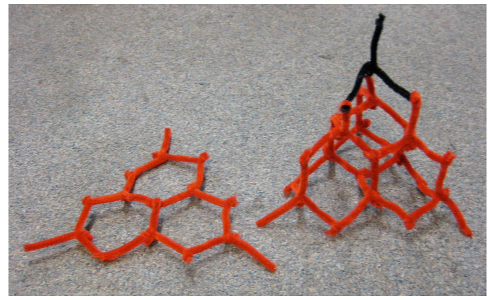
Carbon Configurations

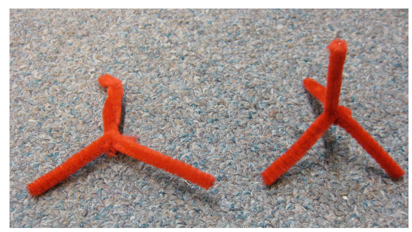
Use geometry to predict the shape of carbon



Materials
chenille stems or thin wire or plastic twist ties
scissors

To do and notice
1. Cut a chenille stem into four equal pieces. Twist the ends together so they are joined at one end.
2. For now, keep two of the pieces together and treat them as one. Move the other two pieces so that their open ends are as far apart as possible. What shape does this make? If you drew lines that connected neighboring ends, what shape would this be?
3. Now separate the fourth strand so you have four legs to play with. Again, move each segment so that the ends are as far apart as possible. What shape is this now?

What's going on?



The chenille stem pieces represent bonds between different carbon atoms. Imagine a carbon atom at each end. A carbon atom has four valence electrons that can bond with four other atoms. When you had four pieces, you may have found that the configuration where the ends are the furthest apart has a pyramid shape. If you were to draw lines that connected the ends, you would get a tetrahedron. A carbon bound to four neighbors is said to have **tetrahedral** geometry. Sometimes a carbon binds to only three neighbors because it shares two of its valence electrons with one of the atoms to create a double bond. When bonded to three neighbors, the outer atoms arrange themselves 120° apart with the carbon in the center. If you draw a line connecting the neighbors, you should get a triangle. Since it's flat, this geometry is called **trigonal planar**.

One of carbon's favorite bonding partners is another carbon. The carbon-carbon covalent bond is one of the strongest in nature. The neighboring carbons are free to bond just like the central carbon. If you treat the open ends of your trigonal planar form as a new carbon center, you will see that the pattern can expand forever and forms hexagonal spaces in between them. One sheet of carbon bonded like this is called graphene. Several graphene layers on top of each other form **graphite**, which is the lead in your pencil. This works well as a writing instrument because the sheets can slough off and leave a graphite mark on your paper. When carbons attach in a tetrahedral geometry, they can bond with additional carbons to make a 3D structure. This structure is very rigid, and carbon in this form is called **diamond**.

Going Further
Since the geometry of all the carbons in graphite is identical, the location of the double bonds is always changing. This movement of electrons allows them to be delocalized and is why graphite

is a good conductor of electricity. Diamond has no double bonds. The electrons don't move, and diamonds are electrical insulators.

Graphite and diamond are both **allotropes** of carbon, since they have the same chemical formula (pure carbon), but different bonding configurations. Recently, another class of carbon allotropes, the fullerenes, has been discovered. These are pure carbon in the form of hollow spheres or tubes called buckyballs and carbon nanotubes, respectively. If you want to learn more about them, check out the Tiny Tubes activity at www.exo.net/~jyu/activities/tinytubes.