Food Webs & Interaction Webs

Background information on food-getting by organisms:

Plants convert solar energy into useable stored sugar energy. These organisms are called autotrophs (auto=self; troph=feeding/energy). Most autotrophs are photosynthetic organisms like plants that build (synthesize) their food from light (photons). There are a few autotrophs that are not photosynthetic . Some deep-sea bacteria, for example, build their food using chemical energy. We call these autotrophs chemosynthetic.

Many organisms are not able to make their own food directly from other forms of energy. Most animals must acquire energy by eating the sugars that are stored in the bodies of plants or other animals.* These heterotrophs (hetero=other; troph=feeding/energy) are often divided into different categories depending on what they eat. Heterotrophs that eat plant material are called herbivores, while those that feed on animal material are called carnivores. Some animals feed on both plant and animal material, and are called omnivores. Organisms that kill and eat other organisms are predators, but it is possible to get food without killing it. Autotrophs do this by making their own food. Parasites do this by taking food from their host without killing it. Scavengers that feed on plant or animal matter that is already dead are called detritivores. Decomposers also feed on dead material, but they are distinctive in that they actually break it down into its chemical components. Decomposers are critical in the recycling of nutrients in the environment.

Organisms are also categorized by the position they occupy within the food web. Producers are the same as autotrophs in that they "produce" food by storing sunlight energy in a useable form. Consumers are the same as heterotrophs. Primary consumers are the animals that feed on producers. They are the first, or primary, link between the producers and the other consumers. Secondary consumers feed on primary consumers, tertiary consumers feed on secondary consumers, and so on. Some organisms may occupy more than one level of consumption. Omnivores like ducks that eat pondweeds as well as insects are both primary and secondary consumers.

*Stored energy is not readily available to organisms when they eat a plant or animal. They must release the energy through a complex series of chemical reactions called cellular respiration.

Materials:

- Large poster or butcher paper
- Colored index cards: green, blue, red, purple, yellow, white
- Markers, at least 3 colors
- Tape

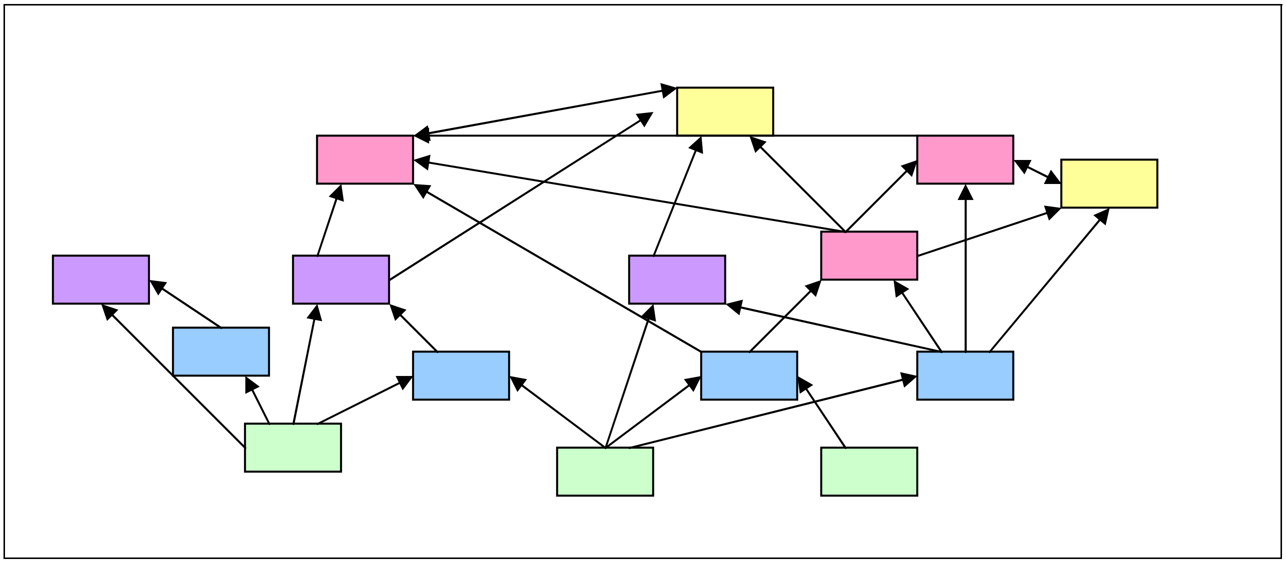
Students will build their own food web based on organisms in the intertidal that they have been studying. Color-coding of cards helps organize the web.

Green	Autotroph/Producer
Blue	Herbivore
Red	Carnivore
Purple	Omnivore
Yellow	Detritivore/Scavenger/Decomposer
White	Unkown/Not sure

Nerita picea Black nerite snail	Eats algae- Enteromorpha, and turfs. Eaten by different kinds of drupes (Morula); maybe by mantis shrimp. No symbiosis. Competes with Littorina pintado for food.

Have students post cards on web approximately where they think they fit into the trophic chain. Draw in trophic connections, can add competitive or symbiotic interactions as well.

Model Food Web



Questions:

1. What kinds of organisms are near the bottom of the web? Near the top? Why?
   Autotrophs or producers are found near the bottom of the web, because they are the basis of the food web by virtue of their ability to store energy and produce food. Carnivores are near the top, because they are higher-level consumers. Detritivores and decomposers, though, are always the last link the web, because they consume dead things.
2. What kinds of organisms are most likely to compete with each other?
   Organisms that are the most alike will be most likely to compete with one another because they have the same requirements. Competition will probably be strongest within a species because those organisms are the most alike.
   a. Are all possible competitive interactions accounted for on this web?
      Since this is a trophic web, it only accounts for competition for food, not for shelter, space, water, or other requirements.
3. How can organisms that are not directly connected affect one another?
   They are connected indirectly through other organisms. For example, if a mantis shrimp eats cone snails, and cone snails eat cowries, the mantis shrimp has an impact on cowries by controlling the population of their predator.
4. Which organisms do you think are most important in the web?
   Autotrophs provide energy by producing food from sunlight. Decomposers recycle nutrients that are needed by the autotrophs and other organisms. Some organisms are connected to many others and may have a big impact in the web. You could argue that all the organisms are important because they all have a place or role within the web.
5. Which organisms are there more of in the web?
   There tend to be more producers and primary consumers or herbivores.
   a. Which organisms do you think are the biggest?
      Usually the top consumers are the biggest.
   b. Which organisms do you think have the biggest populations?

The producers usually have the biggest populations, followed by the herbivores.

c. Which organisms do you think have the greatest biomass?
Biomass is the amount of material present. Producers have the greatest biomass.

Concepts connected to Food Web activity:

Competition is most intense between organisms that are most alike.
One of the things students may notice when competitive interactions are drawn in, is that organisms that are most like one another tend to compete with one another. This is because they have similar needs, and so will be competing for the same resources. It should become obvious that competition will probably be strongest between individuals of the same species, because they will have identical requirements. Of course this web only focuses on competition for food resources. Organisms may compete for other things too, like space, shelter, mates, light or chemical nutrients, or dominance (which is really a way of insuring that the animal gets access to some other desirable resource). You can help distinguish between the kinds of competition. Exploitation is competition where one competitor uses up a resource, preventing the other from getting it. Interference is actual physical fighting to keep a competitor from getting the resource.

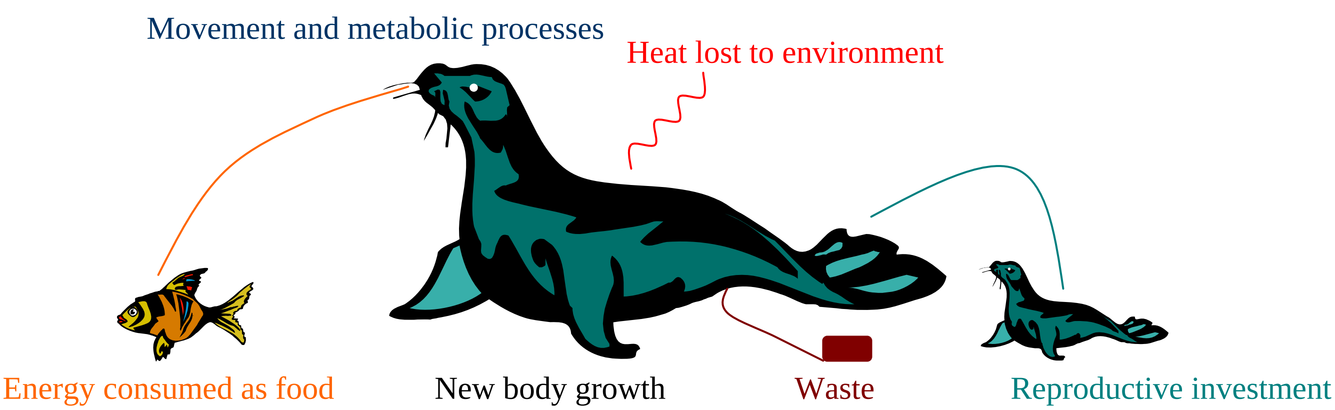
There is interconnectedness that is both direct and indirect.
You may notice that the food web very quickly becomes extremely complex. There are many connections between organisms that are both direct and indirect. Because of these connections, disruptions to web can have unanticipated effects. Examine the ripple effect through the web by looking at what happens if an organism is removed. You can trace the consequences through the web by following the connections.

There are some species that, by their presence or absence, can change the entire structure of a community. We call these keystone species. One very famous example of a keystone species is the sea otter, *Enhydra lutris*, in the kelp forest environment off the Pacific coast of North America. Sea otters feed on clams, mussels, and sea urchins living in the kelp forest. During the 19^{th} century, otters were hunted extensively for their fur. As one of the few marine mammals without blubber, otters have a thick pelt, which was highly valued in the fur trade. Hunting of these animals reduced their populations drastically, but had an unanticipated effect on the community in which they lived. Sea urchins, a primary component of the otter diet, are extremely efficient herbivorous grazers. Without the presence of the predator otters to keep the sea urchin population in check, urchins gradually began to increase their population, and the amount of grazing they were doing. This led to decrease in kelp, as urchins consumed more and more, causing so-called “urchin barrens,” areas devoid of kelp. The elimination of kelp also meant the elimination of many other organisms that used the kelp as food, or for nest sites, hiding places, and shelter. Following legislation to reduce otter hunting, and the reintroduction of populations of otters gradually led to the decrease of urchin barrens, and the revitalization of the kelp forest community.

Energy transfer is inefficient.

The basic measurement of energy useage is a calorie. One calorie is the amount of energy required to raise the temperature of 1 gram of water 1^{o} Centigrade (food calories are actually kilocalories, or one thousand energy calories). If the amount of calories consumed is equivalent to the amount of calories needed, then an optimal situation is achieved. If more calories are consumed than are used, the excess energy is stored as fat, but if fewer calories are consumed than used, then those energy stores are used. If the body does not have enough fat to burn, it turns to other sources, such as muscle tissue, for energy.

Organisms use the energy that they take into their bodies for many purposes. Although you may eat several kilograms of food each day, you do not gain an equivalent amount of mass. This is because most of the food energy acquired through consumption is not converted into additional stored energy (or bodily growth) but is used for many other purposes. All of the daily activities that organisms do require energy, this includes obvious things like movement: running, jumping, swimming, flying, even squirming, but it also includes maintaining a heartbeat, breathing, and for homeothermic animals like birds and mammals, maintaining a constant body temperature. This actually requires a very large amount of energy. This is why birds and mammals oftentimes require a larger amount of food than poikilotherms (animals that do not maintain a constant body temperature). For this reason, poikilothermic animals like fish and reptiles can go for a very long time, if necessary, without feeding. It’s why you need to feed your pet dog every day, but your pet python only twice a week. Some energy is also lost to environment as heat given off by the organism, and some is lost as waste.



The actual amount of energy actually used to build new material, either in the form of offspring, or as bodily growth, is fairly small, on average only about 10%, because so much energy is used for other purposes. This means that for one cowrie snail to gain one gram of body mass, it needs to consume roughly ten grams of algae. For one octopus to gain one gram of body mass, it needs to consume roughly ten grams of snail, and for one barracuda to gain one gram of body mass, it needs to consume ten grams of octopus. For one seal to gain one gram it needs to eat ten grams of barracuda, which translates to 100 grams of octopus, 1000 grams of snail, and 10,000 grams of algae!

Biomagnification is a phenomenon related to the inefficiency of energy transfer. Some kinds of pollutants or toxins are not readily eliminated from the bodies of animals because they are stored in fat, or slow to metabolize. We refer to these contaminants as persistent, because they persist in the body. Often, they are also slow to degrade in the environment and persist there too. These persistent toxins then can slowly accumulate at each level of the food chain. So that at the top levels they can be found at concentrations a million or more times higher than in the environment. In a simple food chain where eagles eat fish that eat fish that eat frogs that eat insect larvae that eat phytoplankton, there may be a small amount of environmental contaminant in the water. The level of contamination might actually be quite low, but if it is persistent, can accumulate in the food chain. Let's suppose that we have a level of contamination of approximately .001% in the water. Phytoplankton conducting photosynthesis may take in this contaminant at the environmental level, but it persists in their tissues. A larva consuming plankton, will not consume just one, because there is not enough energy in one phytoplanktor to support growth. If we adhere to the 10% rule we might assume that one larvae will have to consume the equivalent of 10 plankton for growth, and will also be taking in the equivalent of 10 units of contaminant. So now we have a larva with a contamination level of .01%. As we move up the food chain, the amount of contamination will increase by about a factor of ten at each level. That means that frogs will have a level of .1%, fish a level of 1%, and eagles a level of 10%. This is significant when you consider that many contaminants are lethal at doses of less than one percent. Biomagnification led to tragic declines of bald eagle populations in the United States following application of the pesticide DDT to control mosquitoes. Although the level of DDT in the environment was considered to be at a safe level, because the pesticide is persistent, it concentrated at high levels of the food chain, leading to birth defects and sterility, and death in the eagles at the top of the food chain. Humans have also fallen victim to biomagnification when they feed on fish from food chains contaminated with mercury, a persistent metal contaminant. Mercury can lead to massive birth defects when pregnant women consume it. This is why pregnant women are advised to limit their intake of tuna and other top carnivores that may have high concentrations of the metal in their tissues.

<u>Decomposers are an especially important, if overlooked, component of the food web.</u>
Decomposers fill a vital role in the food web by breaking down dead plant and animal material into its chemical components. These nutrients are then returned to the environment where they can be used. Plants do not grow only by conducting photosynthesis and producing sugar. This would be the equivalent of living solely on Twinkies. Nutrients like nitrogen and phosphorous are also required to build body parts and structures, and it is these that the decomposers play a vital role in recycling through the environment. In environments with lots of growing plants, all recycled nutrients are immediately taken up and used. For this reason, soils in rainforests and waters surrounding coral reefs are actually very nutrient poor, because all the nutrients deposited back into the system are taken up so quickly. This very delicate balance can

be easily disrupted. When large amounts of plants are removed and not allowed to decompose back into the soil, via logging, for example, this can lead to nutrient depletion. Nutrient enrichment can also be harmful. When too many nutrients are artificially added to the environment through fertilization or sewage contamination, for example, fast-growing algae can rapidly overgrow and smother slower growing corals.