

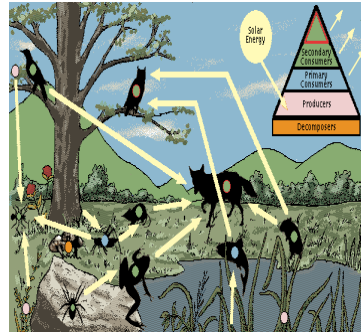
What is a Food Web?

A **food web** is a diagram of the links among species in an ecosystem – essentially **who eats what**. A **food chain** shows only the organisms that contribute to the diet of the top consumer.

Figures 1 and 2 (right) show examples of typical terrestrial and aquatic food webs, respectively. The triangular diagram in Figure 1 is an example of the main components of a food web.

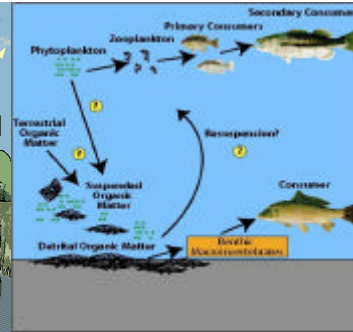
- The base of a food web is occupied mostly by vegetation (producers) and fine organic debris (decomposers).
- Herbivores (primary consumers) and carnivores (secondary consumers) occupy the higher levels.
- Omnivores occupy an intermediate level in the food web.
- Food webs are complicated by the fact that many species feed at various levels.

Figure 1



This diagram shows the relations between typical terrestrial organisms. The arrows connect the prey (diet) to the predator (consumer). The colored dots on the animals are coded to the colors in the triangular diagram at the upper right.

Figure 2



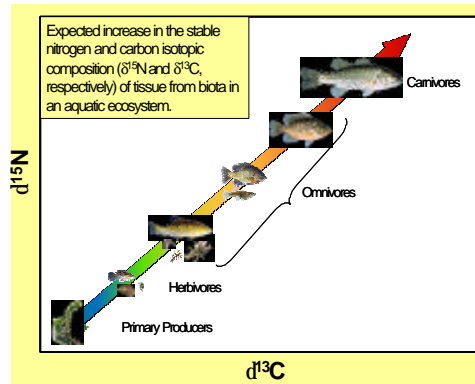
This diagram shows the relations between typical aquatic organisms. The arrows connect the prey (diet) to the predator (consumer). Several different food webs are shown.

How Are Isotopes of Carbon and Nitrogen Used in Food Web Studies?

Isotopes of carbon and nitrogen are used to determine where an animal belongs relative to potential food sources and other animals in its ecosystem. The soft tissue of living organisms is composed of roughly 40% carbon and 10% nitrogen, which are obtained through diet.

Animals take on the isotopic composition of the food they eat with a small isotopic enrichment -- the isotopic ratios become higher in both carbon and nitrogen compared to diet, as shown in Figure 3. In this way, we are able to determine at what level an animal is feeding in relation to its ecosystem.

Figure 3



The nitrogen ($\delta^{15}\text{N}$) and carbon ($\delta^{13}\text{C}$) isotopic composition of tissues are integrated measures of diet that can be used to distinguish the relative food chain (food web) positions of biota.

* Laboratory and field studies demonstrate increases in $\delta^{15}\text{N}$ (about 2 to 3 “permil” units) and $\delta^{13}\text{C}$ (about 0 to 1 “permil” units) between consumers and their diet, as shown in the figure above. So “you are **not exactly** what you eat”. Isotopers refer to this as “you are what you eat plus 2 permil”.

Why Study Food Webs?

The study of food webs is critical to understanding the route by which pollutants get concentrated (bioaccumulated) up the food chain (e.g., in game fish such as bass). Current examples of bioaccumulation that the USGS is studying are mercury in the Florida Everglades, selenium in the Central Valley, and selenium and mercury in San Francisco Bay.

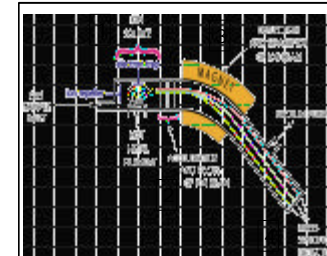
The knowledge of how species interrelate is also necessary to understanding how natural and man-made environmental pressures affect ecosystems. These include destructive pollution (toxic chemicals such as PCBs, DDT, mercury, and selenium) which can break or alter the food chain, and nutrient pollution which can shift whole ecosystems toward nutrient-hungry species. An example of the latter is crop fertilizers, sewage, and animal waste escaping into lakes and streams, causing massive algae blooms at the expense of fish and other species.

The adjacent poster and the ones across the hall show some examples of how isotopes are used to understand food web relations.

How is your fingernail sample prepared and analyzed?

- 1) About 1 milligram of your fingernail clippings will be put into a tiny tin foil capule, which will then be crushed closed.
- 2) The tin capsules are loaded into an automated sampler which will drop the samples, one by one, in to a furnace heated to 1100 °C where the sample is instantly combusted to CO_2 , N_2 , H_2O , and other gases.
- 3) A flow of helium then carries the gases through scrubbers that remove unwanted gases, and a gas chromatograph column that separates the remaining CO_2 and N_2 gases so that they can be separately analyzed (Figure 4)..
- 4) The gases then flow into the mass spectrometer where the isotope ratios of CO_2 ($^{13}\text{C}/^{12}\text{C}$) and N_2 ($^{15}\text{N}/^{14}\text{N}$) are measured.
- 5) A computer controls the mass spectrometer, collects the data, and calculates the isotope ratios from the small voltages measured.

Figure 4



An isotope ratio mass spectrometer (IRMS) measures the relative abundance of different isotopes in a gas sample. This is accomplished through **four** basic steps (keyed to the diagrams):

1. Conversion of the gas molecules into positively charged particles in the ion source.
2. Focusing and acceleration of these positively charged ions into a high-speed ion beam.
3. Separation of the total ion beam into mass-specific beams within a strong magnetic field.
4. Detection and measurement of the individual mass-specific ion beams (e.g., masses 28 and 29 of N_2 gas: ^{14}N and ^{15}N).

This is all done under high vacuum within metallic framework.

