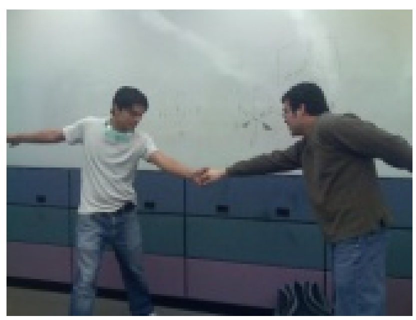
PEER-LED TEAM LEARNING
LEADER TRAINING

Body Geometry

Lizabeth Ronquillo

Preparing for the Activity

1. Begin by forming teams of about 3 to 6 people, based on workshop numbers.
2. To get students started you can show them an example of linear body geometry. Stand with feet together and hands clasped held above your head. In this example, your navel is the central atom and your hands and feet are the bonded atoms.
3. Now give them a chance to try both drawing and modeling the other possible geometries.
4. We have found geometries for up to five bonded atoms maintaining the navel as the central atom using one person. Beyond this, having two people work together to show an octahedral geometry will suffice.
5. Once teams have established how the shapes look they can be challenged to demonstrate shapes of actual molecules.



Two students performing body goemetry of the Ethane molecule

For the Peer Leader

Part A

1. Stressing the importance of taking the time to draw the molecule using Lewis structures cannot be overemphasized.
2. Then, once drawn, two students from each team race to show the geometry with their bodies.

Part B

The peer leader should now ask questions about the geometry pertaining to the bond angles and the Lewis structure the students made.

1. This is the trickiest part because these molecules contain lone pairs and thus it is necessary for the Lewis structure to be drawn correctly.
2. And of course, the students race for the first correct body geometry.

The distinction can now be made between the molecular and electronic geometries. The peer leader can specify which one they want to see and hear explained.

Part C:

1. The Peer leader can follow the instructions from above to complete the activity.

Hybridization is a difficult subject to simplify and should be reviewed and discussed for a fair amount of time before jumping into the jumble of molecules provided for this section. These examples are to build practice in all three parts to be sure students can explain why and how they arrived at their choices of Body Geometry.

The peer leader has the option of assigning a different molecule to each team or having them all work on the same molecule with the fastest group winning the point. In practice, some Peer Leaders have found assigning different molecules is a good choice for a large Workshop size.

Body Geometry Suggested Molecules

Section A: Only the geometry around the central atom should be considered (Molecular Geometry), the students should be able to come up with shapes up to tetrahedral (4 bonds) easily, trigonal bipyramidal (5) is tough, but do-able, and octahedral is possible with two people.

(LINEAR)

$BeCl_2$, CO_2, HCN, NO_2^+

(TRIGONAL PLANAR)

NO_3, BF_3 (both good for resonance) formaldehyde (H_2CO)

(TETRAHEDRAL)

CH_4, $SiCl_4$, ClO_4^-, BrO_3F (tough)

(TRIGONAL BIPYRAMIDAL)

PCl_5

(OCTAHEDRAL)

SF_6, XeO_6

Section B: Now the students must differentiate between Molecular and Electronic Geometry. Have them form the structure then name either one of the geometries (or both).

(Electronic/Molecular)

(TRIGONAL PLANAR/BENT or ANGULAR)

O_3, NO_2^-

(TETRAHEDRAL/TRIGONAL PYRAMIDAL)

NH_3, NF_3, $ClOF_2$ (tough)

(TETRAHEDRAL/BENT)

H_2O, OF_2, SF_2

(TRIGONAL PYRAMIDAL/SEESAW [DISTORTED TETRAHEDRON])

SF_4

(TRIGONAL PYRMIDAL/T-SHAPED)

BrF_3, ClF_3

(TRIGONAL PYRAMIDAL/LINEAR)

I_3^-, XeF_2

(OCTAHEDRAL/PYRAMIDAL PLANAR)
$ClOF_4^-$, $XeOF_4$
(OCTAHEDRAL/SQUARE PLANAR)
XeF_4, ClF_4^-

Section C. Now you can explain the hybridization and have the students keep in mind that they must draw the molecule out to understand the type of hybridized orbitals.

PCl_3 (TETRAHEDRAL/TRIGONAL PYRAMIDAL), SO_2 (TRIGONAL PLANAR/BENT), ICl_4^- (OCTAHEDRAL/SQUARE PLANAR), $SnCl_5^-$ (TRIGONAL BIPYRAMIDAL (both)), $AsCl_5$ (TRIGONAL BIPYRAMIDAL (both)), NBr_3 (TRIGONAL PLANAR (both)), PCl_4^- (TRIGONAL BIPYRAMIDAL/PYRAMIDAL PLANAR), SO_4^{2-} (TETRAHEDRAL(both)), $SeCl_2$ (TETRAHEDRAL/BENT), N_3^- (LINEAR(both)(can also discuss resonance)).

Body Geometry Activity

Directions for the Peer Leader

Molecular and Electronic Geometry with Hybridization Concepts

The underlined portions are those you share with the students throughout the activity, those portions in (parentheses) are the information you are trying to "coax" out of your students.

A. Taking into account molecules with only bonded atoms:

1. According to valence electron shell pair repulsion theory (VESPR), double and triple bonds can be viewed as single bonds. (We are aiming for overall molecular shape; this is an approximation and is still good for our qualitative purposes. In reality these multiple bonds are both larger and shorter than single bonds, but this does not affect us for this exploration.)
2. Thus, resonance structures should have the same shape no matter what. (Because resonance structures are structures with only the electrons moved (bonds, lone pairs) **not atoms**. The molecules are considered constitutional isomers if the atoms are moved.)
3. Atoms bonded to the central atom will stay as far apart as possible from each other. (The atoms bonded to the central atom have positive nuclei that will repel each other when brought into too close proximity.)
4. These types of molecules only contain Molecular Geometry. (There are no lone pairs to consider yet.)

B. Now, considering molecules with both bonded atoms and lone pairs, the following applies:

5. Lone pairs will also stay as far away from each other as possible. (Because all electrons are negatively charged, it is the same concept as the positive nuclei, negative repels negative.)

6. Remember for every lone pair, the angle opposite its position will be 2 degrees less than what it would be without lone pairs. (Lone pairs are only associated with one atom, the central atom, while bonded electrons are associated with two, the central atom as well as the bonded atom, thus signifying why a lone pair would be spatially "larger" and thus take up 2 more degrees of space.)
7. The geometry of an atom with both bonded atoms and lone pairs has two types of geometry, Molecular Geometry and Electronic Geometry. (Molecular Geometry takes into account only the bonds made from the central atom to another atom, leaving out lone pairs and creating the odd shapes such as bent and trigonal pyramidal. Electronic Geometry takes into account both the bonds from central atom to atom and the lone pairs, thus everything is accounted for.)

C. All bonds accounted for; we now explore hybridization and its relationship to VESPR theory.

8. To determine the hybridization just count the number of "things" (bonded atoms and lone pairs) that are associated with the central atom. For each bonded element add an orbital and the hybridization becomes clear. (For example, a central atom with 4 bonded atoms and 2 bonded lone pairs will have square planar molecular geometry, trigonal bipyramidal electronic geometry, and sp^3d^2 hybridized orbitals around the central atom. The number of bonded elements corresponds to the increasing energy of the amount of bonds to the one central atom, thus for each one, one more orbital type is added to the hybridized mix in the following order, [s,p,p,p,d,d]. Thus, counting the number of things bonded to the central atom in the Electronic Geometry equals the number of hybridized orbitals. REMEMBER: The number of molecular (hybridized) orbitals formed is equal to the number of atomic (from central atom) orbitals combined.)

NOTE

When considering the hybridization of an atom, the students MUST draw out the molecule using Lewis structure; just looking at the molecular formula will not provide enough information for the correct answer in most cases.

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