You Are What You Eat

Some Uses of Carbon and Nitrogen Isotopes

- Food Web Studies

From Thomas D. Mangelsen's "Catch of the Day"

- Determining subsurface water flowpaths

You are what you eat! This means that the isotopic composition of your body is similar to that of your diet.

For example, if salmon is the main food source to bears, then the isotopic composition of bears should be similar to the salmon – but a few units higher in carbon and nitrogen isotopic composition.

- Tracing sources of nitrate pollution in ground- and surface water

Nitrogen isotopes of nitrate from fertilizers, sewage and animal waste often have distinctive compositions. In many cases, the main sources of nitrate pollution can be determined with the aid of nitrogen isotopic analysis.

- Testing for authenticity of food products and consumables such as wines and cigars honey, maple syrup, and alcohol

Tests for the adulteration of food and related products most often take advantage of the large difference in carbon isotopic composition between corn and sugar cane and most other plants.

Maple syrup, for instance, plots in the field for fruits, vegetables, and grains on the left figure on the reverse side.

Maple syrup with added cane sugar will plot somewhere between the field for vegetables and the field for sugar cane, depending on the percentage of added sugar.

- Tracing sources of petrochemical pollution

In a test for ulcers, the patient drinks some urea with a distinctive carbon isotopic signature.

If no ulcer is present, the urea is eliminated without assimilation. If an ulcer is present and caused by the common ulcer-producing bacteria *H. Pyroli*, the urea is assimilated and its carbon isotopic composition can be easily measured in a breath sample within about 30 minutes.

Other medical tests use similarly labeled compounds that can be detected if certain conditions exist.

- Medical testing for ulcers, liver function, pancreatic function, and intestinal bacterial overgrowths

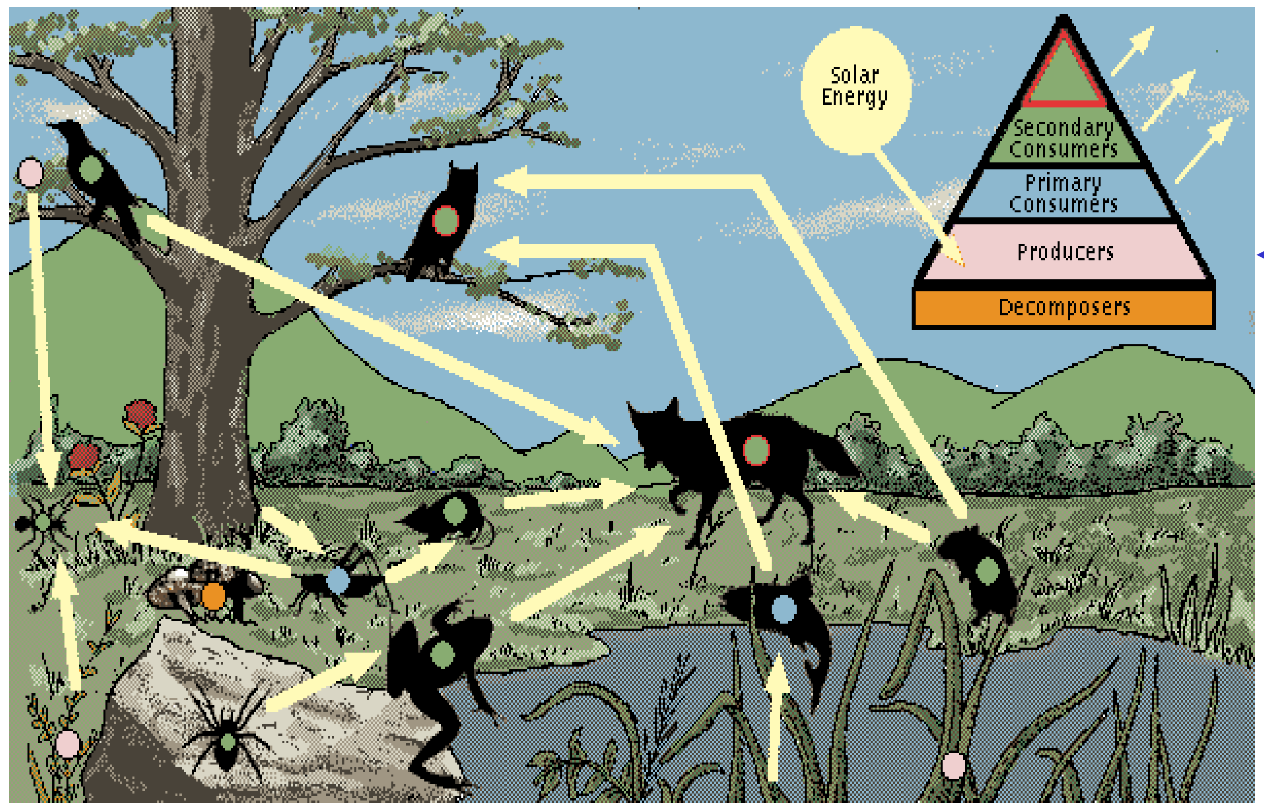

Figure 1. This diagram shows the relations between organisms. The arrows connect the prey (diet) to the predator (consumer). The colored dots on the animals are coded to the colors in the triangular diagram at the upper right.

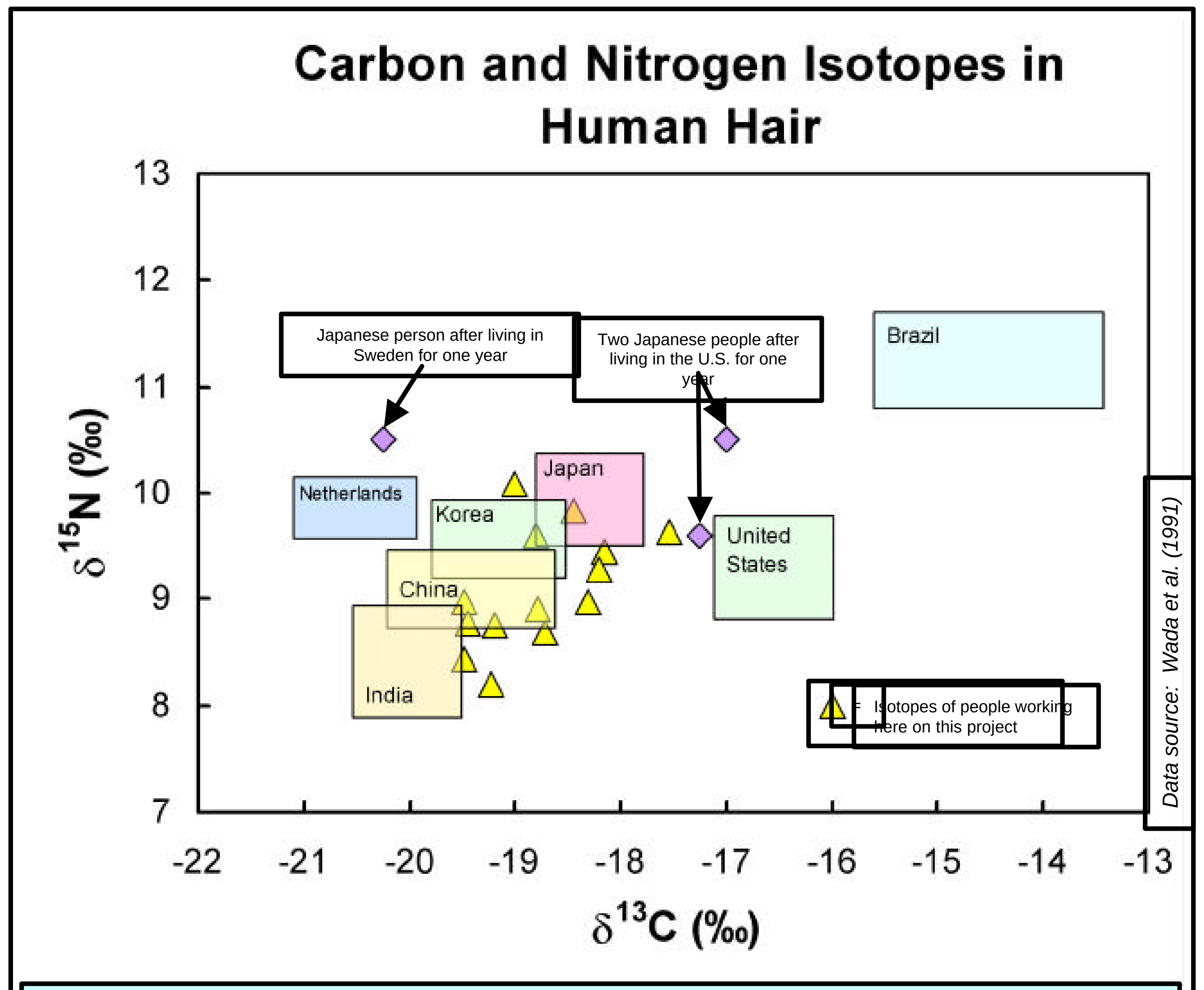

Figure 2. Average diets vary among people living in different countries, and these differences are recorded in the isotopic composition of our hair. Note the isotopic shifts (particularly $\delta^{13}C$) of the Japanese people who lived in other countries for one year. With a hair sample, one could reasonably guess where they had lived!

What is a Food Web?

A **food web** is a diagram of the links among species in an ecosystem – essentially **who eats what**.

The triangular diagram at the top of figure 1 (left) 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).

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. In this way, we are able to determine at what level an animal is feeding in relation to its ecosystem.

Take a look at left figure on the reverse side, and note the relations of various animals to their diets. Hair, fingernail, or feathers have been used in each case to represent animal tissue. Human hair on average is about 3 units higher in terms of nitrogen and 1 unit higher in terms of carbon than the human diet.

Dogs and cats have relatively short digestive tracts designed for meat. Much of the vegetable matter in their food is not assimilated, causing relatively large differences between their diets and their hair for carbon isotopes. Compare the difference between diet and animals for dogs and cats to vegetable-eating animals like rabbits, goats, and sheep.

Why Study Food Webs?

The study of food webs is critical to understanding the route by which pollutants get concentrated up the food chain (bioaccumulation). 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.

Related studies look at the diets of ancient man and animals. Changes from a grain-based to corn-based diet or from a terrestrial to a marine diet are easily revealed by isotopes. You can see the distinctive compositions of these food groups on figure 3. Note also the difference between Russian black bears and grizzly bears. The grizzly bears feed largely on marine salmon while the black bears eat mostly vegetation.

Figure 2 is taken from a 1986 study of people living in different parts of the world. You can see that the isotopic compositions of the two Japanese people who are living in the US and the one who is living in Sweden have shifted as their diets changed to the local cuisine.