Activity 5.4: Other Organic Materials Reading Cellulose, and Combustion of Wood

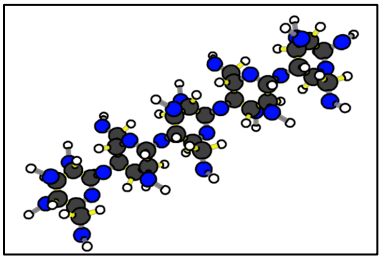
You probably know that wood burns when it lights on fire, but how does this happen? What causes the wood to catch on fire?

The energy that makes wood burn starts out as chemical energy in cellulose. This reading answers two questions:

1. What is wood?
2. What happens to wood when it burns?

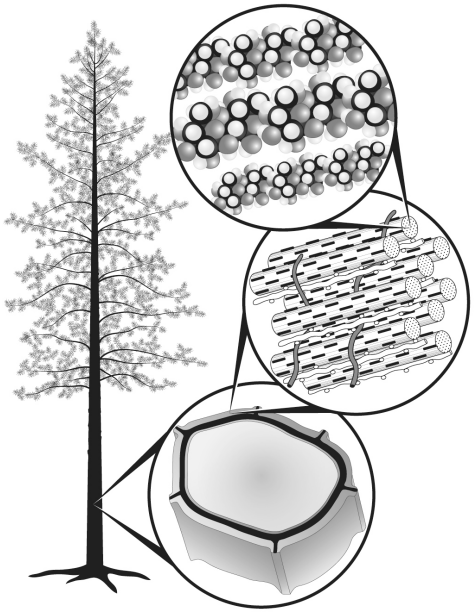
What is wood?

Wood is a mixture of solid organic materials. (Wood in living trees is also about 50% water, but living wood is usually dried out before it is burned or used to build things.) The materials in wood mostly consist of organic molecules made of only hydrogen, carbon and oxygen.



One main molecule in wood is *cellulose*. Here is the structure of a small part of a cellulose molecule. You can see that it is a big long molecule (a polymer) made of lots of smaller molecules bonded together. Each of those smaller parts of the cellulose molecule has the same structure, with the chemical formula $C_6H_{10}O_5$. (The small parts are made from molecules of glucose, the sugar that plants make during photosynthesis.) Cellulose molecules come in different sizes, but a single molecule of cellulose usually has thousands of glucose units, so its chemical formula is something like: $C_{6000}H_{10000}O_{5000}$.

Cellulose is a strong, tough molecule. It makes up a major part of the cell walls in woody plants, such as trees. The cellulose helps trees grow wide and tall, and still stand upright. When we build houses and furniture out of wood, we rely on the strength of the cellulose molecules in the wood.



Cellulose has another property that makes it valuable to people: It has lots of chemical energy stored in its C-C and C-H bonds. For all of human history, people have kept warm by burning wood. Let's explain how that happens.

What happens to wood when it burns?

Let's explain what happens to a piece of wood on a fire. If you watch, it looks like the fire is consuming the wood—the flames wrapping around it and burning until the wood is gone and only a few ashes are left. What happens to the wood, and to all the cellulose molecules in its cell walls?

You already know some parts of the answer to this question. It can help to think about how burning cellulose is *alike* and *different* from burning other organic materials that you have studied, such as ethanol and methane.

Alike: Like ethanol and methane, cellulose is an organic material, with lots of high-energy C-C and C-H bonds that can release energy when they are combined with oxygen.

Different: Cellulose molecules are huge (for molecules) and all tangled up with other molecules in the cell walls of the wood, so they can't just leave the wood and go into the flame. So how can cellulose burn if its molecules cannot leave the wood?

Here's the answer: When the wood increases to a certain temperature (over 250°C), the cellulose inside will begin to break down. The big cellulose molecules break down into little pieces of a few atoms each.

Alike: The smaller pieces of cellulose molecules are still organic molecules (like ethanol and methane), so they can combine with O_2 to form CO_2 and H_2O. So, the overall chemical equation for burning cellulose looks something like this:

$$C_{6000}H_{10000}O_{5000} + 6000\ O_2 \rightarrow 6000\ CO_2 + 5000\ H_2O$$

Use the worksheet to tell the rest of the story, answering the Three Questions, based on what you know about combustion from explaining ethanol and burning.

Digging deeper

Here are some more places that you can go to learn about where wood comes from, what is in it, and how combustion works:

- Learn more about the chemistry and properties of wood:
  - Chemistry of wood, https://vimeo.com/1865701
  - The structure of wood, https://www.doitpoms.ac.uk/tlplib/wood/structure_wood_pt1.php
- Learn more about how combustion of wood works:
  - Wood Combustion video, https://www.youtube.com/watch?v=B0E4PX3e3RE
- Learn more information about combustion:
  - Fire Challenge video, https://www.youtube.com/watch?v=5ymAXKXhvHI