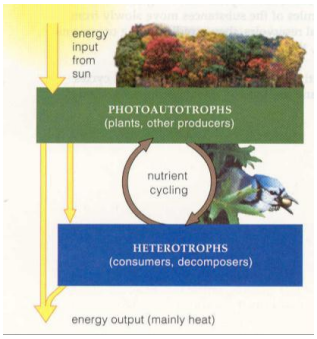
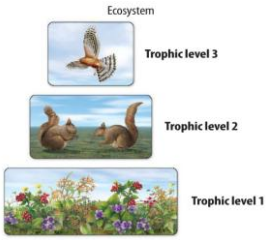
Energy Flow in Ecosystems

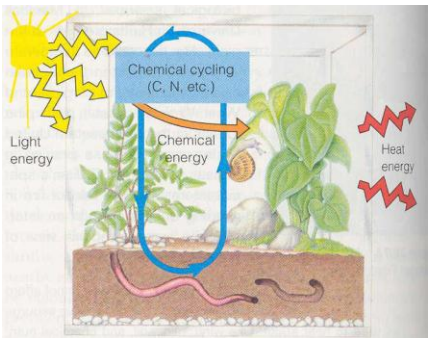
"Who eats what and where it all comes from"



Trophic Levels

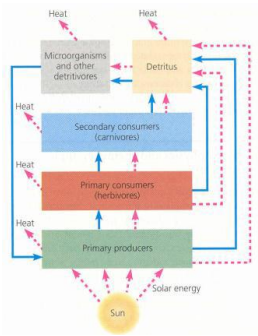
- Troph = "nourishment"
- Levels make up a "food chain" or expand into a "food web"
- Always begin with an autotroph
- Molecules cycle endlessly
- Energy flows in one direction and is lost as it transfers between levels Energy lost as heat
- "Rule of 10": Only 10% maximum of energy can pass to the next trophic level

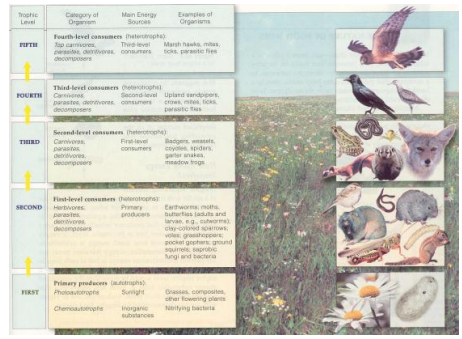




Note that all energy comes from the sun!

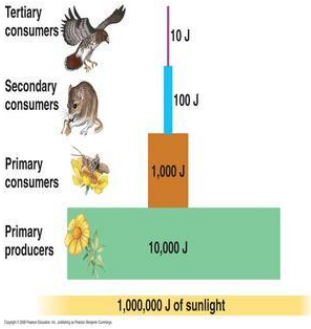
Each day 1019 kcal of solar energy = 100 million atomic bombs





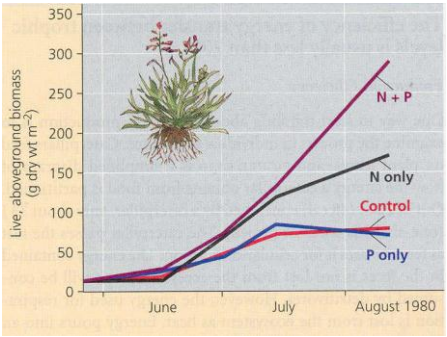
Trophic Level	Category of Organism	Main Energy Sources	Examples of Organisms
FIFTH	**Fourth-level consumers** (heterotrophs): *Top carnivores, parasites, detritivores, decomposers*	Third-level consumers.	Marsh hawks, mites, ticks, parasitic flies
FOURTH	**Third-level consumers** (heterotrophs): *Carnivores, parasites, detritivores, decomposers*	Second-level consumers	Upland sandpipers, crows, mites, ticks, parasitic flies
THIRD	**Second-level consumers** (heterotrophs): *Carnivores, parasites, detritivores, decomposers*	First-level consumers	Badgers, weasels, coyotes, spiders, garter snakes, meadow frogs
SECOND	**First-level consumers** (heterotrophs): *Herbivores, parasites, detritivores, decomposers*	Primary producers	Earthworms; moths, butterflies (adults and larvae, e.g., cutworms), clay-colored sparrows, voles; grasshoppers; pocket gophers; ground squirrels; saprobic fungi and bacteria
FIRST	**Primary producers** (autotrophs): *Photoautotrophs*	Sunlight	Grasses, composites, other flowering plants
	Chemoautotrophs	Inorganic substances	Nitrifying bacteria

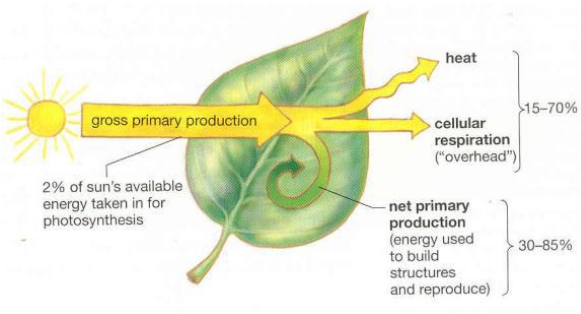
"Rule of 10" Only ~10% passes to the next level. Therefore, ~90% LOSS at each trophic level!



Producers

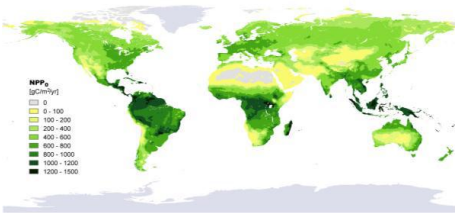
- Autotrophs ("self nourishers")
- Use solar or geothermal energy to convert inorganic molecules into organic ones
- 1% sunlight used for photosynthesis
  - *170 billion tons of organic product*
- Production limited by N on land, P in the water biomes

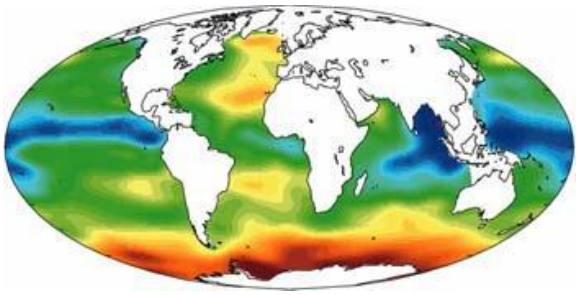




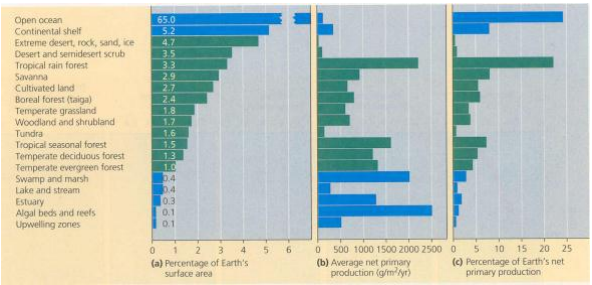
PP varies depending on…

- Amount of CO_2
- Amount of light
- Minerals available
- Amount of water
- Temperature – roughly doubles each 10°C



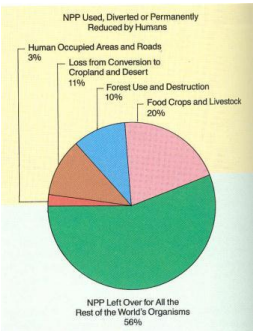


- Usually 50-90% GPP becomes NPP
- Low NPP in
  - hot subtropical deserts
  - high latitudes
- High NPP in
  - tropical forests – neither water nor temperature is limiting! *HOWEVER, tropical forests can have very nutrient poor soil for the same reason!

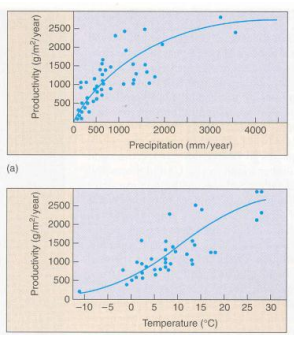


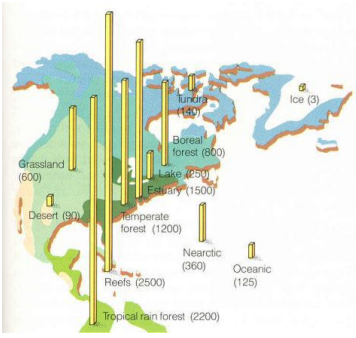
- Polar biome = 0.6% world's NPP
- Tropical Rain Forests biome = 44.5%
- Oceans = 25.8%
- Most productive per square meter = Intertidal Zone
- Humans take 40% of terrestrial NPP, the greatest consumption by a single species

Human use of NPP…



Abiotic Impacts on NPP…





Primary Consumers

- "herbivores" (herb = grass, vor = eat)
- Most efficient procurers/most inefficient consumers
- Many successful adaptations
- Stable isotope tracing allows molecules to be followed

Secondary Consumer

- "Carnivore" (carne = flesh, vor = eat)
- Consume primary consumer
- Less efficient procurement – requires more energy for finding prey BUT
- Relatively more energy efficient than herbivores

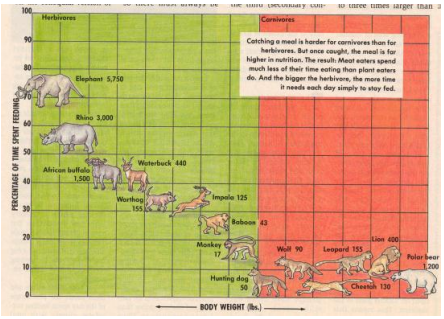
Tertiary Consumer

- "carnivore"
- Consumes secondary consumers
- Rare to have more than four trophic levels in a food chain
- "top carnivores" usually search for food over wide areas/ are generalists, eating what ever they find – sharks, eagles, mountain lions

- Some organisms eat at many trophic levels = omnivores!
- Some organisms eat whatever they can find = scavengers or detritivores
  - (detritus = dead material from all levels)
- Some organisms eat at different trophic levels at different stages of their lives
- Some organisms are cannibalistic

- Feces of carnivores poor in nutrients/ herbivores much richer in nutrients
- Herbivores less efficient at energy transfer than carnivores
- Birds and mammals very low in energy transfer efficiency 1-3%
  - Fish 10%
  - Invertebrates 25-35%
  - Insects 50-60%

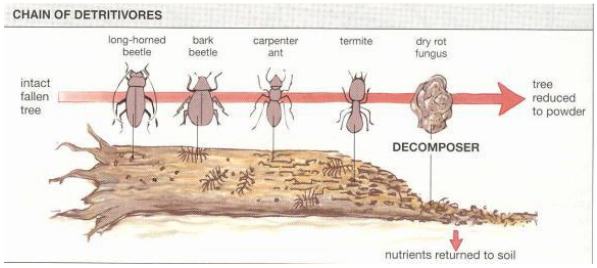
Interesting effect of herbivory....



Decomposers

- Convert dead tissue and wastes back into basic molecules for recycling
- Also called a saprobes

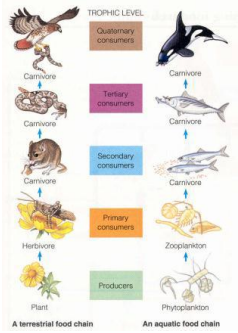
Detritivores follow a pattern…

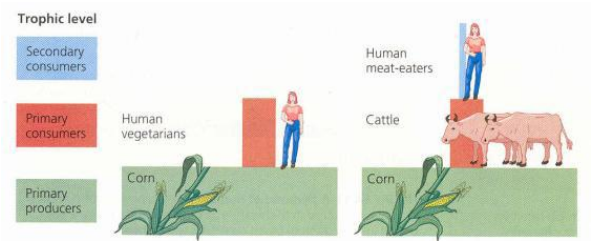


Coprophagy

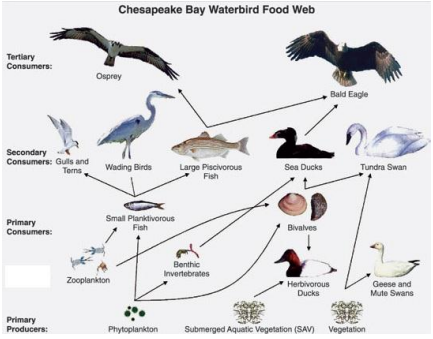
Food Chain

Sequence of food transfers from producer to final consumer: rarely more than 5 links





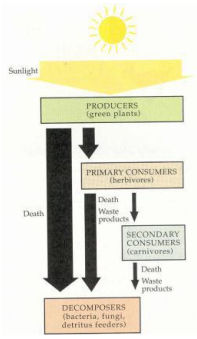
It requires 2500 gallons of water, 16 pounds of grain, 35 pounds of topsoil, and 1 galloon of gasoline to produce 1 pound of beef: meat consumption is expensive!!



- All chains, webs have photosynthesis at the beginning
- The shorter a chain, the more efficient
- The abundance of any consumer is ultimately determined by the number of steps in its food chain

Note: world's largest land animal, elephant, is vegetarian! So is largest marine creature, the blue whale/ so was largest dinosaur

Vegetarianism makes bigger animals!

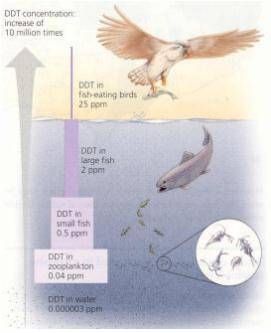


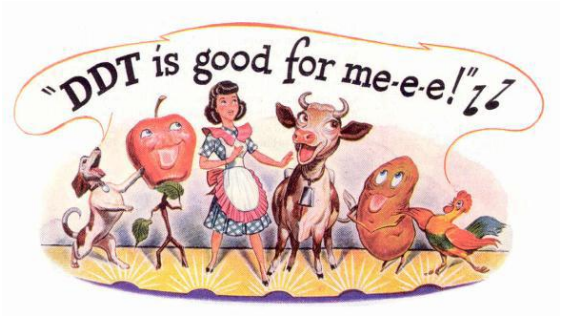
Human Manipulation of Food Chains

- Eliminates competition of other species
- Eliminates "predators"
- Speeds up growth
- Breeds for higher yield strains

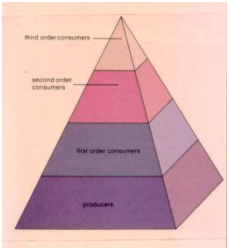
Biomagnification

- Rachel Carson's *Silent Spring 1962*
- Bioconcentration of toxic chemicals in upper levels of the food chains
- Persistent, mobile, not biodegradeable
- DDT, Mercury, synthetic estrogens

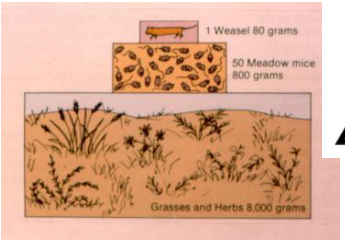




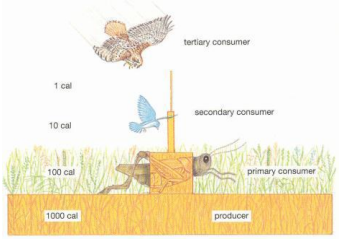
Food Pyramids



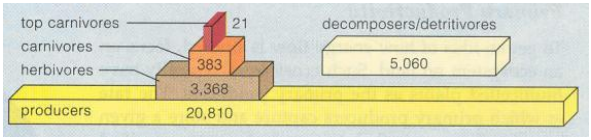
Pyramid of numbers



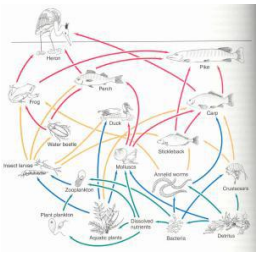
Pyramid of energy

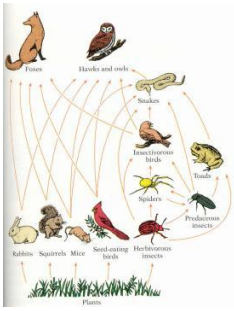


Pyramid of biomass

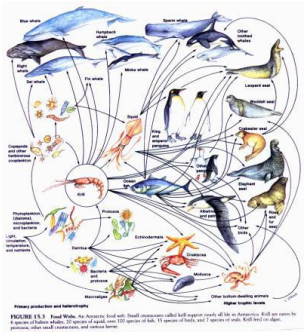


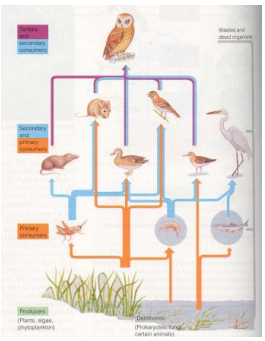
Food webs





Let's model a food web!





Food webs change based on season…

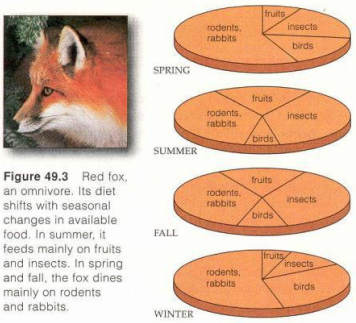


Figure 49.3 Red fox, an omnivore. Its diet shifts with seasonal changes in available food. In summer, it feeds mainly on fruits and insects. In spring and fall, the fox dines mainly on rodents and rabbits.

Keystone species

- Numerically small species which exerts strong control on a community's structure by nature of its important ecological niche
- Often top predators

Photo by: Daisy Gilardini