Pre-AP Chemistry

September 4, 2011

16. Covalent Bonding III

Review

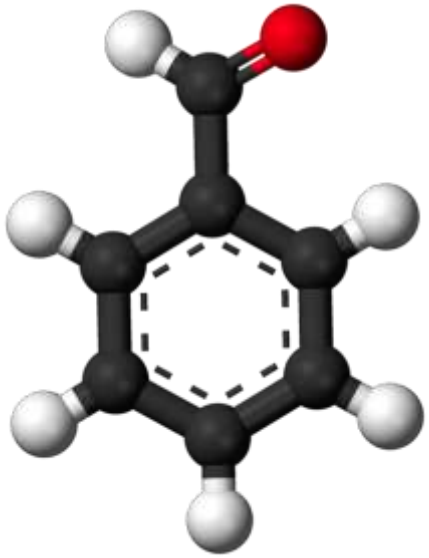
Draw the Lewis structures for

CO_2 CH_4 SF_6

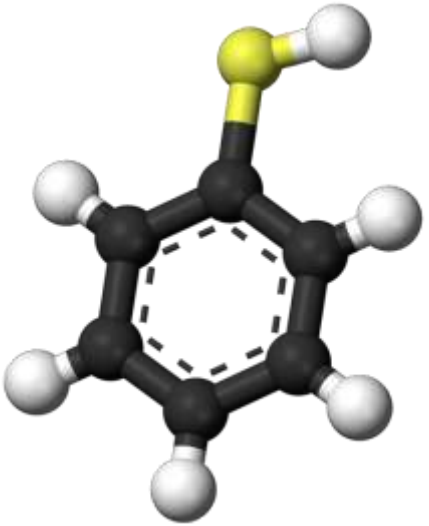
Remember that atoms with n > 2 can hold ‘expanded’ octets of more than eight valence electrons

Molecular Geometry

- Two large influences on a molecule's chemical reactivity:
  1. Electron Distribution
  2. Shape



Benzaldehyde



Thiophenol

Benzaldehyde and thiophenol don't look that different …

Molecular Geometry

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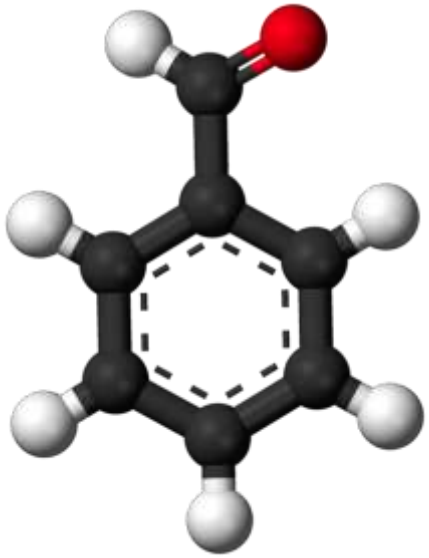
  1. Electron Distribution
  2. Shape



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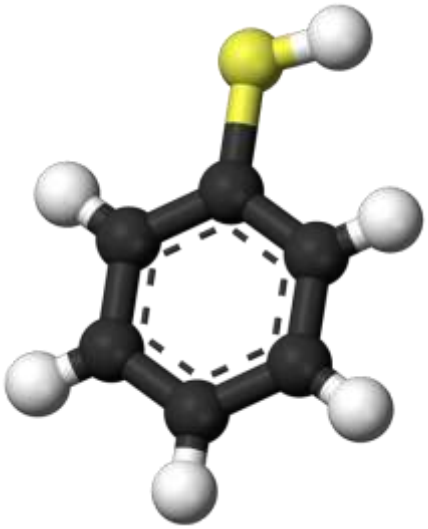
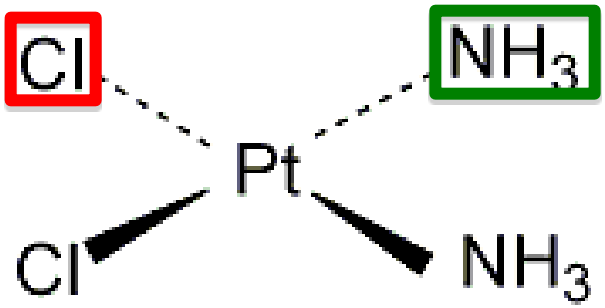


Thiophenol

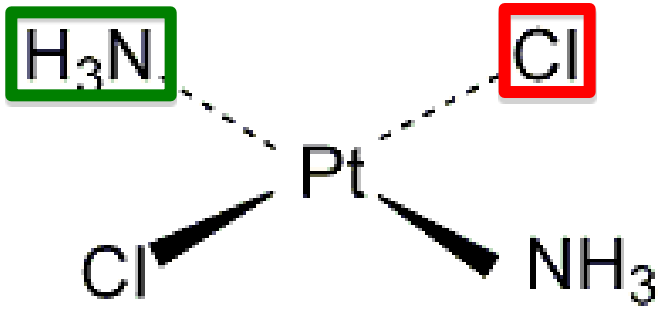
… but small changes in shape make a big difference!

Molecular Geometry

- Two large influences on a molecule's chemical reactivity:
  1. Shape
  2. Electron Distribution



Cisplatin

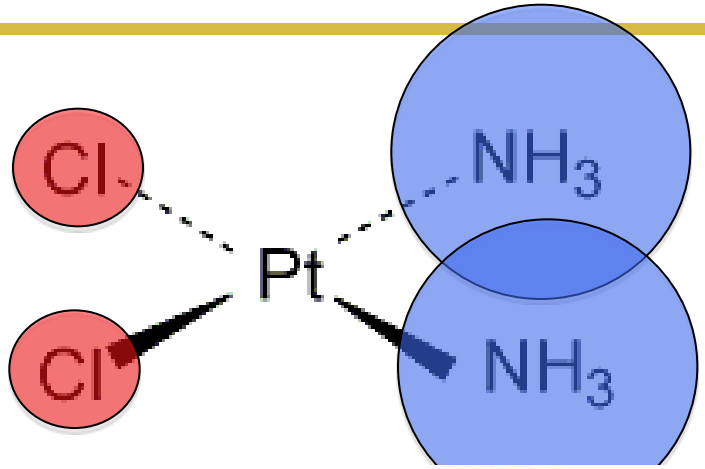


Transplatin

Cisplatin and Transplatin only differ in the position of two groups …

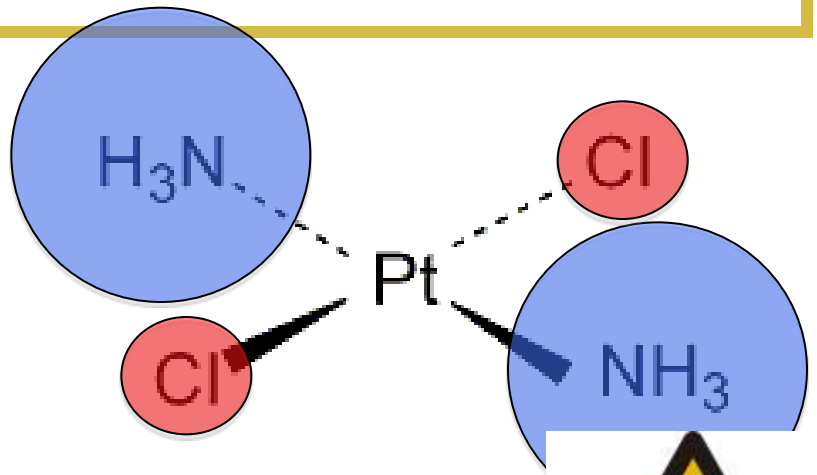
Molecular Geometry

- Two large influences on a molecule's chemical reactivity:
  1. Electron Distribution
  2. Shape



Cisplatin

Powerful Cancer Drug



Transplatin

Slightly Toxic

… but their electron distribution makes a big difference!

Outline

- Shape
- Electron Distribution
- Introduction to Biochemistry

- Shape
  - VSEPR Theory
  - Predicting Molecular Geometry
- Electron Distribution
  - Polarity
  - Molecular Dipoles
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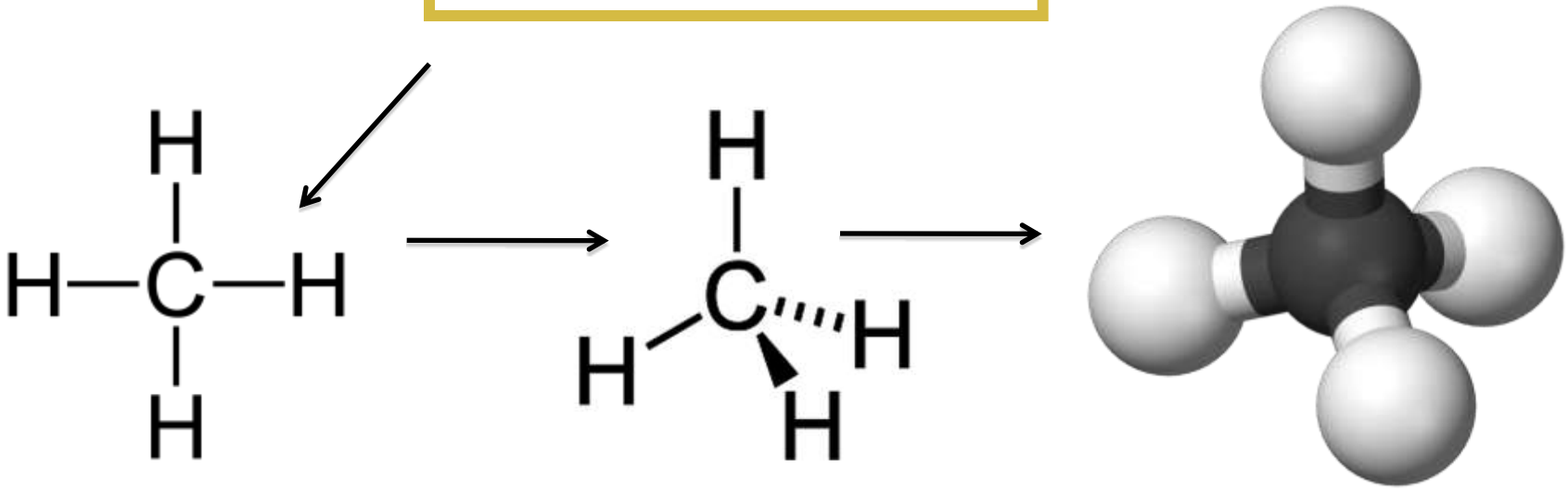
Molecular Geometry

- Lewis structures help chemists predict the shapes of molecules

CH_4

Molecular Formula



Structural Formula

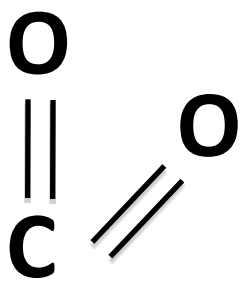
Wedge-and-Dash Structure

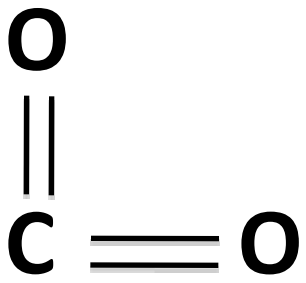
Ball-and-Stick Model

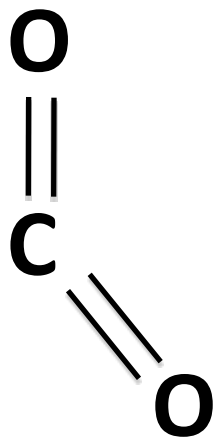
Molecular Geometry

- Valence Shell Electron-Pair Repulsion (VSEPR) Theory describes the shape of molecules based on their Lewis structures
- VSEPR predicts shapes that minimize electron repulsion
- Electron groups can be lone pair or electrons in bonds

- Consider CO_2



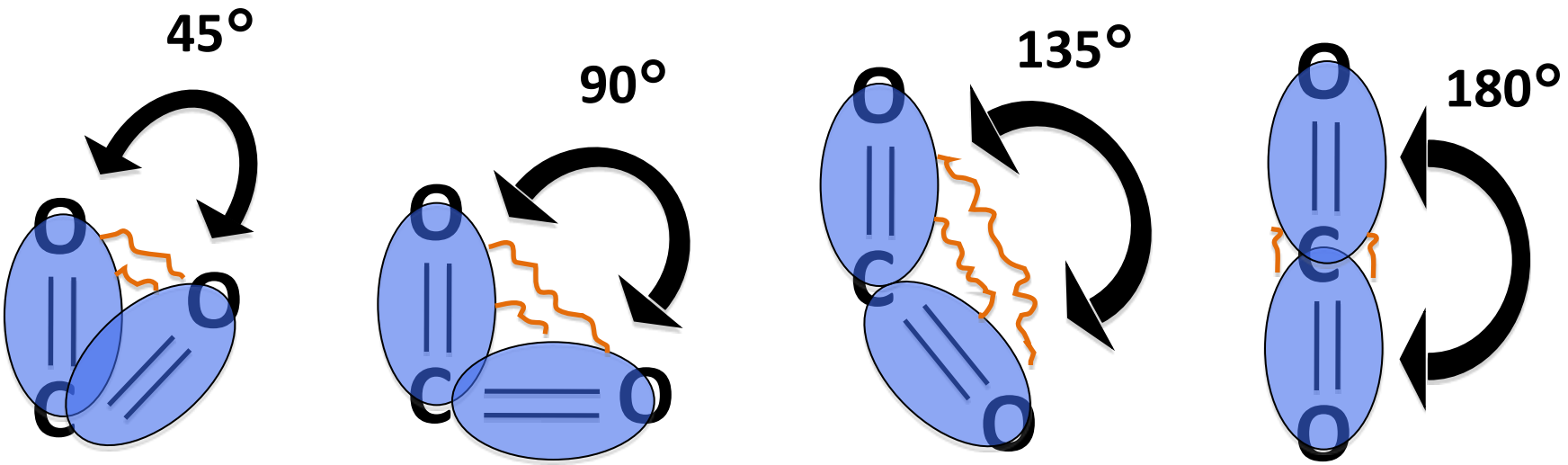




- Which of the geometries above do you predict is correct?

Molecular Geometry

- VSEPR predicts shapes that minimize electron-pair repulsion



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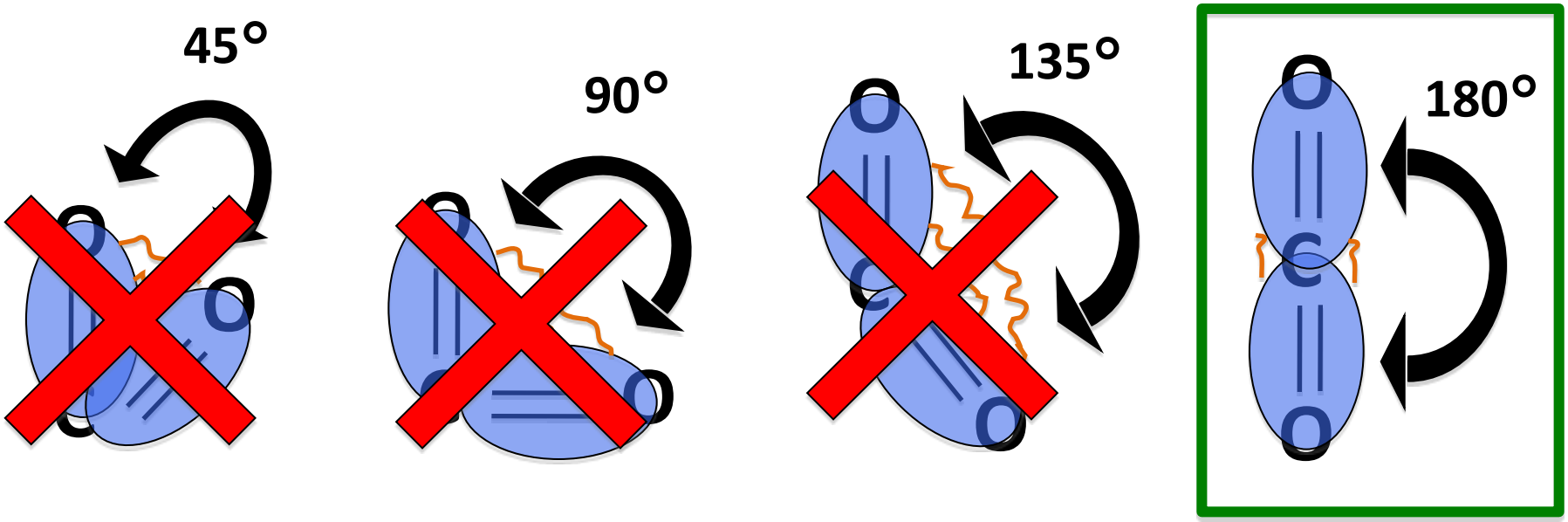
Molecular Geometry

- VSEPR predicts shapes that minimize electron-pair repulsion



CO_2 is a linear molecule.

Molecular Geometry

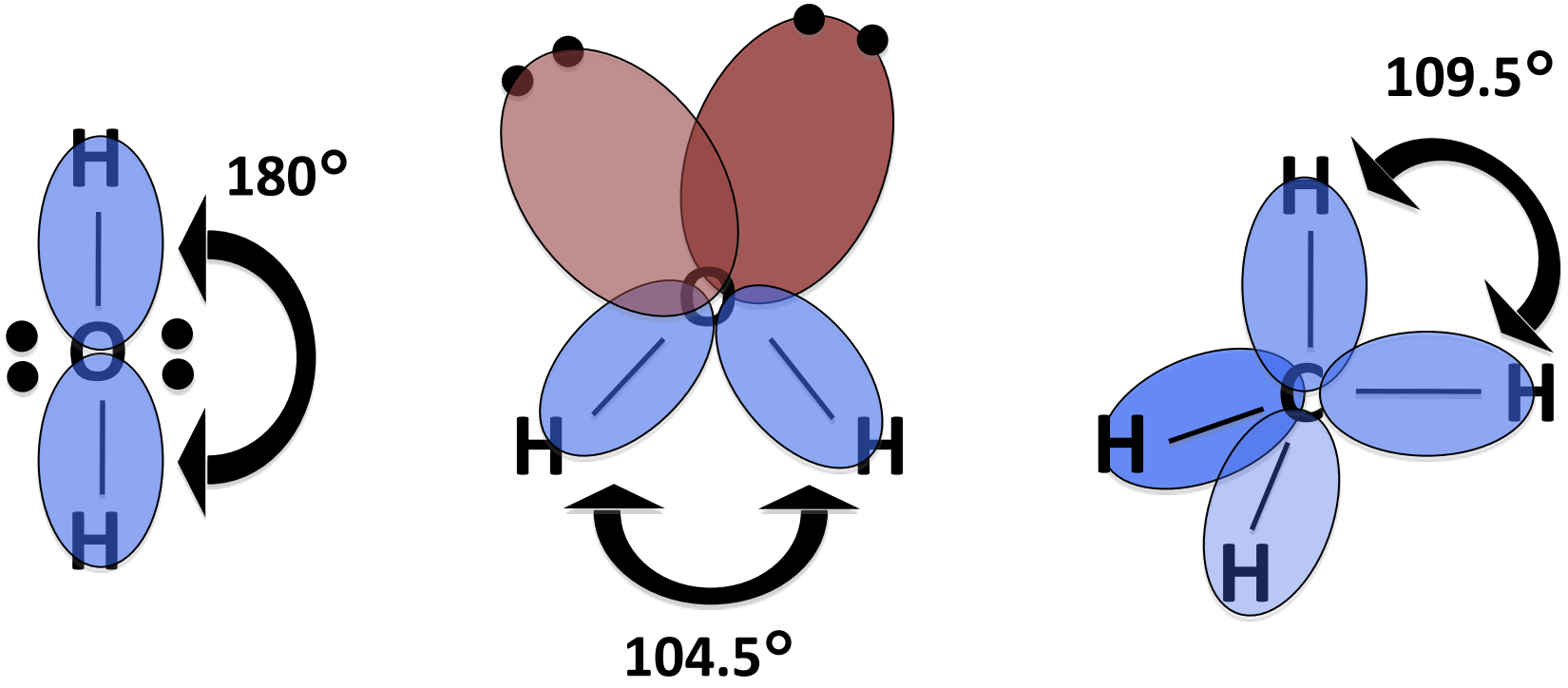
- Electron pairs can be lone pair or electrons in bonds

We might expect water to be linear

if only electrons in bonds repelled each other

Molecular Geometry

- Electron pairs can be lone pair or electrons in bonds



In fact, lone pair electrons are more repulsive than electrons in bonds

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Molecular Geometry

- To predict the shape of a molecule we need to know
  1. The total number of 'electron groups' around the central atom
  2. The number of 'electron groups' that are lone pairs

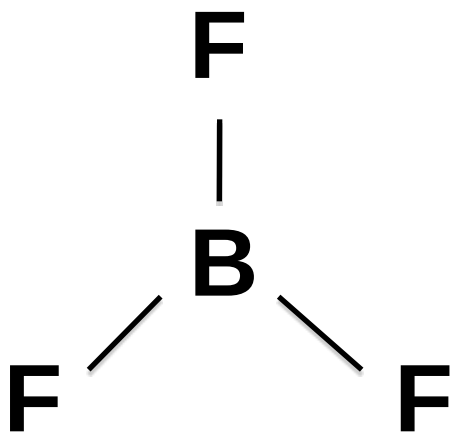
Electron Groups	Electron Group Geom.	Lone Pairs	Molecular Geom.	Bond Angles
2	linear	0	linear	180

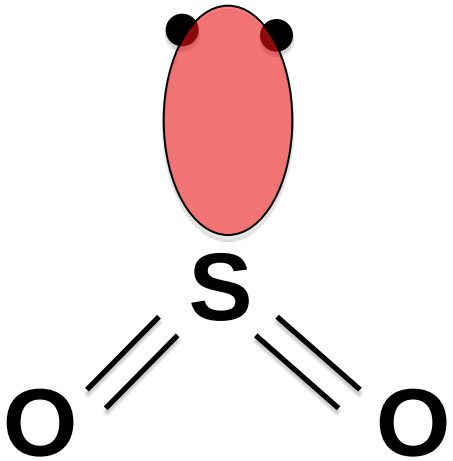
Electrons in double and triple bonds are treated as one electron group

Molecular Geometry

- To predict the shape of a molecule we need to know
  1. The total number of 'electron groups' around the central atom
  2. The number of 'electron groups' that are lone pairs

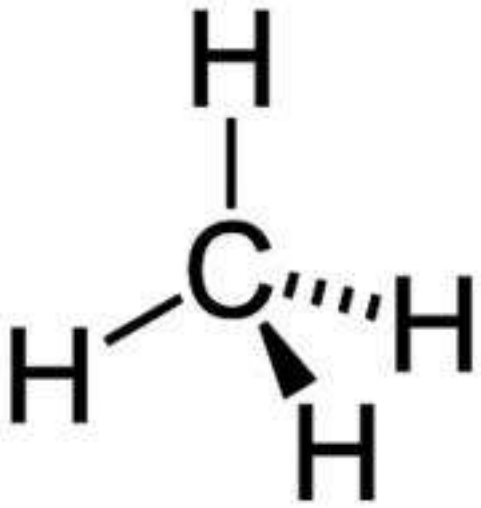
Electron Groups	Electron Group Geom.	Lone Pairs	Molecular Geom.	Bond Angles
3	trigonal planar	0	trigonal planar	120
3	trigonal planar	1	bent	120

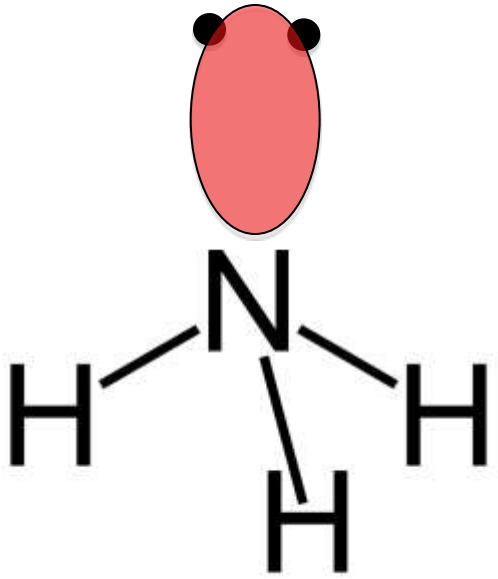


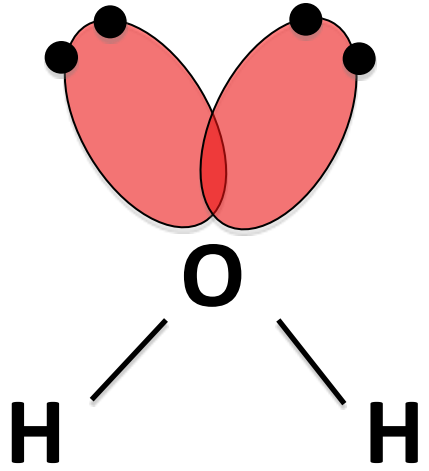


Molecular Geometry

Electron Groups	Electron Group Geom.	Lone Pairs	Molecular Geom.	Bond Angles
4	tetrahedral	0	tetrahedral	109.5
4	tetrahedral	1	trigonal pyramidal	109.5
4	tetrahedral	2	bent	109.5

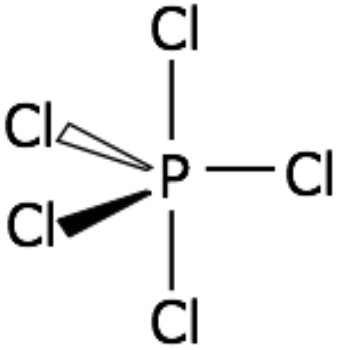


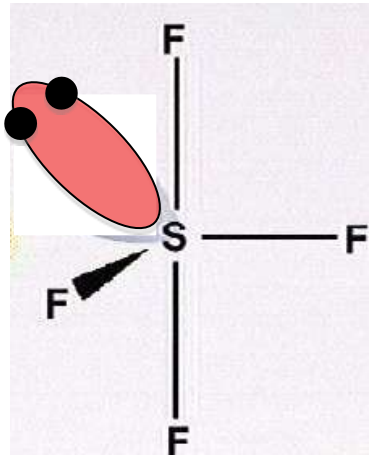


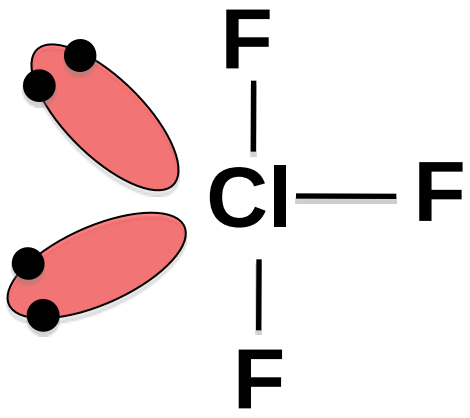


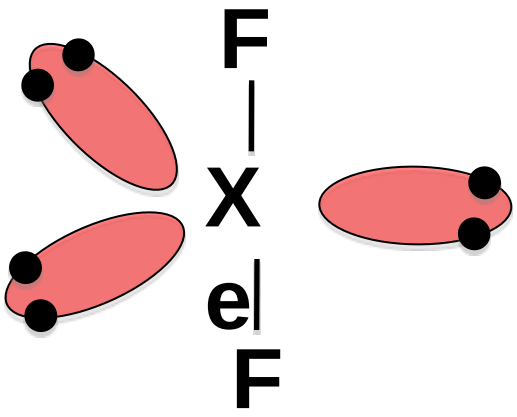
Molecular Geometry

Electron Groups	Electron Group Geom.	Lone Pairs	Molecular Geom.	Bond Angles
5	trigonal bipyramidal	0	trigonal bipyramidal	90, 120
5	trigonal bipyramidal	1	seesaw	90,120
5	trigonal bipyramidal	2	T-shaped	90
5	trigonal bipyramidal	3	linear	180



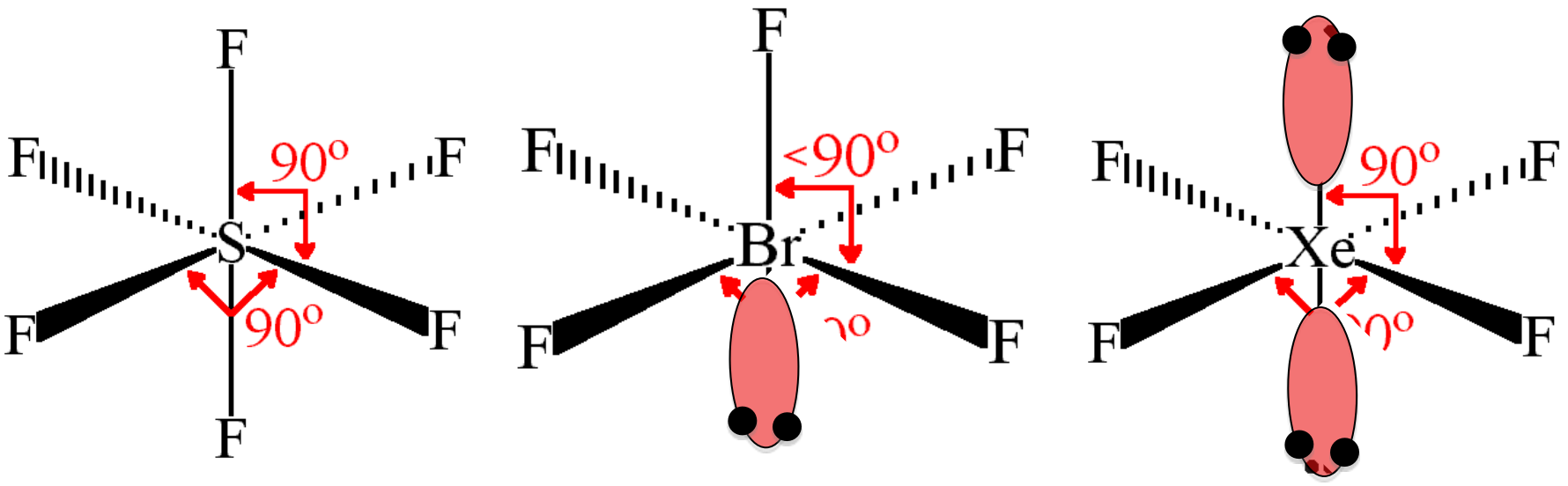






Molecular Geometry

Electron Groups	Electron Group Geom.	Lone Pairs	Molecular Geom.	Bond Angles
6	octahedral	0	octahedral	90
6	octahedral	1	square pyramidal	90
6	octahedral	2	square planar	90



Mini Quiz

Name the molecular geometry and draw the best possible Lewis structure for the following molecules:

ONF **ICl_3**

Mini Quiz

Electron Groups	Electron Group Geom.	Lone Pairs	Molecular Geom.	Bond Angles
2	linear	0	linear	180
3	trigonal planar	0	trigonal planar	120
3	trigonal planar	1	bent	120
4	tetrahedral	0	tetrahedral	109.5
4	tetrahedral	1	trigonal pyramidal	109.5
4	tetrahedral	2	bent	109.5
5	trigonal bipyramidal	0	trigonal bipyramidal	90, 120
5	trigonal bipyramidal	1	seesaw	90,120
5	trigonal bipyramidal	2	T-shaped	90
5	trigonal bipyramidal	3	linear	180
6	octahedral	0	octahedral	90
6	octahedral	1	square pyramidal	90
6	octahedral	2	square planar	90

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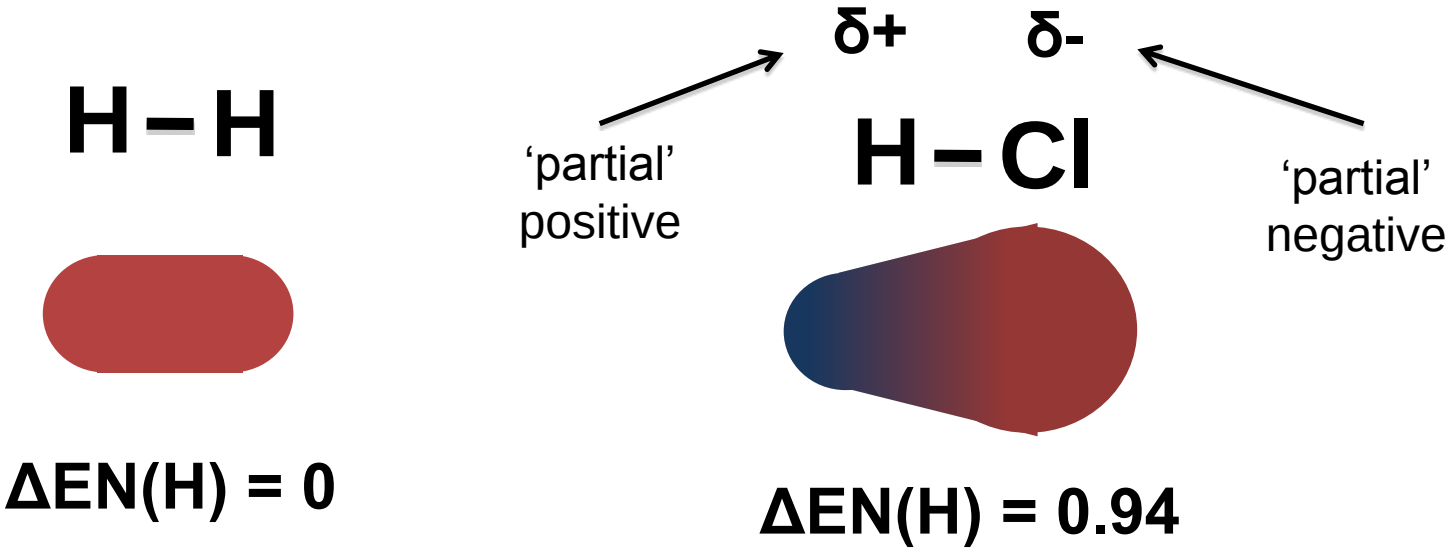
Molecular Dipoles

- One important property of a molecule's electron distribution is its **polarity**
- We saw examples of polar molecules in our discussion of electronegativity



- A polar molecule has a separation of positive and negative charge, shown by **δ+** and **δ-**

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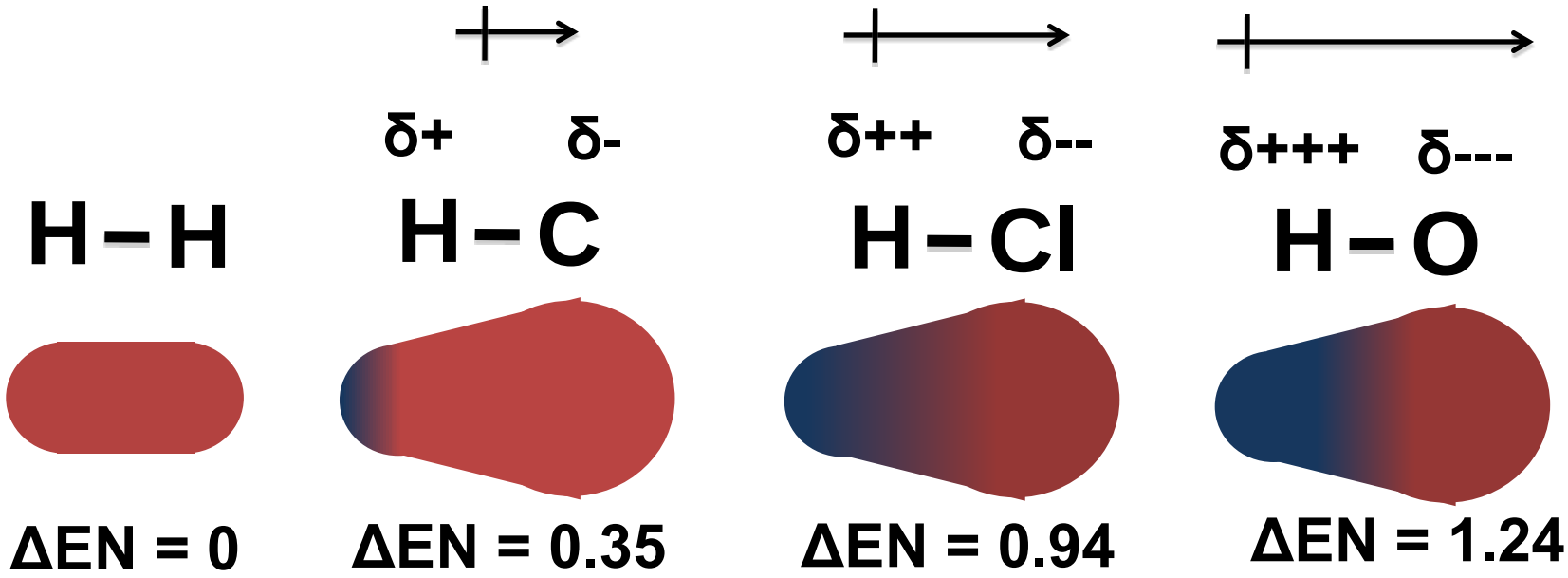
Molecular Dipoles

- A molecule's dipole moment indicates the **magnitude** and **direction** of a molecule's polarity
- **Magnitude** = length of arrow
- **Direction** = points from positively (less electronegative) to negatively (more electronegative) charged



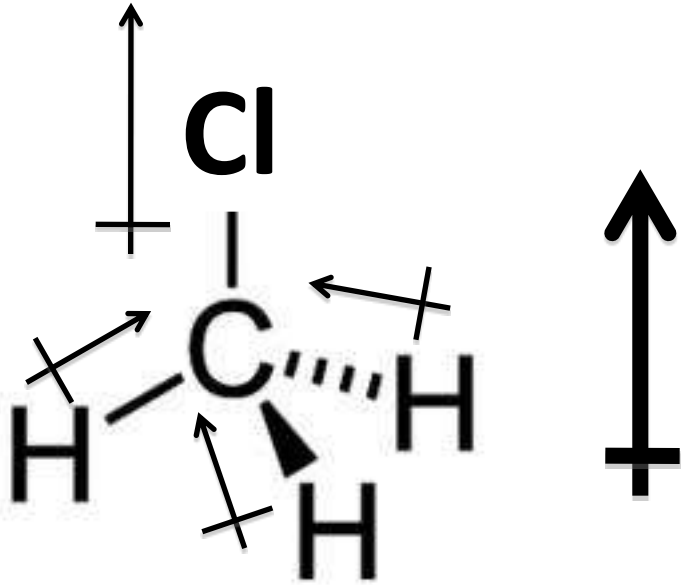
Do you notice a trend between ΔEN and dipole moments?

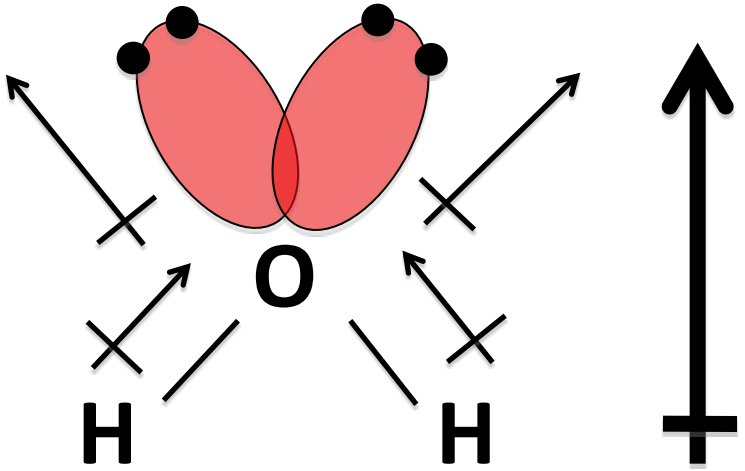
Molecular Dipoles

- We can also draw dipole moments for molecules with more than two atoms
- Polar molecules have a net dipole moment

Bond Dipole

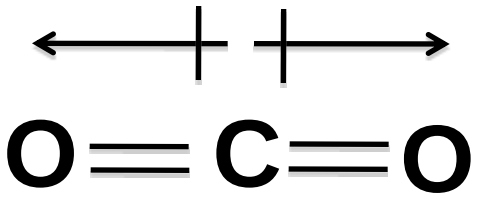
Molecular Dipole

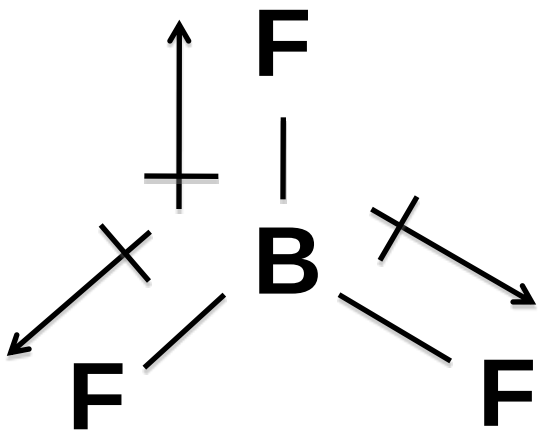




Molecular Dipoles

- Bond polarity does not guarantee molecular polarity
- Non-polar molecules have no net dipole moment





Relationship between ΔEN only works for diatomic molecules

Mini Quiz

Are the following molecules polar or non-polar?

ONF

XeF_4

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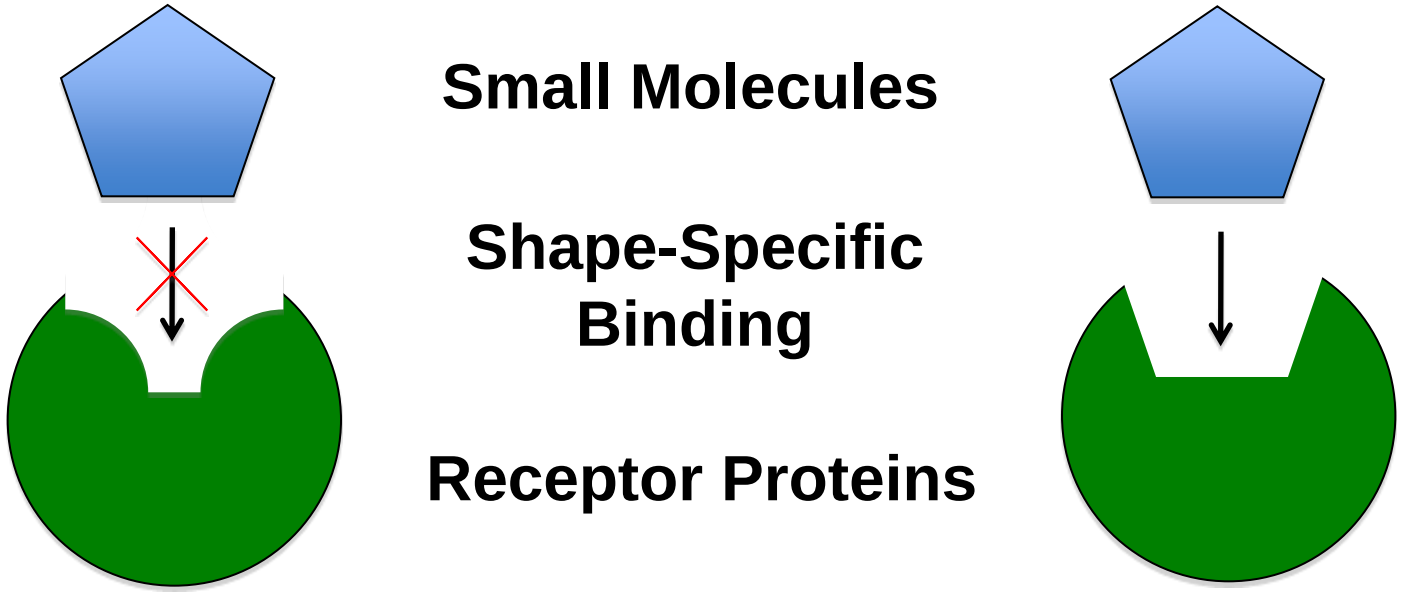
Introduction to Biochemistry

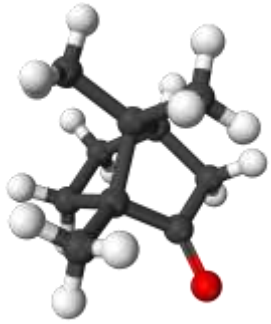
- Many biological processes depend on molecules called **receptor proteins** binding to specific small molecules
- The specificity in binding depends on the shapes of the small molecules

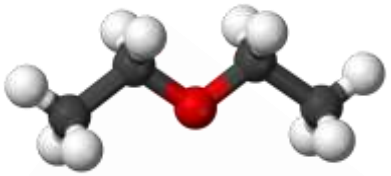


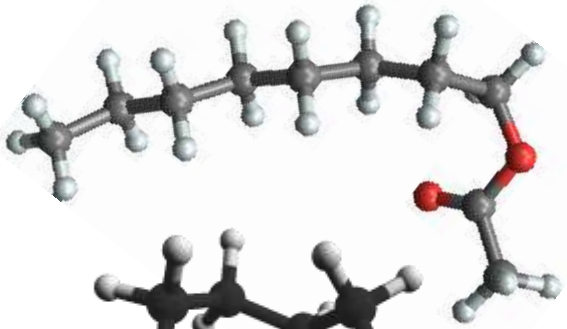
Different **tastes** and **smells** come from different small molecules binding to different receptor proteins

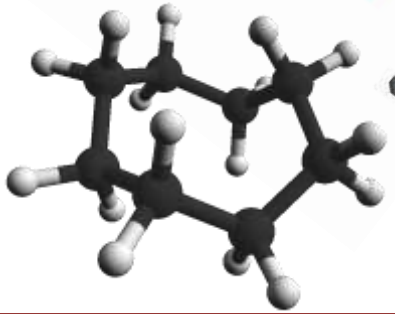
Mini Quiz

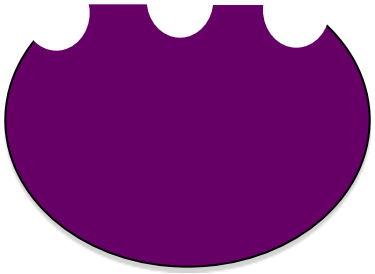
Can you match the following odor molecules to their protein receptors?

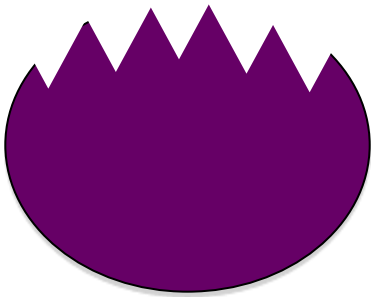


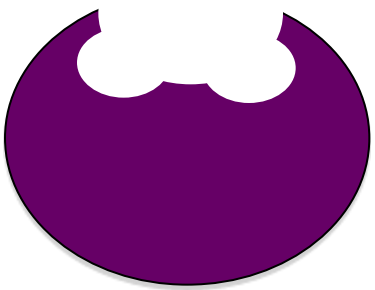












Summary

- We can predict the shape of a molecule using VSEPR theory
- The electronegativity of the atoms in and the shape of a molecule influence its polarity via its dipole moment
- Molecular shape and electron distribution determine the biochemistry and taste and smell

Homework

- TBD