

The Chemistry of Photosynthesis and the Carbon Cycle

Don't be alarmed by the chemical equations accompanying this column, you don't need to understand the chemistry. But it is important that everyone understand the basics of photosynthesis and how carbon is cycled and recycled in the ecosystem. First photosynthesis.

All green plants and some bacteria have a form of chlorophyll. It is a chemical compound that enables (or catalyzes) the conversion of carbon dioxide in the air and water plus sunlight into carbohydrates. The chlorophyll isn't used up or changed in the process, but without it carbon dioxide and water would not react to form carbohydrates.

You will notice in the chemical equation for photosynthesis, oxygen is the byproduct of that chemical reaction. In fact, this is the process that produced oxygen for the first time on the young Earth, and the reason why animals could not have evolved until enough green plants produced enough oxygen for animals to live.

The chemical equation I have included shows the product of photosynthesis to be glucose. Glucose is a simple carbohydrate also known as a sugar. It is also the building block for all other carbohydrates; sugars, starches and celluloses. All of these larger and more complex molecules are made up of glucose molecules strung together in different ways.

Sunlight is essential to make photosynthesis work—plants can only produce glucose and other carbohydrates in the daylight. And it is the light energy from the sun that is stored in the carbohydrate molecules that drives just about all living ecosystems. It is the energy stored in the carbohydrate molecules (cellulose) in the trunk of a tree that is released when the tree is burned.

Burning, or combustion, is a process of reacting oxygen with carbon-containing materials to produce carbon dioxide and water, plus the heat that is produced when burning. You will note that the reaction for combustion is exactly the reverse of the photosynthesis reaction.

So the simple carbon cycle is for green plants to capture the energy from the sun to produce carbohydrates from carbon dioxide and water, using chlorophyll to enable the reaction. Then the stored energy in the carbohydrates can be released when a carbohydrate is burned (combusted) or even digested or decayed. Digestion and decay are the same reaction as combustion, just slower and more controlled.

When a corn plant grows from a seed it uses photosynthesis to make the stems and leaves and kernels. When we eat the corn, our bodies get energy by the digestion process in which the starch is converted back into glucose and then into carbon dioxide

and water. When the corn plant dies and decays, the same process takes place, although at a much slower pace. If the farmer burns the corn stalks in a still to make moonshine, he gets the energy trapped in the carbohydrates of the stalks.

The corn is thus a source of what we would call renewable energy, because the carbon dioxide and water produced in the burning process (well, not exactly the same molecules) can be used next year in the photosynthesis process to grow more corn, and this process can continue, theoretically, forever.

But if instead of using the corn stalks for fuel, he uses coal, or oil or natural gas, then the farmer is using a non-renewable fuel. Non-renewable because the formation of these “fossil fuels” required millions of years and complex geologic activity to convert carbohydrates from ancient plants and animals into these carbon-based fossil fuels. This long-term heat and pressure over millions of years caused a chemical transformation in which the carbohydrates were stripped of much of their oxygen, forming what we call hydrocarbons, a different class of compounds that are not found in living organisms.

Since the formation of these fossil fuels takes many orders of magnitude longer times than anything on a human time-scale, they are not considered renewable and thus their use is a one-time thing. Once they are burned, they are gone, but the carbon dioxide and water formed in the combustion is added permanently back to the Earth’s atmosphere.

This is obviously an over-simplified picture of the carbon cycle. It doesn’t account for conversion of small amounts of carbohydrates into proteins, fats and other compounds in plants and animal bodies. We use all of these food types to provide the energy to run our bodies and keep us warm, and then we exhale carbon dioxide and water with every breath as we “burn” our calories.

Until next time...

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