SCHEMATA

A 3D DIGITAL HAND GESTURE RECOGNITION TOOL FOR STUDYING 3D CONCEPTS IN CHEMISTRY

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i263: Technology for Creativity and Learning, Spring 2014

schema |ˈskēmə|

noun (pl. **schemata** |-mətə| or schemas)

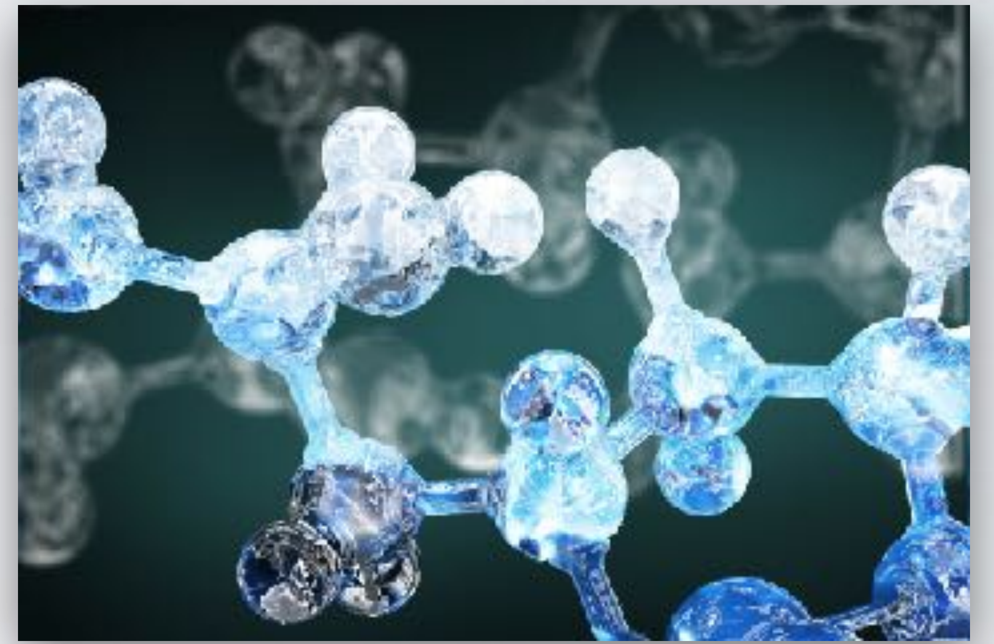
a representation of a plan or theory in the form of an outline or model: *a schema of scientific reasoning.*

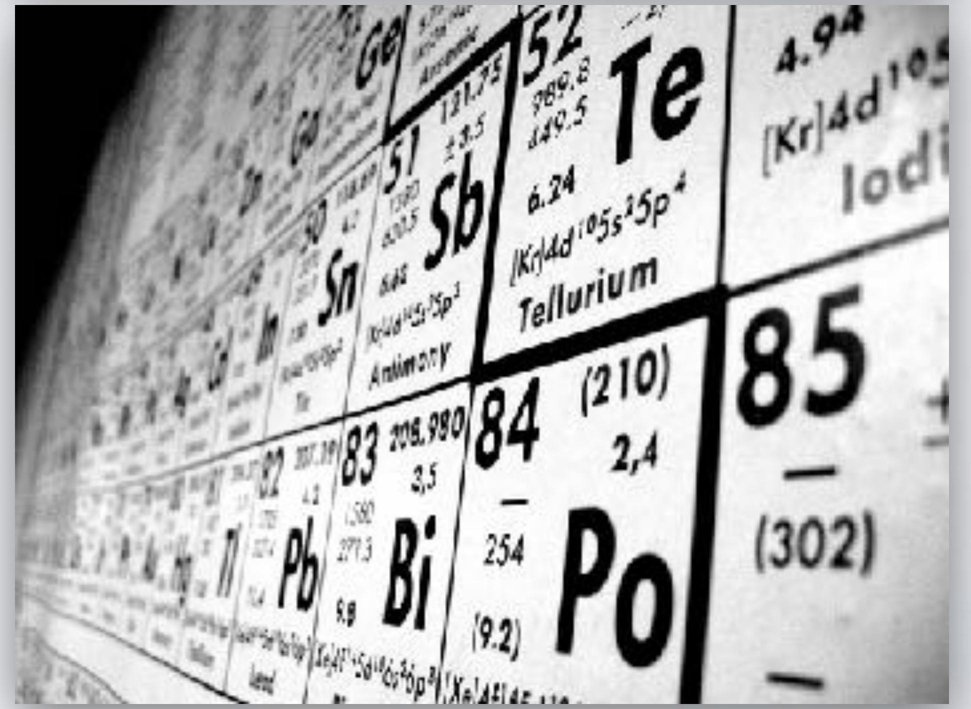
sCHEMATA

MOTIVATIONS

CHEMISTRY

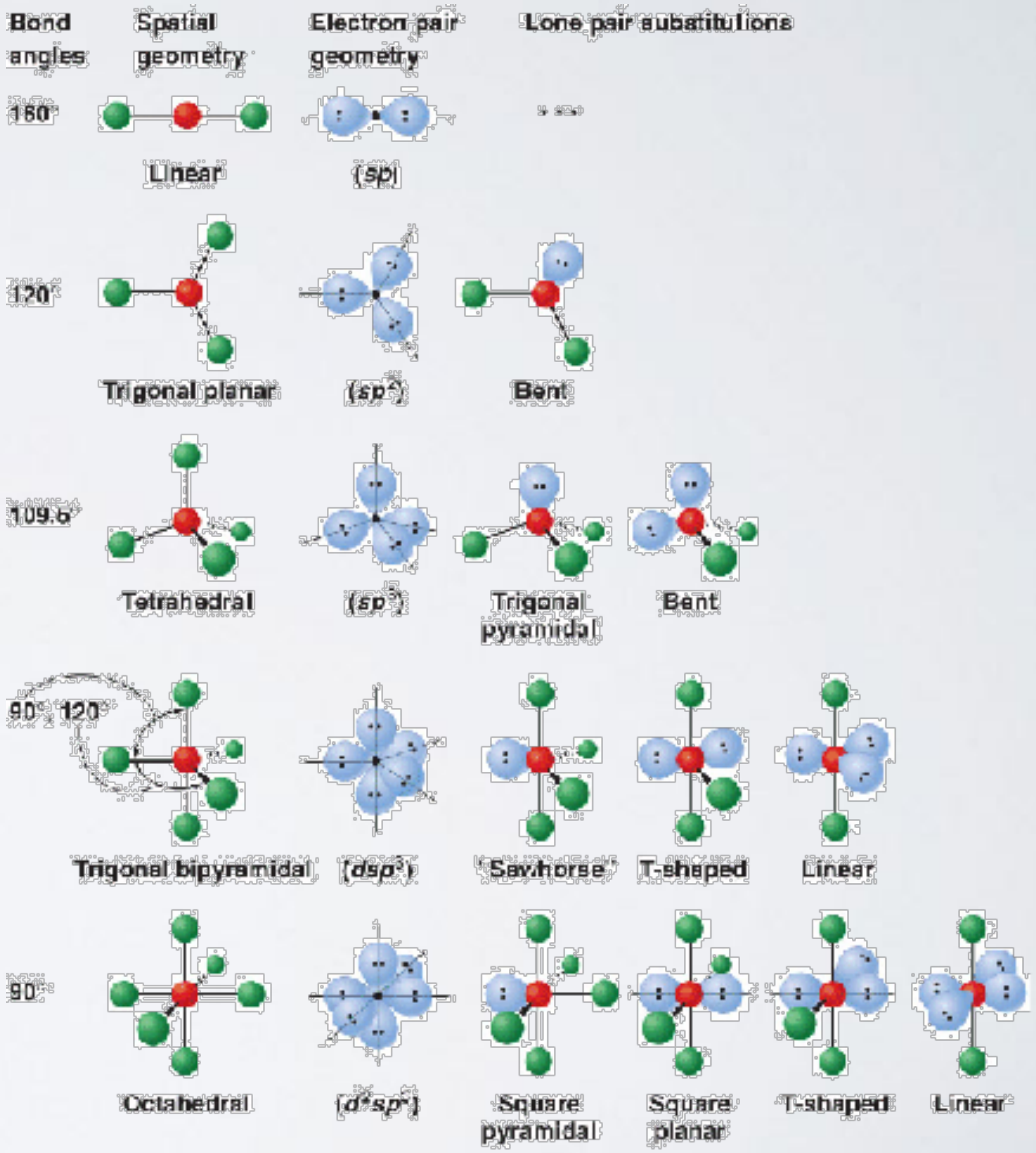
- A physical science!
- But we can't really see teeny tiny molecular and atomic interactions…
- How to create 3D representations of molecules and reactions to visualize otherwise intangible concepts and make them seem REAL?





THE LESSON

- VSEPR Model Theory
- VSEPR = Valence Shell Electron Pair Repulsion
- But first, a little background…

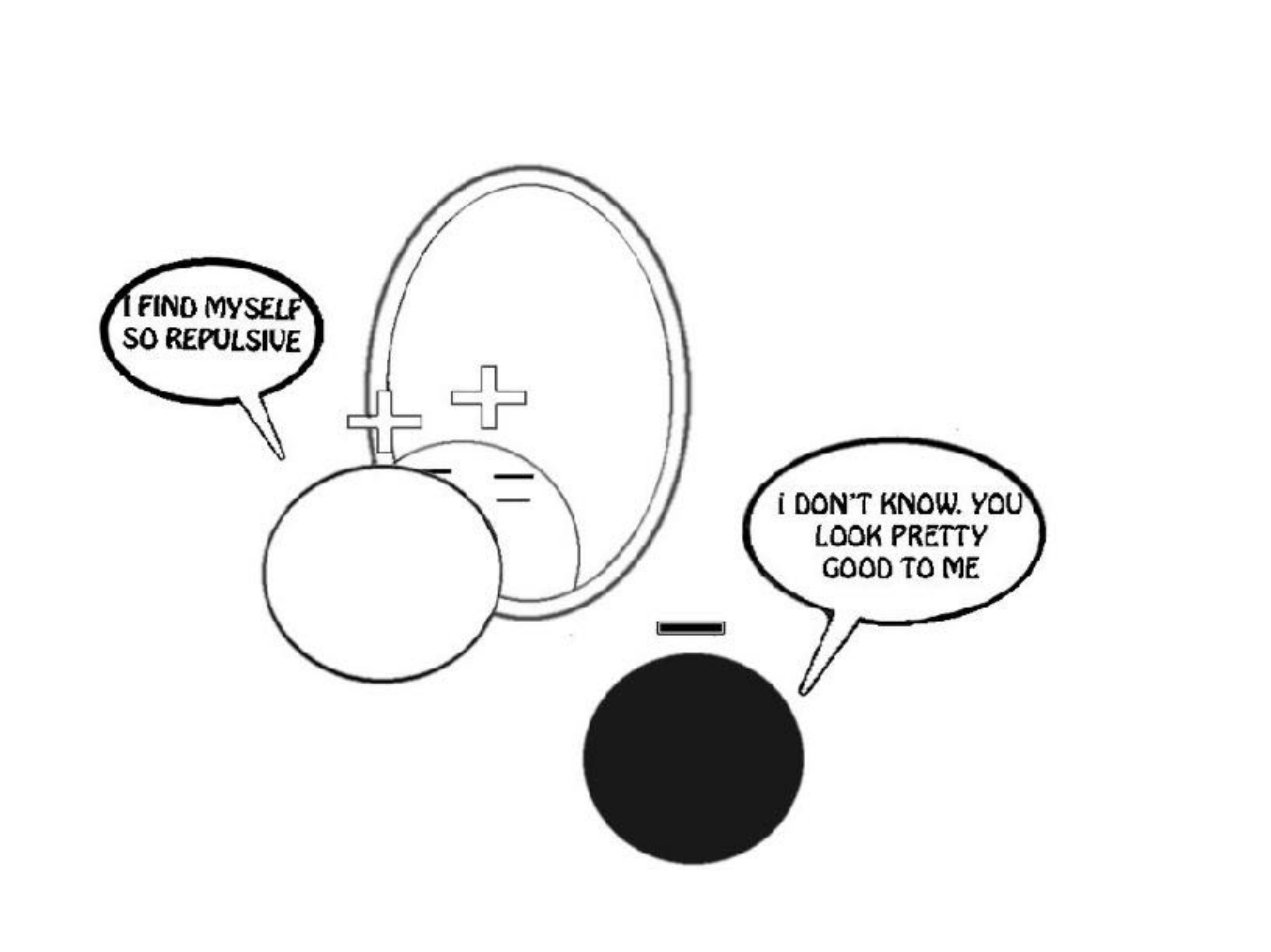


BASICALLY…

- Atoms need full valence (outer) shells (usually 8 electrons) to be considered stable
- Two atoms can share electrons in "bonds"
- Unshared electrons are called "lone pairs"
- These bonds and lone pairs have negative charge

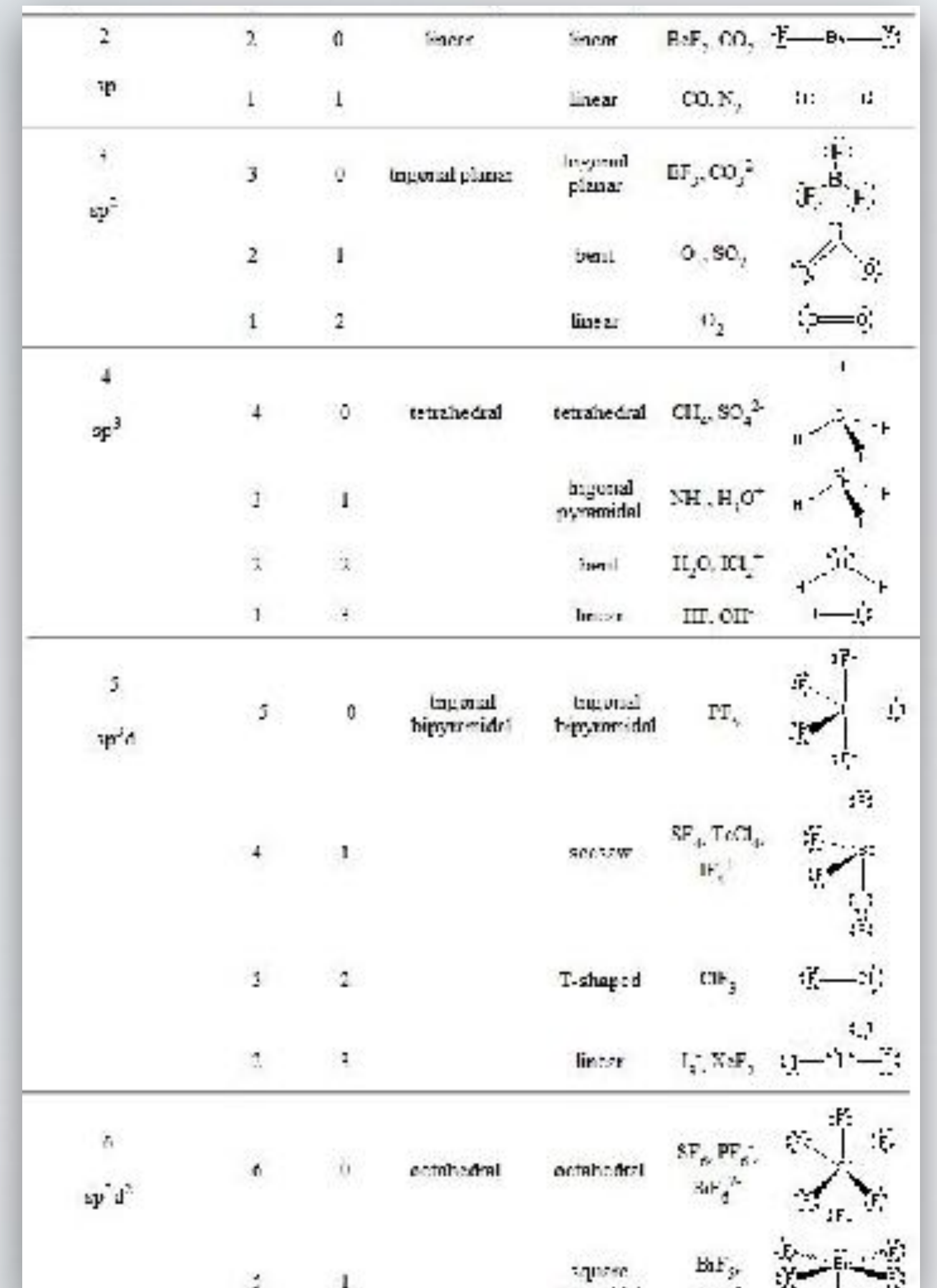
THE MAIN POINT

- In chemistry, opposites attract and like things repel
- So, these negatively charged bonds and lone pairs want to get as far away from each other as possible!
- AKA… Electron Repulsion
- Hence, Valence Shell Electron Pair Repulsion Theory can predict the shape (aka geometry) of molecules


I FIND MYSELF SO REPULSIVE
I DON'T KNOW. YOU LOOK PRETTY GOOD TO ME

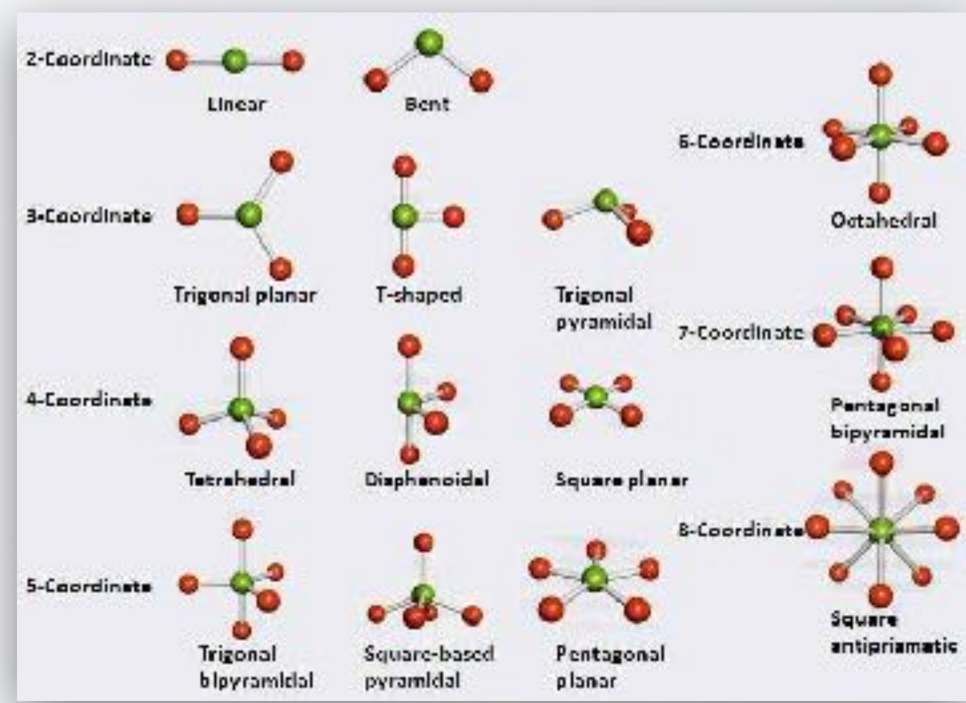
EXISTING APPROACHES

TYPICAL CLASSROOM METHODS



Handout

Notes/Worksheet



Textbook

PHYSICAL MANIPULATIVES:

INDIGO INSTRUMENTS

SMALLAB

LIMITATIONS

- Standard: Difficult to translate 3D concepts from 2D means
- Indigo: Lack of digital feedback or meaningful connections
- SMALLab: Limited space in classroom or lab settings

DESIGN PRINCIPLES

DESIGN PRINCIPLES

- Embodied learning & body syntonicity
- Partner collaboration
- Constructionist learning
- Learning narratives

BENEFITS OF EMBODIED LEARNING

Is the technology much better than physical representations of the molecules? What are the benefits here?

- "learner's **physical actions** enacted in synchrony with **computational feedback** can influence the developmental trajectories of learners' cognitive schemes"
  - Charoenying, Gaysinksy, Ryokai (2012): The Choreography of Conceptual Development in Computer Supported Instructional Environments

BENEFITS OF EMBODIED LEARNING

- "Recent research supports the idea that **body activity** can be an important catalyst for generating learning, and new technologies are being developed that use natural **human physicality and gesture as input**."

    - Lindgren (2013): Emboldened by Embodiment: Six Precepts for Research on Embodied Learning and Mixed Reality

BENEFITS OF COLLABORATION

Would they be able to play together to accomplish a task with a lab partner?

- Piaget: "among peers, **difference in perspective** leads to cognitive conflict, which, in turn, leads to cognitive restructuring and **growth**"
  - Cassell (2004): Towards a model of technology and literacy development: Story listening systems

BENEFITS OF CONSTRUCTIONIST LEARNING

- Piaget: "**in order to know** objects, **the subject must act** upon them: he must displace, connect, combine, take apart, and reassemble them"
    - Charoenying, Gaysinksy, Ryokai (2012): The Choreography of Conceptual Development in Computer Supported Instructional Environments

BENEFITS OF LEARNING NARRATIVES

- "The best learning experiences, for most people, come when they are actively engaged in designing and creating things, especially things that are **meaningful** to them or around them."
  - Resnick & Silverman (2005): Some Reflections on Designing Construction Kits for Kids

DESIGN EVOLUTION

- mapEdge: Interactive knowledge maps
- Focus on Embodied Learning
- Added collaboration and narratives based on class discussions and feedback
- …sChemata!

DESIGN

Introducing… sChemata!

THE TECHNOLOGY

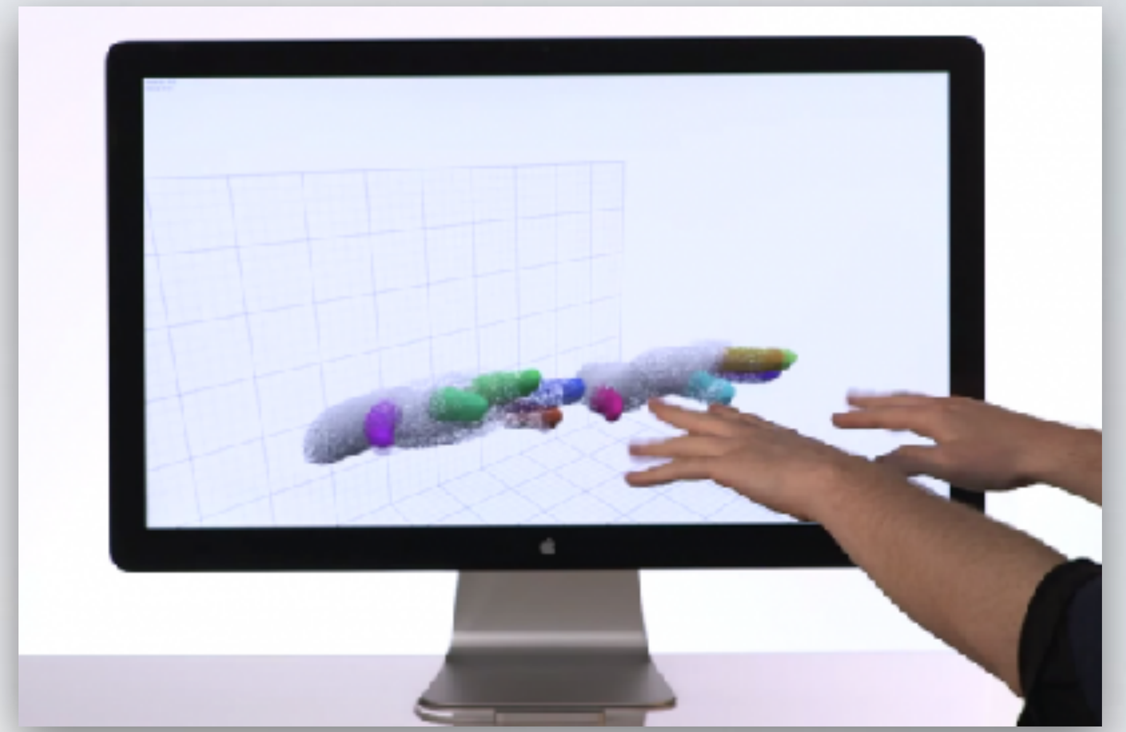
- 3D hand gesture recognition screens
- Storytelling adventure framework to encourage mnemonics and meaningful connections
- Two person mission-like labs
- Quizzes, aka "Quests" to evaluate understanding and give feedback *('using this as an assessment tool would be fascinating')*

THE SETUP

- High school AP Chemistry class (or college general chemistry lab) *('Is the chemistry classroom setting the ideal setting or just what you think is the realistic space it will be used in?')*
- Two students per sChemata screen work together
- Teacher can walk around for tips and guidance *('Does the teacher need to demonstrate? Wouldn't the kids be potentially more engaged if they tried first?')*

THE DEVICE

- Large, thin screen
- No keyboard or mouse required
- Easy to learn, intuitive hand gestures with tutorial (i.e. make a fist to grab, release to let go; point twice to select option; grab and rotate both hands to rotate molecule)



3D HAND GESTURE RECOGNITION

WHY NOT JUST MAKE AN APP?

It sounds like this could be an app with 3D images.

- Encourages greater engagement in the learning process through physical interaction in a digital feedback environment, i.e. body syntonicity!

- Removes distractions of touchscreen, keyboard, mouse, or other browser window tabs, texts, notifications, etc. on a multi-use device

WHY NOT JUST MAKE AN APP?

- "finger touch leaves <u>fingerprints</u> on the screen, some on-screen content is <u>occluded</u> by the fingers, and for large displays some display regions might be <u>inaccessible</u>. For 3d applications the biggest disadvantage is the <u>limitation to two dimensions</u>. Here, 3d gesture tracking allows a much **more direct interaction** with 3d objects."
    - Caputo, Denker, Dums, Umlauf (2012): 3D Hand Gesture Recognition Based on Sensor Fusion of Commodity Hardware

SCENARIOS

SCHEMATA

Home | Save | New Lab | Lesson | Help

VSEPR Tool Kit

Grab, drag, and drop into Valence Land!

Single Bond

Double Bond

Triple Bond

Electron Pair

Add Atoms

Pop-up of Periodic Table to select from.

Random

Generates random molecule or geometry for student to build.

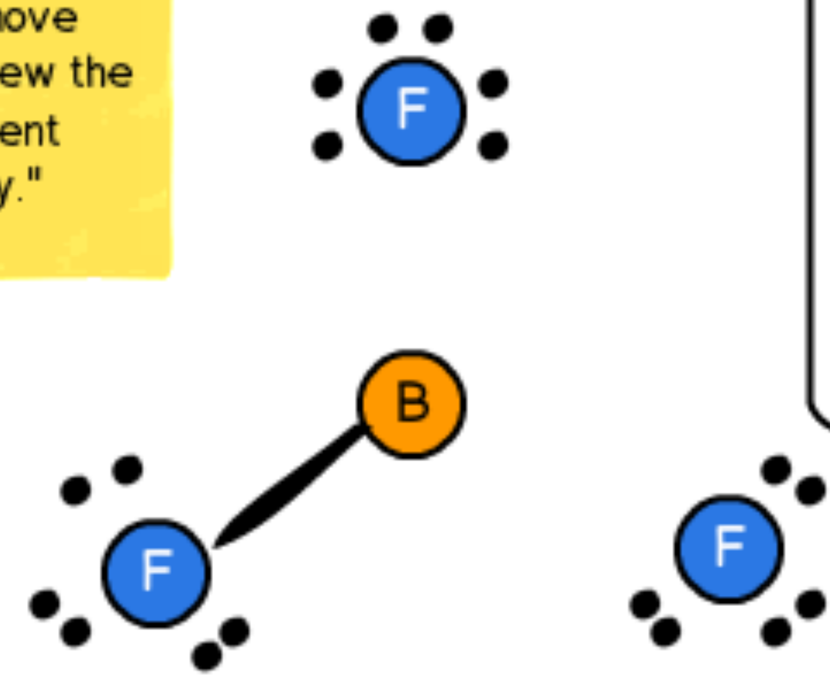
Valence Land

Experiment with building your own molecules. Valence Land needs your help!

Note: Molecule and tools are 3D. Students can also use hand gestures to rotate and move the molecule around to view the 3D geometry from different perspectives in their "city."

Need a Hint?

Fluorine is the "Electron Hog!" Looks like you have two unstable Fluorines right now causing chaos in the city. How might our Sheriff Boron save the day to establish peace over Valence Land again?



Atoms with unstable valence shells should be vibrating to show unrest.

Test it!

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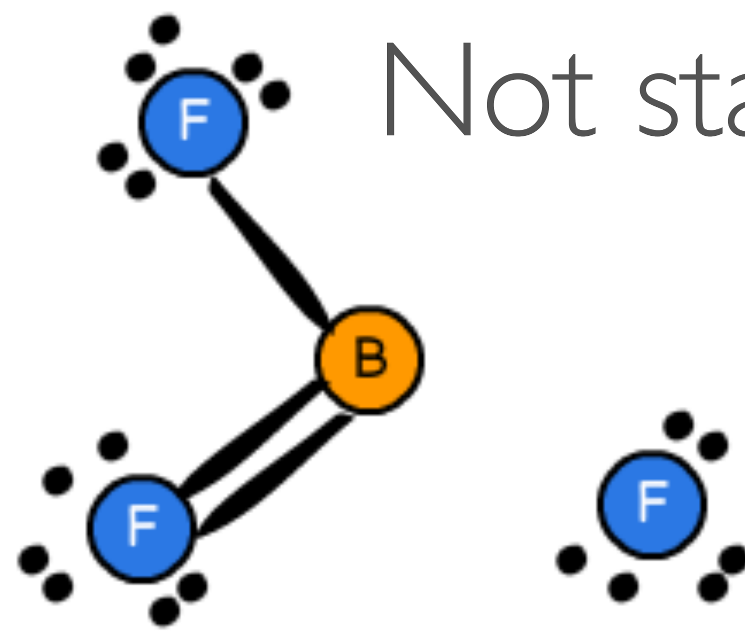
Need a Hint?

Not stable yet!

Explosion animation!



! Uh oh! Looks like you have two unstable Fluorines. Keep experimenting!

Try Again

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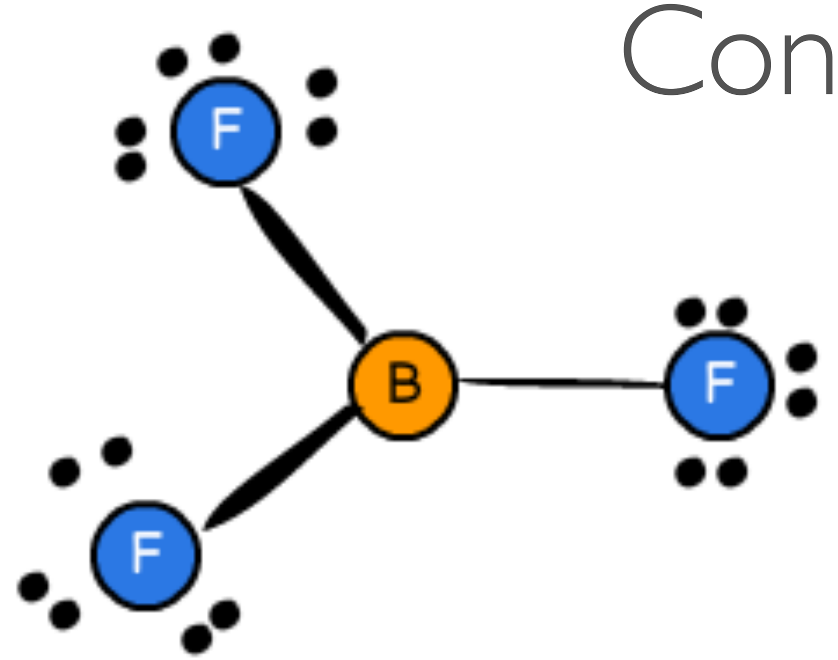
Valence Land

Experiment with building your own molecules. Valence Land needs your help!

Congrats!

Animation of atoms congratulating player!



✓ Success! You made a trigonal planar molecular geometry! Now all your Fluorines are in bonds and Valence Land is peaceful once again. ☺

Keep Experimenting

Try a Quest?

ISN'T THIS SUPPOSED TO BE 3D?

- Yes!
- The molecules should look a bit more like this:
- Perfect example of an octahedral molecular geometry
- Images are nice, but now, imagine you could rotate, spin it around, and build one yourself!

EVALUATION

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Home Save New Lab Lesson Help

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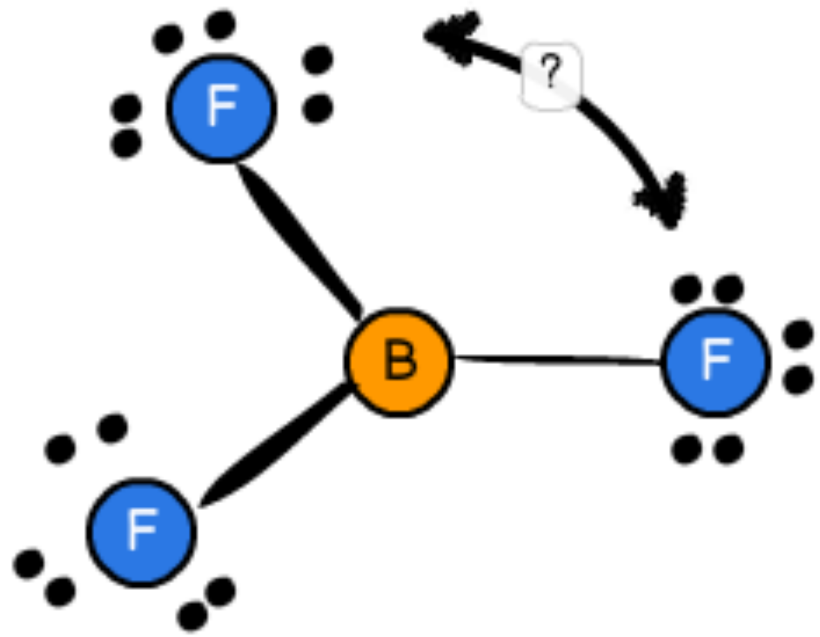
Quest

Discuss with your partner or try quizzing each other!



1) Rotate the BF3 molecule around to see it from different perspectives. What is the bond angle between each Fluorine atom?

Hint: Imagine you and your partner are arch enemy villains in bonds like electrons. That sounds like a negative situation! Which angle allows you two to get as far away from each other as possible?

120 degrees

Q W E R T Y U I O P

A S D F G H J K L

Z X C V B N M

123 space return

✓ Success!!

Next

FUTURE DIRECTIONS

Can you integrate physical manipulatives? Can you integrate real *chemicals and their reactions? Can you use the lab equipment as input? i.e. does turning on a bunsen burner add "heat" to the virtual environment?*

Might not be super relevant to *VSEPR* theory, but…

MORE CHEMISTRY TOPICS!

- Physical input could be helpful for learning…
  - chemical reactions
  - gas laws
  - acids & bases
  - thermodynamics
  - organic chemistry

OTHER SUBJECTS

- 3D Gesture Technology could be helpful for learning…
  - physics
  - biology
  - math
- sChemata could also potentially be simplified for younger ages, or developed for more complex concepts for research experimentation

THE ORIGINAL PLAN…

- Eventually, this could be one small module of a massive interactive 3D knowledge map! Fancy that, mapEdge returns!

THANK YOU

Questions? Comments? Feedback?