Energy and the Natural World: How Energy is Passed Up the Food Chain

All living things require energy to live, to grow, and to reproduce. With the exception of a few rare species that live near deep ocean vents or a few species of bacteria living around hot springs, the ultimate source of all of that energy is the sun. All plants, except for various types of fungi which obtain energy from other plants, use energy absorbed from sunlight to produce all of the chemicals that make up the plants. This is accomplished by using the electromagnetic radiation (light) from the sun to convert carbon dioxide in the air and water into chemical energy (the chemical bonds that hold the plant's molecules together) by a process called photosynthesis, using chlorophyll as a catalyst.

Fortunately, the Earth gets lots more light energy than is needed for that process. In fact, most of the light energy that reaches the Earth is absorbed by the land and the seas or reflected back to the upper atmosphere or to outer space. And a lot more energy reaches the Earth than we can see. We only see light in the visible wavelength range, but the Earth receives radiation from many other wavelength ranges, so the visible light range is only a small part of the total amount of energy we receive.

It is estimated that only about 1% of all of the visible light received by the Earth is converted into chemical energy by plants. That may not seem like a lot, but it is enough to produce about 170 billion tons of biomass every year! It also means that all of the living world has to live on that amount, or less, every year.

The plants use the chemicals they produce in this energy transformation, the carbohydrates, proteins, oils, etc., as the building blocks for the structures of the plants themselves. The plant growth and all of the flower, seed, fruit, etc. production comes from the chemicals produced, initially, by photosynthesis.

And all of the above is also the source of energy for all animals. All animals either consume plants directly or indirectly if they consume other animals. Animals use the chemicals they get from plants (fuel) to "burn" in their cells (producing carbon dioxide and water) which powers all of the functions of a living animal.

When an animal eats a plant it is only able to convert about 10% of the energy in the plant tissues into energy for itself. If another animal then eats the first animal, it again is only able to convert about 10% of the energy in the first animal into energy for itself.

So if an insect (grasshopper, caterpillar) eats the leaf of a plant, 90%, on average, of the energy in the plant chemicals are lost to heat or not digested. If an armadillo or lizard then eats an insect, the same loss of energy occurs, and then if a hawk eats the lizard or a vulture eats the armadillo, another 90% of the energy is lost.

Plants are considered primary producers because they produce the chemicals that store the energy from the sun. The insects, in the example above, would be considered primary consumers, the lizard a secondary consumer, and the hawk a tertiary consumer. Put another way, to supply the hawk with one unit of energy (say 1 kcal), requires 10 kcal of energy at the lizard level, 100 kcal at the level of the caterpillar, and 1000 kcal at the plant level.

All of this explains why some people who are concerned that the human race is using too many of the Earth's resources, advocate we all become vegetarians. When we eat meat, we are functioning as a secondary consumer, getting only 10% of the energy in the animal, which is only 1% of the energy in the plants. But if we ate only plants, then we would be primary consumers and we could get 10 % of the energy in the plants and thus we would require only 10% as much biomass as we do when we eat meat. We would be eliminating one consumer level. The fewer consumer levels, the more efficient the whole process.

All of this also explains why it takes many primary consumers and secondary consumers to support a single tertiary consumer, i.e. it takes many prey animals to support a single predator. And likewise, it takes many plants to support a single herbivore.

Until next time…

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