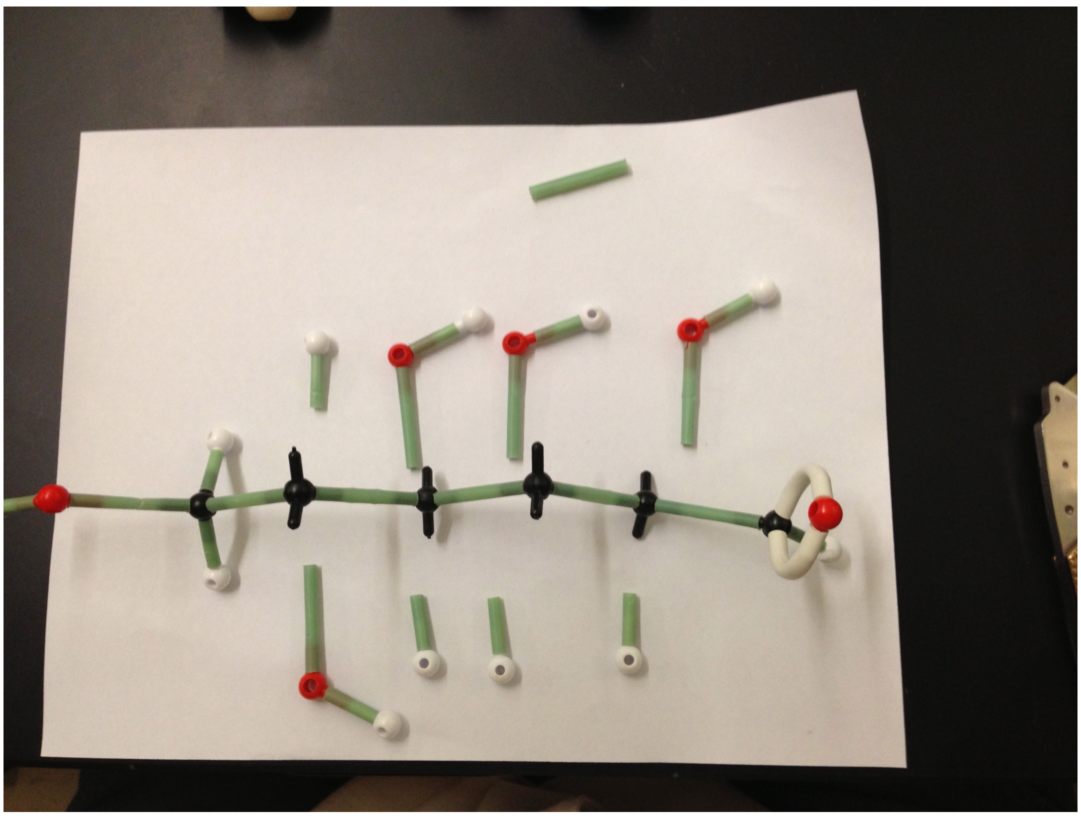
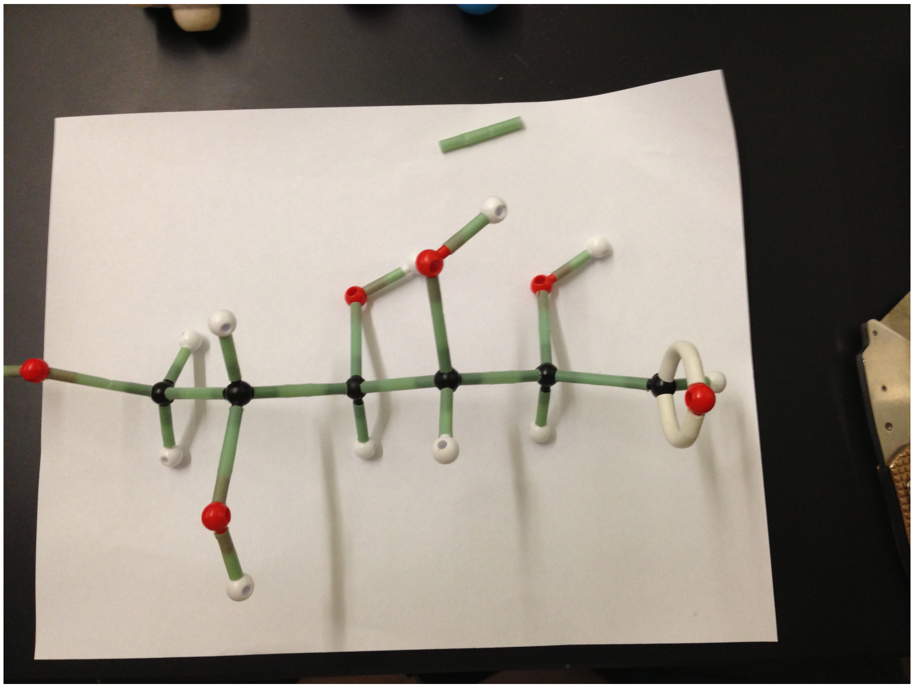
Glucose Guide

1. Take out six carbons (black), six oxygens (red) and the 12 Hs (white). The H's may already have a short bond on them and 5 OHs may already be constructed.
2. If not, construct 5 OHs using short bonds and put short bonds on the remaining 7 H atoms.
3. Connect the six carbons using the long bonds, attach the remaining oxygen with two flexible bonds to one of the end carbons. That becomes Carbon 1. Also add one hydrogen.
4. Add an OH to the carbon on the other end (now carbon 6) and also add to Hs to the remaining two bonds on carbon 6. Add two H's to carbon 6. It should look like this: Notice the up-and-down zigzag. The "H" on the OH of carbon 6 is out of frame…

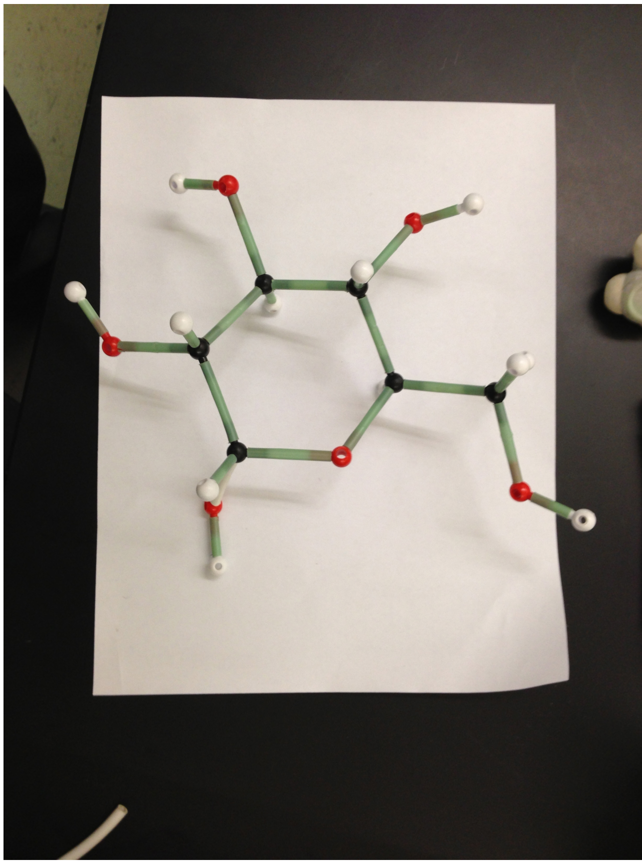
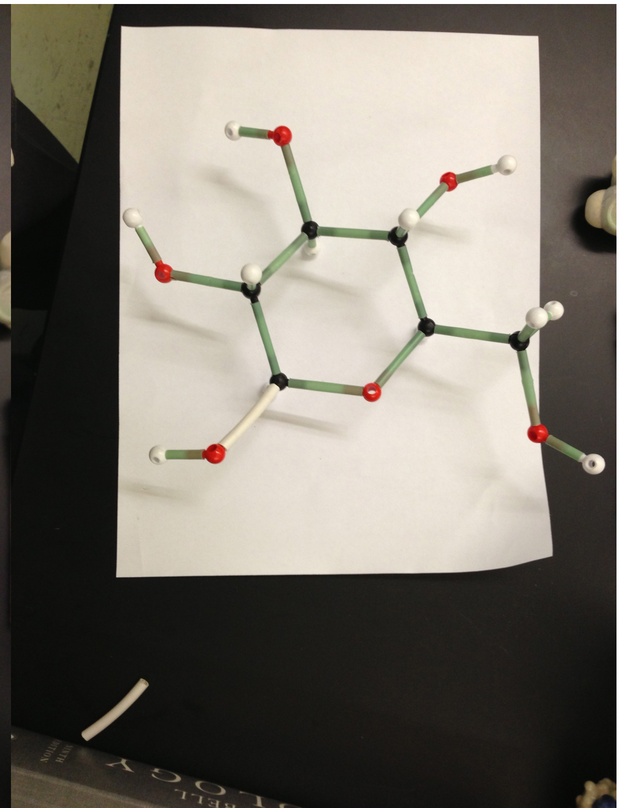
   sorry.
5. Line up the OHs and Hs the way they are in the picture, then attach them to the sides indicated:



Imagine your right hand is a protein. The tips of your index and middle finger touch the carbonyl oxygen and you thumb interacts with the OHs on carbons 2 and three. Would your left hand be able to do the same thing? If you moved the OHs on carbon 2 and three to the other side, would you still be able to contact them with the thumb on your right hand? Try exchanging the OH from carbon 2 with the H. Is there any way you can rotate it so that it looks exactly like the picture above? More importantly, can you still make the contacts with your right hand the way you did before? Try your left hand.

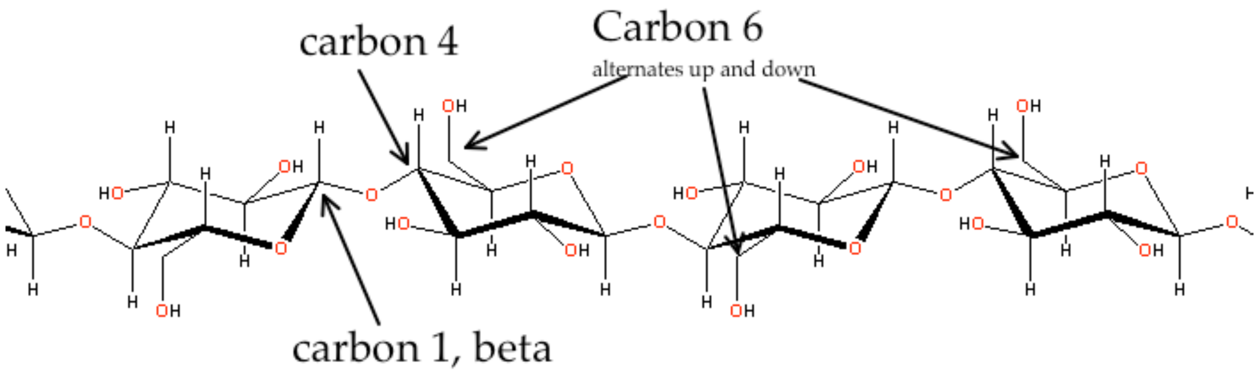
Carbons 2, 3, 4 and 5 are Chiral or "Handed." For carbon, that means there are four distinct directions, each of which is different from the other 3. As a result, It matters which side you put the OHs. Check out the "L" form of glucose I made.

6. Try moving the carbonyl on carbon 1. Switch one of the double bonds with the spot where the H is. Now can you rotate that to look like the picture above (you should be able to). Carbon 1 is not chiral. Bonus question: is carbon 6 chiral?
7. **The Cyclic form:** I lied (a little). In water, glucose doesn't look like that. It forms a ring called a "pyranose." There are no losses in atoms. It will remain $C_6H_{12}O_6$. You will need one more "long" bond. **It will not make a flat ring, but will maintain the zig-zags.** Follow these steps to make it.:
   a. Identify carbon 5 (just count). It's the one with the OH on the opposite side as the others. Remove the H from the OH on carbon 5 and replace it with a long bond. Save the H with its short bond
   b. Remove one of the double bonds from the carbonyl.
   c. Connect the long bond now on carbon 5 to carbon 1 at the open spot where the carbonyl was and place the last hydrogen on the Oxygen at its open spot. It should look like one of the next two pictures. You will need to play with it (gently) to get it to look like one of them.

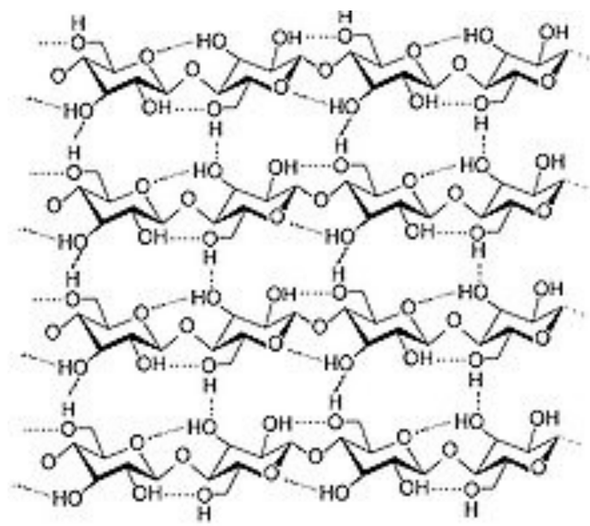
Can you see the difference? Carbon 6 is the one outside the ring (on the right in the picture). The oxygen is in the ring and carbon 1 is next to it in the lower-left corner of the molecule. You may notice that making the ring has made carbon 1 chiral. It now has four distinct things around it.

8. The top one is called "alpha" and has the OH sticking straight down. That's called the "Axial" position. If you switch it to the other, beta form, the OH is sticking more off to the side, and is called the "equatorial" position.
9. We will connect a couple of alphas and a couple of betas together as a disaccharides, to see how they look. To do this we will bond position 1 of one ring to position 4 of the other, removing water.
10. If Glucose has a molar mass of 180, what is the mass of two glucose molecules linked together in this way?
11. The main thing you will see at first is that when we connect beta forms is that carbon 6, the one out of the ring, alternates "UP" and "Down."



This makes the chain straighter and allows for many hydrogen bonds among the molecules:

Each of those chains would be thousands of monomers long, not just three.
This leads to cellulose being so strong. But, the strands also can slide along each other a bit, making H bonds with the next unit over. This leads to the flexibility cellulose shows.



Starch would appear with carbon 6 on the same side of the chain, leading to a gentle spiral and far fewer hydrogen bonds to add structure.

Isn't it cool how such a small change at the level of the position of one bond makes such a huge difference in the behavior of the macromolecule?
Here's a question to ponder: on the East coast in the summer, people put rice (mostly starch) in their salt shakers to soak up water. Also, you know that starch such as rice or pasta soaks up water when you cook it. Why would starch be so much better at soaking up water than cellulose?