

## Frequently Asked Questions and Teacher Tips

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## 1. Teacher Facilitation

### How can I use this in my class?

You can use the Molecule Shapes sim:

- **In class** by having your students work individually or in pairs at computers. Check out the sample activities for this simulation available in the Teacher Resources section (below where you download the sim).
- **As a demo** by projecting the simulation onto a screen. Now you have a way to build molecules for your students dynamically, while projecting them large enough for the entire class to see! You can do all the building, or you can select students to come up and build molecules for the class.
- **As homework** before introducing VSEPR by asking students to come up with some rules for what happens to the geometry when you add bonds/lone pairs, or after introducing VSEPR by asking students to practice naming molecules while using the sim. You can also ask students to determine if single, double or triple bonds affect the molecule shape differently, what is the difference between electron geometry and molecule geometry and/or to compare the angles predicted by the VSEPR to the angles in real molecules.
- **With clicker questions** by asking students the geometry of a molecule or angles within a molecule with a clicker questions, and then use the sim to see if they were correct.

### What can students learn from playing with this sim?

A lot! Students can learn to:

- Recognize that molecule geometry is due to repulsions between electron groups.
- Recognize the difference between electron and molecular configuration.
- Name molecule and electron geometries for molecules with up to six electron groups surrounding a central atom.

Students can also:

- Compare angles between atoms in a range of geometries
- Compare the effect of single, double and triple bonds as well as lone pairs on molecule geometry ( in the **Real Molecules** tab).

### What are some things students might find difficult?

From interviews of undergraduate students using the Molecule Shapes sim:

- Students might get the initial impression that all angles between atoms are the same for a given a geometry. To help with this, you could ask questions like: Are there cases where the atoms are as far apart as possible, but that the angles between atoms are not all the same? What molecule shapes are these, and why might that happen?
- Students might get the initial impression that you cannot add more than 6 'things' to a central atom in real life. While the sim stops you from adding more than six electron groups to an atom, it's possible to have higher coordination numbers than six. You could show students a few examples of higher than six coordination, or ask students to predict based on what they have learned from the sim how a seven-coordinated molecule might look (this could be a challenge question).

## 2. Bonds/Lone Pairs

### How do I add bonds or lone pairs?

There are two ways to add electron groups (bonds and lone pairs) to the central atom in the simulation.

- Click and drag bonds/lone pairs from the upper right corner of the sim. Notice how electron groups move as you add new groups to the central atom.
- Click on the bond/lone pair that you want. It will appear attached to the central atom.

### How do I remove bonds/lone pairs?

There are two ways to remove bonds/lone pairs.

- You can select the red 'X' button next the type of bond or lone pair you want to remove.
- Click on the 'Remove All' button to remove all bonds/lone pairs from the central atom.

## 3. Play Area

### How do I interact with my molecule?

There are multiple ways to interact with your 3D molecule.

- Grab individual atoms or lone pairs and move them around. As you move them, the molecule changes geometry as electron groups are repulsed.
- Grab the center atom, or any place not on an atom or toolbar to rotate the entire molecule.
- Drag a bond or electron group into the play area, watch as the repulsions between electron groups change the molecule shape.

## 4. Options

### Why is the 'Show Lone Pairs' checkbox greyed out?

This is because you haven't added any lone pairs to your molecule. Once you add lone pairs, you can uncheck the 'Show Lone Pairs' checkbox to see only the molecule geometry. The default is for this box to be checked so that students can see the lone pairs they add at first, and then make them invisible as needed.

### Why is the 'Show Bond Angles' checkbox greyed out?

This is because there aren't enough atoms to show angles between atoms. Add atoms to your molecule, and then you can select the 'Show Bond Angles' checkbox to see the angles between atoms.

## 5. Geometry Name

### How can I see the geometry names?

Select the checkbox next to 'Molecule Geometry' or 'Electron Geometry' to see the geometry names. You can select them both at once, or one at a time.

## 6. Model

### What is the underlying model used for the sim?

We used the Valence Shell Electron Pair Repulsion model (VSEPR) to as guidance for what geometry to show for a given number of electron groups.

On the **Model** tab, the molecule angles are given as if there are no differences in shape from the basic geometry. Much like real molecule building kits with fixed holes, all tetrahedral compounds show 109.5-degree angles. This tab is meant to provide basic understanding of electron and molecular geometry. Using a simple model to introduce molecular shape is common in textbooks as well. Then, as students explore the second tab, **Real Molecules**, they can begin to make sense of how lone pairs change the angles. This sim does not address how different atoms attached to the central atom affects the angle; for example water is shown (bond angle  $104.5^\circ$ ), but not  $\text{SiO}_2$  (bond angle  $102.2^\circ$ ).

On the **Model** tab, non-physical structures can be made. Students could use the **Real Molecule** tab and other resources to explore which structures can be found in nature, but this is not a learning goal for this sim. Interview data with students indicated that only allowing physical structures to be made in the sim limited students' exploration. For example, students would stop adding electron groups once they reached a non-physical structure, even if adding more electron groups would result in a physical structure. Since the goals of the sim are to support students in exploring and making sense of trends in molecule geometry, we decided (in consultation with chemistry faculty) to design the sim to allow the building of non-physical structures to the extent that the sim goals are supported.

## 7. 'Teacher' Menu

### What is the 'Teacher' option for?

In the upper left corner of the sim, there is an option labeled **'Teacher'**. When you select this, a menu will drop down, allowing you to select (or unselect)

- "White Background" inverts all of the colors in the simulation, which may make the simulation easier to see while projecting or make copying and pasting images for black line masters more clear.
- "Show Outer Lone Pairs" will show the lone pairs for the atoms attached to the central atom. For example, when this is selected the lone pairs of oxygen in  $\text{CO}_2$  are visible.