The Concord Consortium

Molecular Workbench as a Tool for Blended Learning Courses

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The Concord Consortium™

Realizing the Promise of Education Technology

- A nonprofit educational research and development organization based in Concord, Massachusetts.
- We create interactive materials that leverage the power of information technologies.
- Our goal is to improve learning opportunities for ALL students.

Benefits of Blended Model

- Better use of student time outside of class.
- More flexibility for using in-class time.
- Materials should be engaging, motivating, and "deep" (i.e. challenging)

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Static attempt at teaching phase change

The phases of matter

Solid, liquid, and gas

Most of the matter you find around you is in one of three phases: solid, liquid, or gas. A **solid** holds its shape and does not flow. The molecules in a solid vibrate in place, but on average, don't move far from their places. A **liquid** holds its *volume*, but does not hold its shape — it flows. The molecules in a liquid are about as close together as they are in a solid, but have enough energy to exchange positions with their neighbors. Liquids flow because the molecules can move around. A **gas** flows like a liquid, but can also expand or contract to fill a container. A gas does not hold its volume. The molecules in a gas have enough energy to completely break away from each other and are much farther apart than molecules in a liquid or solid.

Intermolecular forces

When they are close together, molecules are attracted through *intermolecular forces*. These **intermolecular forces** have different strengths for different molecules. The strength of the intermolecular forces determines whether matter exists as a solid, liquid, or gas at any given temperature.

Temperature vs. intermolecular forces

Within all matter there is a constant competition between temperature and intermolecular forces. The kinetic energy from temperature tends to push molecules apart. When temperature wins the competition, molecules fly apart and you have a gas. The intermolecular forces tend to bring molecules together. When intermolecular forces win the competition, molecules clump tightly together and you have a solid. Liquid is somewhere in the middle. Molecules in a liquid are not stuck firmly together, but they cannot escape and fly away either.

Strength of intermolecular forces

Iron is a solid at room temperature. Water is a liquid at room temperature. This tells you that the intermolecular forces between iron atoms are stronger than those between water molecules. In fact, iron is used for building things because it so strong. The strength of solid iron is another effect of the strong intermolecular forces between iron atoms.

Temperature

As the temperature changes, the balance between temperature and intermolecular forces changes. At temperatures below 0°C, the intermolecular forces in water are strong enough to overcome temperature and water becomes solid (ice).

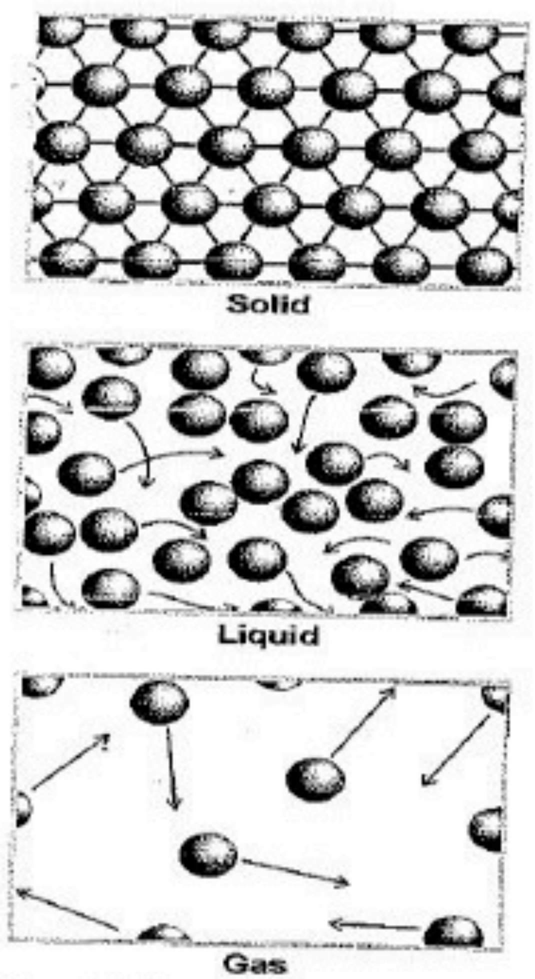


Figure 7.11: *Molecules (or atoms) in the solid, liquid, and gas phases.*

Ideal Learning Environment

- Dynamic nature of atomic/molecular systems not easily conveyed with text and static images.

- Animations help, but don't allow students to construct knowledge. Student is passive learner.

- **Models which are computed in real-time allow users to probe the simulation by changing parameters. Student becomes an active learner.**

The Modeling Environment:

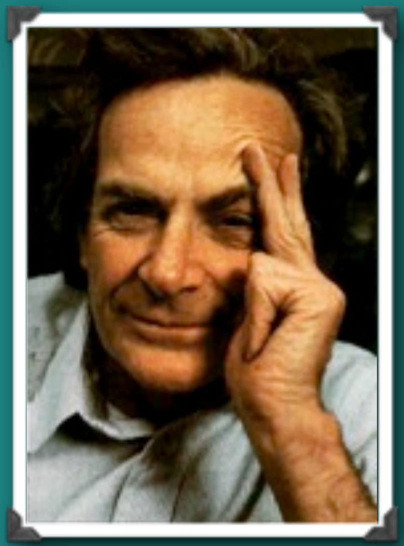
Molecular Workbench – a molecular dynamics tool.

The Molecular Workbench – a molecular dynamics tool.

- Open-source cross-platform molecular dynamic engine.
- Calculates complex real-time interactions between atoms and molecules.
- User friendly interface for creating custom model-based activities.

A concise summary of the last 100 years of science is that atoms and molecules are 85% of physics, 100% of chemistry and 90% of modern molecular biology.

–Leon Lederman

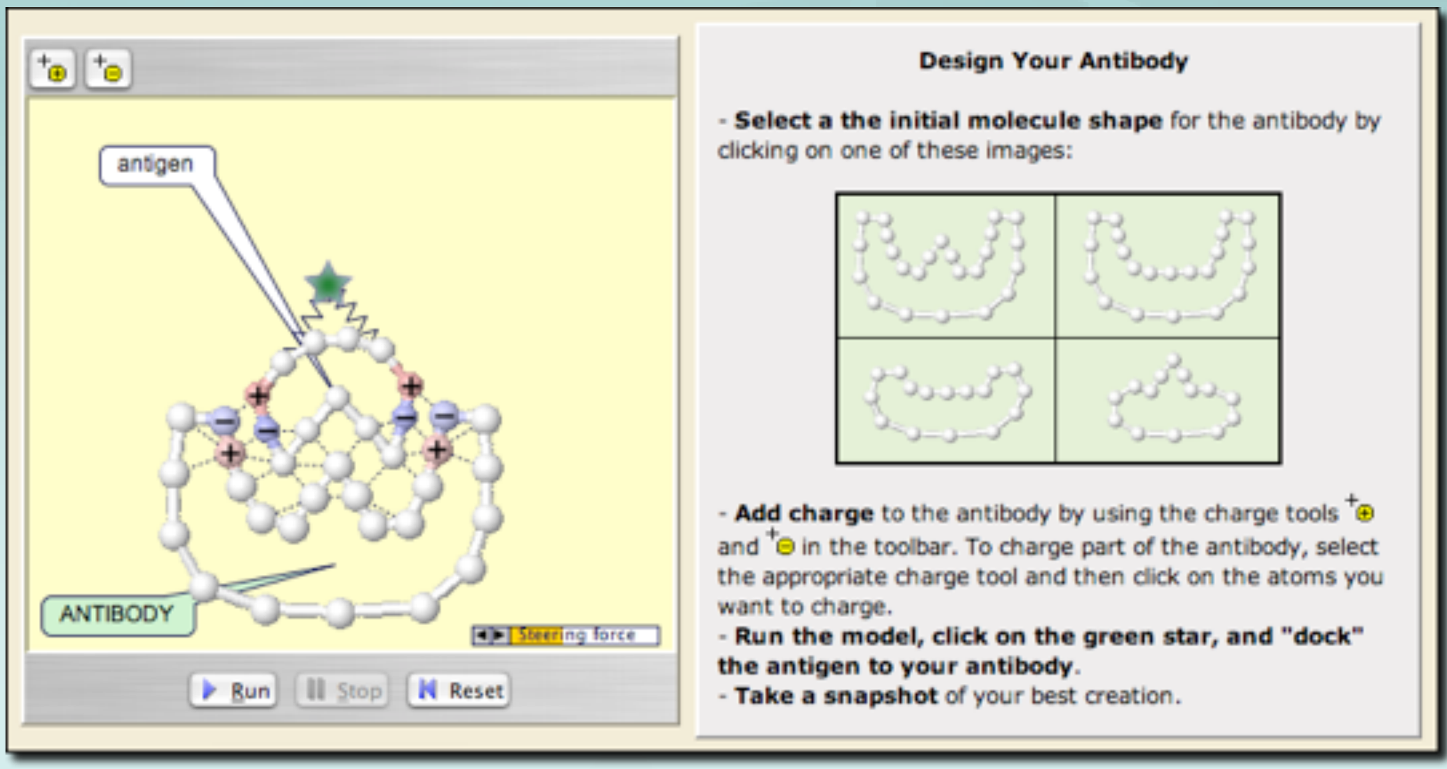


... all things are made of atoms — little particles that move around in perpetual motion, attracting each other when they are a little distance apart, but repelling upon being squeezed into one another.

– Richard Feynman

The Modeling Environment

- 2D and 3D Molecular Dynamics Models
- 3D Exploration of Static Molecular Representation
- Flash based models



- Quantum physics - tunneling, bonding, time dependent Schrodinger representations
- Abstract dynamic models of DNA, RNA and proteins

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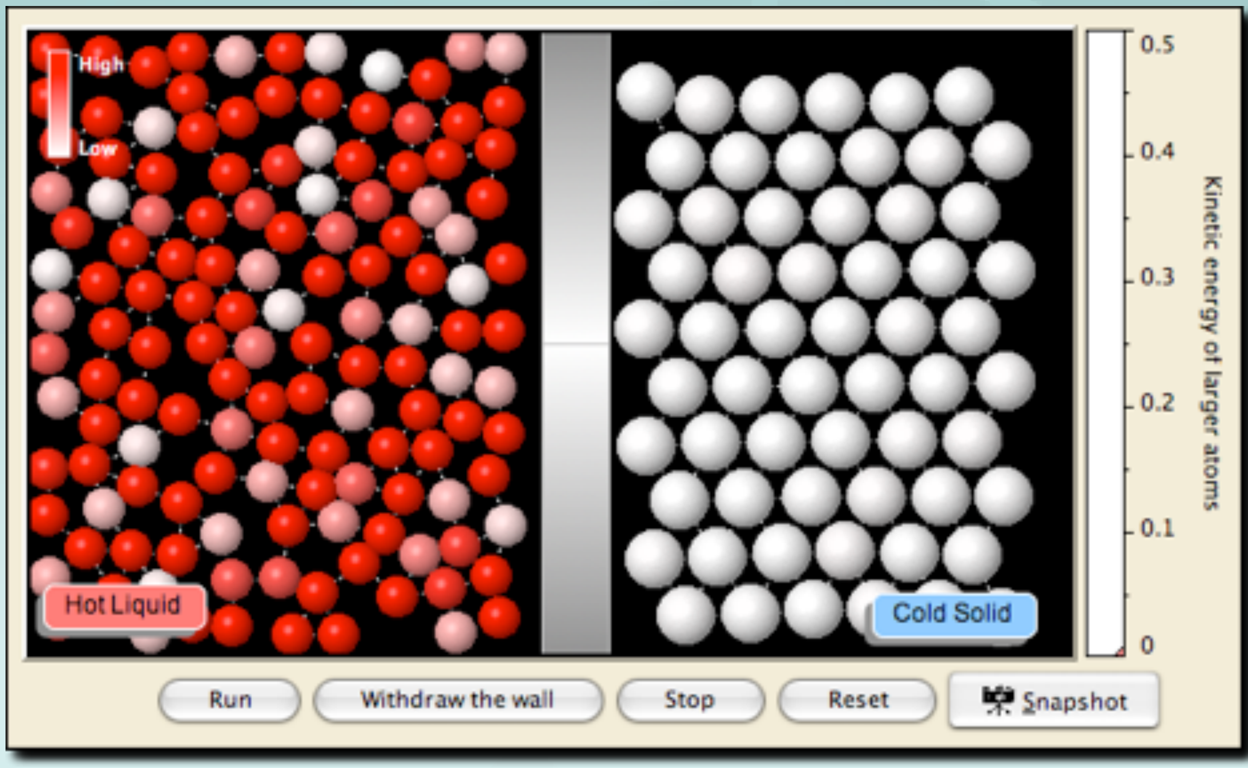

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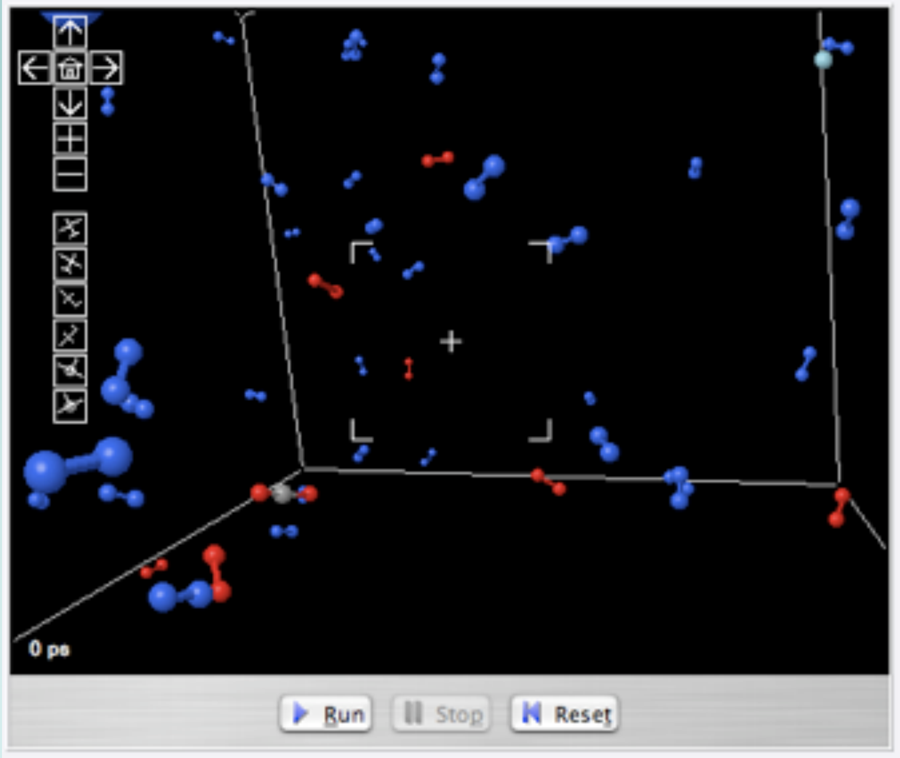

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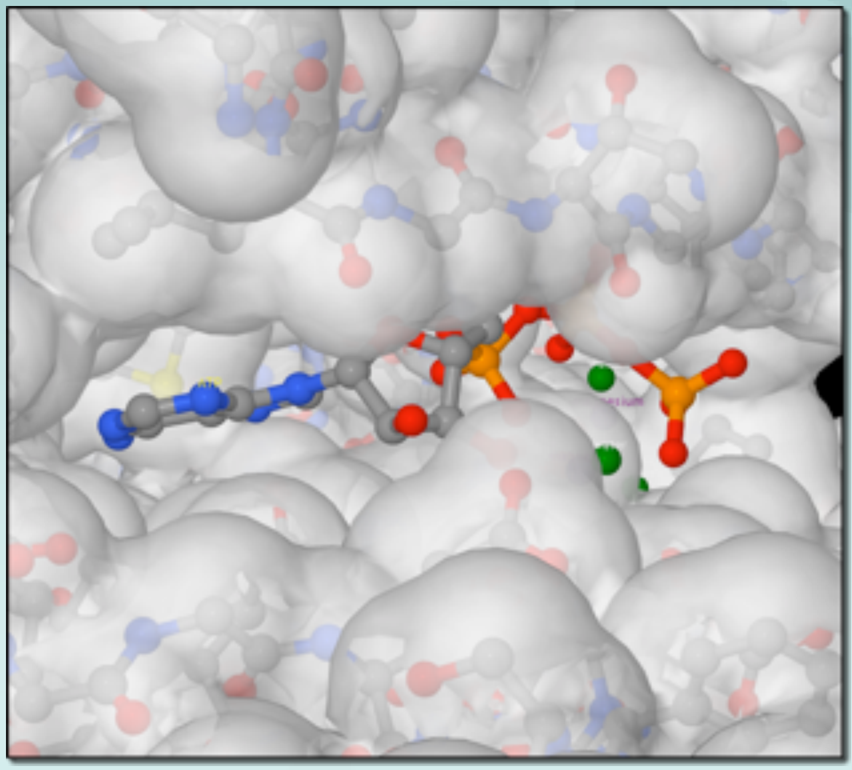

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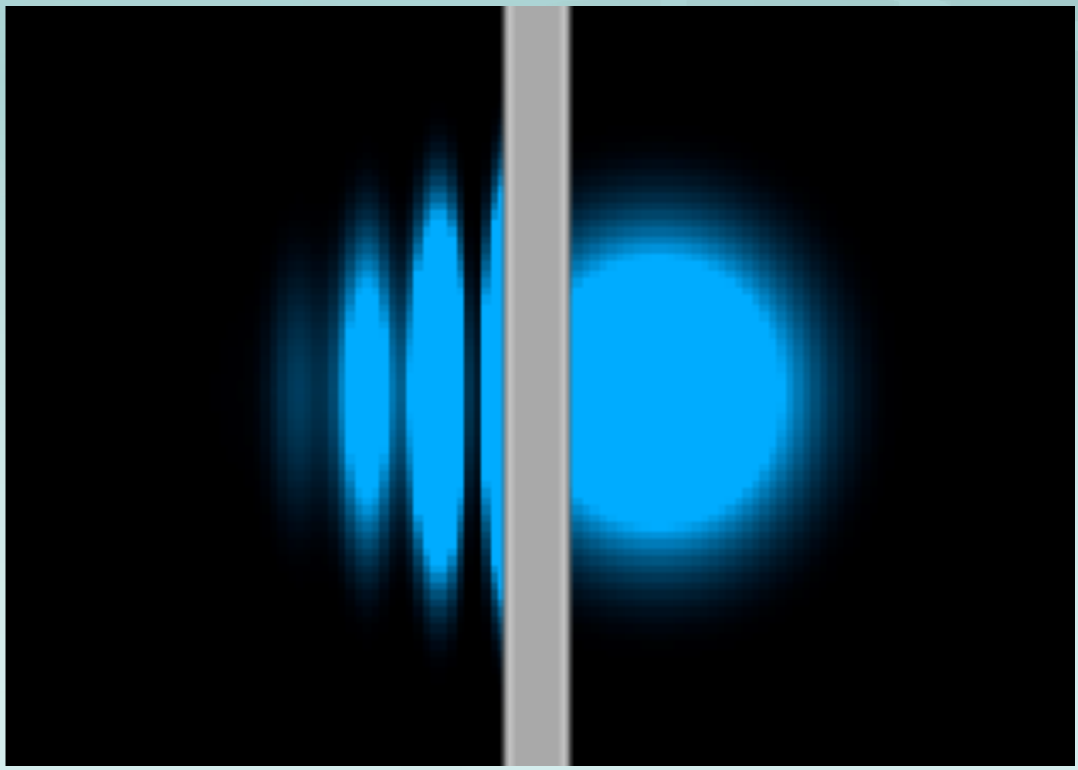

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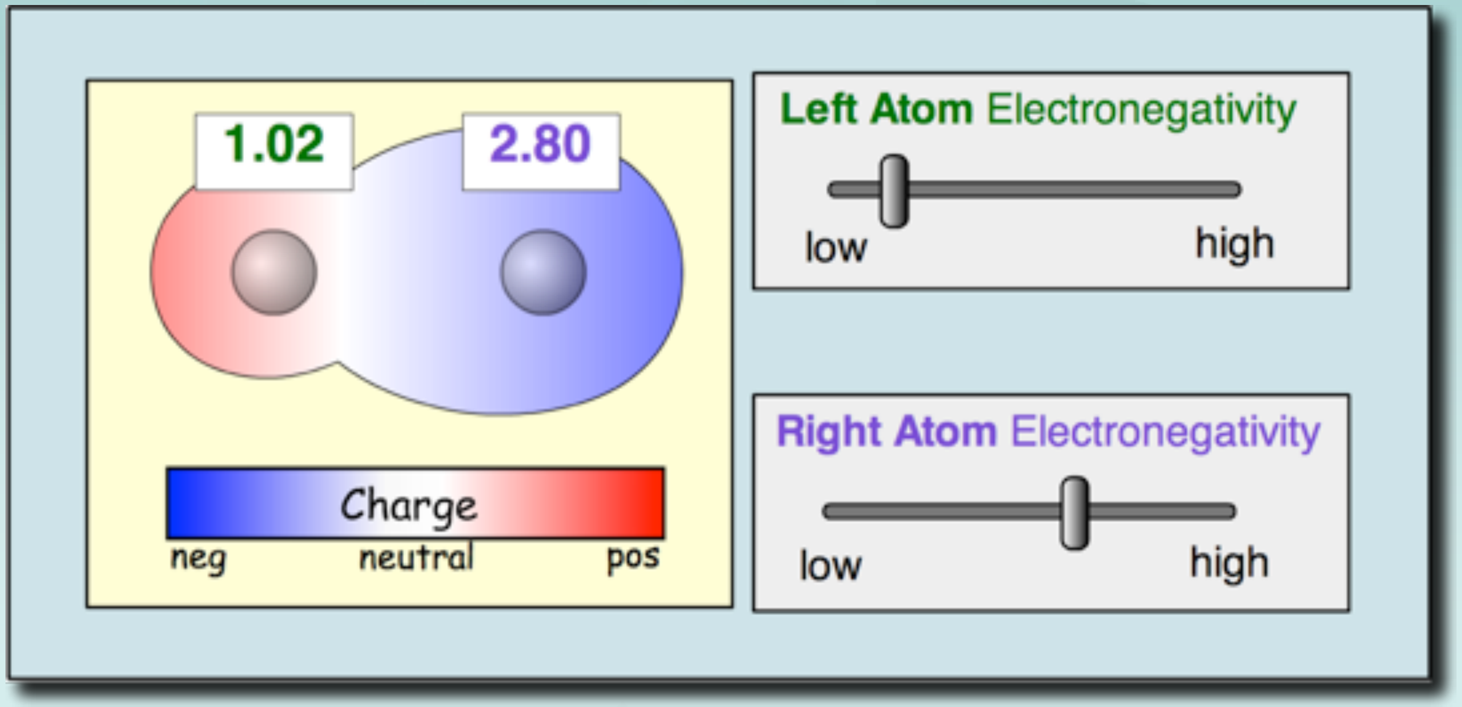

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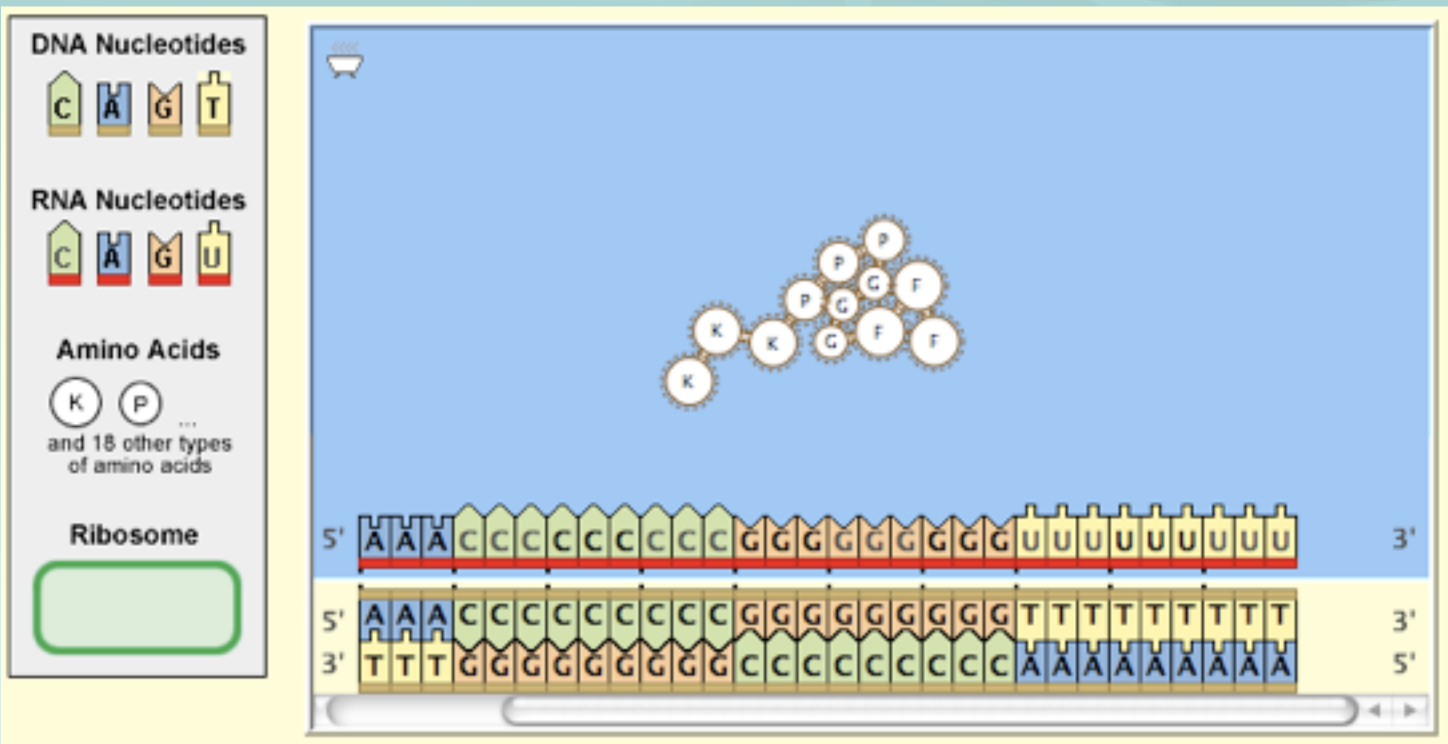
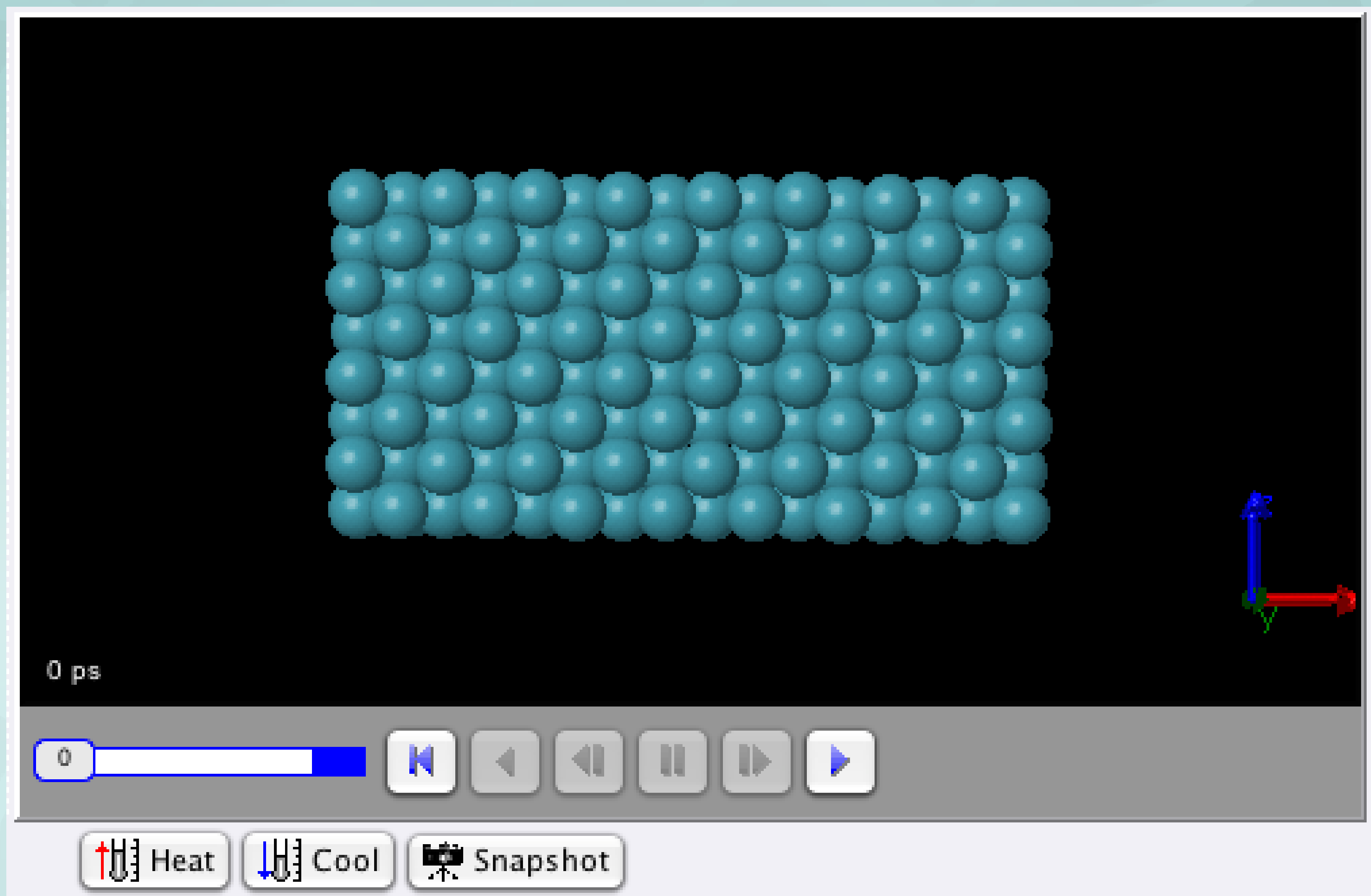


Dynamic Phase Change Model

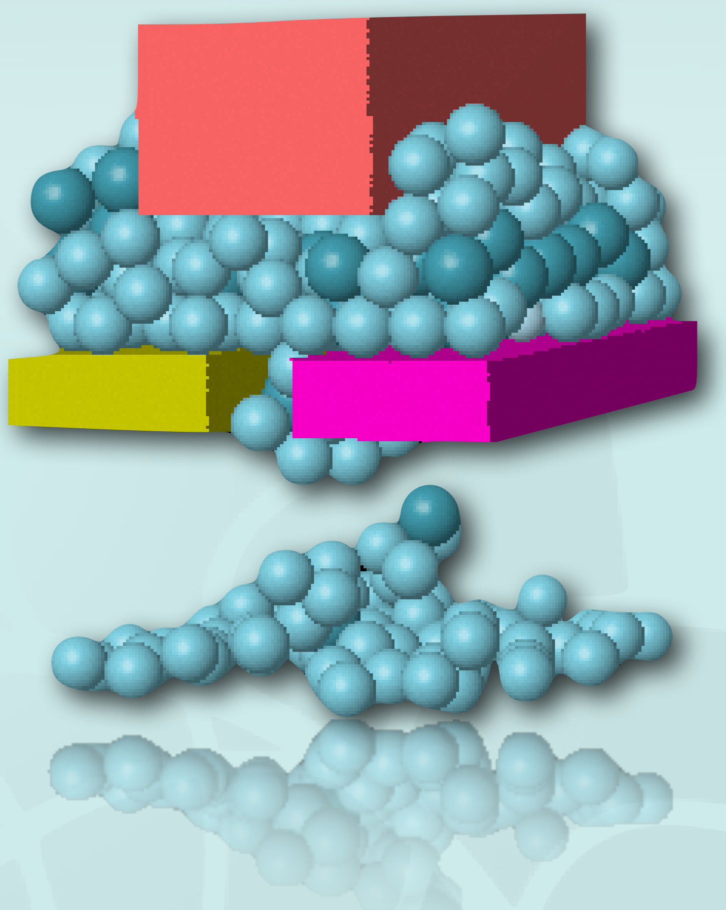


Other Reasons to Like Models

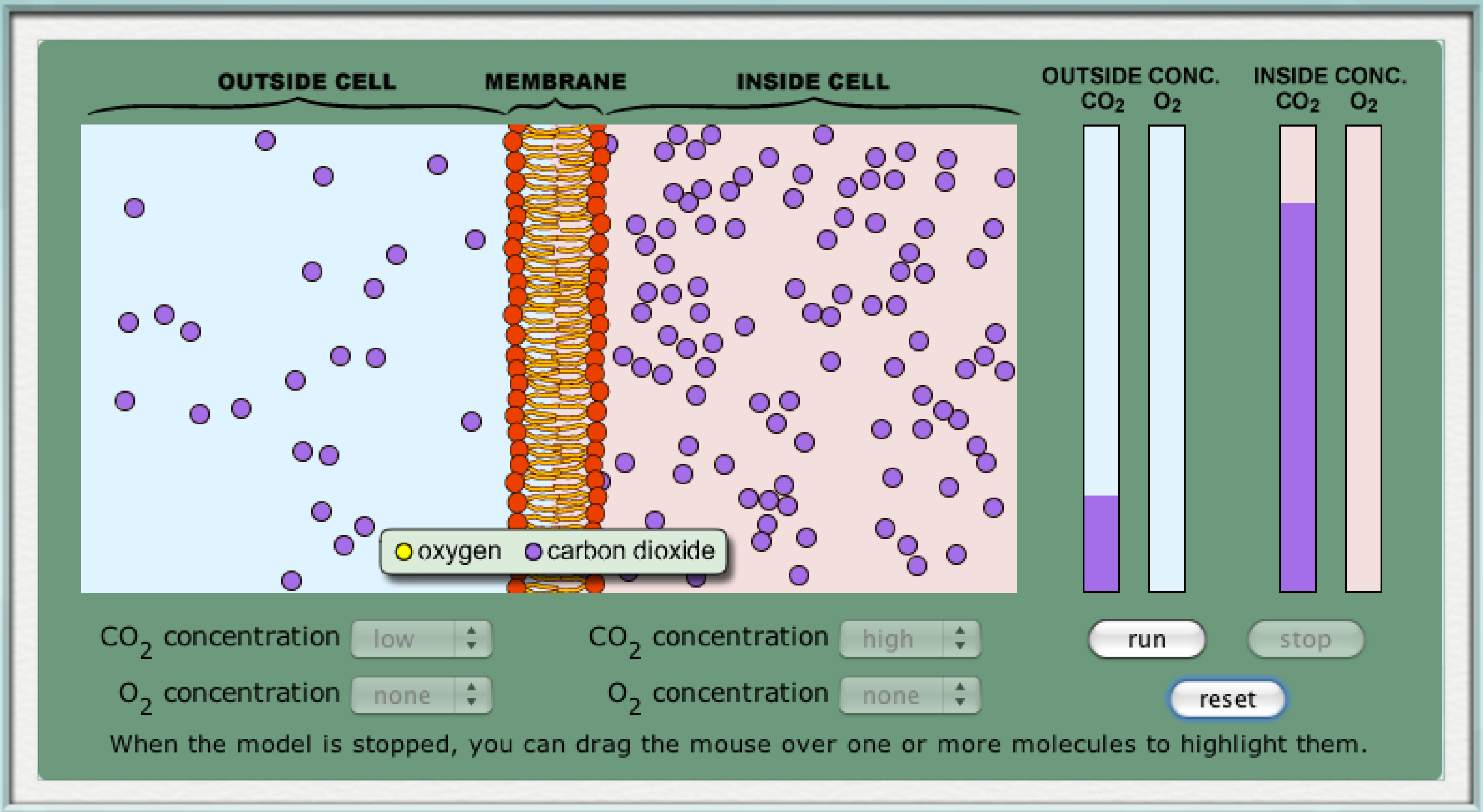
- Help to provide a concrete scaffold for new abstract concepts.

- Can be used in guided inquiry mode.

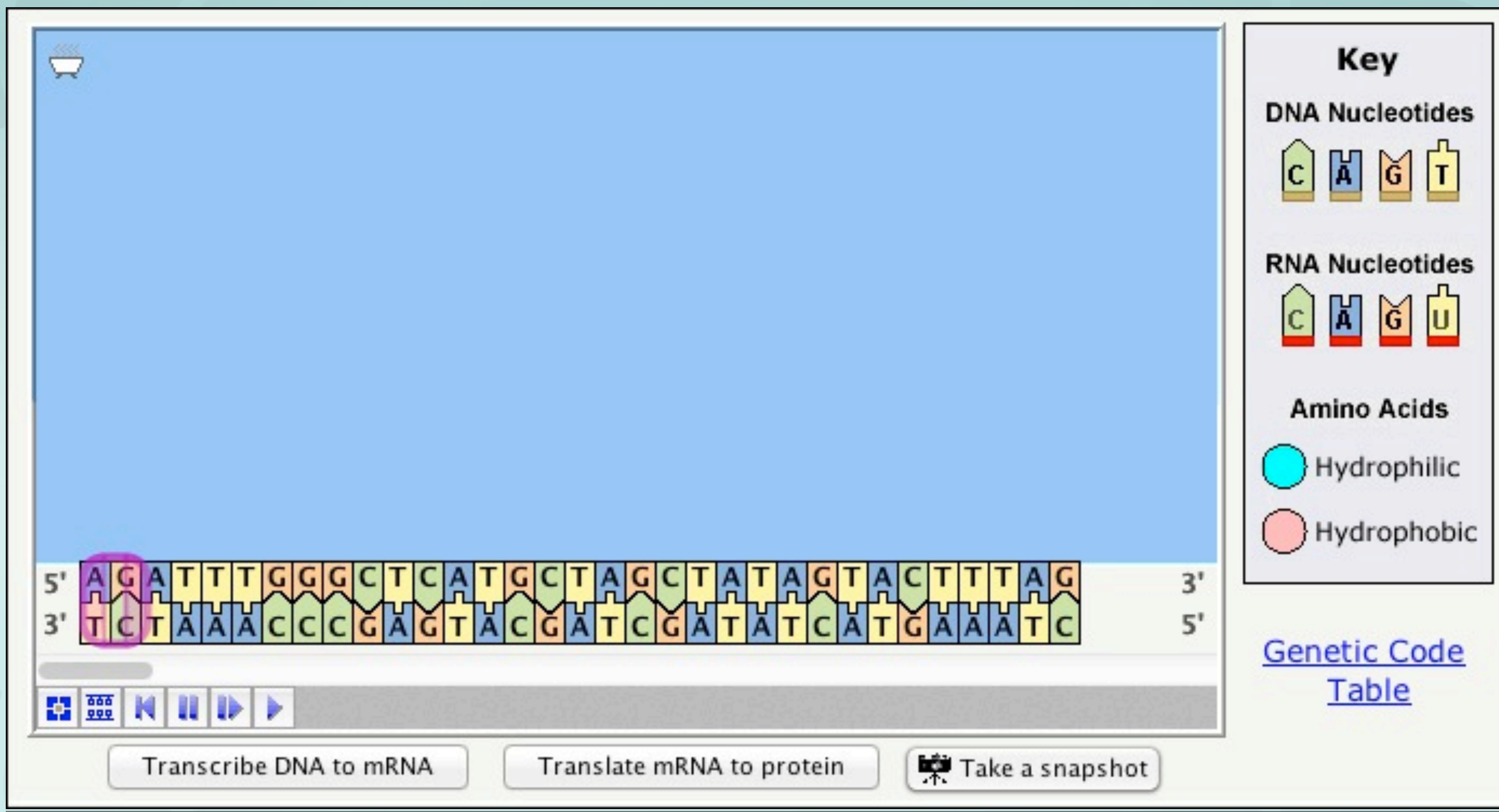
- Promotes reasoning and supporting ideas with evidence.



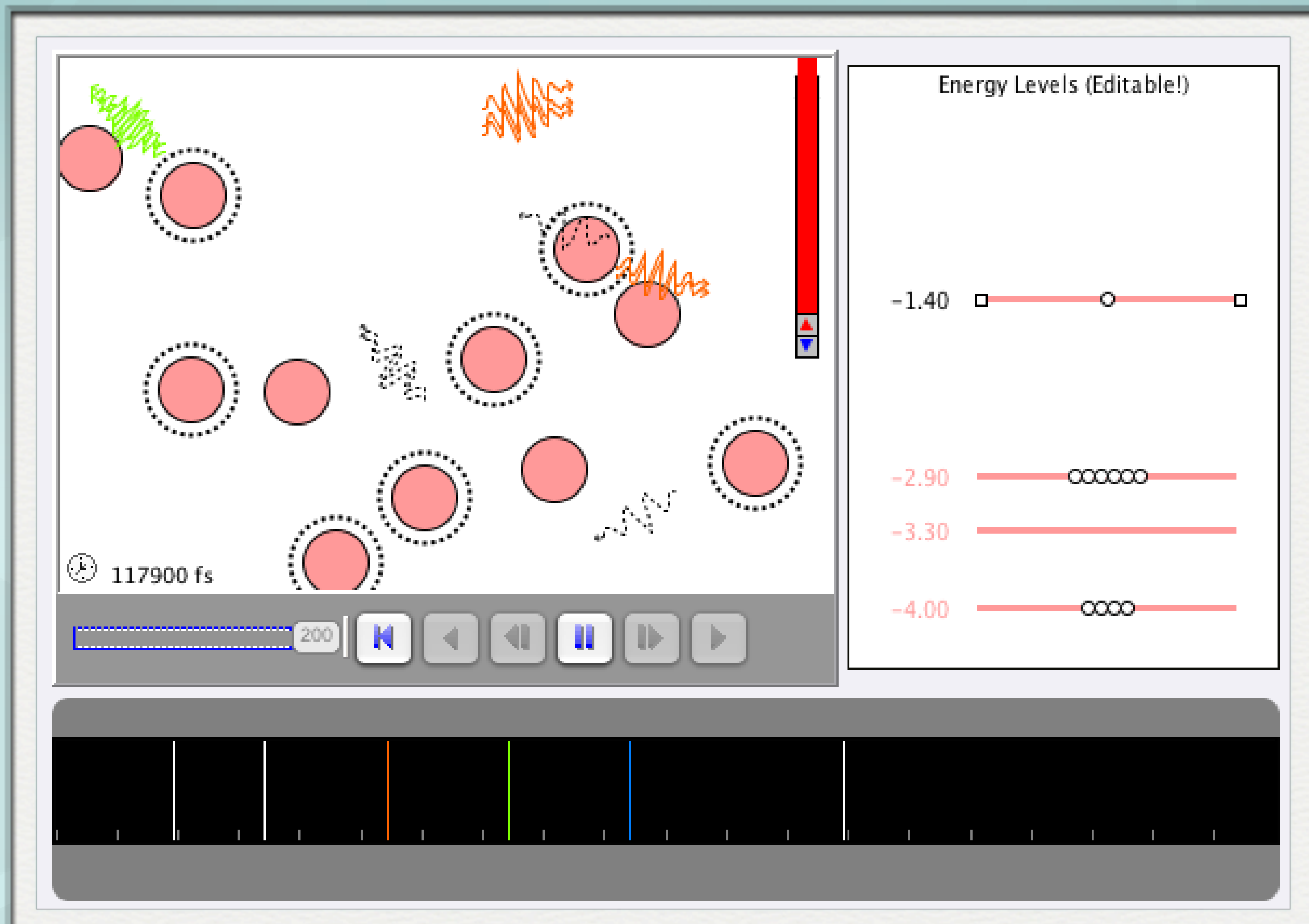
Biology - Equilibrium



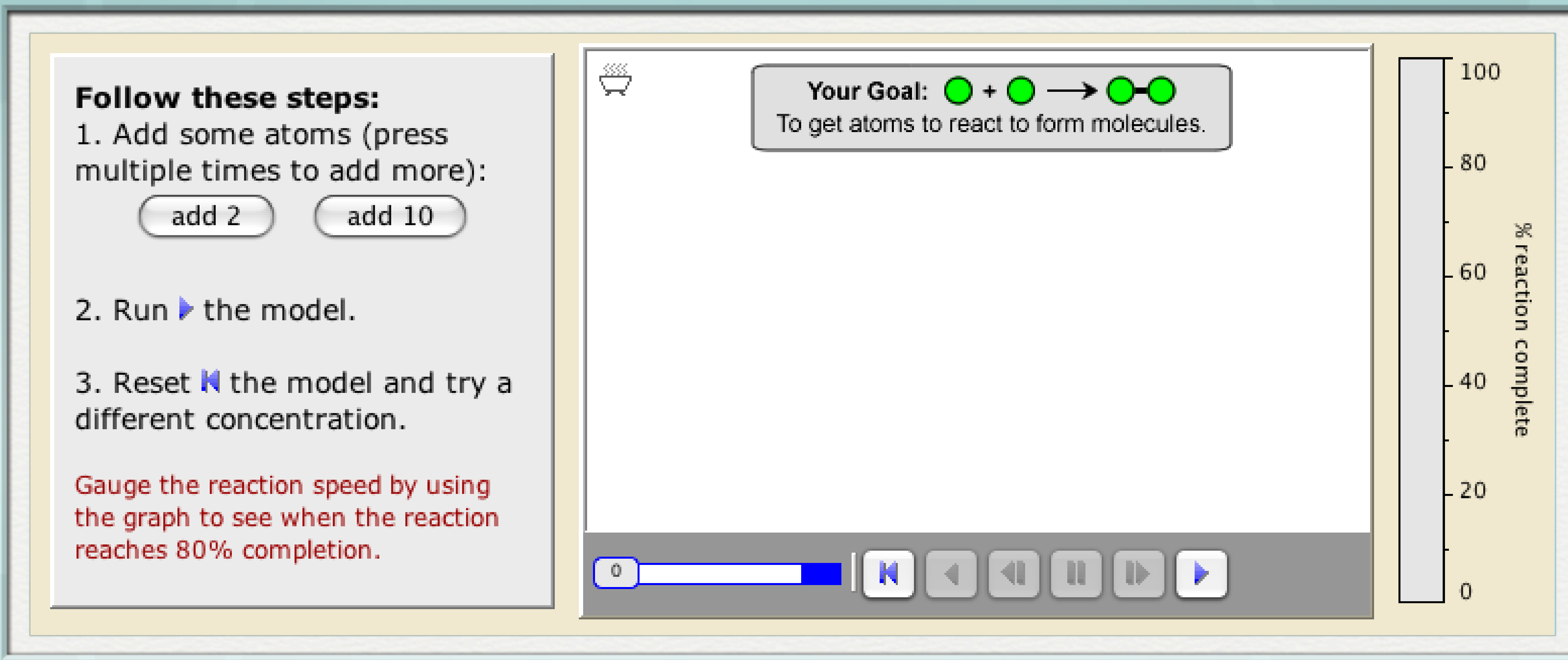
Biology - DNA to Proteins



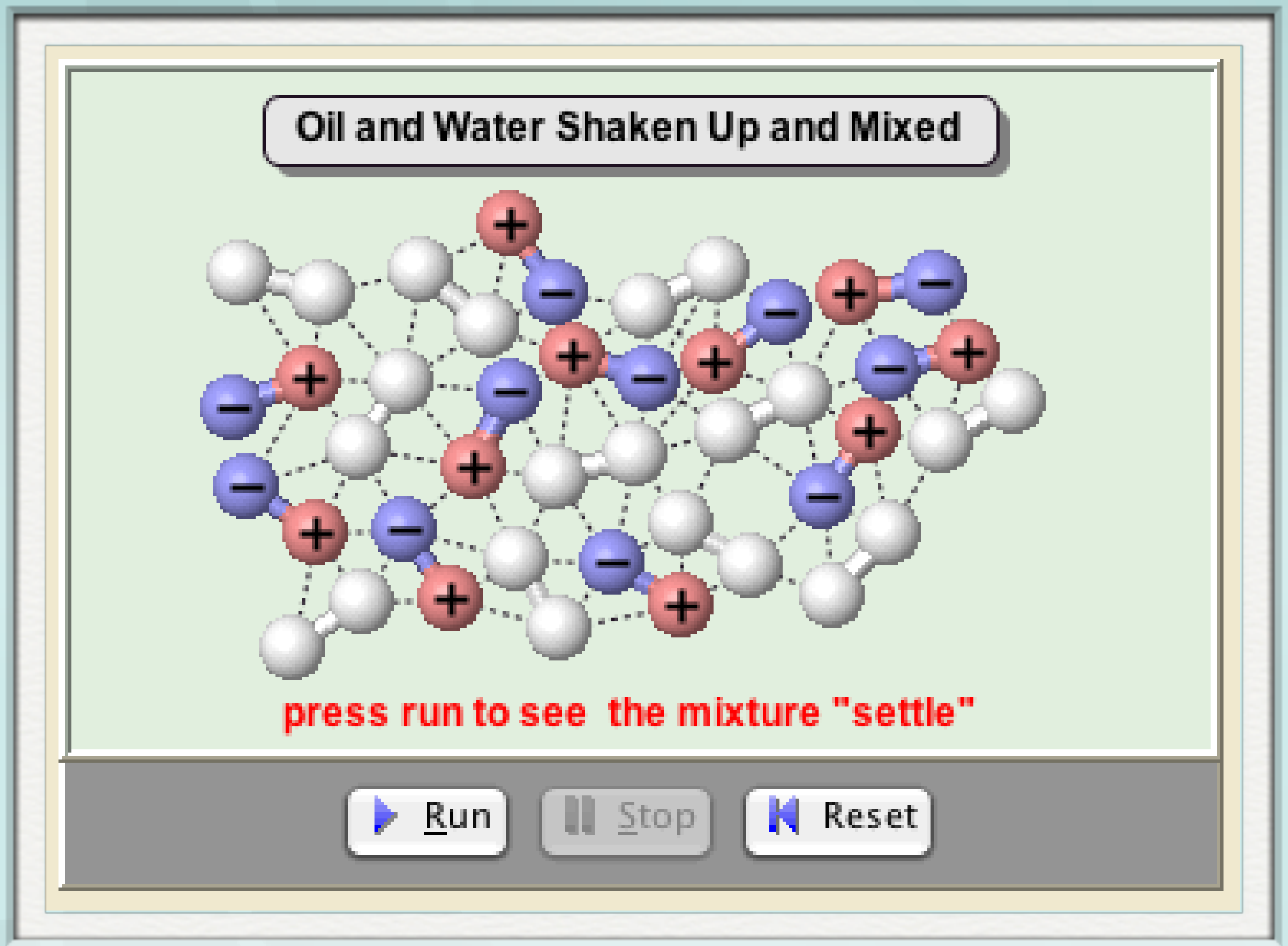
Phys/Chem - Spectroscopy

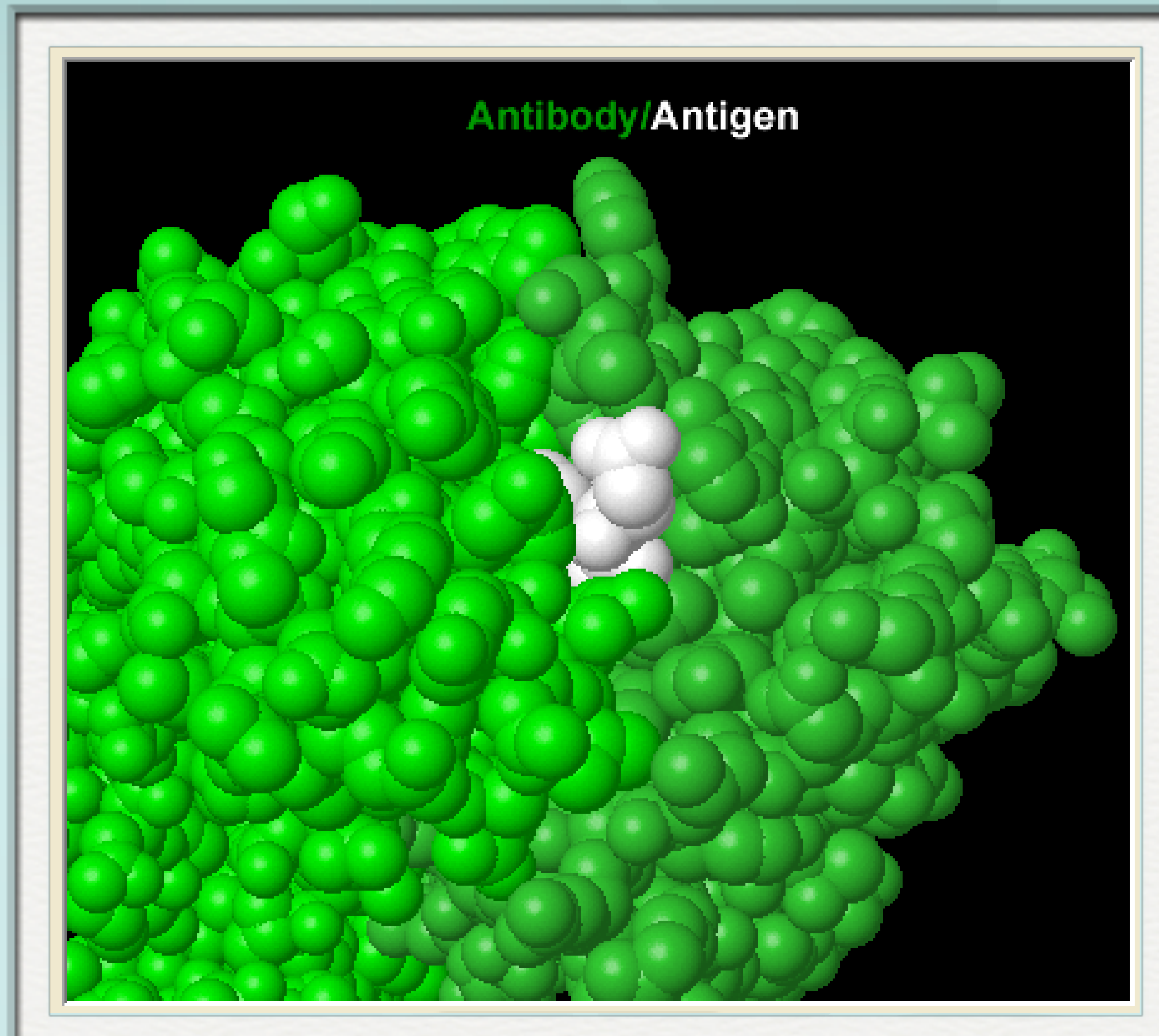


Chemistry - Chemical Reactions

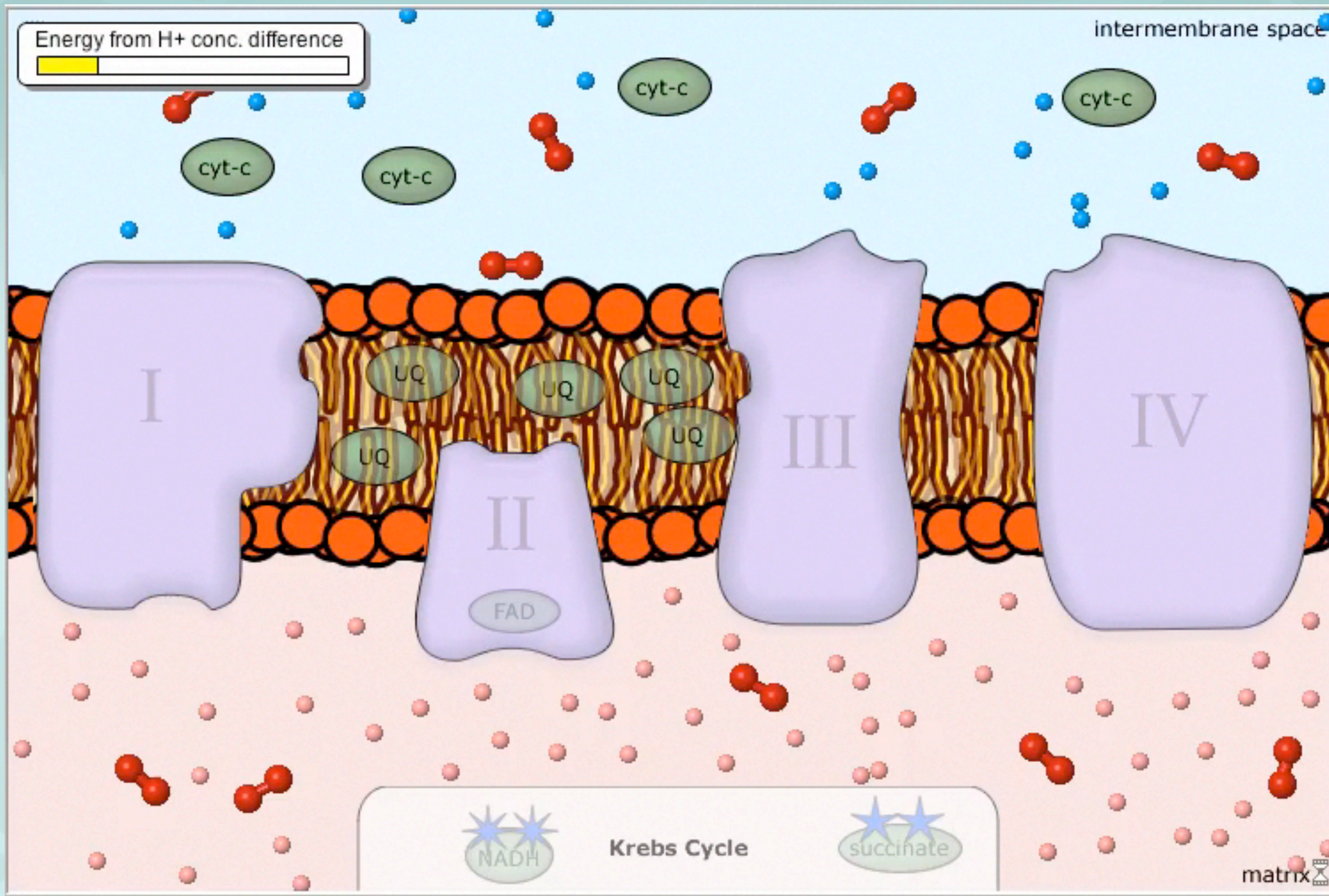


Chem/Bio - Intermolecular Attractions

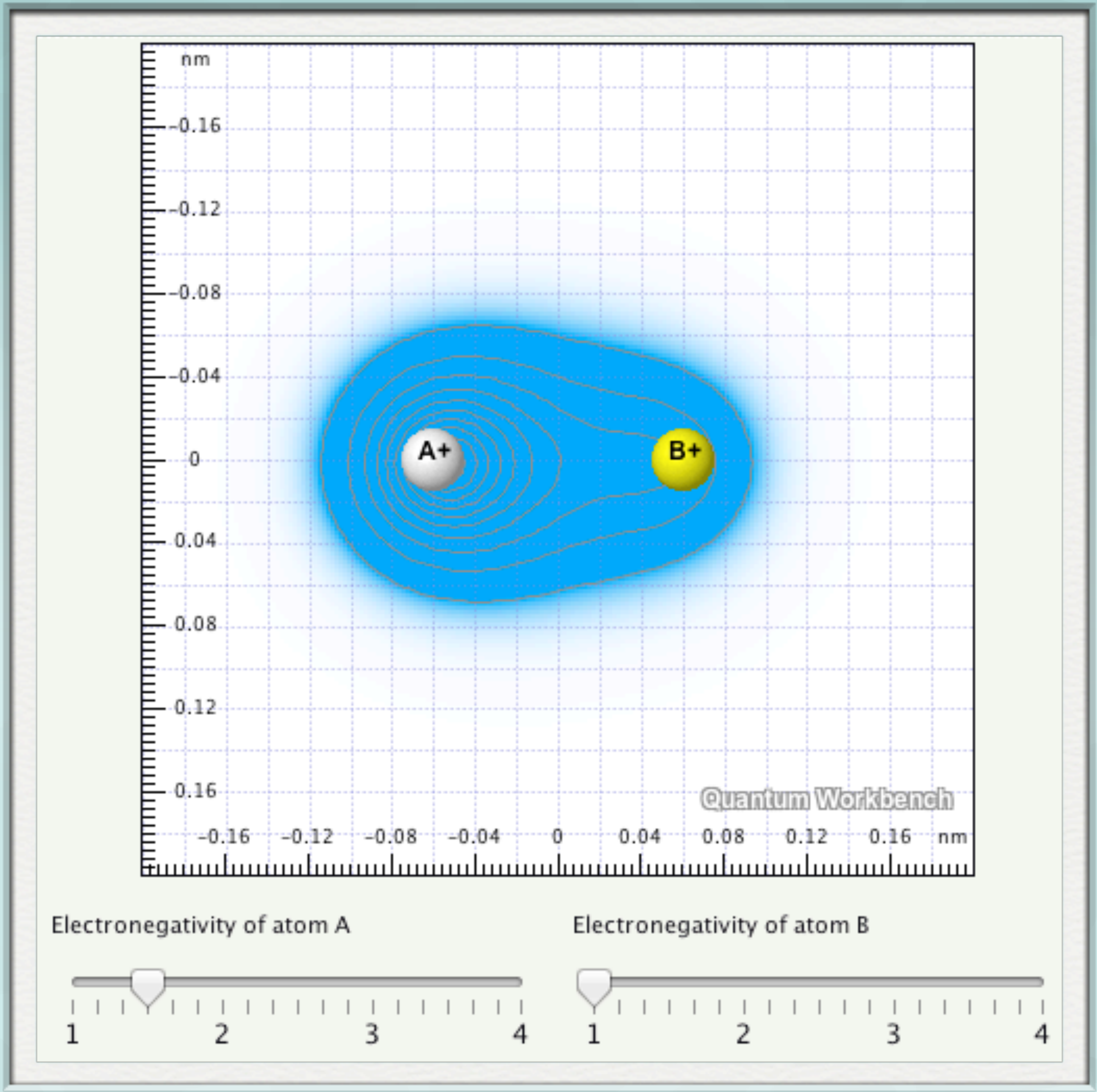




Modeling Macro-level Systems
the electron transport chain



Quantum Chemistry - Polar Bonds



Embedded Assessments

What is true of the rate at which molecules move into and out of the cell at equilibrium?

- A. More move into the cell than out of it.
- B. More move out of the cell than into it.
- C. Equal amounts move into and out of the cell.
- D. They move randomly, so it is not predictable.

Check Answer

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Embedded Assessments

Cells generally stay in equilibrium with their surroundings. What are two ways you know the cell has reached equilibrium?

- [ ] A. Water stops flowing into and out of the cell.
- [ ] B. The concentrations inside and outside of the cell are the same.
- [ ] C. The osmotic pressure inside and outside of the cell is the same.
- [ ] D. The cell gets as small as it possibly can.

Check Answer

Embedded Assessments

Describe how the chemical energy in ATP is converted into electric potential energy. (hint)

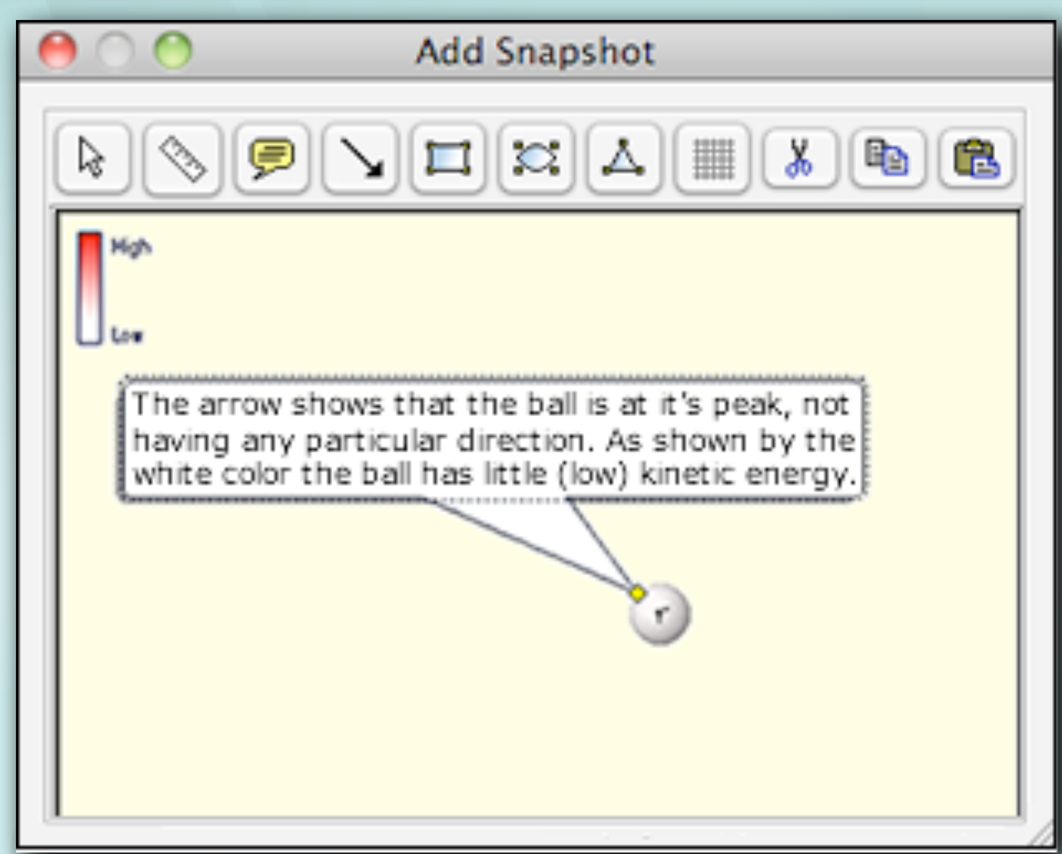
Embedded Assessments

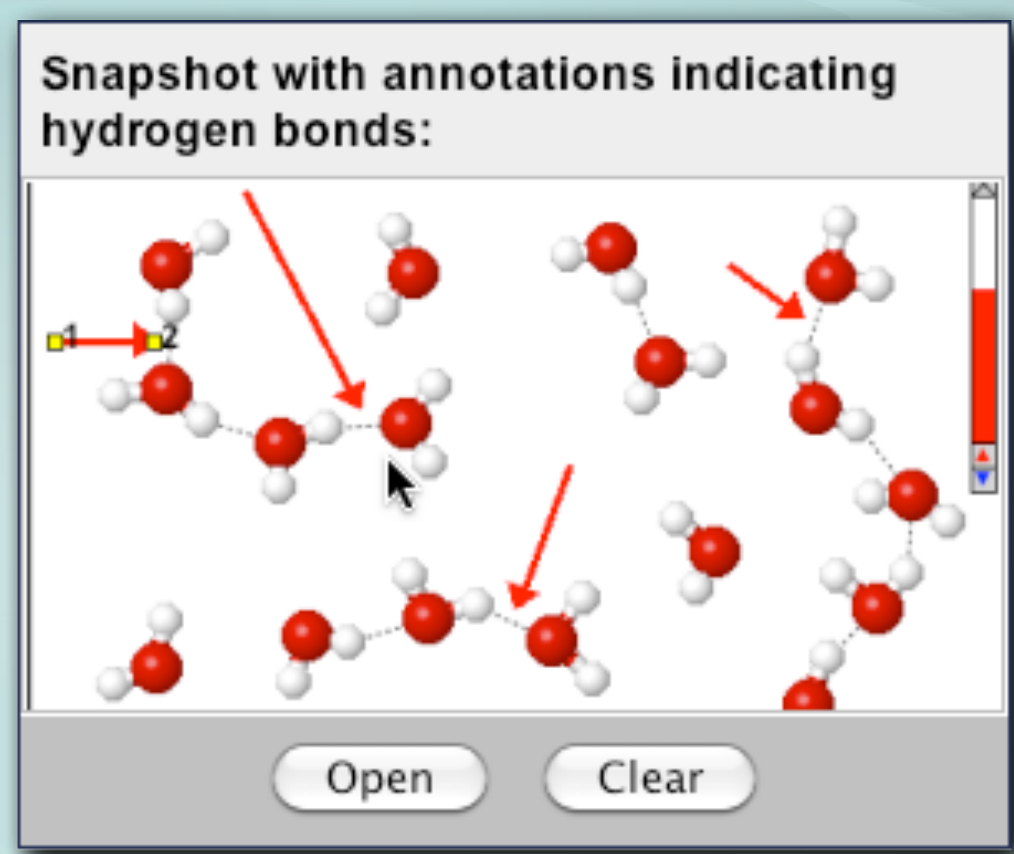
Set up the model so that it is IN equilibrium. Then use the "snapshot" button below the model to take a picture of your setup. Use the "open" button below to place that image here.

Click the Open Button,
and then drag a thumbnail here.

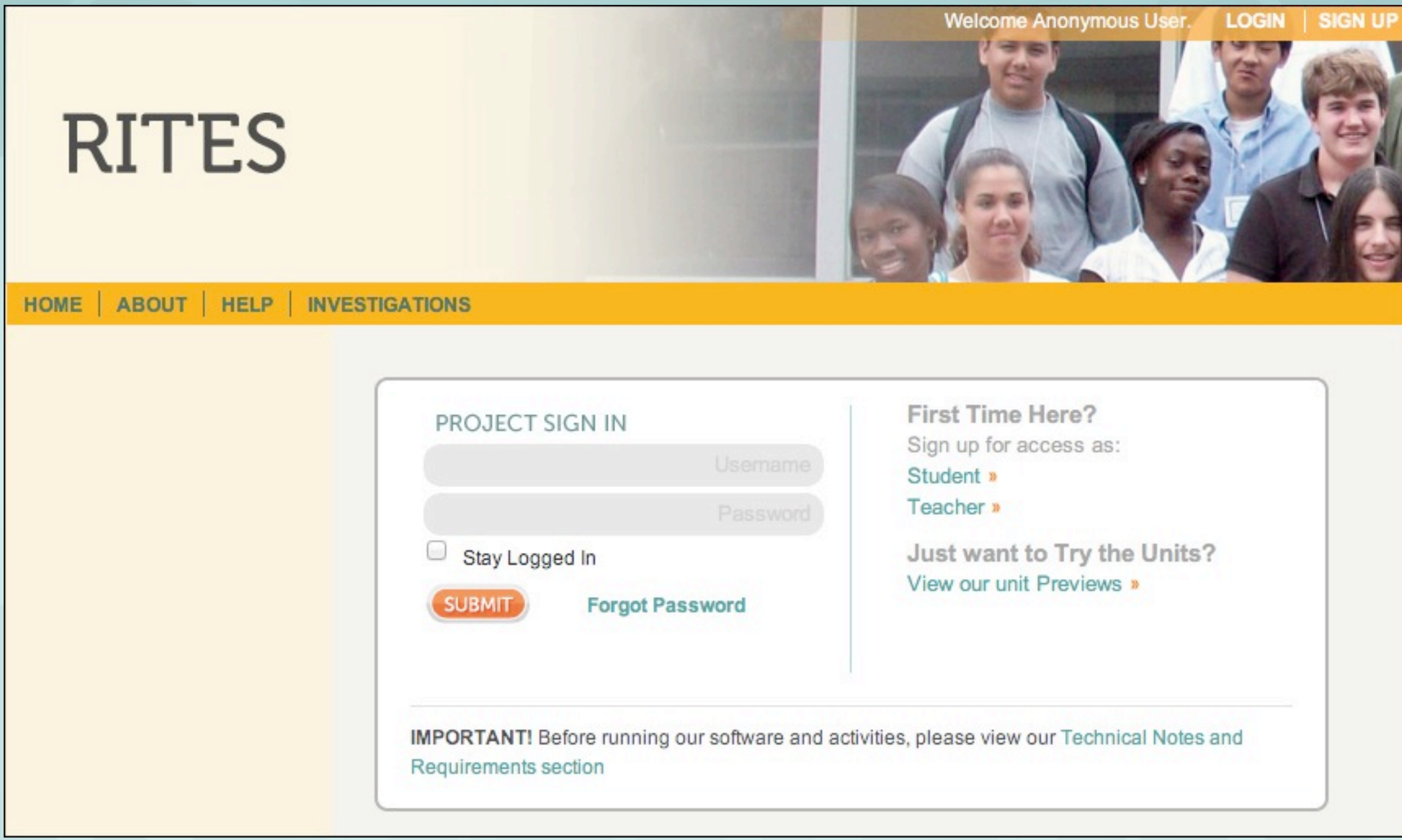
Open Clear

Embedded Assessments





Previewing Models and Using a Portal



Student Quotes

“It can be difficult to visualize some of the more complex concepts of chemistry, so the visual models can really help [me] understand these concepts.”

Student Quotes

"The best part of using the SAM tools was to be able to see things that we would not normally be able to see with labs. The tools were fun and easy to use, the instructions were straightforward and I found it interesting to watch the simulations."

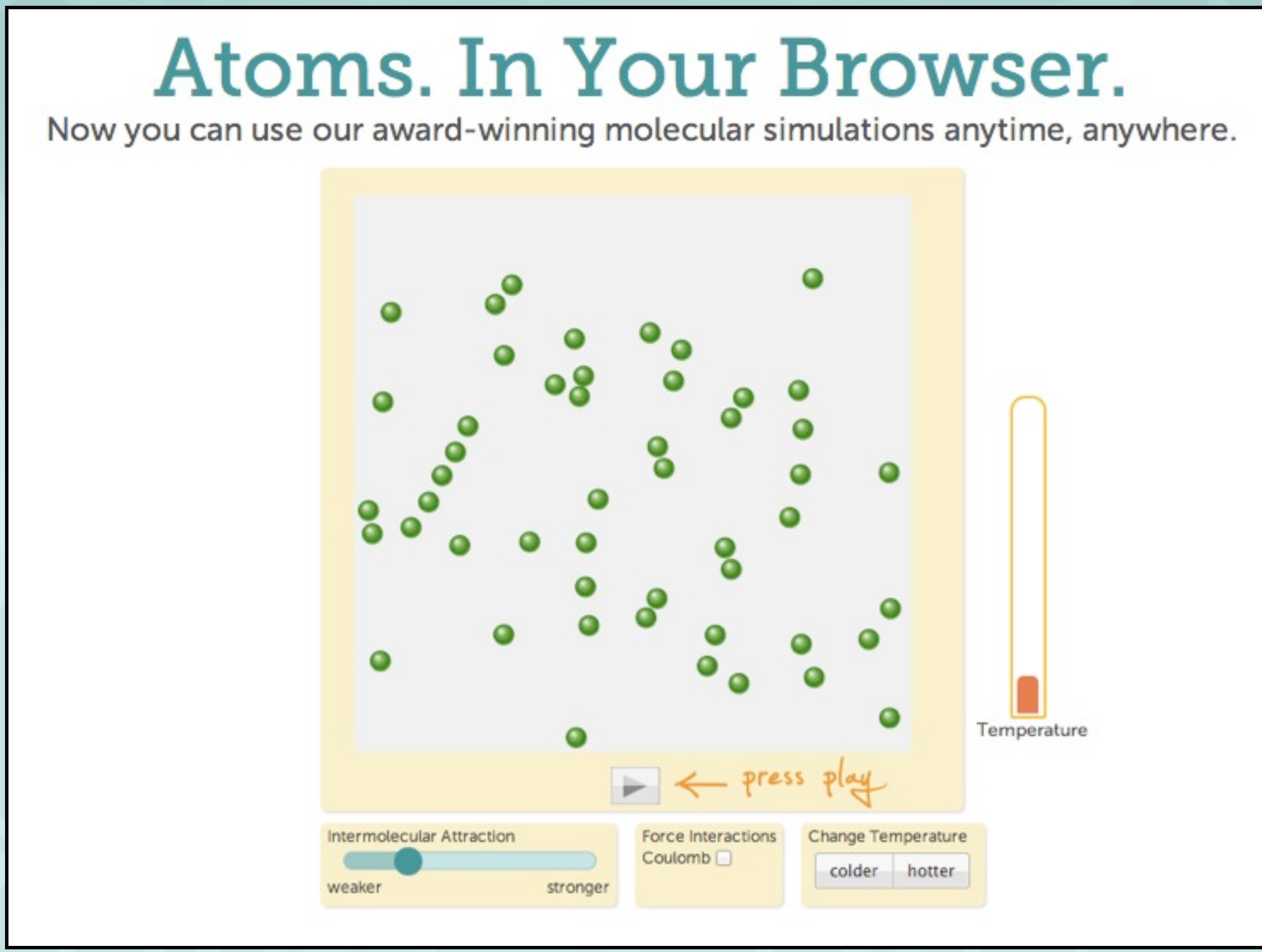
Teacher Quotes of Their "Best Experiences"

"In a lesson on electrostatics (not the RI-ITEST model) a student referred back to something he had learned while doing a RI-ITEST activity. The classroom discussion went far more smoothly as a result of the students having learned about atomic structure via the interactive models.

Teacher Quotes of Their "Best Experiences"

"Students begging to do more units on the computer … [and] … writing more than they usually do in response to something they did only moments before."

Next Generation Molecular Workbench



Possible Modes of Usage and Best Practices

- During class (full activity or in “projector mode”).
- Outside of class
- Through one of our portals or via MW directly.
- Via a hyperlink embedded in course.
- Individual models embedded into course materials

Customization

- Using MW as standalone app.
- Customizing Portal based activity.

- NSDL grant will help pull together disparate resources.
- Parallel work on Next Gen MW will focus around making customized versions of models and activities.

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Finding Models and Activities - Current and Past Projects

- Science of Atoms and Molecules (SAM/RI-ITEST)
- High Adventure Science
- Geniverse
- Evolution Readiness
- Electron Technologies
- Innovative Technology in Science Inquiry (ITSI-SU)
- Engineering Energy Efficiency

Science of Atoms and Molecules

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Geniverse

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Evolution Readiness

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Electron Technologies

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ITSI-SU

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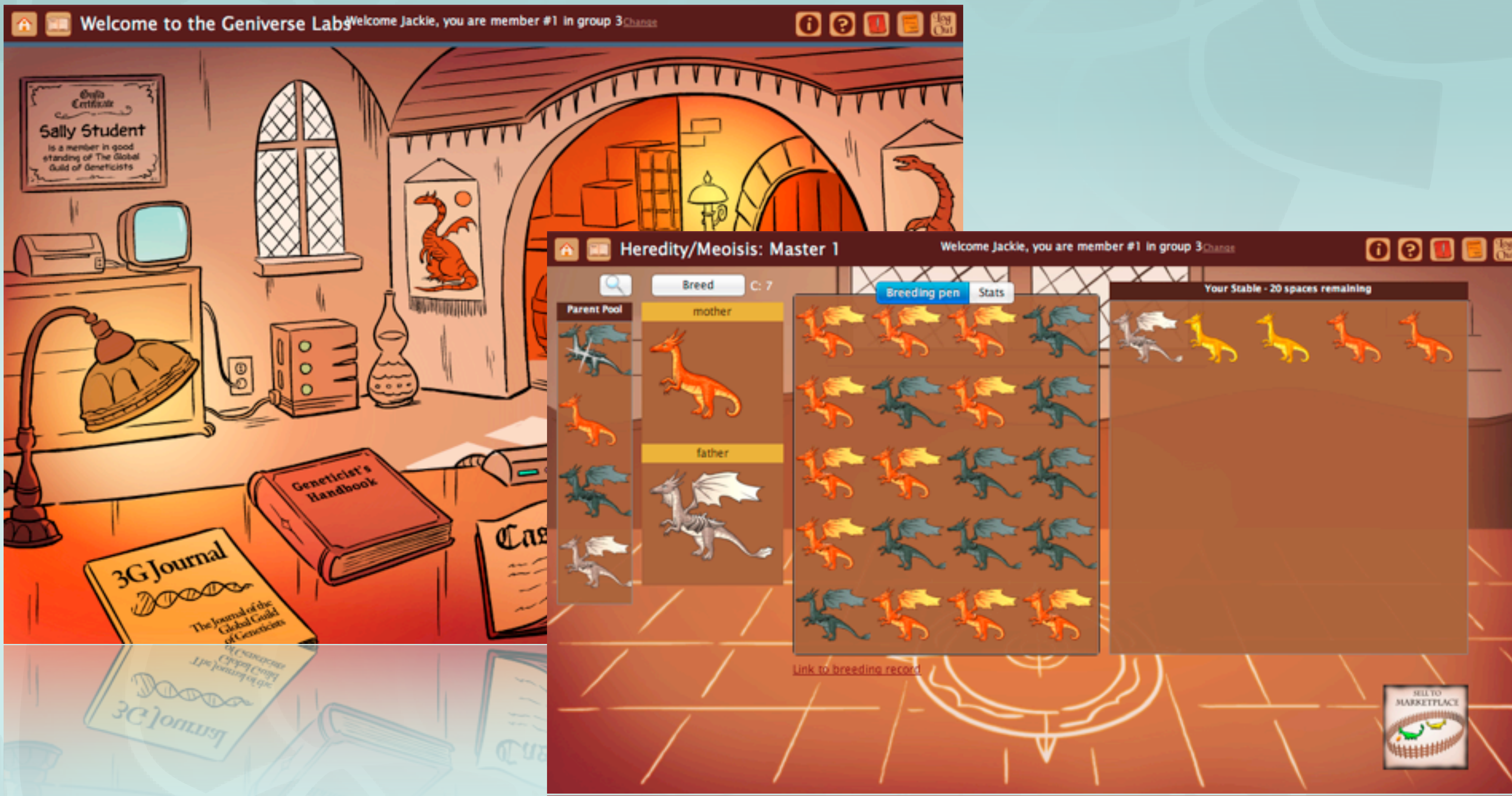
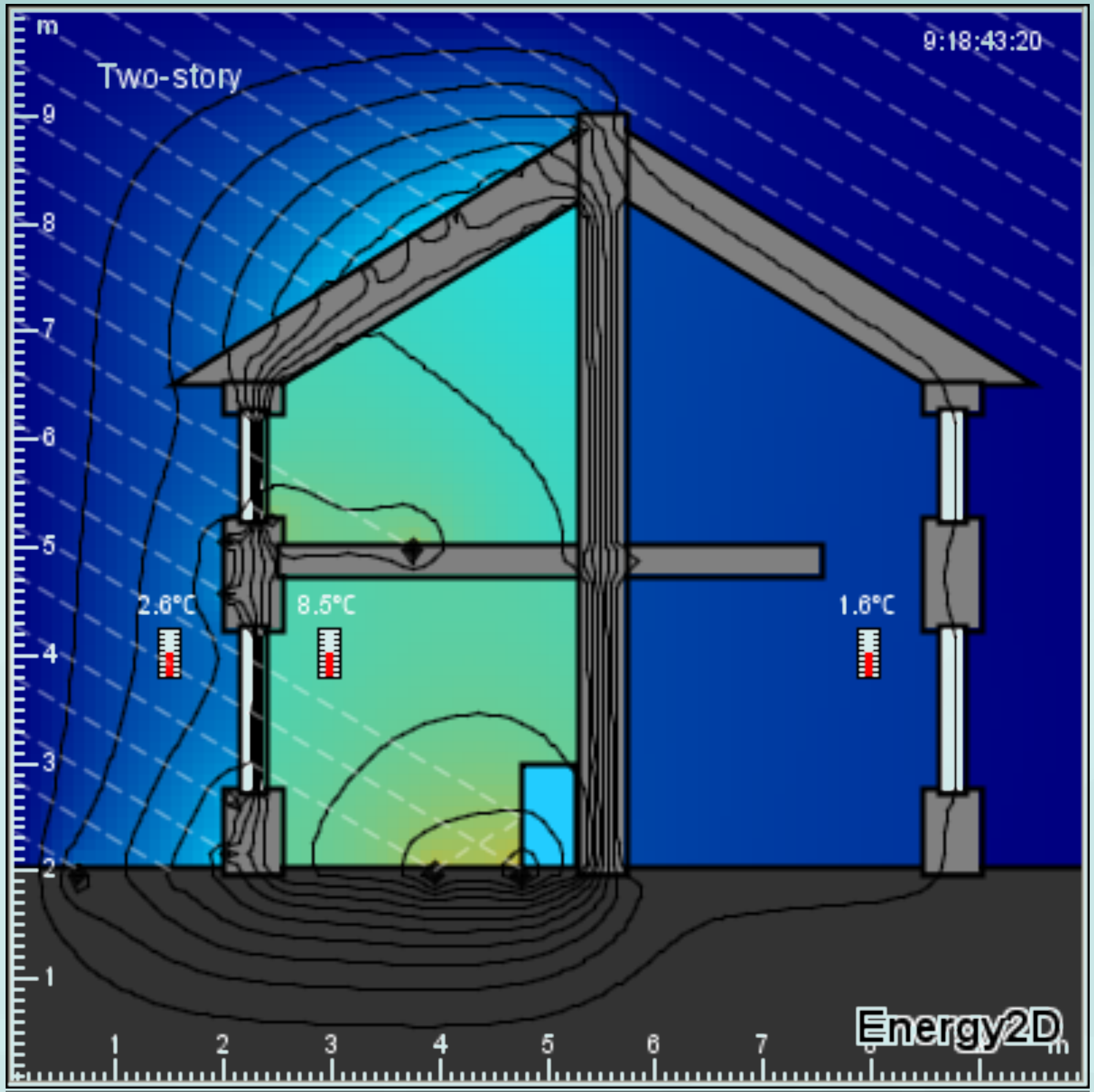
Geniverse

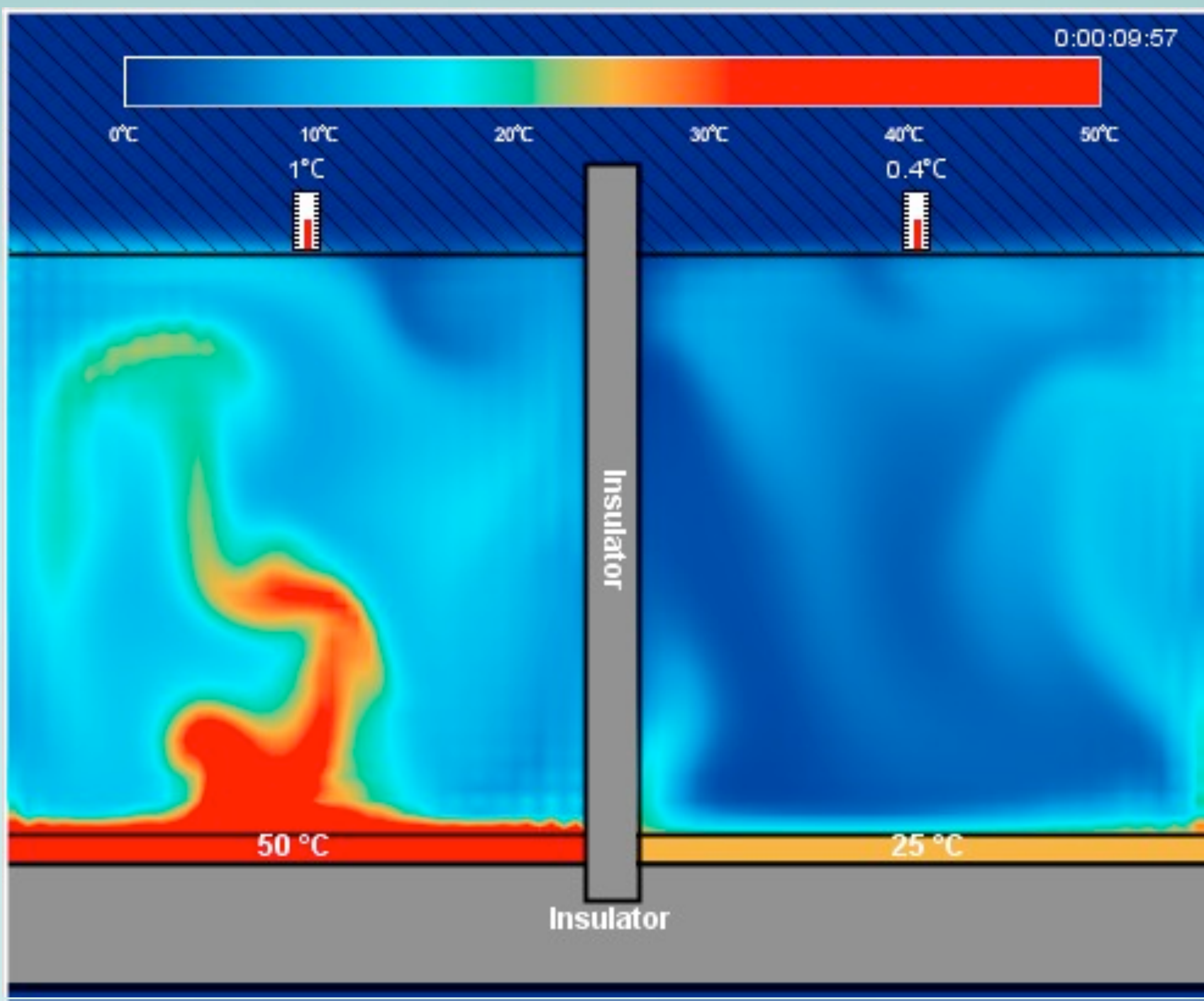


Welcome to the Geniverse Labs
Welcome Jackie, you are member #1 in group 3
Change
Sally Student
is a member in good standing of The Global Guild of Geneticists
Geneticist's Handbook
3G Journal
The Journal of the Global Guild of Geneticists
Heredity/Meoisis: Master 1
Breed
C: 7
Parent Pool
mother
father
Breeding pen
Stats
Your Stable - 20 spaces remaining
Link to breeding record
SELL TO MARKETPLACE

Design Principles



Convection



Inquiry Is Key

- Going deeper can simplify science
  - Most scientific phenomena can be explained by fundamental ideas of the atomic nature of matter, conservation of energy, Nature's tendency toward equilibrium.
  - Science through this lens is more connected - less individual facts to "memorize".
- Conceptual understanding is the goal.
- Utilize interactive models, to allow inquiry at the atomic level.
- Teachers are essential for inquiry approach to work.

Finding Materials

- Concord Consortium Activity Finder
  http://www.concord.org/activities
- Molecular Workbench Application and Database
  http://mw.concord.org
- Various Project portals
  http://www.concord.org/projects

Contact Info

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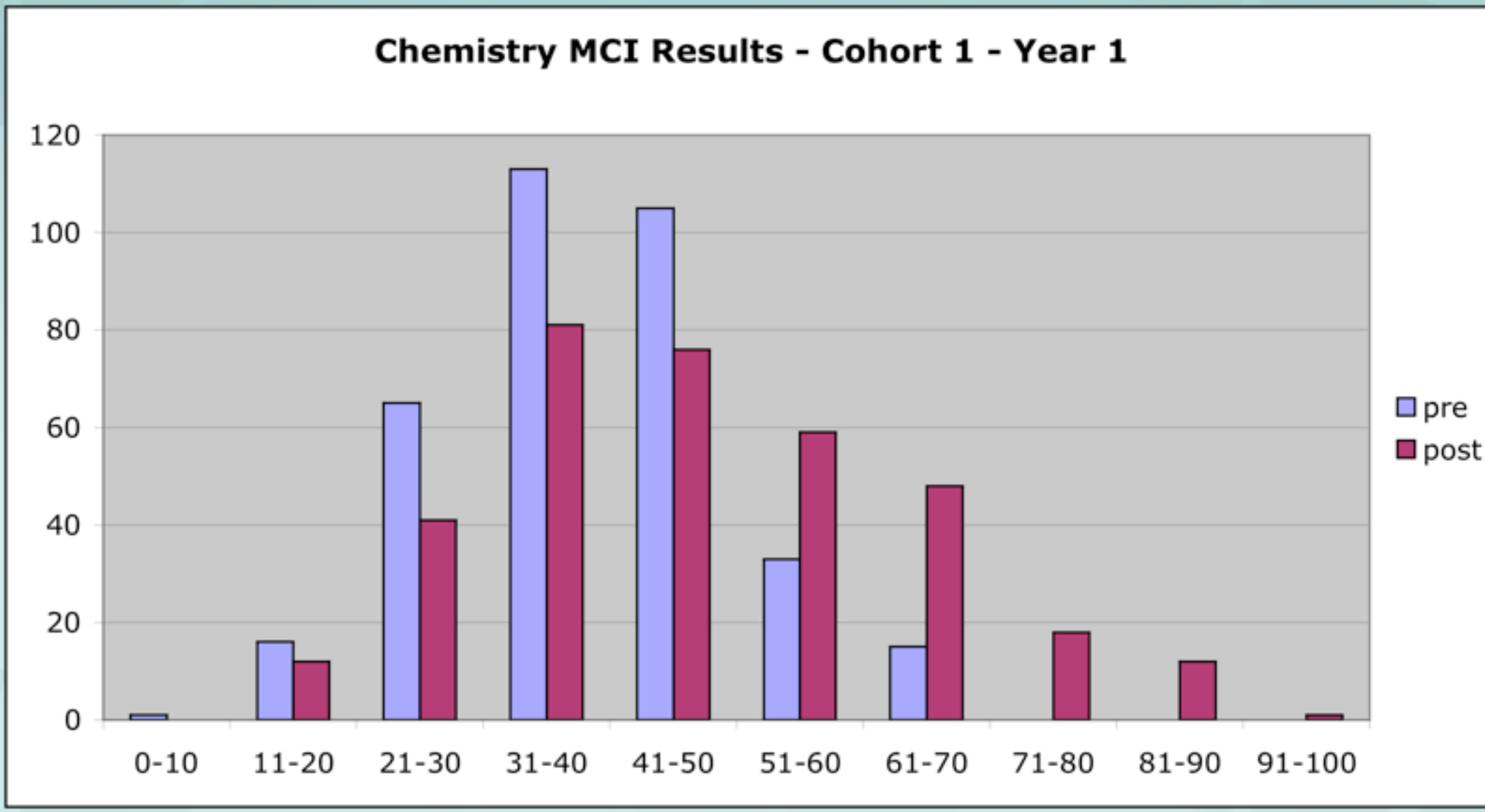
RI-ITEST Project

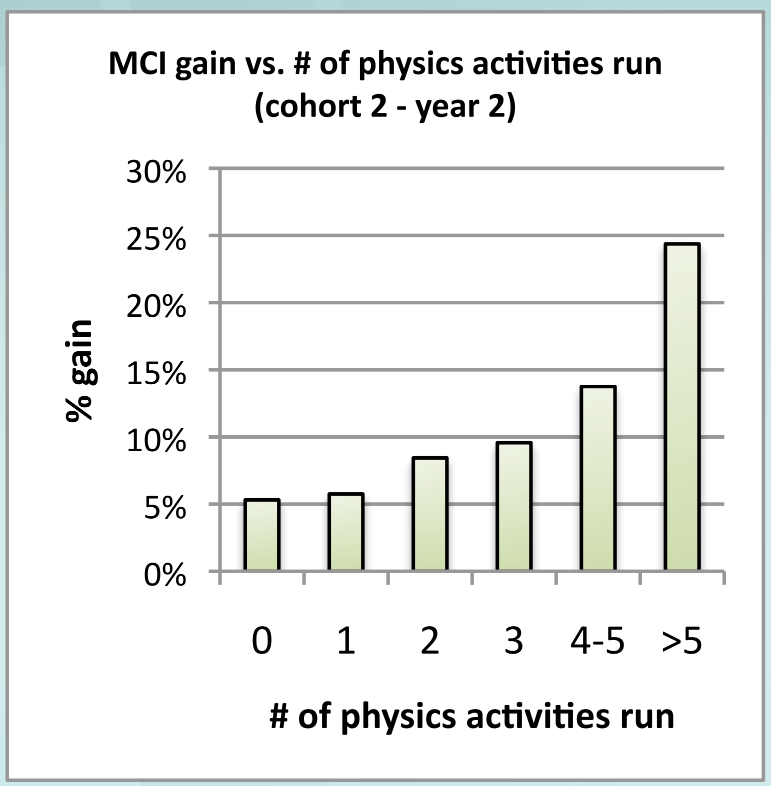
	Physics	Chemistry	Biology
Motion and Energy	Atoms and Energy	Phase Change	Diffusion, Osmosis, and Active Transport
	Heat and Temperature	Gas Laws	Cellular Respiration
Charge	Electrostatics	Intermolecular Attractions	Four Levels of Protein Structure
	Electricity	Molecular Geometry	Protein Partnering and Function
		Solubility	
Atoms and Molecules	Atomic Structure	Chemical Bonds	Intro to Macromolecules
			Lipids and Carbohydrates
	Newton’s Laws at the Atomic Scale	Chemical Reactions and Stoichiometry	Nucleic Acids and Proteins
			DNA to Proteins
Light	Atoms, Excited States, and Photons		Harvesting Light for Photosynthesis
	Spectroscopy		

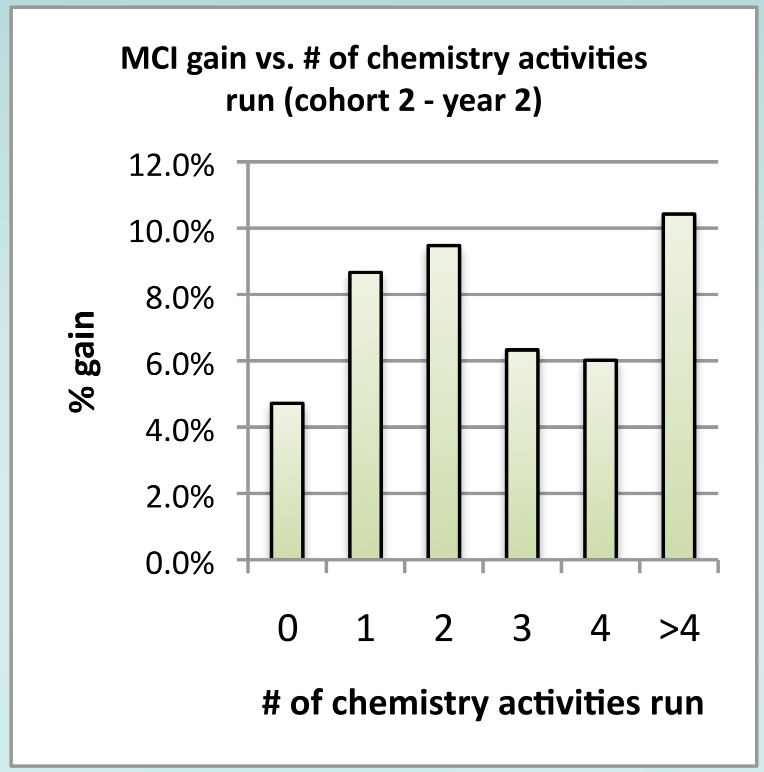
MCI Results
Cohort 1 - Chem

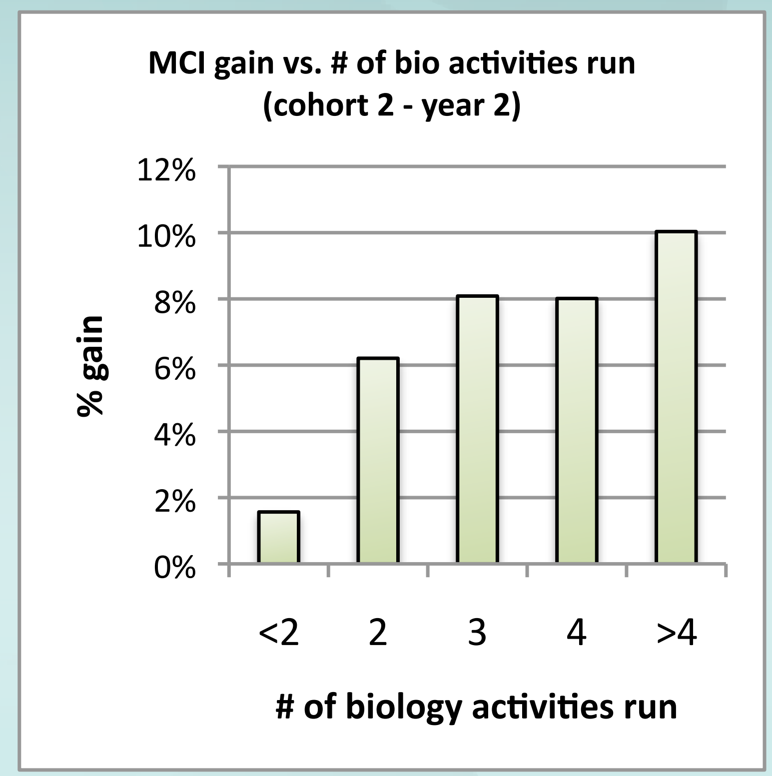


Group	Pre-test mean	Post-test mean	n	p-value based on paired t-test	Cohen’s d	Effect size
Chemistry	39%	47%	348	7.8e-32	0.6	Moderate

Score increases related to number of SAM activities completed







Improvements Over Time

Cohort 2	Pre-test mean	Post-test mean	gain	p	d	Effect size
Year 1 - Phys.	40%	43%	3%	7.6 e-6	0.2	Small
Year 2 - Phys.	33%	47%	15%	3.1 e-20	1.1	Large
Year 1 - Chem.	45%	51%	6%	8.5 e-16	0.4	Small
Year 2 - Chem.	47%	55%	8%	1.1 e-38	0.50	Moderate
Year 1 - Bio.	30%	33%	4%	2.6 e-07	0.3	Small
Year 2 - Bio.	28%	34%	6%	3.7 e-08	0.5	Moderate