Activity 1.1: Building carbon's allotropes

Background information

The different shapes pure carbon can take (diamond, graphite, buckyballs) are called **allotropes**. Other elements have allotropes, too. Sulfur, for instance, can be found in two different crystal shapes.

You will need:

- One box of Jujubes™ candies
- Two boxes of toothpicks (round or square, not flat)

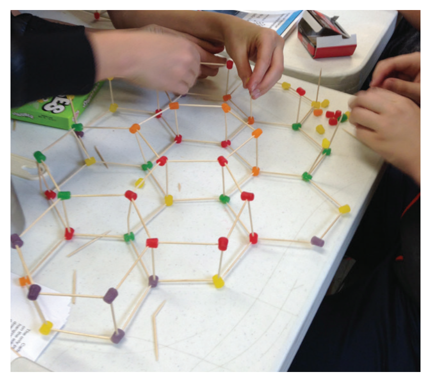
Note: If you can't find Jujubes, you can use small jelly beans. (Gummy bears and marshmallows are not recommended.) Jujubes are good to work with because they are small and hard. The small size keeps the structures from being too heavy, and the hard texture keeps the toothpicks in place. A box of Jujubes contains about 300 candies, which is more than enough to make all three models. (You could probably make two of each model, if the graphite and diamond ones are of modest size.) You will need to buy the sturdier type of toothpick with the square or round center, not the flimsy flat ones. (If you are purchasing for a group, allow three boxes of toothpicks for every one box of Jujubes, four boxes if you anticipate enthusiastic builders who will want large models.)

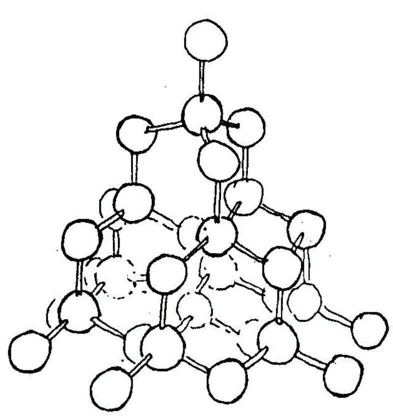
Instructions:

Diamond: Make sure that each carbon atom is connected to four others. The geometry will emerge naturally as a result.

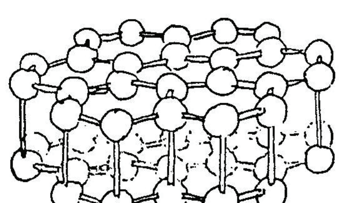
Graphite: You can make several sheets of hexagons, then put them on top of each other, or you can make a flat sheet of hexagons and just build upwards on top of it. (Graphene would be just one layer.)

Buckyball: Start by making 12 pentagons. Each pentagon will contain 5 candies and 5 toothpicks. A buckyball contains 60 carbon atoms, and since 12x5=60, you will not need any more candies. Now use just toothpicks to begin making each pentagon completely surrounded by six hexagons. A pentagon can't touch another pentagon.

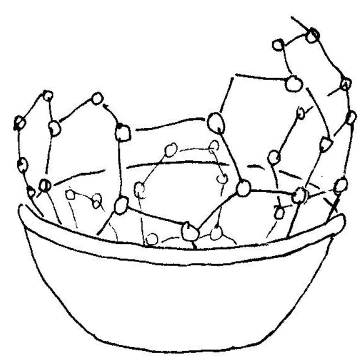




diamond



graphite



A bowl is a big help when making the buckyball!

Activity 1.2: Organic molecules card game

Background information

The molecules you will make in this game may or may not be actual molecules found in nature. There are hundreds of thousands of organic molecules in the world, so your molecules might very well be real ones. If they are not, they will at least be very similar to real ones.

Here is what the letters stand for: H=hydrogen, C=carbon, O=oxygen, N=nitrogen, Cl=chlorine, Br=Bromine, F=fluorine. Notice how many hydrogen cards there are in the game. 90% of all atoms in the universe are hydrogen.

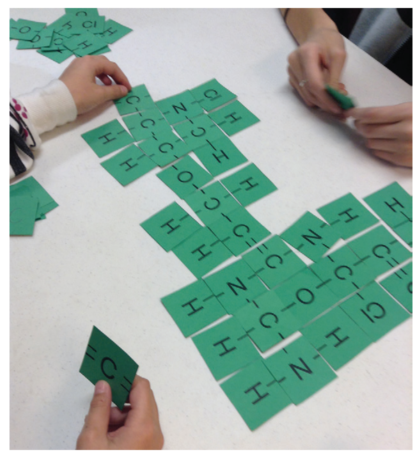
The lines on the cards represent electrons that the atom would like to share with another atom.

You will need:

- copies of the playing card patterns printed onto card stock, then cut them apart into individual squares. (See the web address on the previous page if you need to download pattern pages.)

Note: The game can accommodate 2-6 players. If you have more than six students and decide to make more than one copy of the game, you may want to consider making each set of cards a different color. If all of your sets are the same color, there is a high likelihood that cards will get placed into the wrong deck and you will end up with one set having too many cards and another too few, and the only way to straighten them out will be to painstakingly count all the cards and compare each set to the original patterns. Life is too short to spend time counting cards. Make your sets different colors.

Instructions



Give each player 5 cards. The rest go in a draw pile. Put one of the carbons (with no double bonds) face up to be the starter card. The players take turns laying down cards, trying to get rid of all their cards. The first player to get rid of all their cards wins. HOWEVER, the last card he lays down MUST complete a molecule in order to win the game. If a player lays down his last card on an incomplete molecule, he must then draw another card. He may not lay this new card down immediately, but must wait until his next turn to play it.

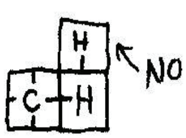
The lines represent bonds. You must match single bonds to single bonds and double bonds to double bonds. The molecule is complete when no bonds are "left hanging." Each bond (line) must have an atom attached to it.

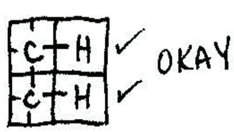
Notice on the double bond O that there are dotted lines. This is so you can turn the card caddy-corner and match the double bond with two single bonds.

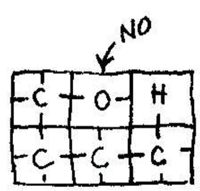
If a player cannot lay down a card, he must take one from the draw pile. He may lay this card down immediately if he can do so.

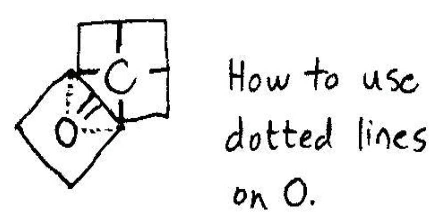
If a molecule is finished and all players are still holding cards, simply begin another molecule. Remember, you must use a single bond carbon (four lines) to begin a new molecule.

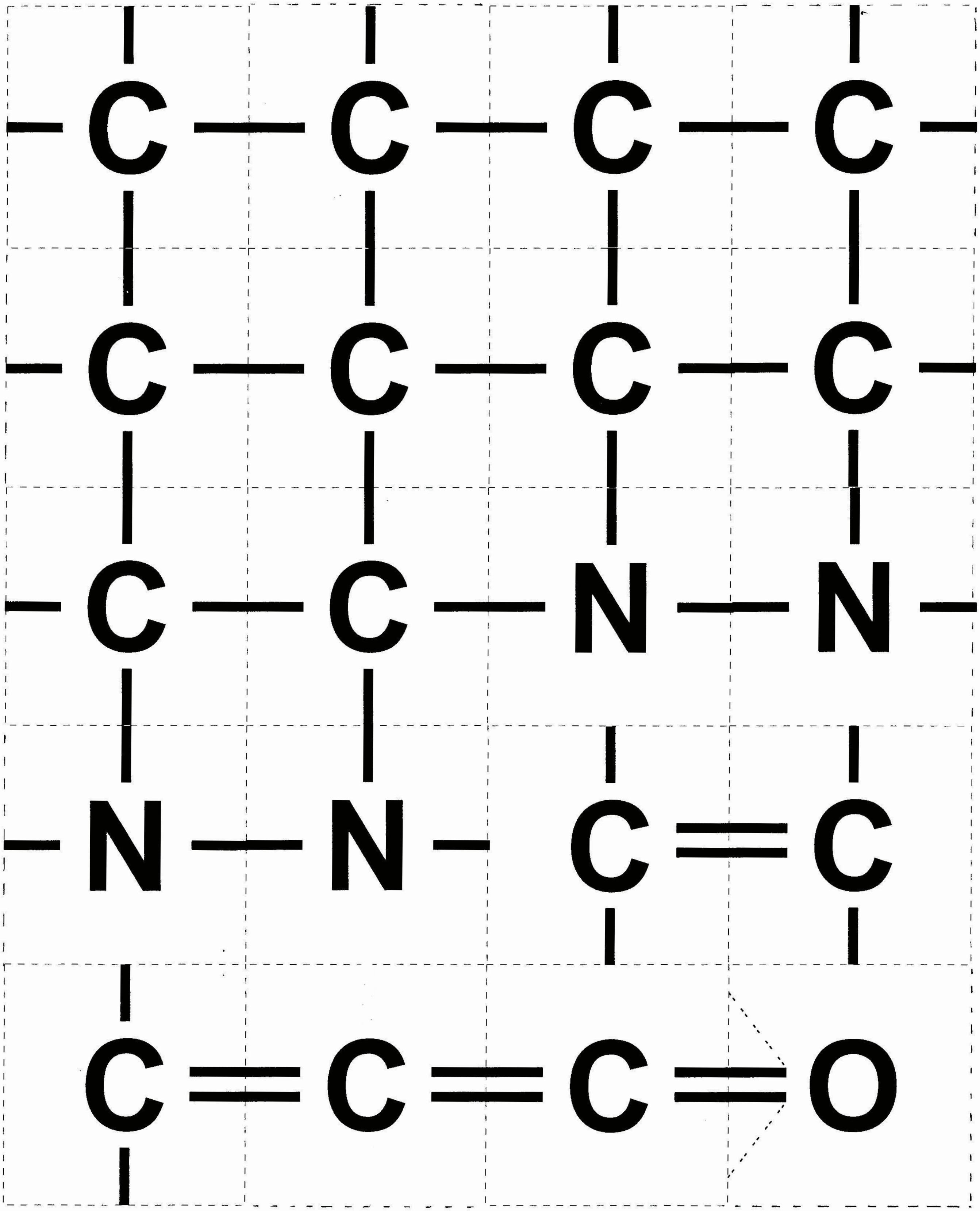
In order to win the game, a player must lay down his last card *as the final atom in a molecule.*







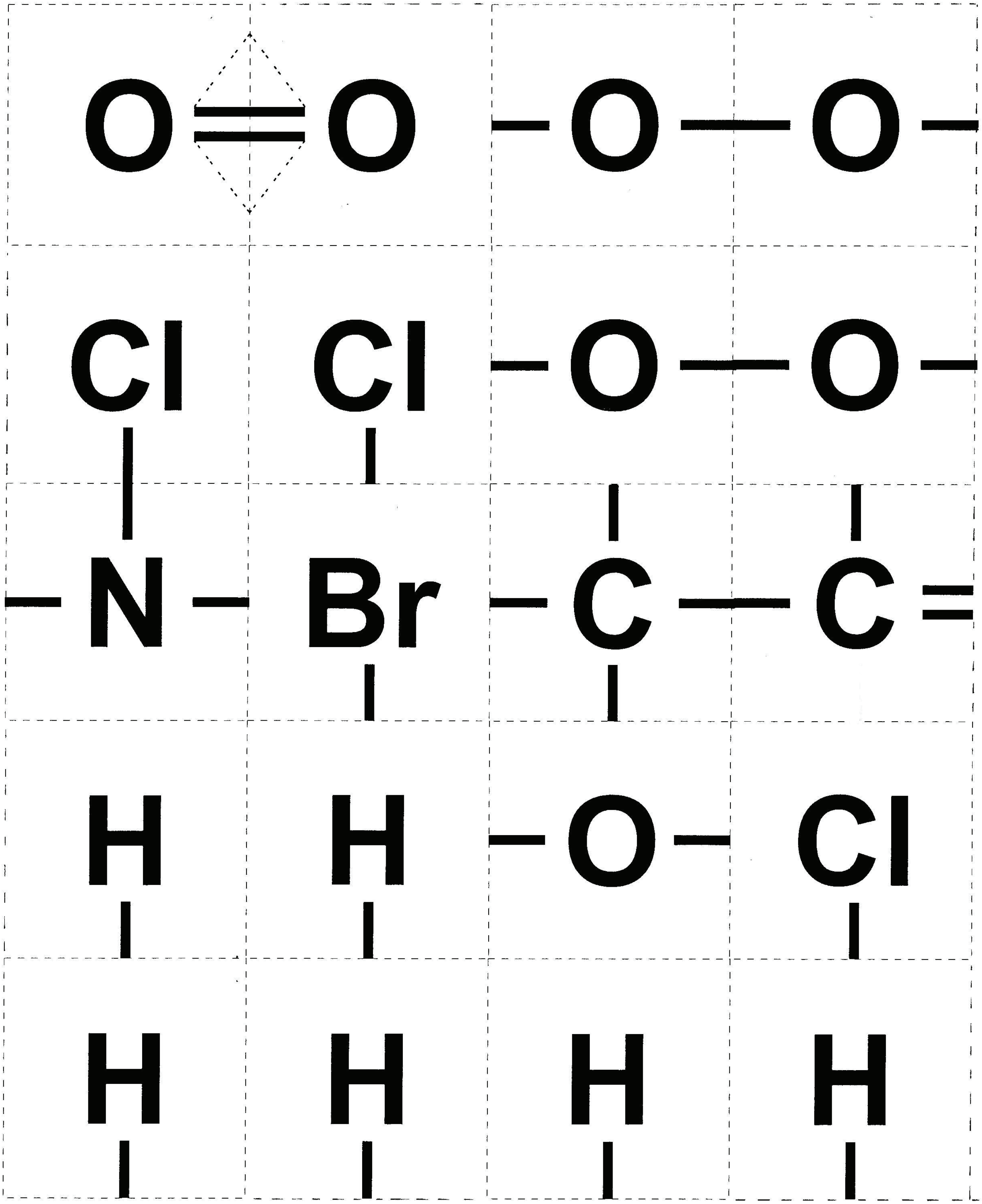




Organic Molecules Card Game page 1 Make one copy (per game) on card stock.

H |	H |	H |	H |
H |	H |	H |	H |
H |	H |	H |	H |
H |	H |	H |	H |
H |	H |	H |	H |

Organic Molecules Card Game page 2 Make one copy (per game) on card stock.



Organic Molecules Card Game page 3 Make one copy (per game) on card stock.

Activity 1.3: Make some buckyballs

You will need:
- a candle and a match
- a glass jar

Instructions

Light the candle. Hold the glass jar just above the flames for a few seconds, or long enough for a black smudge of soot to form on the bottom of the jar. The black soot will contain many buckyballs. They will be too small to see, of course, but it is kind of neat to know that they are there!

Activity 1.4: Burning contest

Background information

Ancient people learned that if they burned wood in a low-oxygen environment they could make a black fuel that would burn longer than wood and produce more heat with less smoke.

You will need:
- charcoal briquette
- block of wood same size as briquette
- matches
- lighter fluid
- marshmallows to toast, if you want to compare quality of heat
- a safe place to do the burning

Instructions

Burn a charcoal briquette and a piece of wood the same size and compare the duration of burning and the quality of heat.

Can you re-light the charcoal you made from the wood? Why not?

Activity 1.5: Take a tour of a coal mine or refinery

Log on to www.YouTube.com/TheBasementWorkshop and find the Carbon Chemistry playlist. Look for some videos on petroleum refineries and coal mines.

Chapter Two Activities

Activity 2.1: Practice Counting 1-10 Carbons

Background information

Learning to count carbons isn't any harder than counting to ten in Spanish or French. Actually, it is easier because you don't have to worry about your accent. Also, several of the prefixes are the same, or similar, to words you use in math.

You will need:

- The list in chapter two

Instructions

Practice counting a few times. Practice without looking. Practice tomorrow once or twice, and a few times the day after. Bet it won't take you long to rattle them off like a pro! Here's an additional idea: Use the tune of the folk song "One Little, Two Little, Three Little Indians" and sing these words:

Meth- little, *eth-* little, *prop-* little carbons,
But- little, *pent-* little, *hex-* little carbons,
Hept- little, *oct-* little, *non-* little carbons,
Dec- little carbon atoms.

Would you like to know more? Here is a list if you would like to continue on counting carbons. You can put "-ane" after each one to name alkanes.

11	undec-	the alkane would be "undecane"
12	dodec-	the alkane would be "dodecane"
13	tridec-	etc.
14	tetradec-	
15	pentadec-	
16	hexadec-	
17	heptadec-	
18	octadec-	
19	nonadec-	
20	eicos-	
21	henicos-	
22	docos-	
23	tricos-	
24	tetracos-	
25	pentacos-	
26	hexacos-	
27	heptacos-	
28	octacos-	
29	nonacos-	
30	triacont-	
31	hentriacont-	
32	dotriacont-	
33	tritriacont-	
34	tetratriacont-	

(If you want a much longer list, there are some available on-line. Just use a search engine.)

Activity 2.2: Build some alkanes

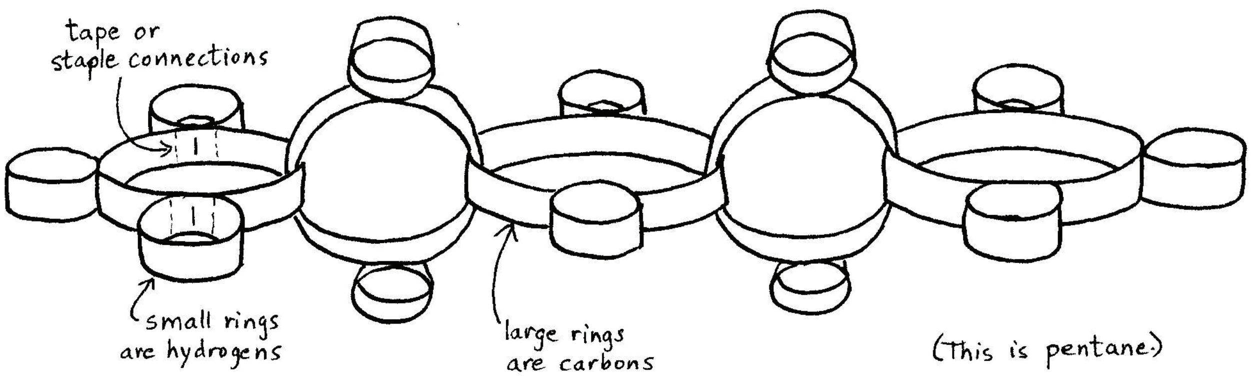
You will need:

- Long paper strips (any colors) cut in two lengths, the shorter length being half the length of the longer one.
- Scotch tape or stapler

Note: If you are going to do the Polymer Party at the end of the unit, you may want to keep these chains in good shape until then, so you can use them as room decorations.

Instructions

You will be making paper chains similar to the standard type made for parties, only these will be scientific models, as well. We suggest that you use just two colors in your chain, one for carbon and one for hydrogen. To use lots of colors, make lots of chains! Use this drawing as your pattern:



You can make the chains as short or long as you want to. Try to name the alkanes as you make them. Don't forget to put a hydrogen on the ends. Each carbon atom should be connected to four other atoms.

Extra technical note:

It is significant that the paper hydrogens are not all pointing in the same direction. Hydrogen atoms do not like to be next to each other. In fact, if a hydrogen atom is removed, the other hydrogens will shift their positions to get even further away from each other, if possible. Sometimes this creates a bend, or "kink" in the chain. These kinks are not bad, however. The omega-3 fatty acids (fish and flax oil, for example) have one or more kinks at the end of their chains.

Activity 2.3: Build some isomers

You will need:

- Some of the cards from the card game you played in chapter one. You will need all of the H and C cards, plus a couple others (you will be using the backs of these cards, so it doesn't matter which ones you choose)
- A pencil

Instructions

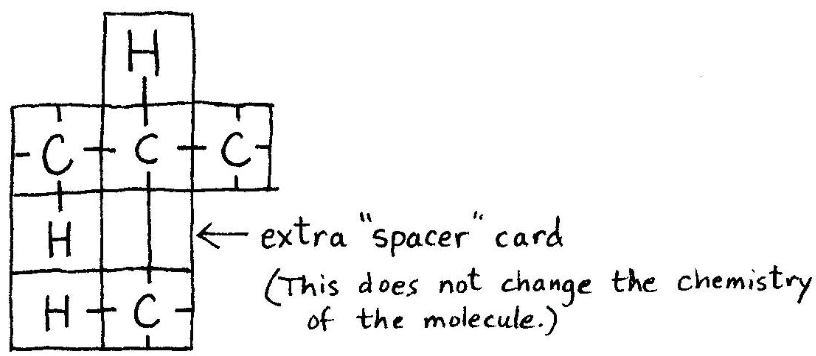
Start by putting out one carbon card. Attach hydrogens. Can you make any isomers of this molecule? *(No.)*

Now lay out two carbons connected to each other. Add the hydrogens. Are there any other ways you could arrange this molecule? *(No.)*

Now add another carbon so you have a chain of three. Add the hydrogens. Are there any other ways you could arrange this molecule? Remember, you have to use all of the atoms and the bonds have to match up correctly. *(You could put the three carbons into an L shape instead of a straight line.)*

Now add a fourth carbon to the chain. Put hydrogens around. Can you rearrange these cards to form a different shape? *(Yes, the carbons could go into a T. They could also go in a "circle," that is, a square circle.)* This circular structure has a special name: cyclobutane. Can you make cyclopentane and cyclohexane?

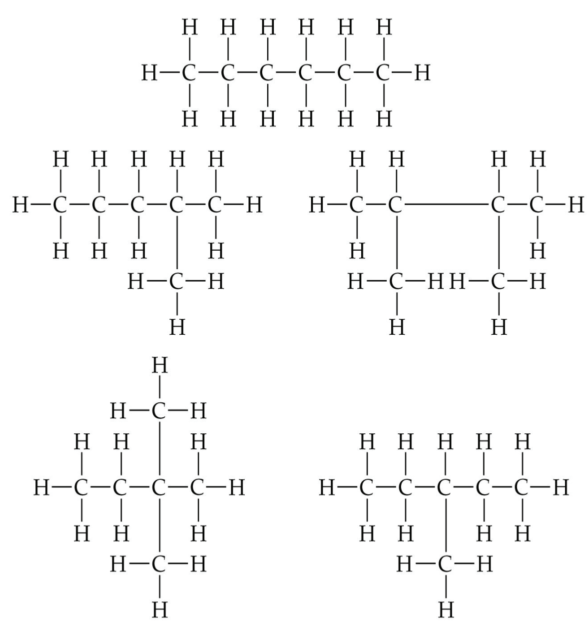
Continue on like this. You may need to make some "spacers" using a pencil on the back of the other cards:



You should have enough cards to make molecules up to decane. (Remember from the text that isomers of octane, nonane, and decane are what gasoline [petrol] is made of.)

If you are working in a class, you could divide up into teams that would work on one alkane each, or you could set it up as a contest to see who could come up with the most isomers or who could rearrange the molecule the fastest.

NOTE: You have to use all of the original cards as you rearrange the molecule. Sometimes students want to rearrange the carbons in such a way that the molecule ends up not needing all of the original hydrogens. If you add or substrate atoms from the molecule, that's not an isomer. Isomers have the same empirical formula, such as C_6H_{14}. If you make C_6H_{13}, that's not an isomer, that's a different molecule.



isomers of hexane

Activity 2.4: Make marbled paper using an alkane

Background information:

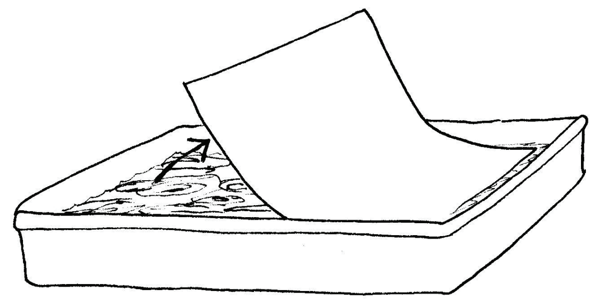
"Paint thinner" and "mineral spirits" are two names for the same thing. They are petroleum distillates—liquids that were distilled from petroleum at a refinery. Their chemistry is very similar to that of gasoline (petrol). They are about 9-16 carbons long. Alkanes do not mix with water—they float on the surface because they are non-polar (see explanation at the bottom) and less dense. We can use these chemical properties of alkanes to create some beautiful marbled paper.

You will need:

- Paint thinner (mineral spirits) [not turpentine]
- One or more colors of oil-based paint (oil pigments that come in tubes work well, but you can also use house paint or craft paint as long as it is oil based, not acrlyic)
- A 9x13 pan with an inch or so of water in it
- Sheets of paper
- Some paper cups and spoons for mixing
- Disposable eye dropper of you have one, or a plastic fork

Instructions:

Pour a few spoonfuls of paint into a cup and add just enough paint thinner to make the paint runny. Use the eye dropper or plastic fork to splash some drops lightly onto the surface of the water. (If you want to use more than one color, repeat this process with as many colors as you will use.) When you have your color droplets on top of the water, swirl them around. When the pattern looks nice, take a sheet of paper and lay it on the surface of the water for just a second, then pull it up. The paint will instantly adhere to the paper transferring the beautiful pattern onto it. Lay the paper out to dry. When it is dry, you can draw on it, or use it in a craft project. (It might be so beautiful, though, that you may want to frame it as art!)



<u>Further explanation of the chemistry</u>:

All petroleum products are "non-polar" meaning that they don't have two sides that behave differently. Water, on the other hand, is "polar." Water molecules have one side that is negatively charged and one side that is positively charged. Any substance that is also polar, with a negative and positive side, will be attracted to water molecules. Substances that will dissolve in water, such as sugar and salt, are actually pulled apart by the polar sides of the water molecules. In non-polar substances (oil, grease, fat, petroleum products) the molecules don't have any areas of positive or negative charge, so there is nothing for the water molecules to pull on, therefore they don't dissolve. This is why oil (or mineral spirits)