Structure and Scent
Grade level: 4th-6th grade

This is a set of activities that is designed to teach grade-school children about molecules and molecular structure. The order is slightly different than for K-1st grade, and the material can be presented on a slightly deeper level. The first activity ("Bonding") is an activity that gets them thinking about the structure of molecules, and the fact that molecules are made up of atoms bonded together. Chemical reactions involve the making and breaking of chemical bonds. The second activity ("Scent Matching") allows the children to associate molecular structure with common scents. This activity can be taken to a deeper level, and the concept of chirality can be explained in the context of the two enantiomers of carvone. The third activity ("Molecular Size") is designed to get children to understand the relative size of a single molecule. The number of sugar molecules is demonstrative. The final activity ("Make Your Own Molecular Models") allows the children to make molecules (we found that water is a good molecule to start with, then 2,3-dibutanone). They will use gumdrops for atoms and toothpicks as bonds.

Materials:

- Scent bottles (squeeze bottles containing a cotton ball charged with ~3 drops of compound – see below for compound list and corresponding product)
- Actual products
- Molecular model kits (R- and S-carvone pairs already assembled, and chiral/achiral tetrahedral carbons ready)
- Gumdrops and toothpicks
- Element signs and number signs (see attached)
- Tape

Scents:

	Molecule	**Product**
1	R-(–)-carvone	spearmint gum
2	S-(+)-carvone	caraway (rye bread or caraway seeds)
3	2,3-dibutanone	buttered popcorn (microwave popcorn)
4	vanillin	vanilla extract
5	citronellal	citronella candle
6	menthol	cough drop
7	naphthalene	moth balls
8	α-Pinene	pine-scented candle
9	cinnamaldehyde	cinnamon
10	benzaldehyde	almond extract
11	isoamyl acetate	banana runts (crushed)

Activity 1: Bonding

Discussion question: What are scents? Really really small particles, or ***molecules*** go in our nose and interact with receptors. These receptors send a signal to our brain. Molecules are made up of even smaller particles called ***atoms***. Atoms bond with other atoms to form molecules.

Tape an H to 2/3 of the students and tape an O to the other 1/3. They are now atoms! Explain that atoms have to make a certain number of bonds when they form molecules. H can only make 1 bond, while O has to make 2 bonds.

Hydrogen molecules contain two H atoms, and oxygen molecules contain two O atoms. Instruct the group to form 'bonds' (by holding hands) and turn themselves into H_2 and O_2 molecules. (How do two students make one O_2 molecule? Remember – O needs two bonds – students will need to figure out that they have to make a double bond by joining both hands.)

Now let's do a chemical reaction – actually, an explosion! When H_2 and O_2 molecules are exposed to heat (like a flame), they explode! The H-H bonds and O=O bonds break apart and recombine to form water molecules (H-O-H). Instruct the students to break apart and recombine to form water molecules. If they like the activity, they can also make hydrogen peroxide (H-O-O-H).

Activity 2: Scent Matching

Each student will be given either a scent bottle or a product. They will have to find their partner that has the same scent.

Ask the students to stand up if they have a molecule called carvone – there will be two pairs. R-(-)-carvone and S-(+)-carvone look very similar, but they smell different (allow all of the students to smell the pair). [At this point, have a helper collect the rest of the scent bottles and products.]

Now pass around a few sets of already assembled *R*- and *S*-carvone molecular models. Ask the students to try to figure out what the difference is. Let this go for a few minutes – in our experience, they figure it out! Once they make the observation that the two carvones are mirror images of one another, show them a molecular model of methane. We already discussed that H can have 1 bond, O has 2 bonds, now tell them that C has 4 bonds, and has a tetrahedral shape. Show them two more tetrahedral carbons that have 4 different groups, and demonstrate that the atoms can be arranged such that the two molecules are identical or mirror images. These molecules are ***chiral*** or ***achiral***. Discuss objects that are chiral (scissors, shoes, etc.) or achiral (pencil, cup, etc.).

Activity 3: Size of Molecules

Show the children a gumdrop, and have them guess how many molecules of sugar are in the gumdrop. Take the number 6 and tape it to a child's shirt. Do they think there are more or less than 6 molecules? Now tape a 0 to another child's shirt (to make 60) – ask again – more or less than 60 molecules? Continue on until there are 21 0's taped to children's shirts – that's how many sugar molecules are in each gumdrop! (We found that we started to lose their attention unless we added 0's in groups of 3's).

Sucrose = 342.3 g/mol, 1 gumdrop ~ 3.6 g; ~0.0105 mol ~ $6x10^{21}$ molecules
6,000,000,000,000,000,000,000, or 6 sextillion molecules (the figure below was copied from Wikipedia for reference)

Prefix	Symbol	1000^m	10^n	Decimal	English word[n 1]	Since[n 2]
yotta	Y	1000^8	10^{24}	1 000 000 000 000 000 000 000 000	septillion	1991
zetta	Z	1000^7	10^{21}	1 000 000 000 000 000 000 000	sextillion	1991
exa	E	1000^6	10^{18}	1 000 000 000 000 000 000	quintillion	1975
peta	P	1000^5	10^{15}	1 000 000 000 000 000	quadrillion	1975
tera	T	1000^4	10^{12}	1 000 000 000 000	trillion	1960
giga	G	1000^3	10^9	1 000 000 000	billion	1960
mega	M	1000^2	10^6	1 000 000	million	1960
kilo	k	1000^1	10^3	1 000	thousand	1795
hecto	h	$1000^{2/3}$	10^2	100	hundred	1795
deca	da	$1000^{1/3}$	10^1	10	ten	1795

Activity 4: Make Your Own Molecular Models

Break up into smaller groups. Show how gumdrops can be used to make molecular models. Have each child assign a color to O and a different color to H. Have them make water.

Now give each table a molecular model of one of the molecules from the scent matching activity, and have each child at the table make it out of gumdrops. They will need to assign a third color to carbon, and possibly a fourth to nitrogen.

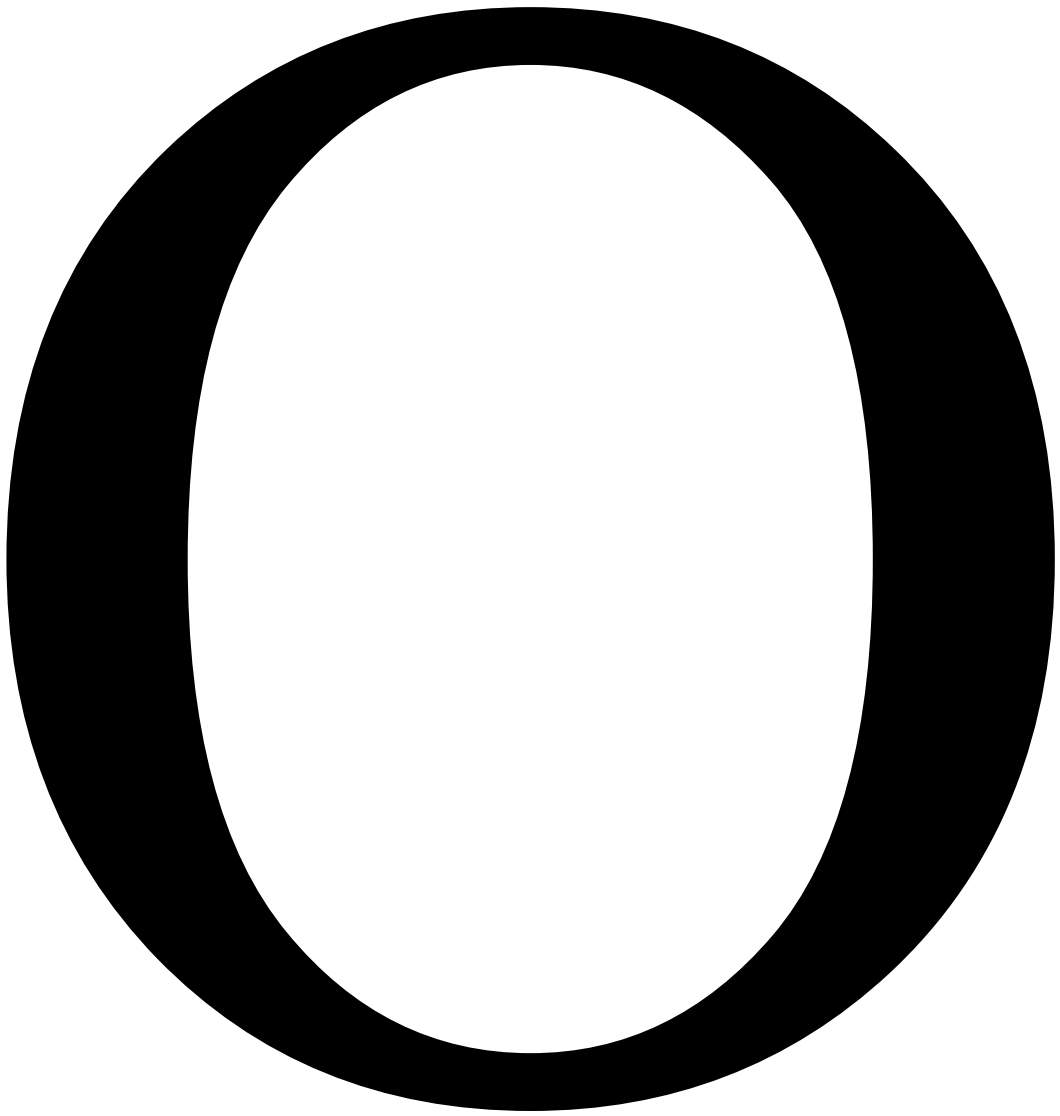
If the concept of chirality was covered above, have them make a chiral carbon (4 different colored gumdrops, arranged in a tetrahedral shape).

Hydrogen

1 bond

Hydrogen

1 bond



Oxygen

2 bonds

6

0

0

0

0

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