainfall) and organisms.



BIOSPHERE

Our entire planet with all its organisms and physical environments.

- The highest level of organization.


Biosphere
Biomes
Ecosystem
Community
Population
Organism

Organisms can be affected by two major variables:

1. **BIOTIC Factors** include all of the organisms in an area, the **LIVING component** of the environment.

2. **ABIOTIC Factors** are the environment's **NONLIVING component**, the physical and chemical factors (gases, wind, moisture, soil).

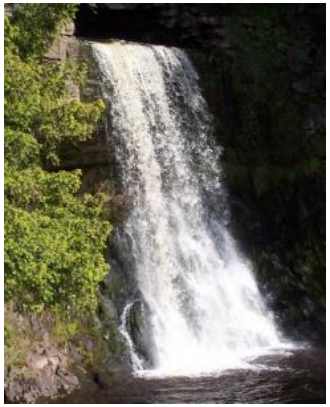
- An organism's **Habitat** includes the biotic and abiotic factors present in its surroundings.

Environmental Factors

- **Biotic** – of or relating to an environmental factor that is living or came from something that was once living.

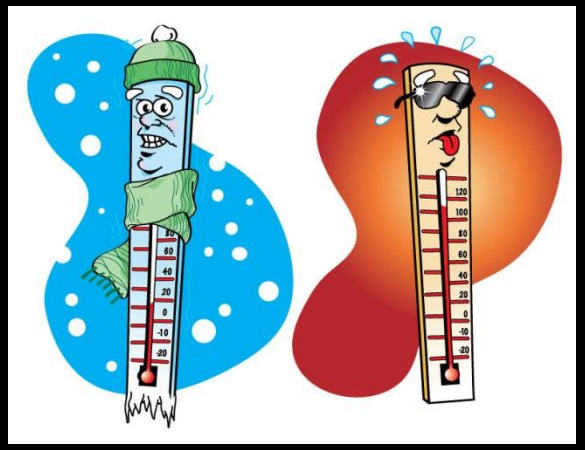



- **Abiotic** – of or relating to an environmental factor that is not living and has never lived.

ABIOTIC FACTORS

- Temperature
- Soil
- Light
- Moisture
- Air Currents
- Nutrients
- Climate



Physical Factors that Affect Living Things:
Abiotic Factors

WATER

1. A basic constituent of the internal environment of living things. Where water is not plentiful, organisms have adaptations to secure and prevent its loss:

    a. *Marine fish* have specialized excretory system to maintain water balance.
    b. *Horned toad* has thick scaly skin to prevent loss of water.
    c. *Xerophytes* (cactus) have fleshy leaves for storage, spines for leaves, and reduced stomates.

2. Water has high specific heat (1 calorie/g° C) therefore temperature of water changes slowly, stabilizing land mass temperature.

3. Medium for the movement of sperm; xylem.

4. Water freezes (at 4° C) and floats on top of water insulating it (at *4° C water's density decreases so ice floats; most solids are more dense than liquids*).

Physical Factors that Affect Living Things:
Abiotic Factors

SOIL

1. Composed of varying mixtures of:
   - rock particles: rock, sand, silt, and clay (pure clay) tightly packed (low O_2)
   - Water, air
   - living organisms
   - organic material, humus: a decaying material.

2. Importance of acid-base balance
   - azaleas and rhododendrum require acid soil.
   - pines (*needles produce acid soil*) vs. maples and elms (*require non-acidic soil*).
   - minerals can "leach" out more in acidic soil (Al, Cd, Zn, Cu, etc.).

$$CO_3 + H^+ \rightarrow HCO_3^- + H^+ \rightarrow H_2CO_3 \rightarrow H_2O + CO_2$$

Equation showing the reaction to produce Acid Rain in the atmosphere which causes acidic soil.

Physical Factors that Affect Living Things:
Abiotic Factors

TEMPERATURE

With exception of birds and mammals, rate of an organism's metabolism depends upon environmental temperature:

a. **Poikilotherm** → cold-blooded (ectotherms)

- *External control of body temperature varies according to outside temperature.*

b. **Homeotherms** → warm-blooded (endotherms)

- *Internal control of body temperature varies according to outside temperature.*

Physical Factors that Affect Living Things:
Abiotic Factors

Light

Ultimate source of energy for all life. A regulator of daily and seasonal activities.

Inorganic Nutrients

Phosphates, sulfates, calcium, sulfur, sodium.

Oxygen

Necessary for all animals and plants. In polluted streams, a lack of oxygen results in death.

Physical Factors that Affect Living Things:
Abiotic Factors

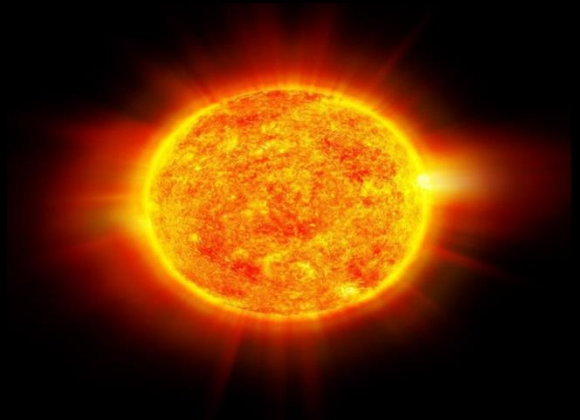
LIMITING Factors

Abiotic factors that set limits on the types and number of organisms that can live in an environment.

e.g. my dad's "trout" pond story (hot summer, low O_2 = dead fish)

Ecosystems

- Abiotic factors determine the limits of each species' distribution, especially temperature and water availability.
- The ultimate abiotic factor is an energy source, which for most ecosystems is **SUNLIGHT**.
- The flow of energy through an ecosystem is one of the most important factors that determines the system's capacity to sustain life.



QUICK CHECK

What levels of organization organisms experience?

What are the TWO major factors involved in ecology?

Name some abiotic factors?

Abiotic elements that set limits on the types and number of organisms that can live in an environment are _____.

QUICK CHECK

What levels of organization organisms experience?

Organism → population → community → ecosystem → biome → biosphere

What are the TWO major factors involved in ecology?

Biotic (living) and abiotic (non-living)

Name some abiotic factors?

Temperature, Soil, Light, Moisture, Air Currents, Nutrients, Climate

Abiotic elements that set limits on the types and number of organisms that can live in an environment are limiting factors.

Interactions in the Ecosystem

HABITAT

An organism's physical environment where they live and feed.

Interactions in the Ecosystem

NICHE

The role an organism plays in the physical environment in which it lives; particularly it's role in relation to food.

e.g. Bird lives in crotch of branch;

The deer is a browser.

Butterfly eats and moves pollen.

Interactions in the Ecosystem

NICHE

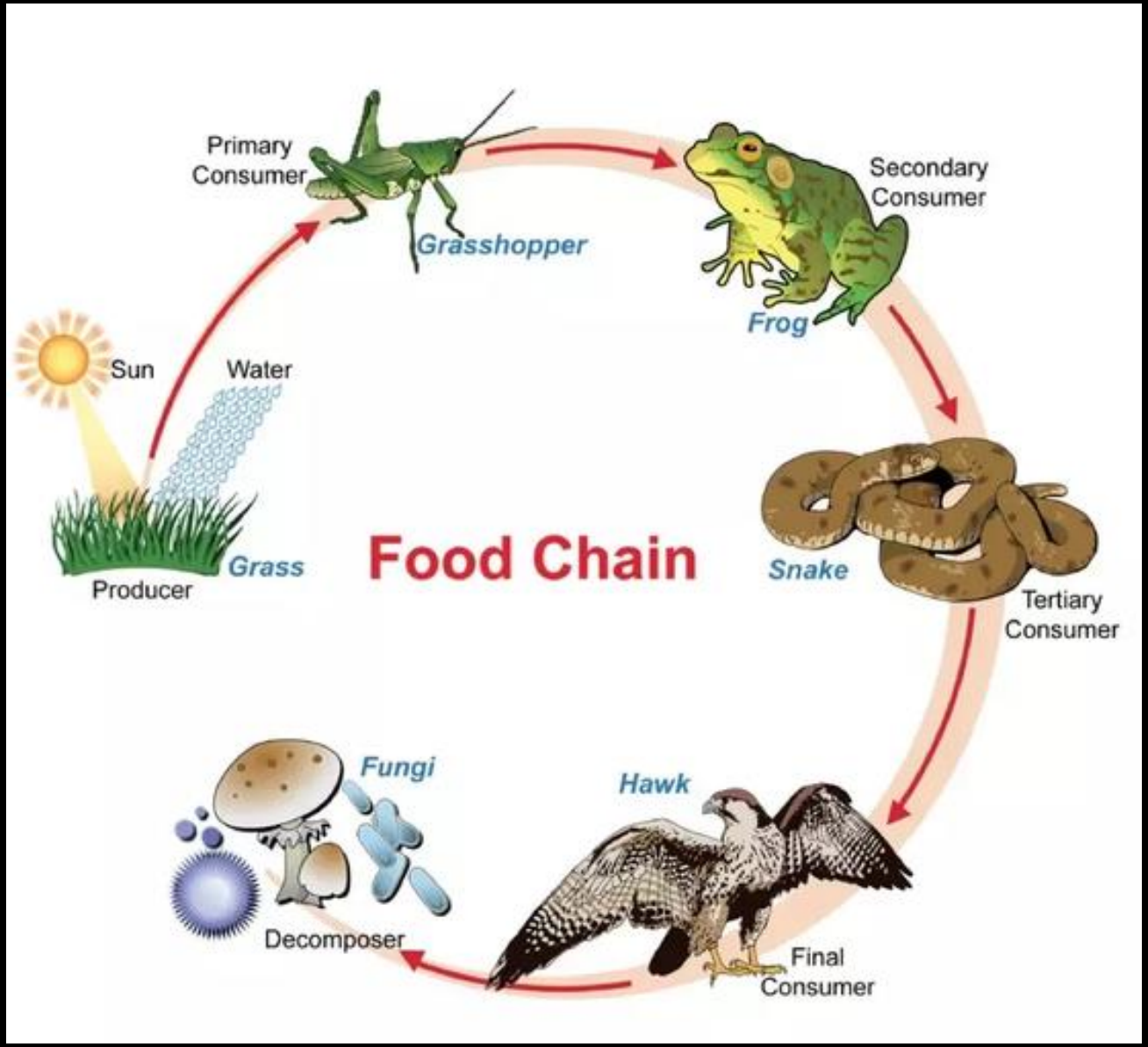
It is NOT the same as its habitat (*place where an organism lives and the environment they live on*).

1. Woodpeckers make nesting holes in the Saguaro cactus in Arizona.
2. Unused holes can be used by elf owls and screech owls.
3. If both occupy adjacent holes they have the same habitat.
4. Elf owl and screech owl eat insects – same niche.

Interactions in the Ecosystem

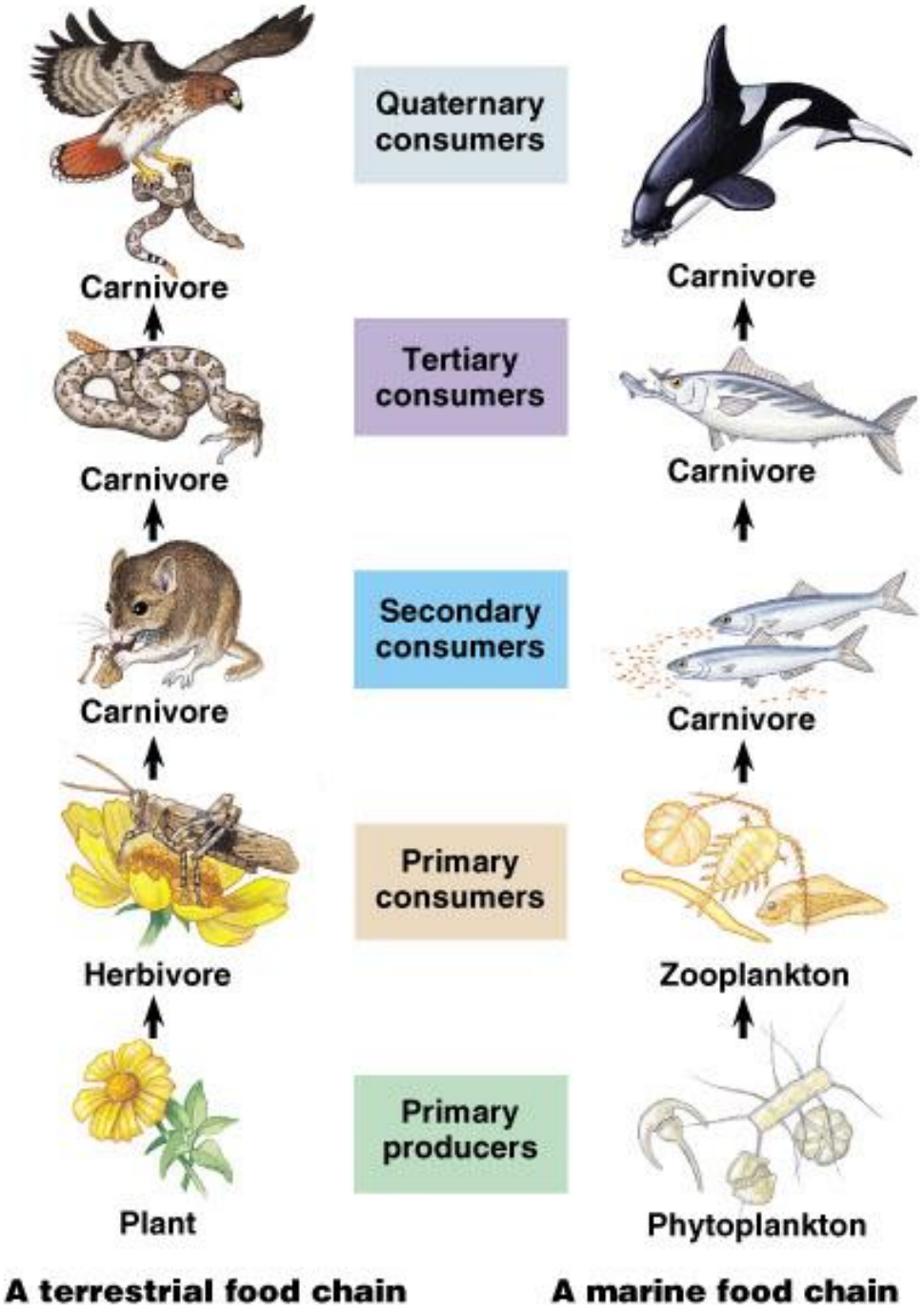
Includes

Food CHAINS



Food Chains

Producers to consumers

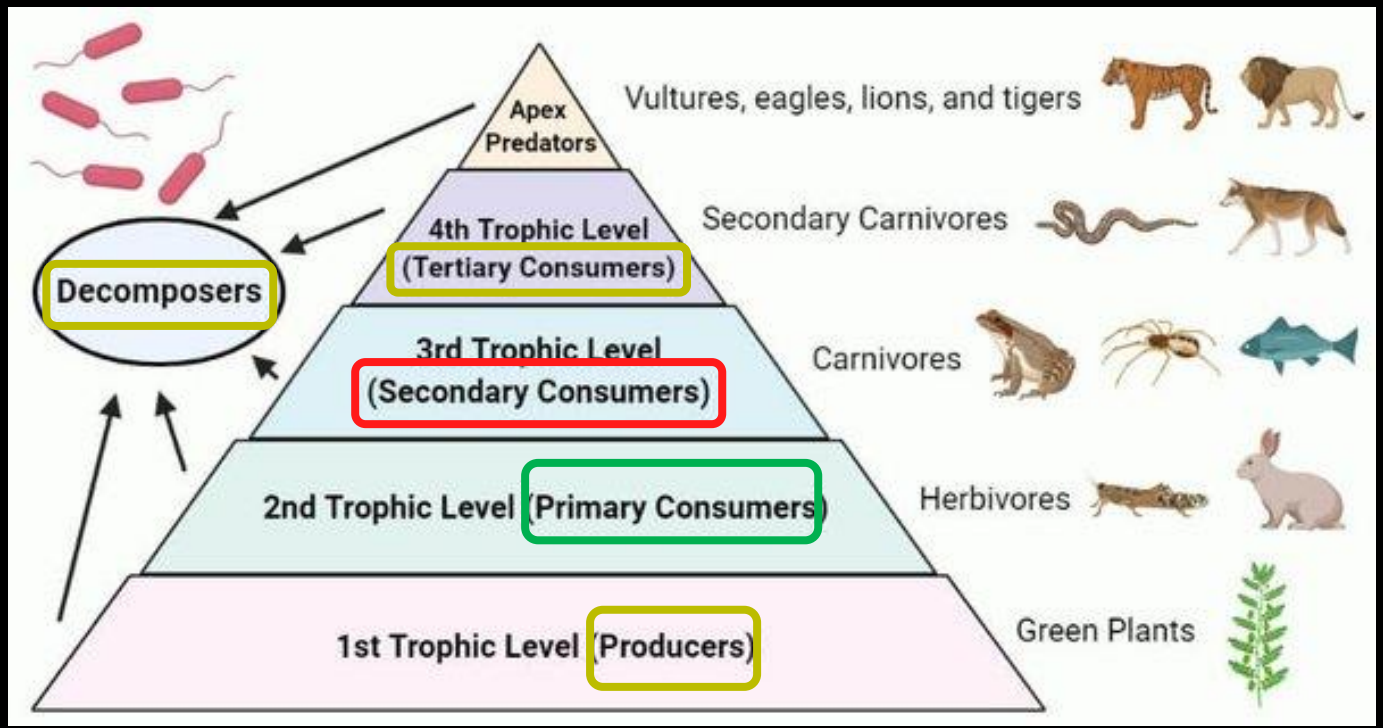


Food Chains

Transfer of ENERGY through a sequential series of organisms.

Planktons/diatoms → water fleas → shrimp → fish → herring → man

Wheat plant → rabbit → coyote → mosquito → bat



PRIMARY PRODUCERS

AUTOTROPHS

Green plants or protists that capture energy from sunlight or chemicals and convert it into a form that living cells can use (glucose).

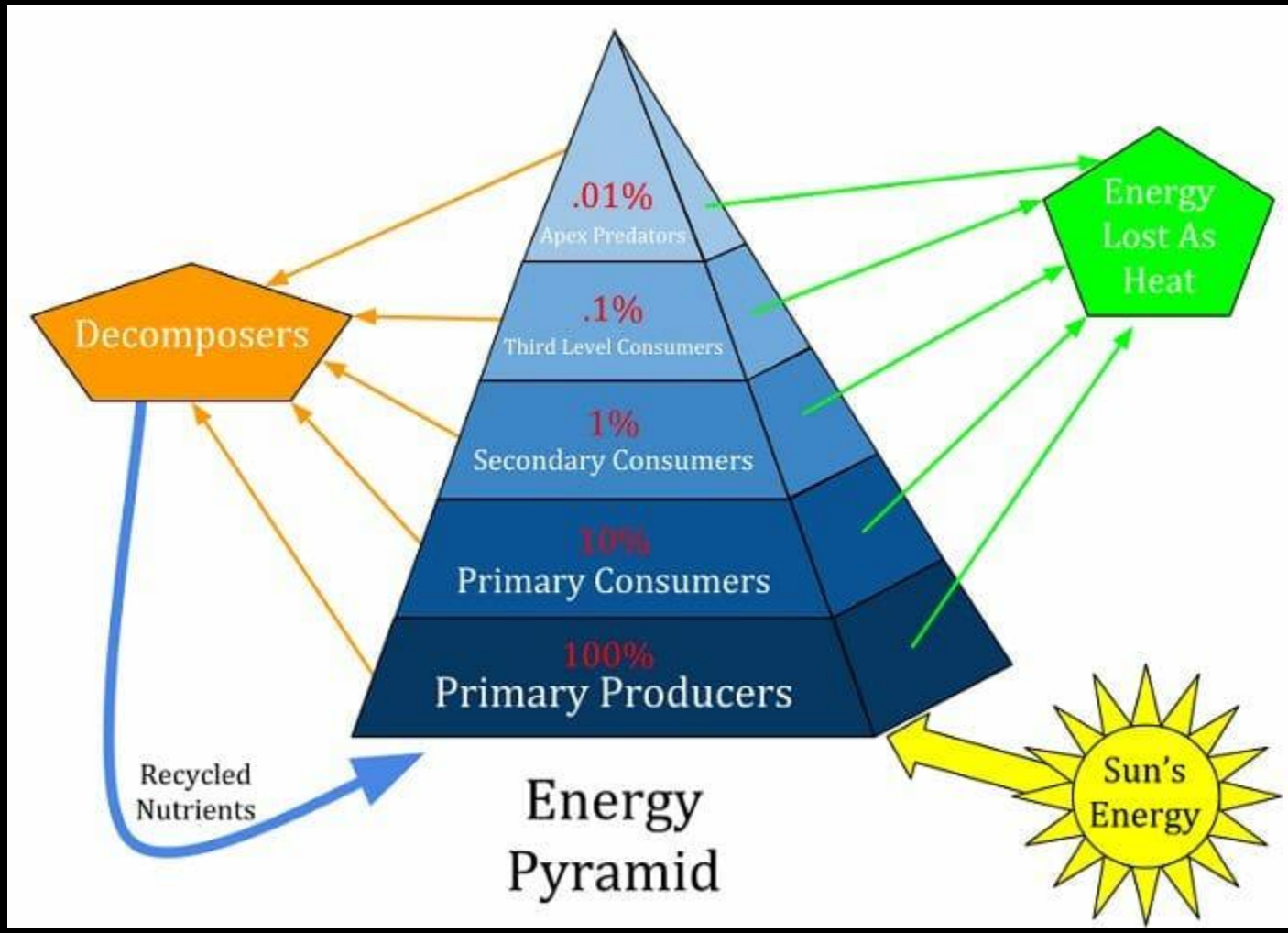
- This occurs mainly by Photosynthesis.

Autotrophs are essential to the flow of ENERGY through the ecosystem.

Primary Producers

FIRST producers of energy-rich compounds that are later used by other organisms.

- **On Land:** Plants
- **In Water:** Algae



1st Trophic Level

Produce 100% of Energy for organisms.

CONSUMERS

Organisms that rely on other organisms for energy and nutrients.

They are HETEROTROPHS: Cannot make their own food.

CONSUMERS

Herbivores = obtain energy by eating only plants.

Carnivores = obtain energy by eating other animals.

Omnivores = eat both plants and animals.

Decomposers = cause decay by breaking down organic matter.

PRIMARY Consumers

Primary consumers **make up the second trophic level**.

They are the herbivores.

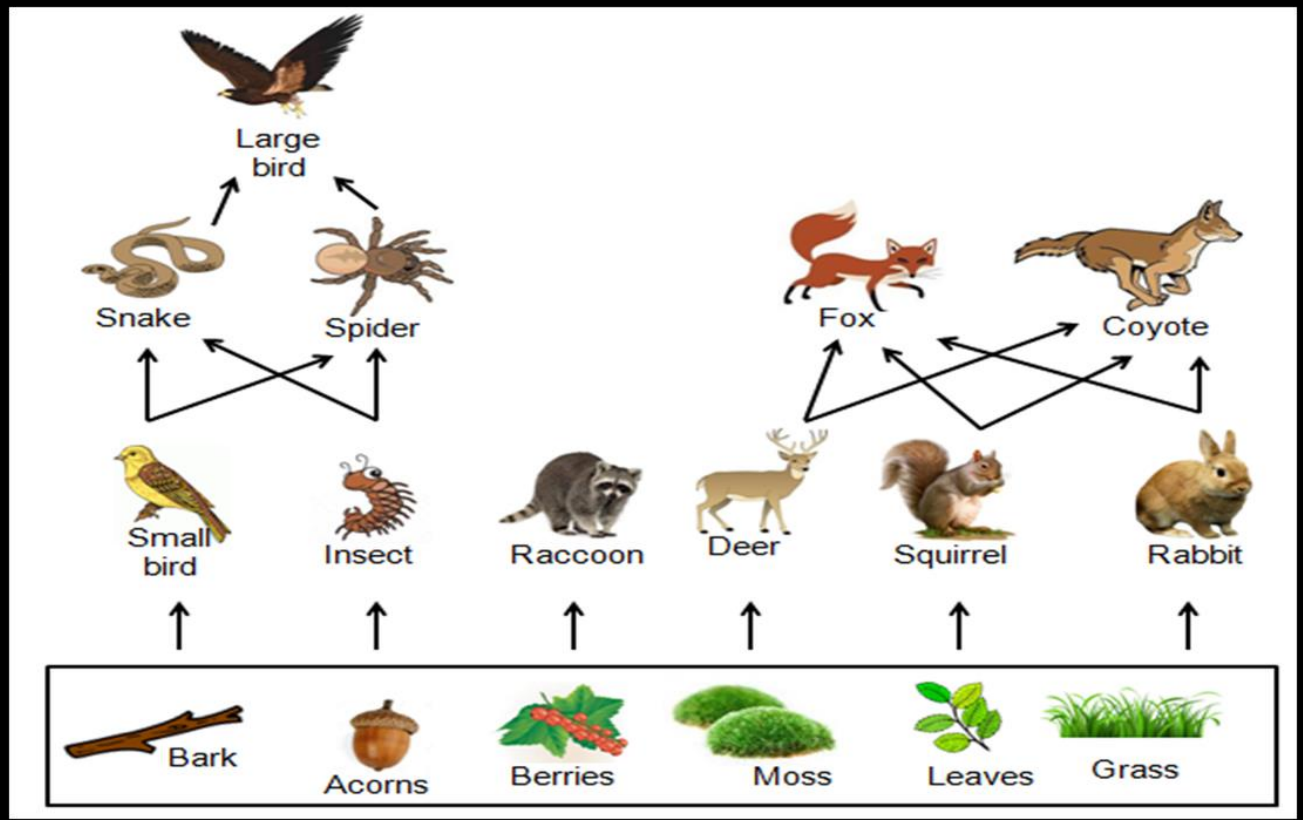
They eat primary producers — plants or algae — and nothing else.

SECONDARY Consumers

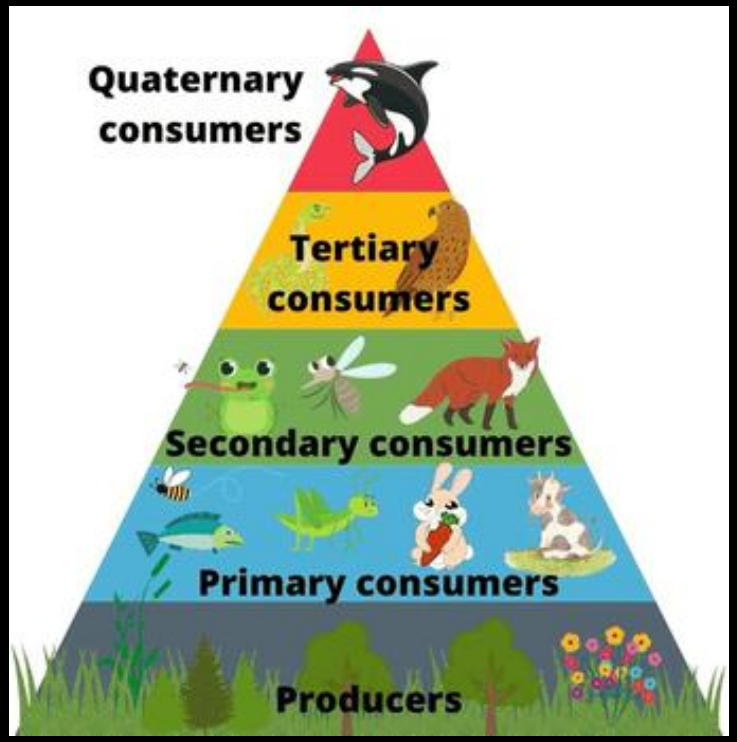
Food Chains

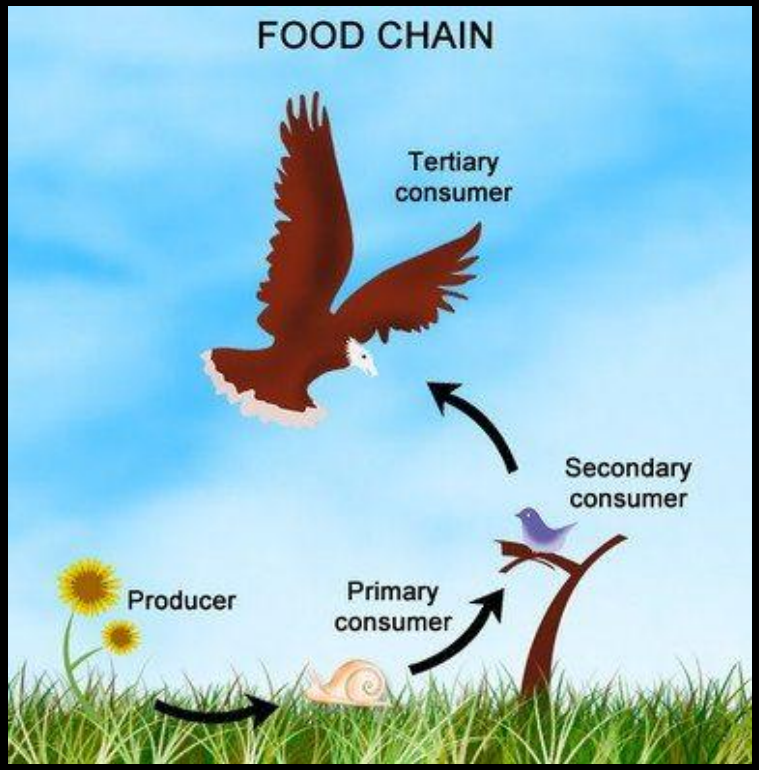
Secondary consumers **are any organism that feeds directly or indirectly off primary consumers.**

They are the carnivores or omnivores.



Food Chains

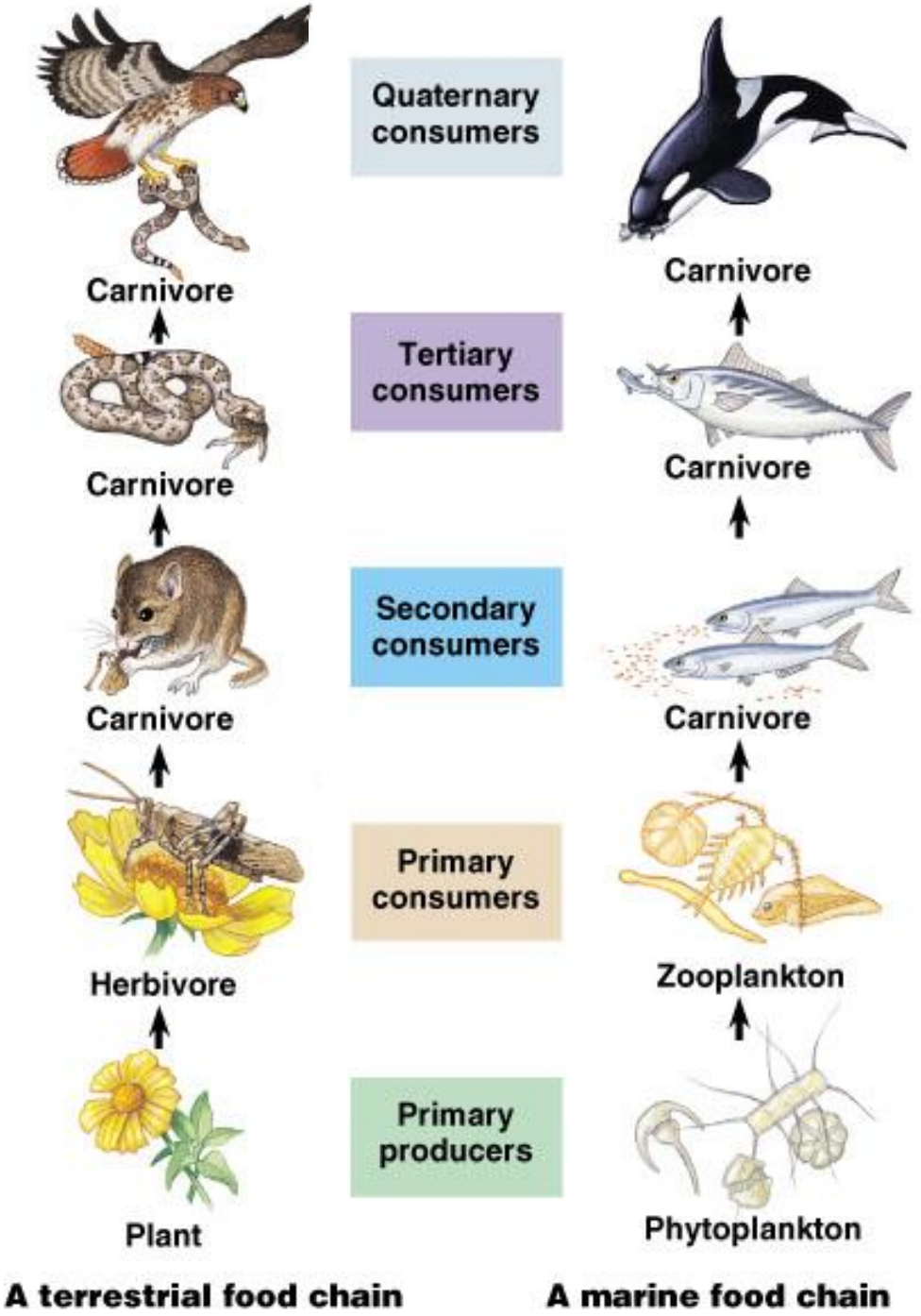

Quaternary consumers
Tertiary consumers
Secondary consumers
Primary consumers
Producers


FOOD CHAIN
Tertiary consumer
Secondary consumer
Producer
Primary consumer


TYPES OF QUATERNARY CONSUMERS

Food Chains

Energy Flows in the direction of the arrows.

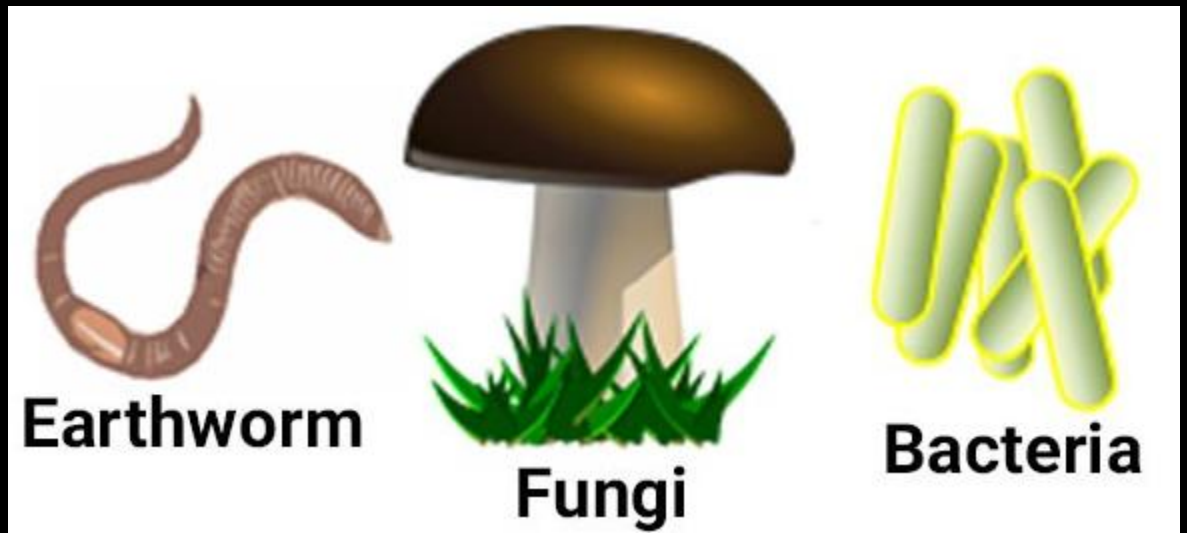


DECOMPOSERS

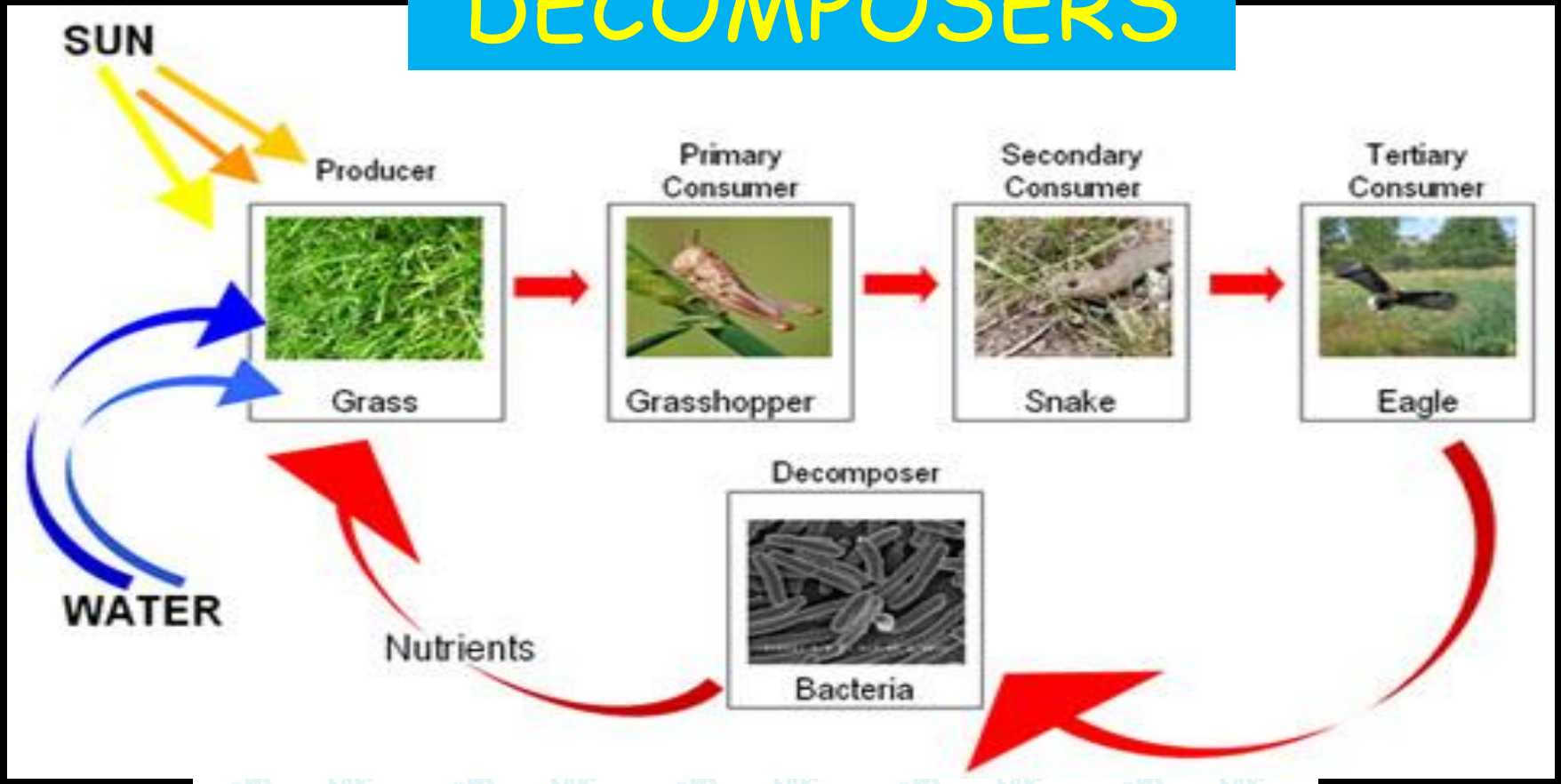
Organisms that live upon dead things.

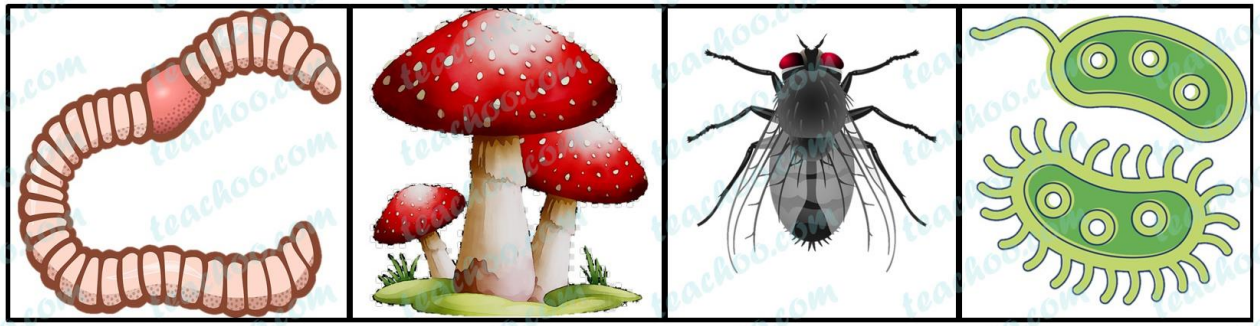
Their purpose is to return inorganic materials to the environment for the producers.

Earthworms, bacteria, and fungi.



DECOMPOSERS





Distinguish “habitat” and “niche”.

QUICK CHECK

List and define the tropic level sequence in a food chain.

Name and define the groups of consumers.

QUICK CHECK

Distinguish "habitat" and "niche".

Habitat is where an organism lives.

Niche is the role the organism plays in its habitat.

List and define the tropic level sequence in a food chain.

Producers (autotrophs) → consumers (eat producers) → decomposers (return nutrients to soil)

Name and define the groups of consumers.

Herbivores (eat producers only/plants)

Carnivores (eat meat/consumers)

Omnivores (eat plants and animals)

Decomposers (return nutrients to soil from other consumers or producers)

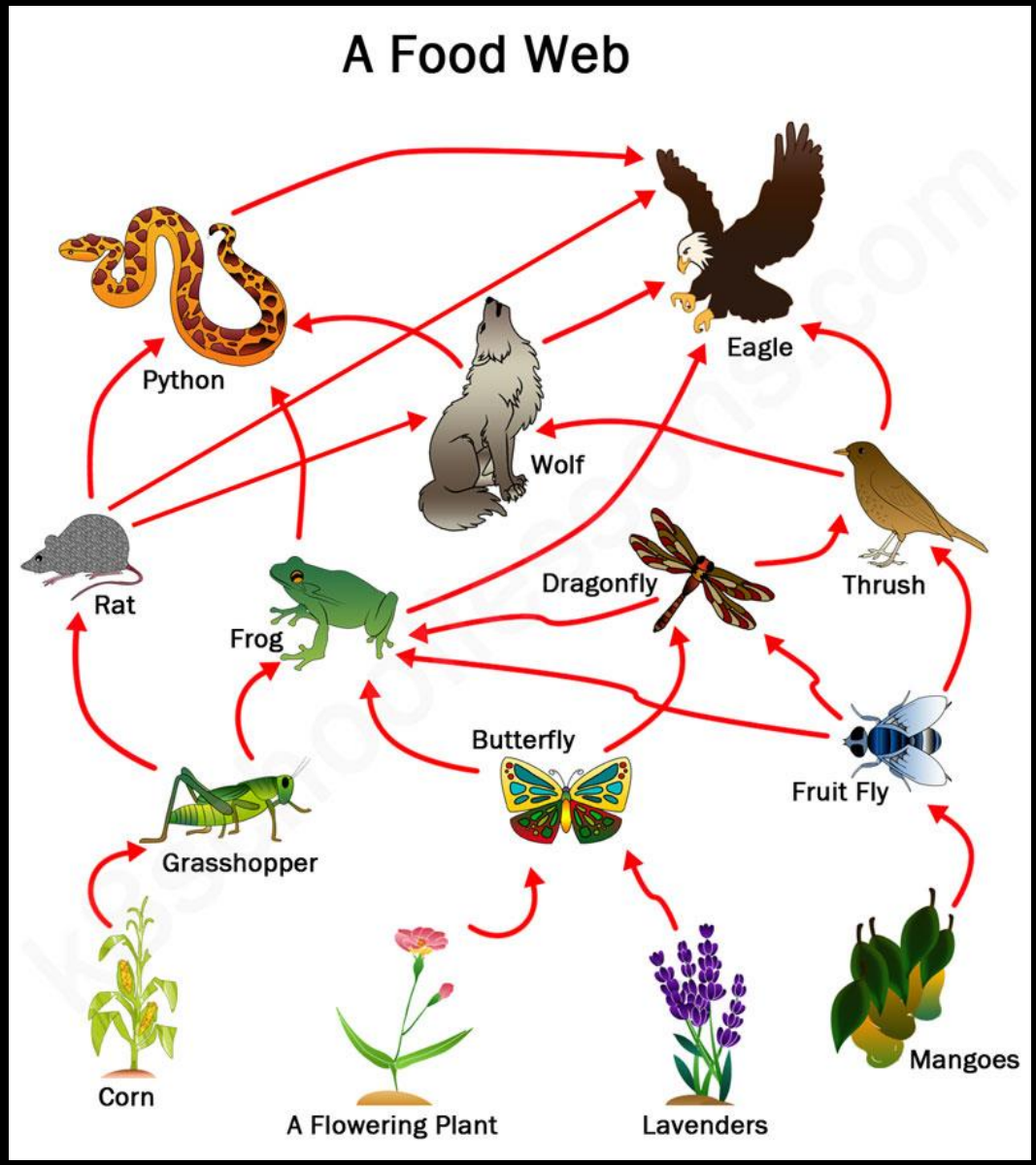
Interactions in the Ecosystem

Includes

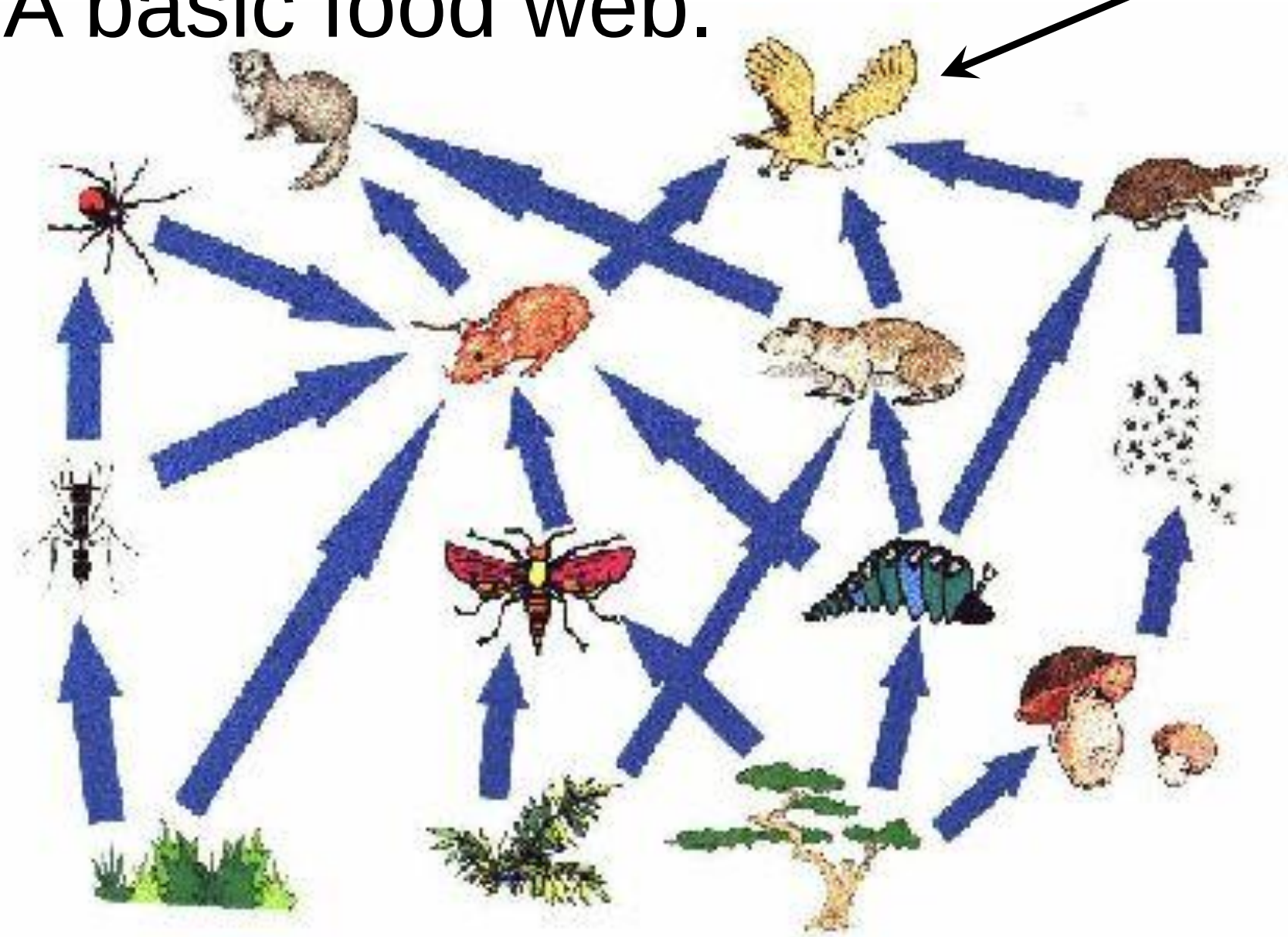
Food chains

Food WEBS

Feeding relationships among organisms in an ecosystem usually form a network of complex interactions shown as a **FOOD WEB**.



A basic food web.

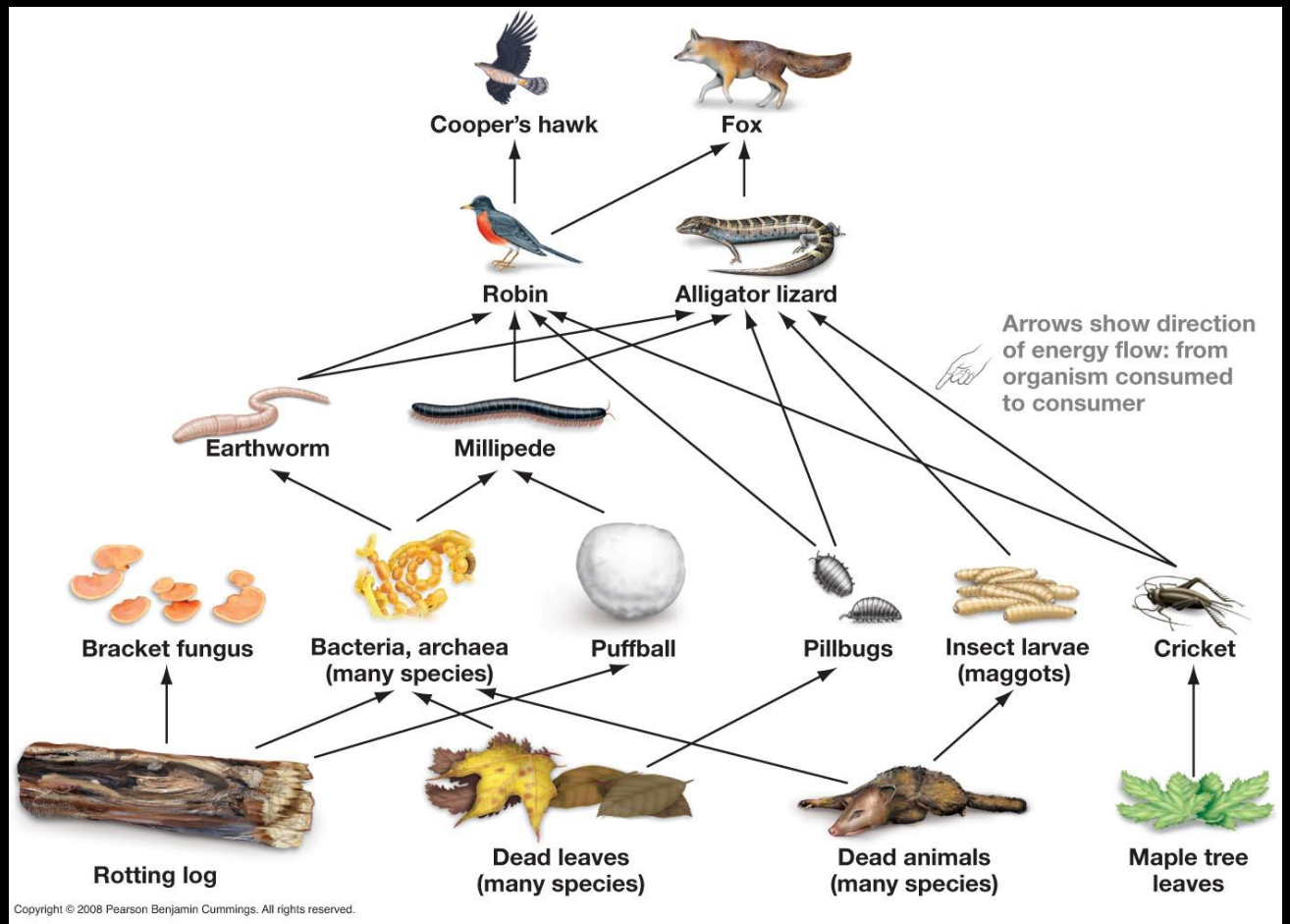


Food Webs

If Pill bugs should die off because of disease, the robin and alligator lizard would not go without food.

Each arrow represents a transfer of energy from one organism to another.

Organisms must ultimately receive energy from the producers.



Understanding Food Webs

QUICK CHECK

Where does the bald eagle get energy? Check all that apply.

[ ] sea ducks

[ ] large piscivorous fish

[ ] tundra swan

What feeds on phytoplankton

[ ] benthic invertebrates

[ ] sea ducks

[ ] bivalves

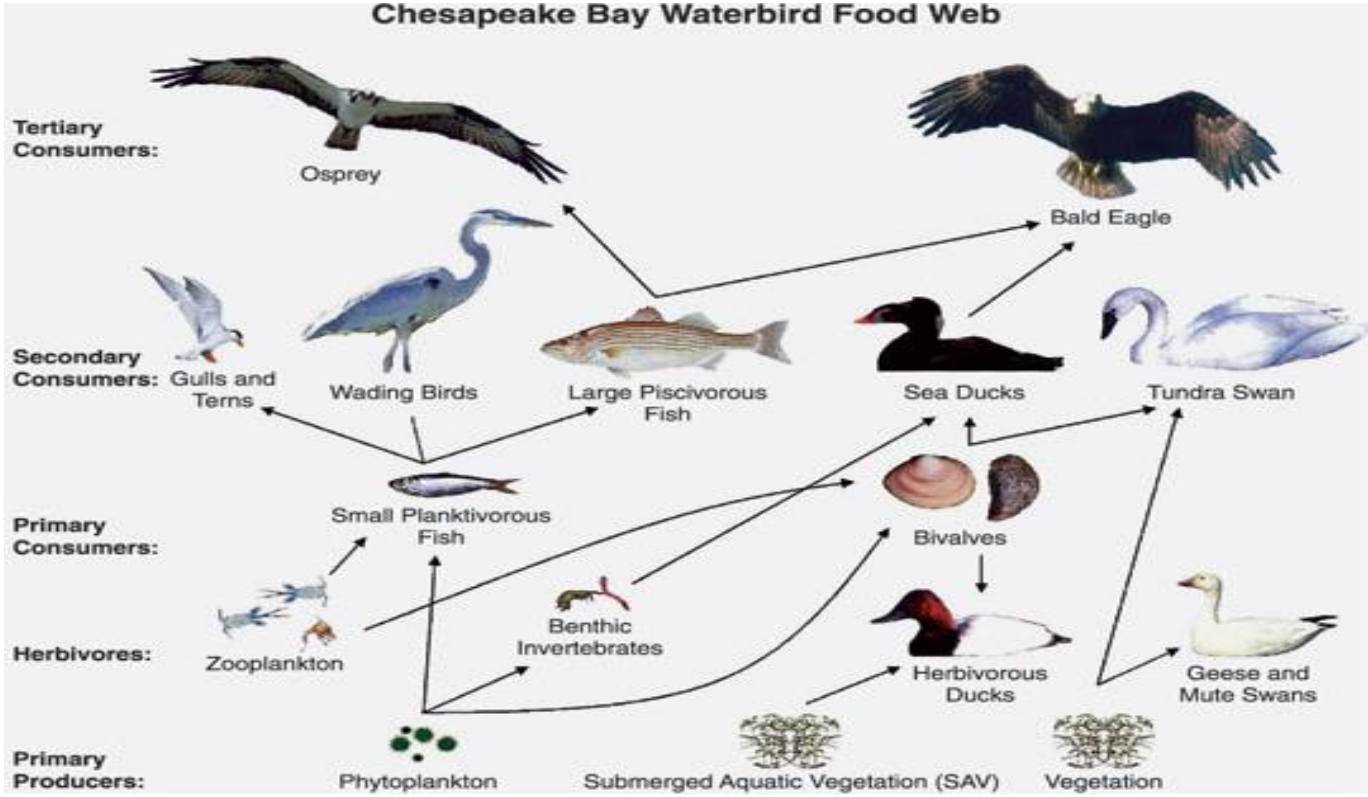


Image by Matthew C. Perry

Understanding Food Webs

QUICK CHECK

Where does the bald eagle get energy? Check all that apply.

[x] sea ducks

[x] large piscivorous fish

[] tundra swan

What feeds on phytoplankton?

[x] benthic invertebrates

[] sea ducks

[x] bivalves

A food web is an illustration of the many food chains that exist in a particular ecosystem.

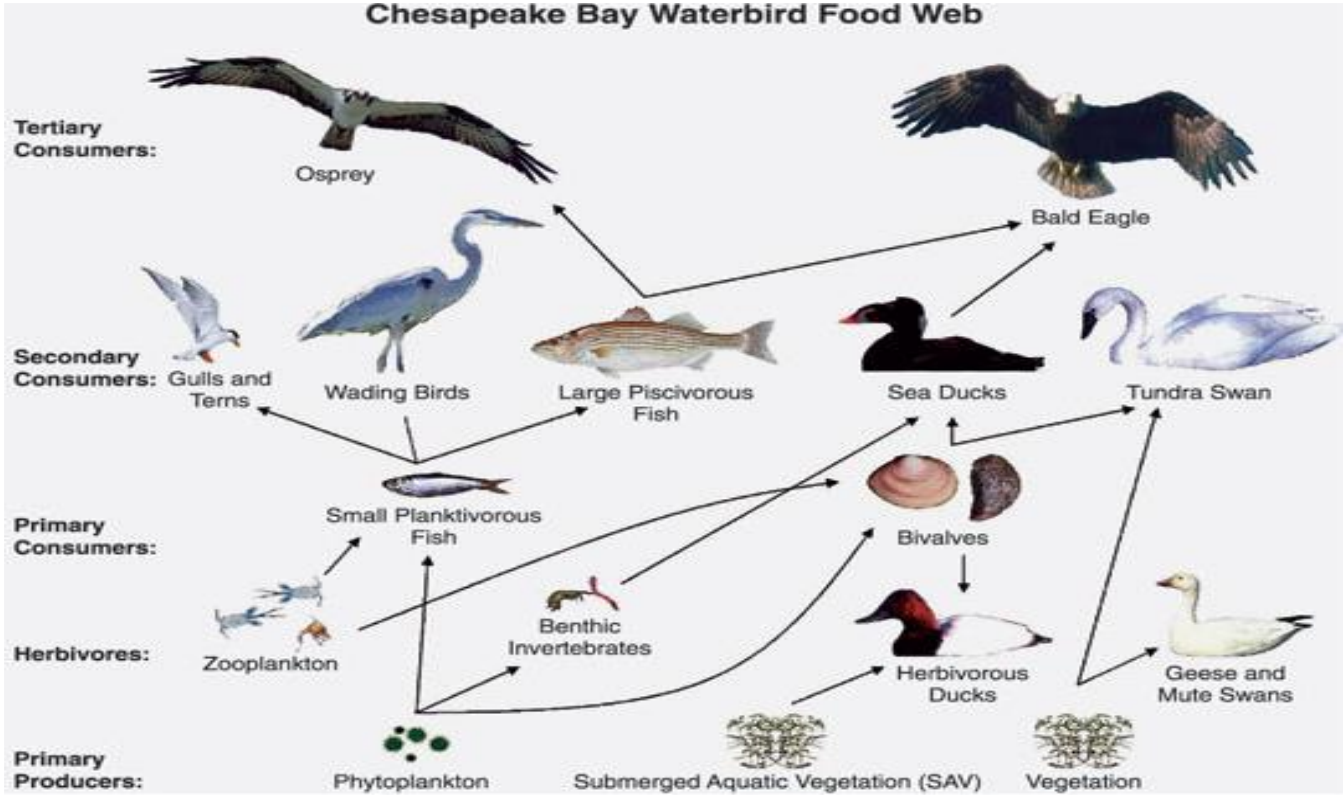


Image by Matthew C. Perry

Food Webs

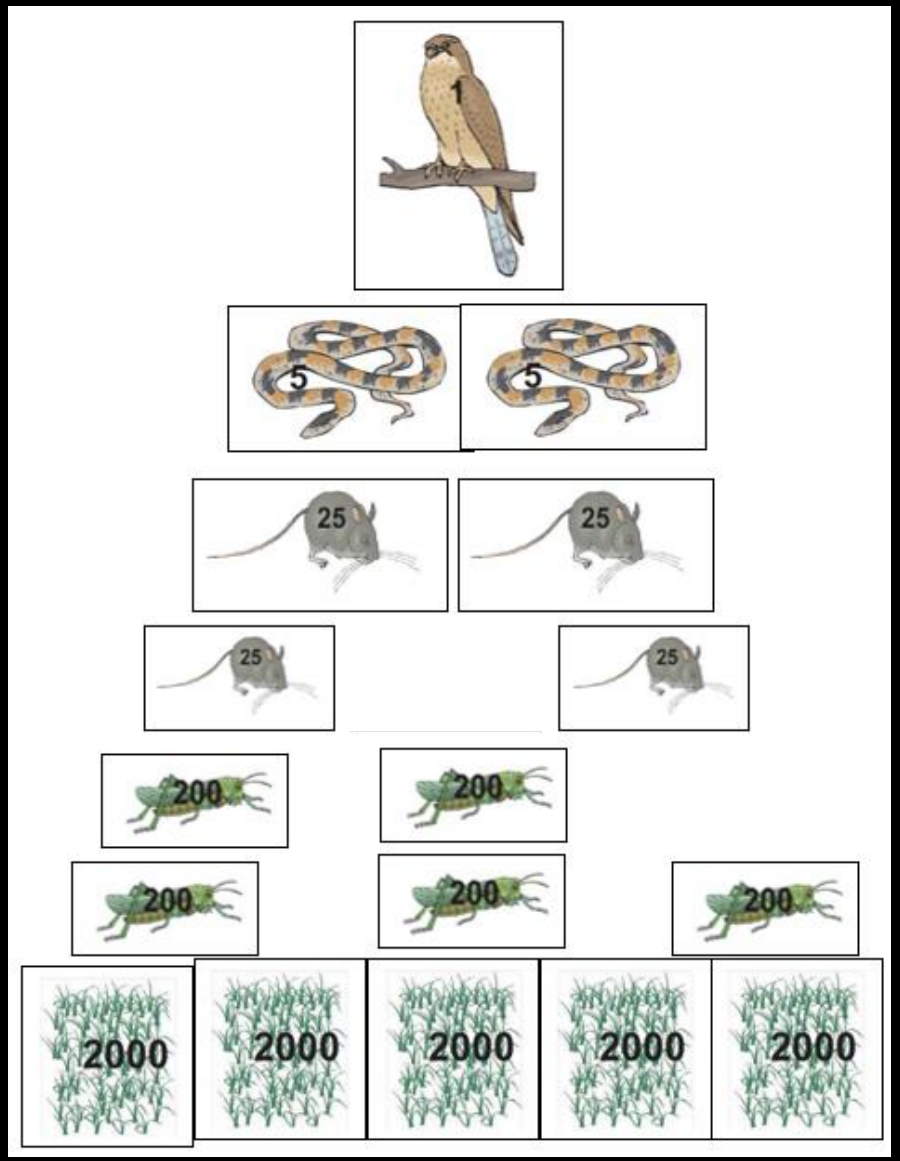
Sometimes the upsetting of food webs by man has unexpected results. A campaign to exterminate owls because of their occasional predation upon chickens may result in an increase in other animals such as rabbits and mice.

Negative Effects	Positive Effects
Human population growth (need more food)	Population control
Over hunting – dodo passenger pigeon; Exploitation – "trophies"	Conservation
Pollution: Water, heat (thermal), chemical, [less O_2 in water]	Pollution controls & stipulations
Air pollution → acid rain	
Pesticides / biocides / herbicides	Biological controls – natural predators vs. pests
Waste disposal	

Food Webs

What would happen if the grasshopper population was significantly reduced due to over predation, pesticides, or other factors?

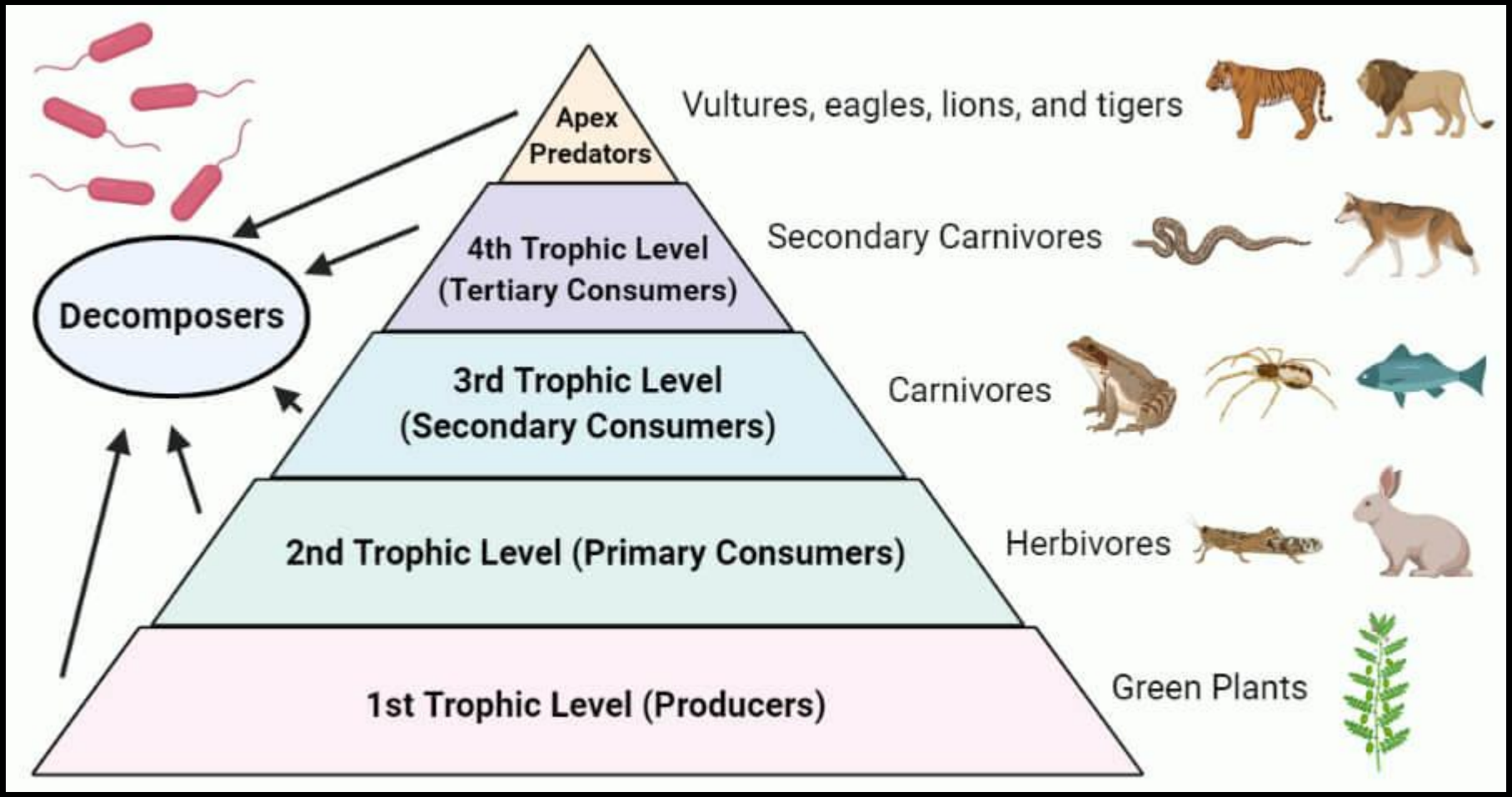
Grasshoppers (primary consumers) support all the other trophic levels in the food chain. Therefore, the secondary, tertiary, and quaternary consumers will be greatly affected. Mice will die off for lack of food, which will cause a food shortage for the snakes, and then, for the hawk.



Interactions in the Ecosystem

Includes

Food chains, Food Webs . . . Food PYRAMIDS

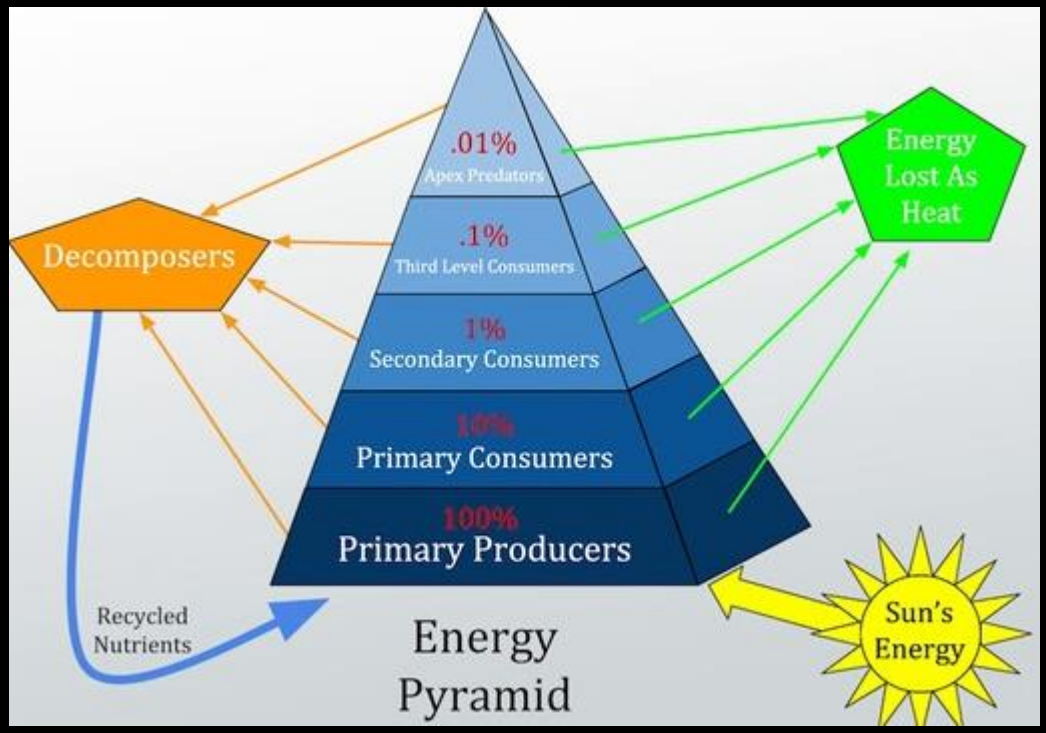


Food PYRAMIDS

Only a small portion (~10%) of the total energy incorporated by photosynthesis by autotrophs in a community is passed on to each succeeding level.

The reason for energy loss is:

1. Each organism uses energy to carry on life processes.
2. Not all food material is extracted (*digestive inadequacy*).
3. Heat loss.



Interactions in the Ecosystem

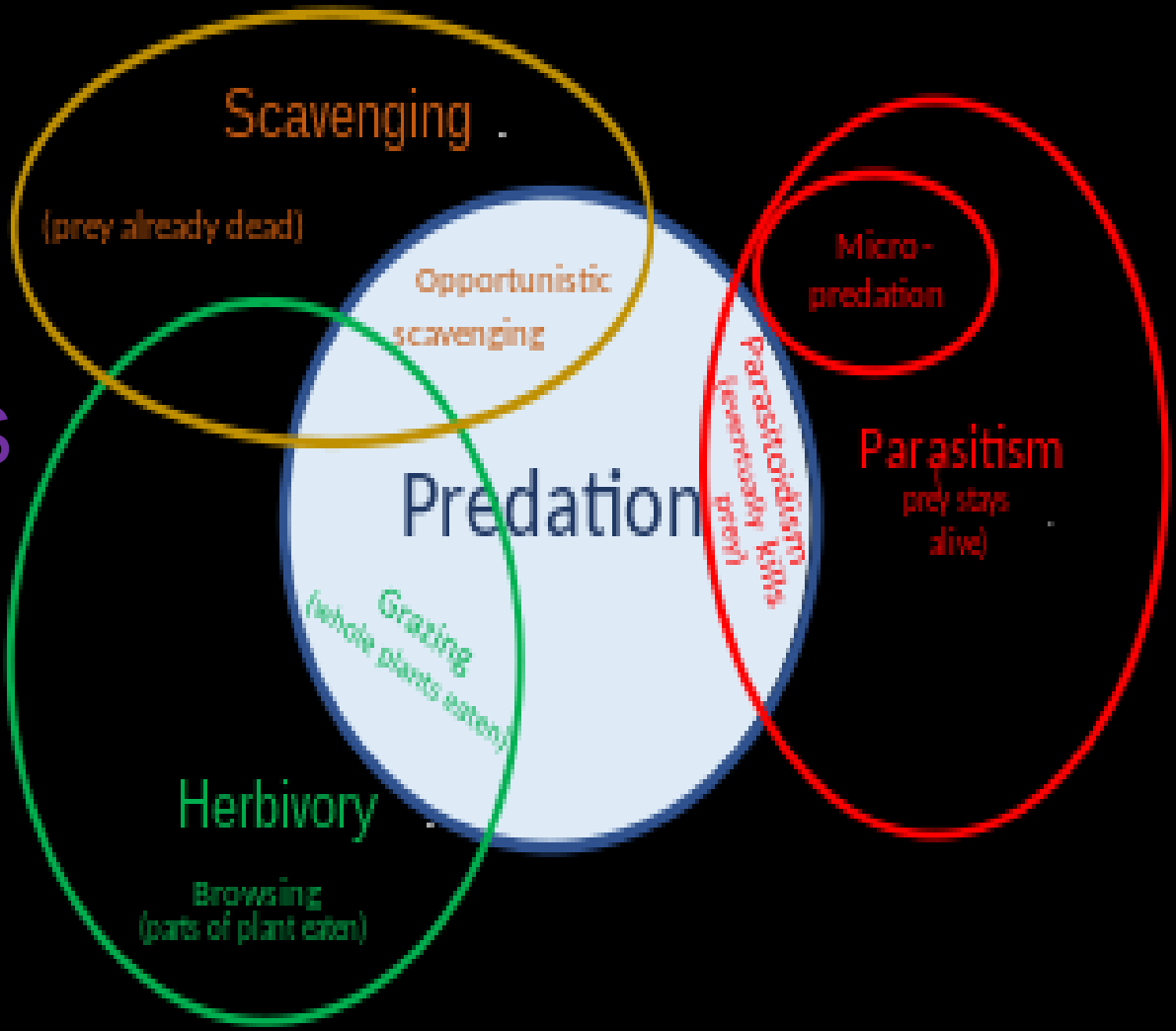
Includes

Food chains

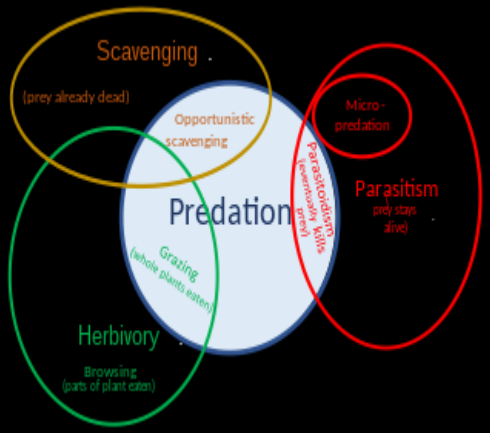
Food Webs

Food Pyramids

Food RELATIONSHIPS (predator/prey)



Food RELATIONSHIPS (predator/prey)



Predation Predator kills another organism and then eats it. (e.g. owl, wolf, man) – energy relationship.

Predators are fitted often with 1) sensitive eyes, 2) Sensitive hearing, 3) Sensitive sense of smell, 4) Strong jaws, 5) Long Claws, etc..

Prey are often fitted with organs of escape of detection (Flying, Mimicry, Blending, Swimming, Running, special behavior patterns).

Scavenging *[Organisms that live upon dead animals and plants]*

Saprophytic organisms that act as decomposers (waste products are broken down and returned to the soil or water) i.e. fungi and bacteria molds.

Interactions in the Ecosystem

Includes

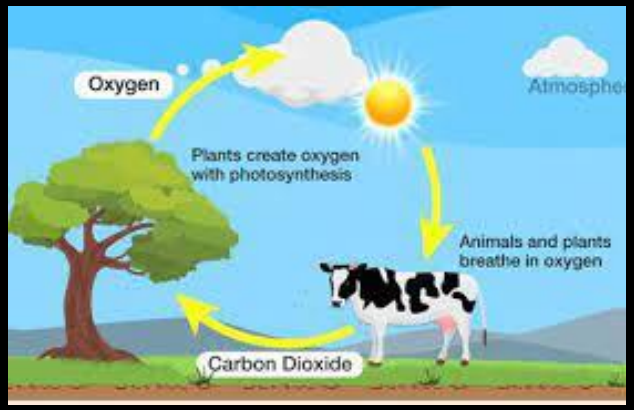
Food chains

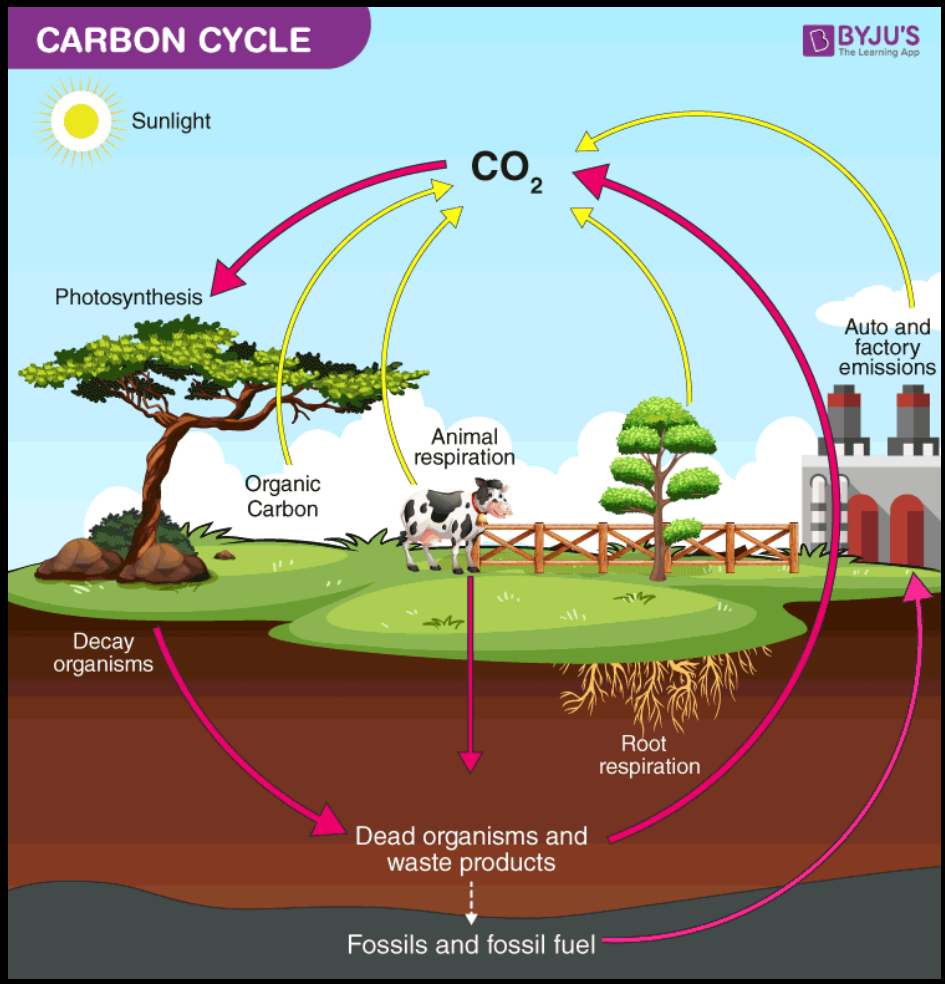
Food Webs

Food Pyramids

Food Relationships (predator/prey)

Cycling of Materials

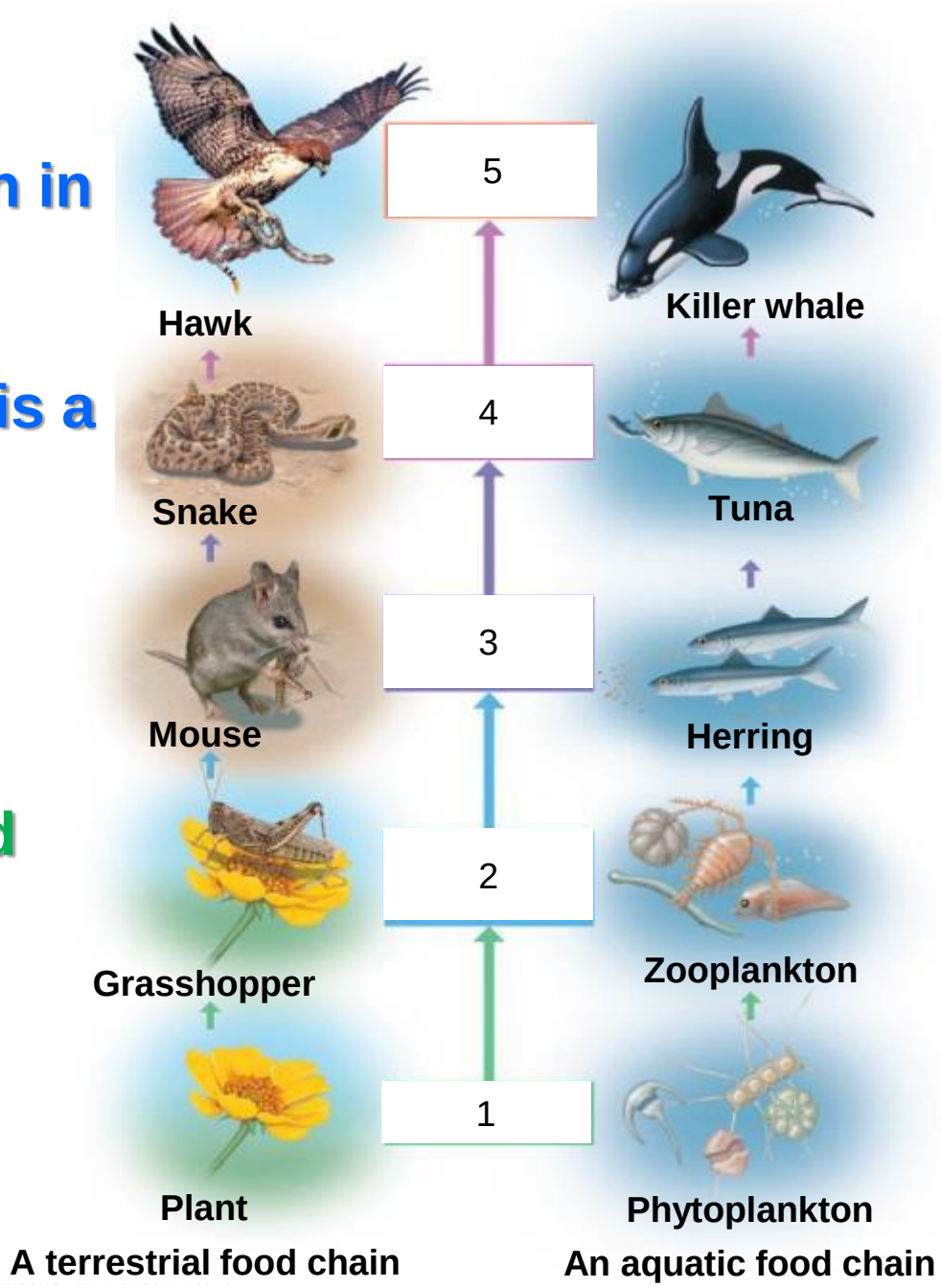




TRY IT

The interaction in an ecosystem that shows trophic levels is a ___.

Interactions involving food relationships include ___, ___, and ___.



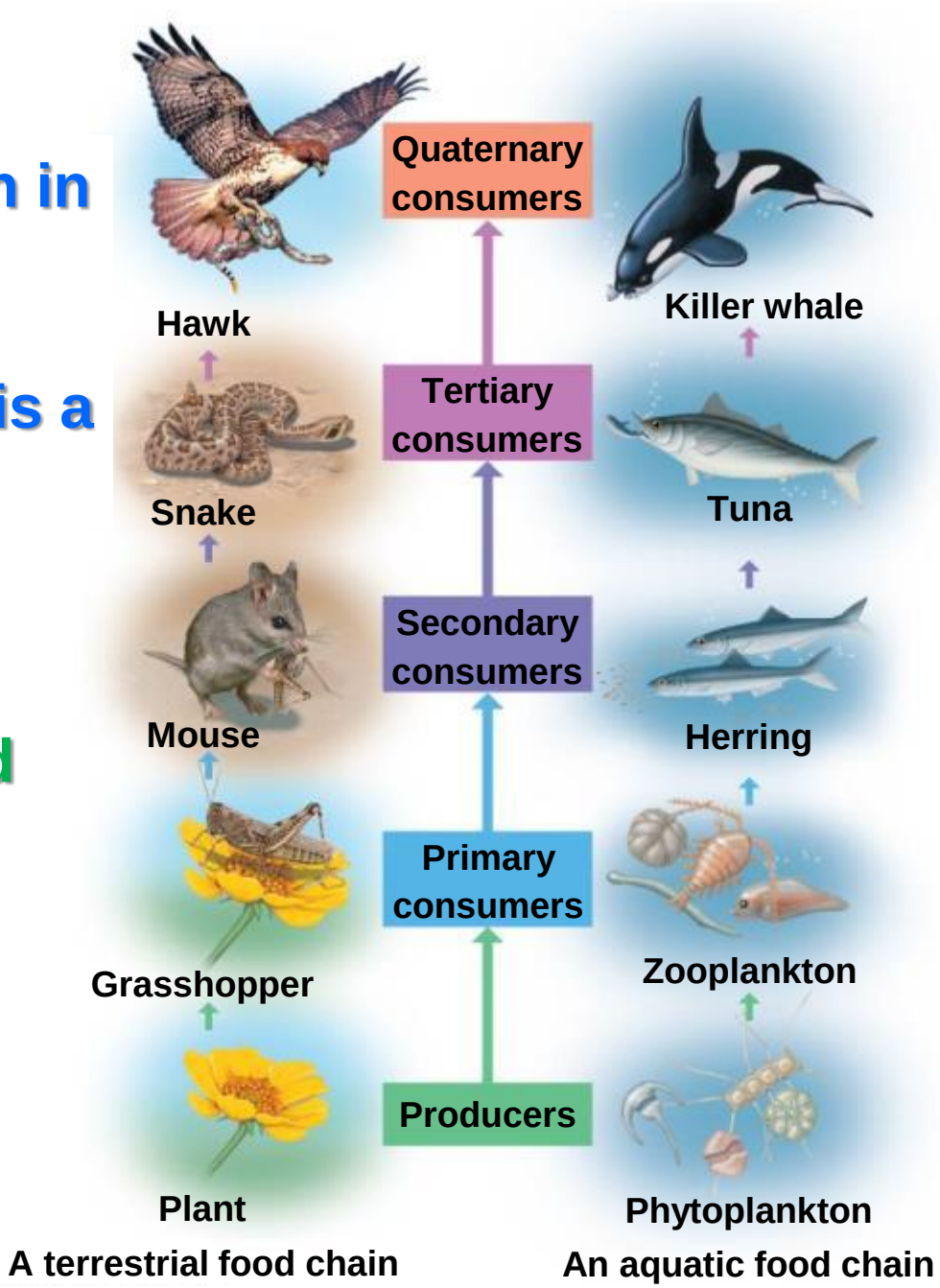
The interaction in an ecosystem that shows a network of complex interactions is a ___.

Carbon, nitrogen, oxygen, water involve ___ of materials.

TRY IT

The interaction in an ecosystem that shows trophic levels is a food pyramid.

Interactions involving food relationships include predators, prey, and scavengers.



The interaction in an ecosystem that shows a network of complex interactions is a food web.

Carbon, nitrogen, oxygen, water involve cycles of materials.

Trophic Levels

Food chains are tools used to show energy flow in an ecosystem from one organism to another, including producers, consumers and decomposers.

Each step in a food chain is called a trophic level.

Only about 10% of energy travels from trophic level to trophic level through a food chain.

All food chains begin with an Autotroph.

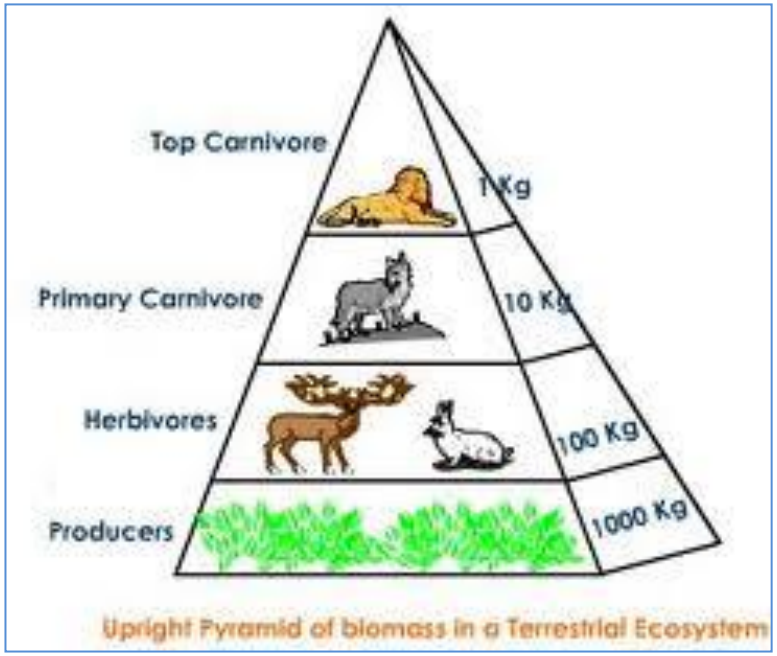
Trophic Levels

ENERGY flows through an ecosystem in one direction:

Sun → Producers → Consumers

Energy from producers can be passed through an ecosystem along a Food Chain (Linear).

- Energy transfers from one organism to another by eating and being eaten.



Trophic Levels

Each step in a food chain/web is called a TROPHIC LEVEL.

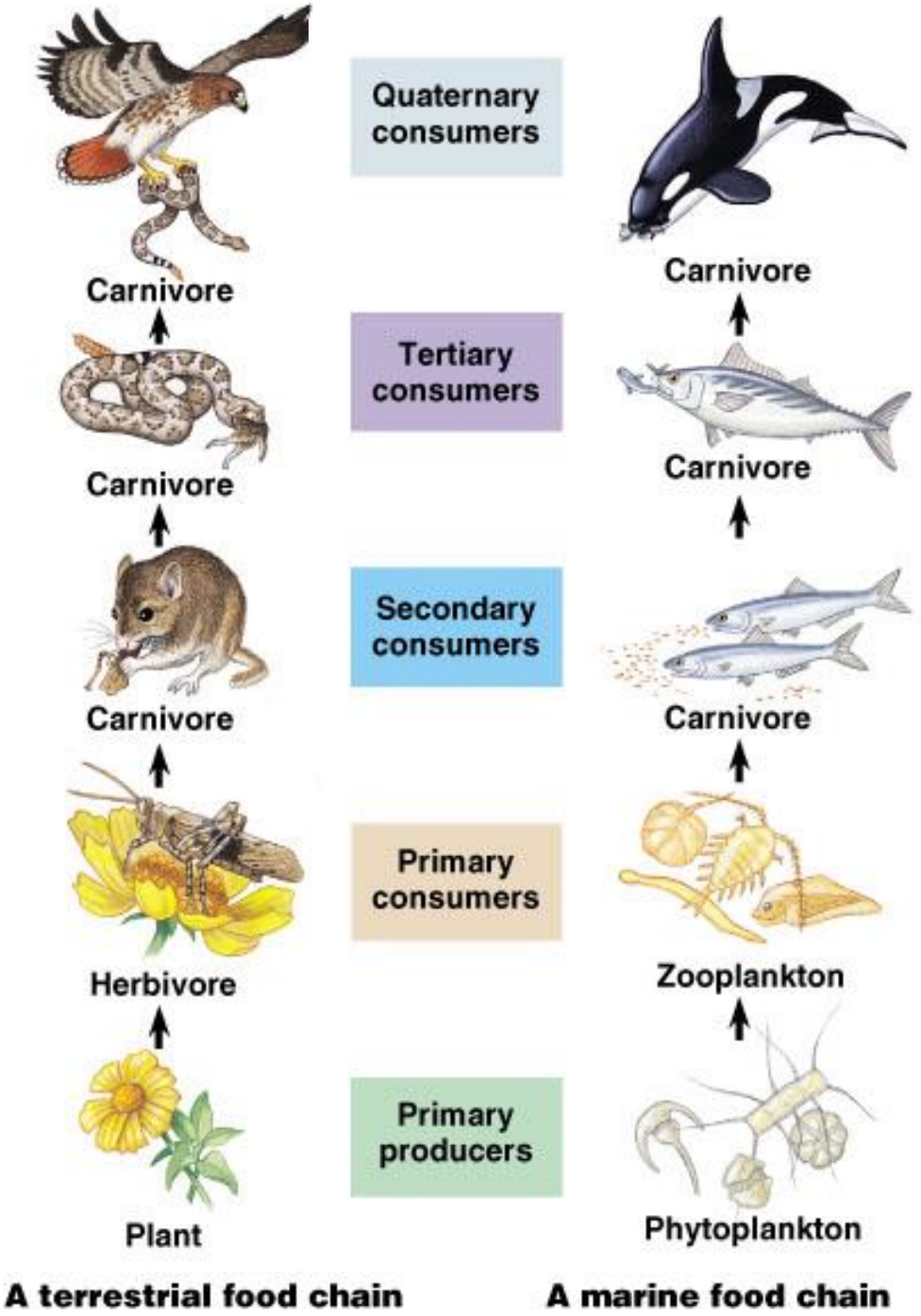
The trophic level indicates the organism's position in the sequence of energy transfers.

The first trophic level in a food chain is always made up of producers. These organisms are referred to as Primary Producers.

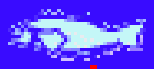
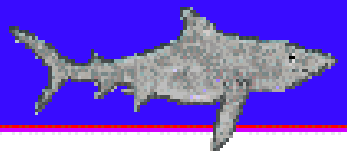
The second trophic level is occupied by the herbivores or omnivores that feed on the producers. These organisms are referred to as Primary Consumers.

Food Chains

Energy Flows in the direction of the arrows.



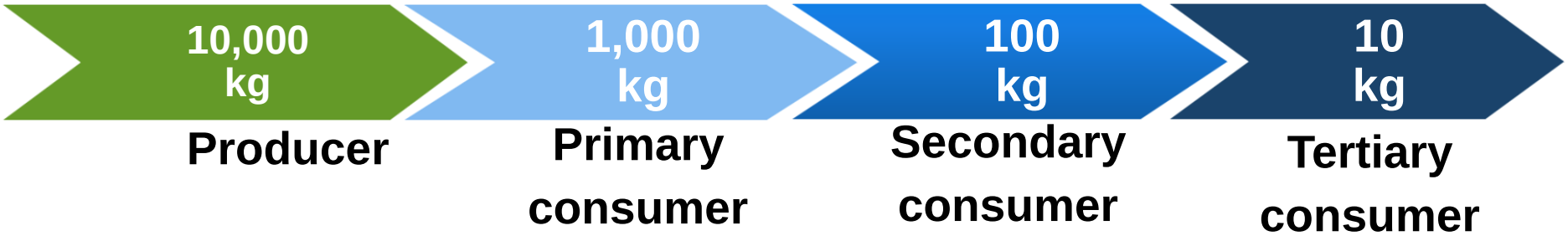
Sample Food Chains

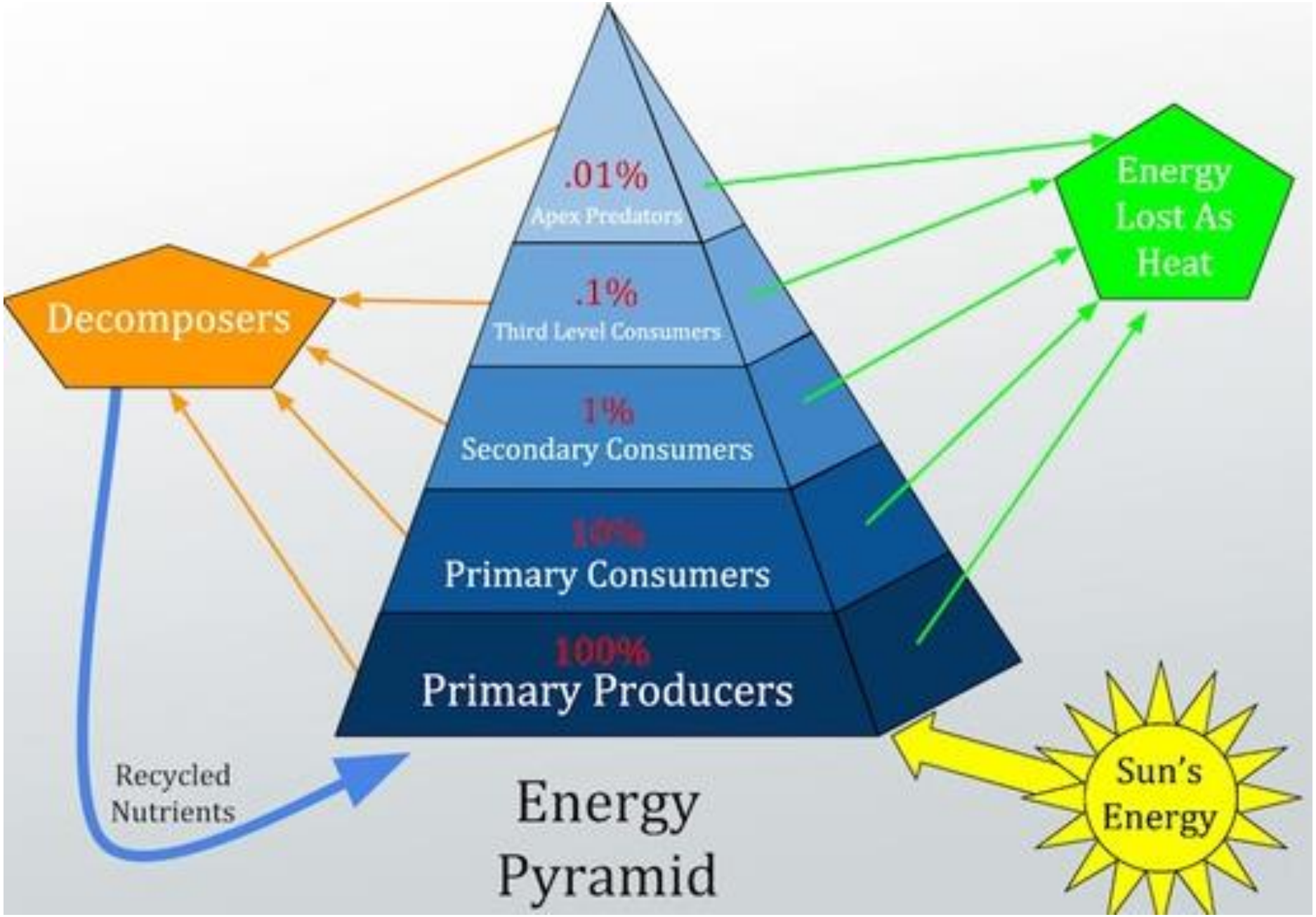
Trophic Level	Grassland Biome	Pond Biome	Ocean Biome
Primary Producer	grass	algae	phytoplankton
Primary Consumer	grasshopper 	mosquito larva 	zooplankton 
Secondary Consumer	rat 	dragonfly larva 	fish 
Tertiary Consumer	snake 	fish 	seal 
Quaternary Consumer	hawk 	raccoon 	white shark 

Energy Flows in the direction of the arrows.

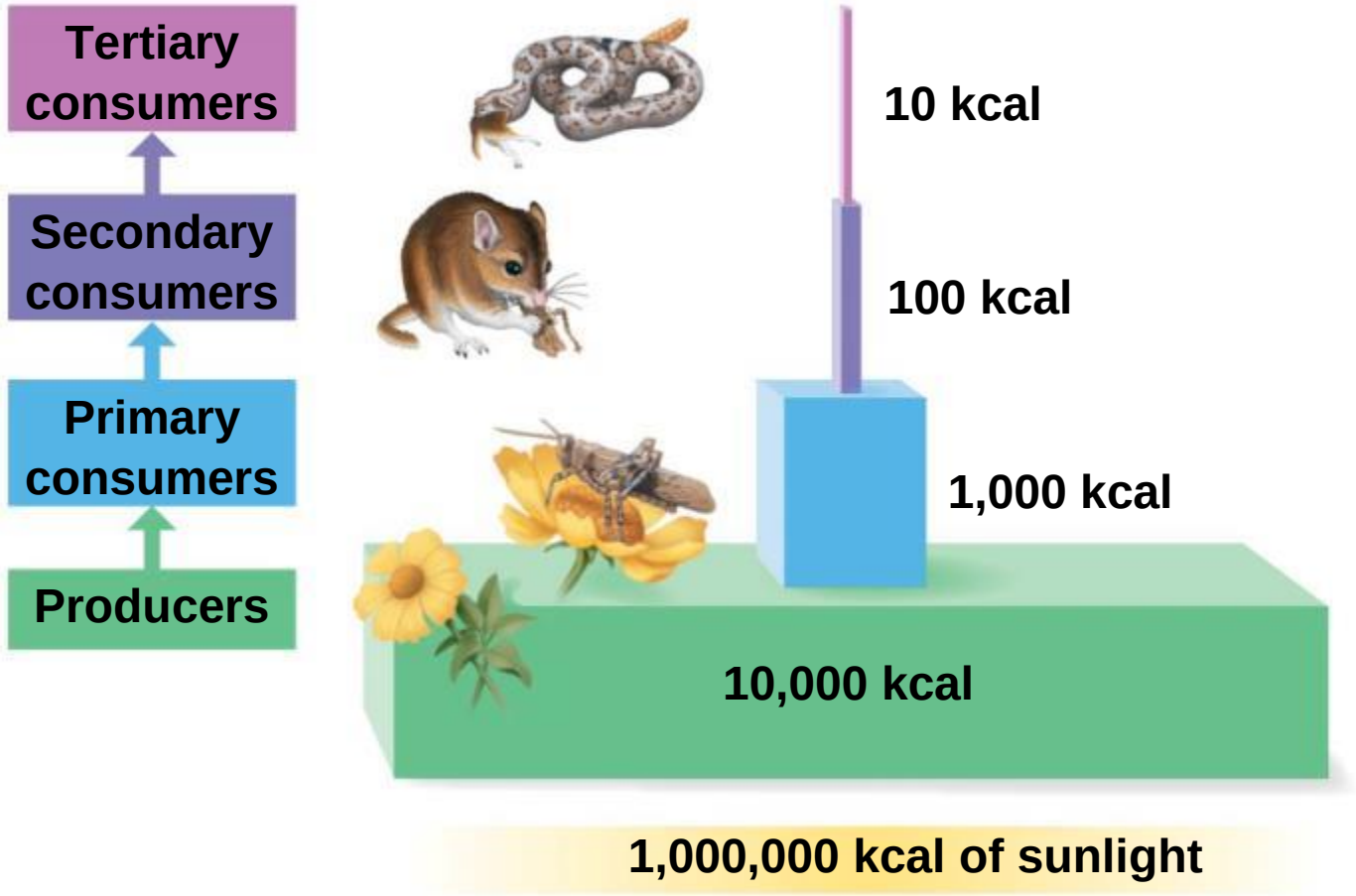
Loss of Energy in Trophic Levels

- Only about 10% of energy is passed from one organism to another in each step of the food chain.
- The remainder of the energy is used in life processes or lost as heat.

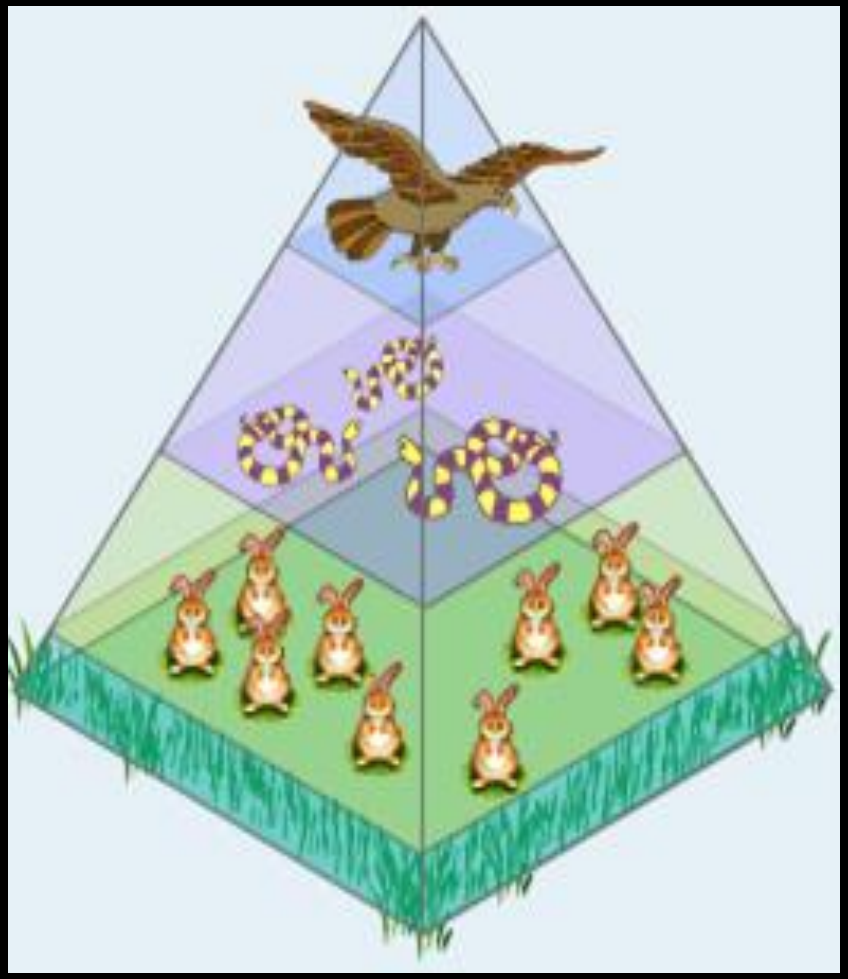



.01%
Apex Predators
.1%
Third Level Consumers
1%
Secondary Consumers
10%
Primary Consumers
100%
Primary Producers
Decomposers
Energy Lost As Heat
Sun's Energy
Recycled Nutrients
Energy Pyramid

Energy Pyramid:



Energy Pyramids Show:



Amount of available energy decreases for higher consumers.

It takes a large number of producers to support a small number of primary consumers.

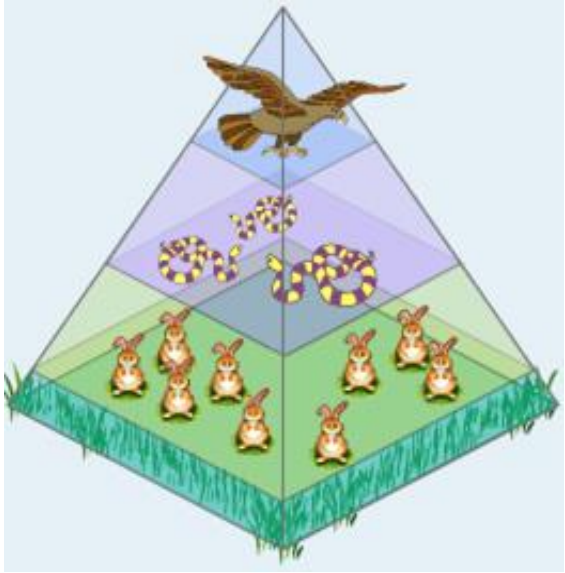
It takes a large number of primary consumers to support a small number of secondary consumers.

Energy supply limits the length of food chains

A **pyramid of production** illustrates the **cumulative loss of energy with each transfer in a food chain**.

Only about **10% of the energy** stored at each trophic level is available to the next level.

An important implication of this stepwise **decline of energy** in a trophic structure is that the amount of energy available to top-level consumers is small compared with that available to lower-level consumers.



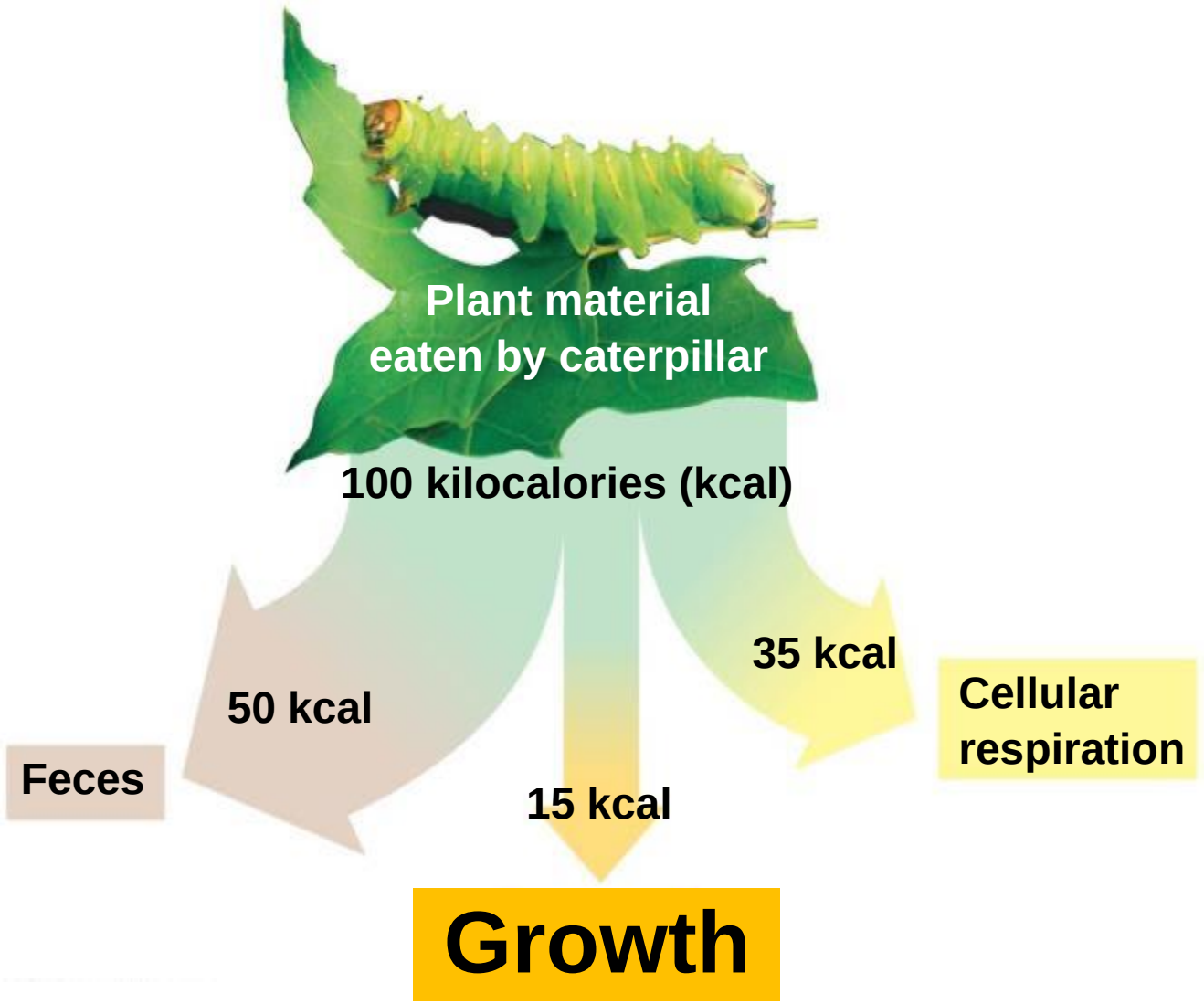
High Level Consumers

Only a tiny fraction of the energy stored by photosynthesis flows through a food chain all the way to a tertiary & quaternary consumer.

This explains why top-level consumers such as lions, sharks, and hawks require so much geographic territory.

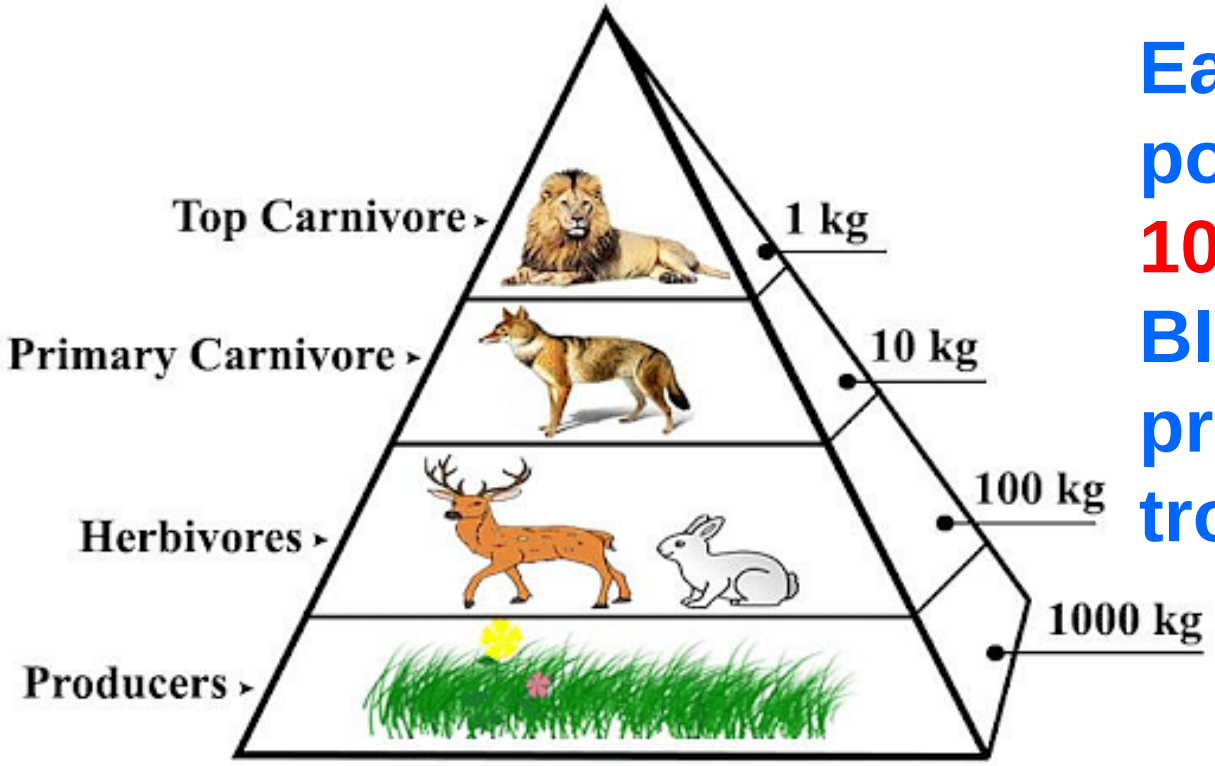
Energy supply limits the length of food chains

- A caterpillar represents a **Primary Consumer.**
- Of the organic compounds a caterpillar ingests, about
  - 50% is eliminated in feces.
  - 35% is used in cellular respiration.
  - **15% is converted to caterpillar BIOMASS.**


Plant material
eaten by caterpillar
100 kilocalories (kcal)
50 kcal
Feces
15 kcal
35 kcal
Cellular
respiration
Growth

Primary Production Sets the Energy Budget for Ecosystems

Ecologists call the amount of mass of living organic material in an ecosystem the **BIOMASS**.



Each trophic level possesses about 10% of the BIOMASS of the previous each trophic level.

Primary Production
Sets the Energy Budget for Ecosystems

The amount of **solar energy** converted to **chemical energy** (in glucose) by an ecosystem's **PRODUCERS** for a given area and during a given time period is called **Primary Production**.

Primary Production

- Autotrophs
- Organic matter from inorganic matter.

Secondary Production

- Heterotrophs
- Consumption of Producers to build BIOMASS.

Primary Production in World Biomes