The Concord Consortium

Using the Molecular Workbench for Inquiry at the Atomic Level

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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.

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

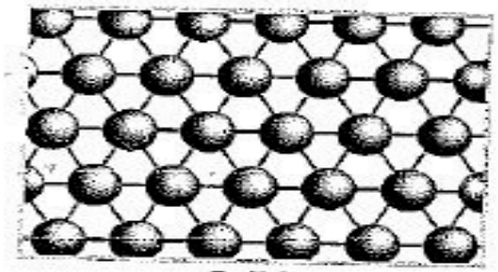
Within all matter there is a constant competition between temperature and intermolecular forces. The kinetic energy from temperature tends to push molecules apart. When temperature wins the competition, molecules fly apart and you have a gas. The intermolecular forces tend to bring molecules together. 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

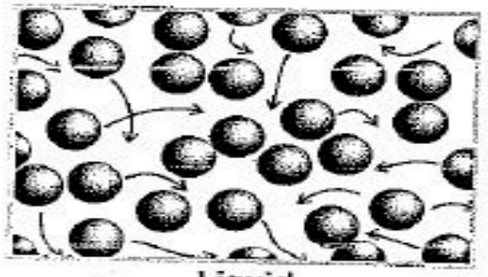
Iron is a solid at room temperature. Water is a liquid at room temperature. This tells you that the intermolecular forces between iron atoms are stronger than those between water molecules. In fact, iron is used for building things because it so strong. The strength of solid iron is another effect of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

Temperature

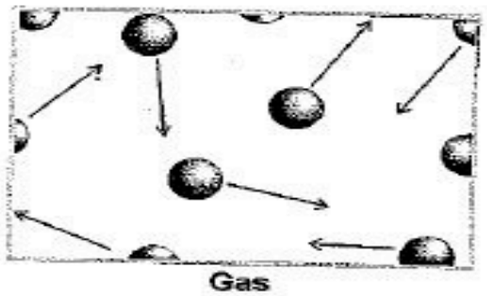
As the temperature changes, the balance between temperature and intermolecular forces changes. At temperatures below 0°C, the intermolecular forces in water are strong enough to overcome temperature and water becomes solid (ice).



Solid



Liquid



Gas

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.**

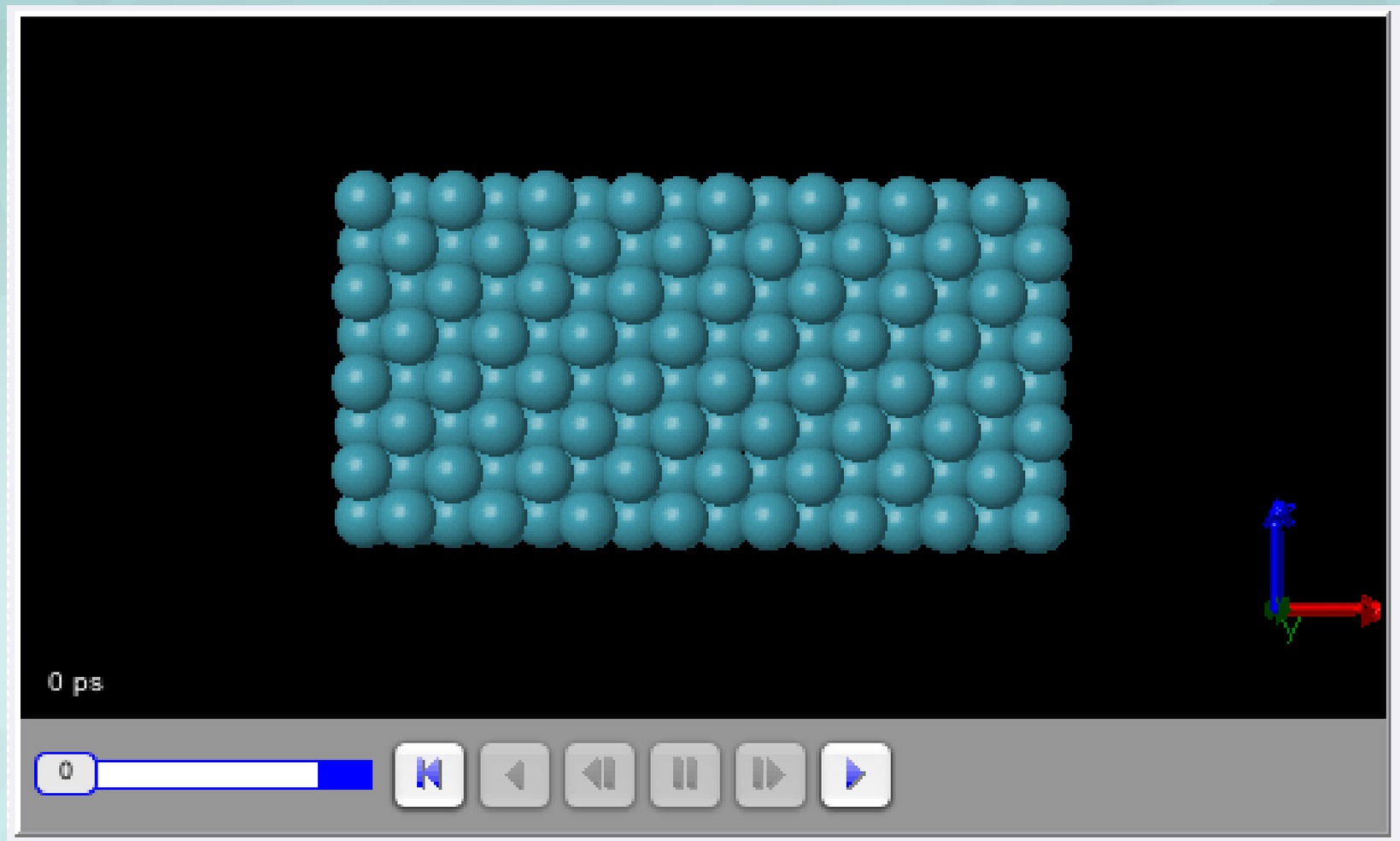
The Modeling Environment:

Molecular Workbench – a molecular dynamics tool.

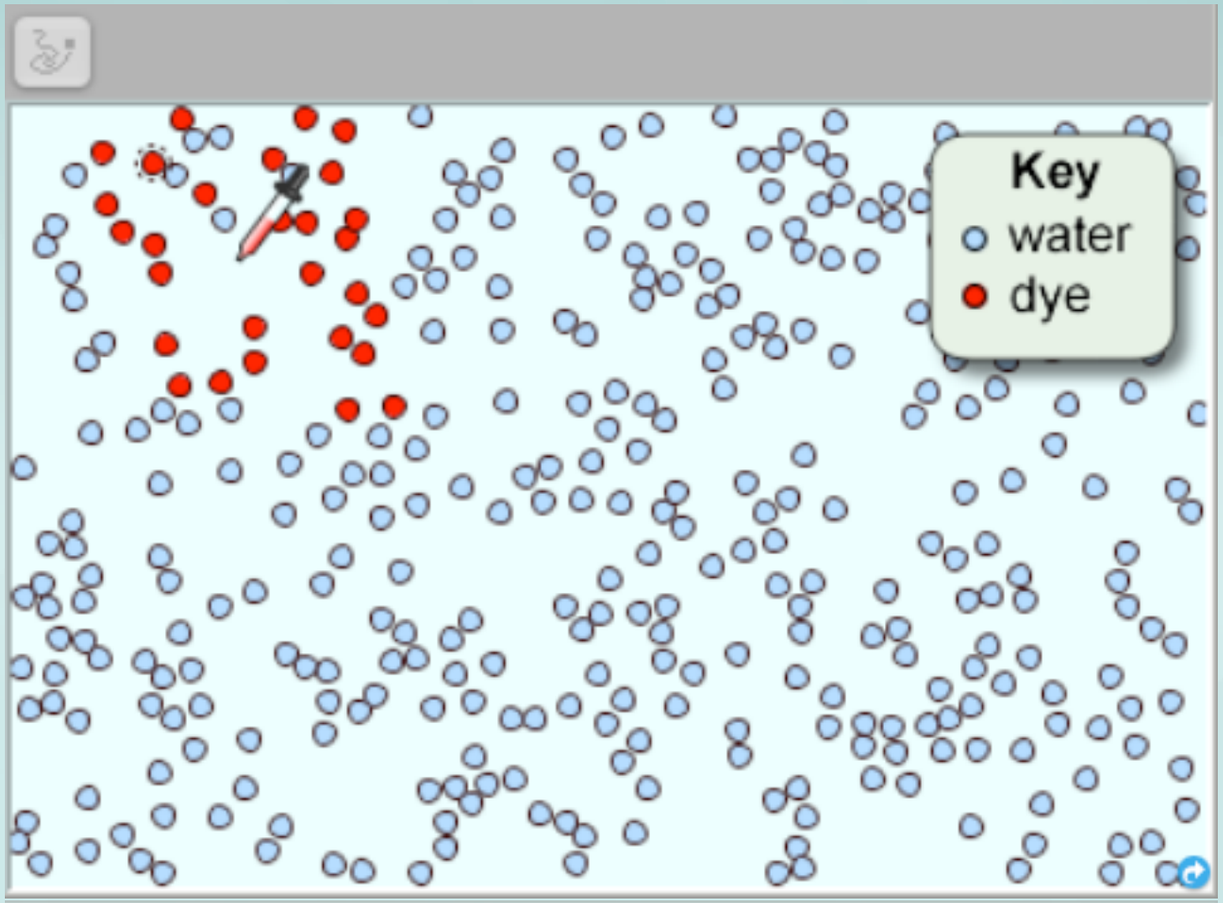
The Molecular Workbench – a molecular dynamics tool.

- 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.

Dynamic Phase Change Model



2D Dynamic Motion
simple diffusion



Chemistry - Chemical Reactions

Follow these steps:

1. Add some atoms (press multiple times to add more):

add 2 add 10

2. Run the model.

3. Reset the model and try a different concentration.

Gauge the reaction speed by using the graph to see when the reaction reaches 80% completion.

Your Goal: ● + ● → ●–●

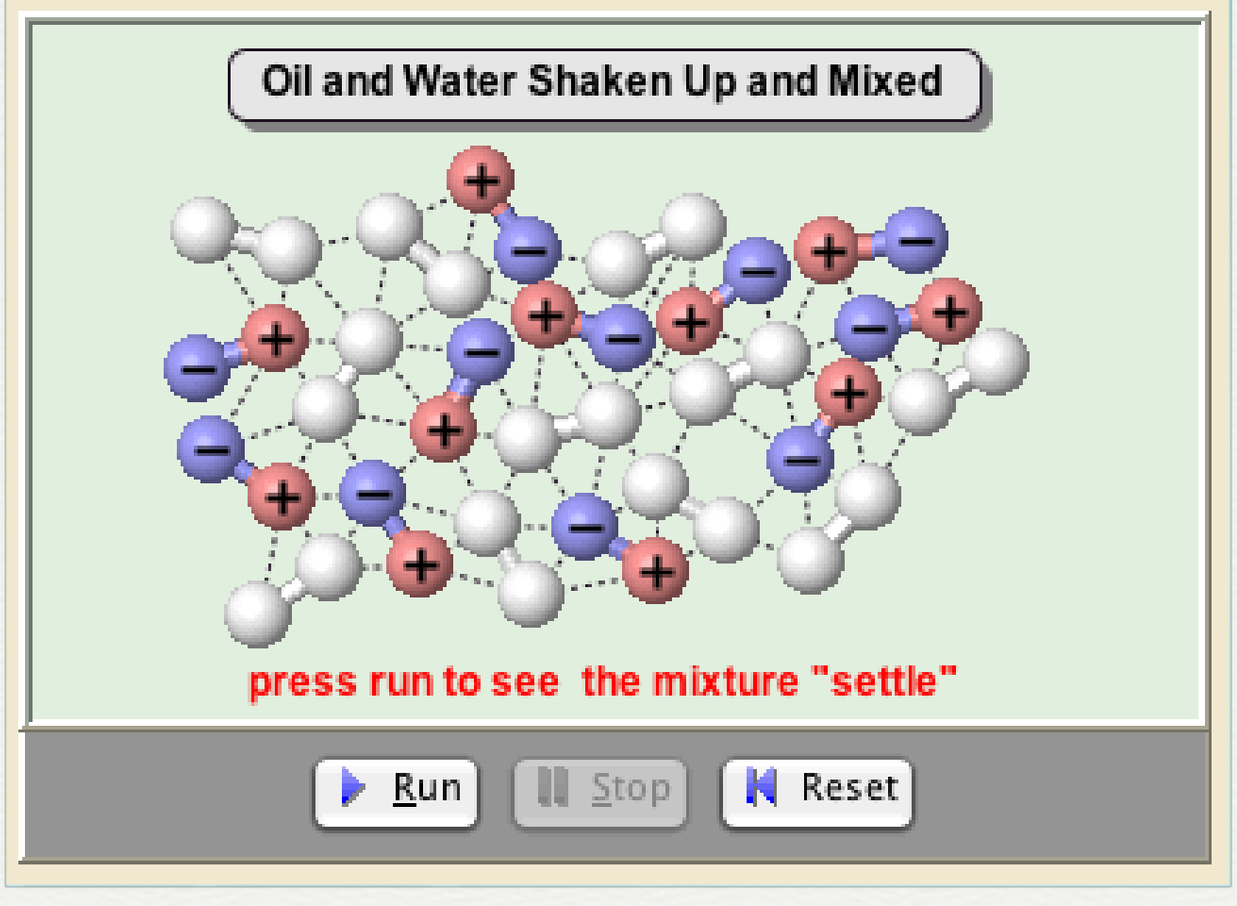
To get atoms to react to form molecules.

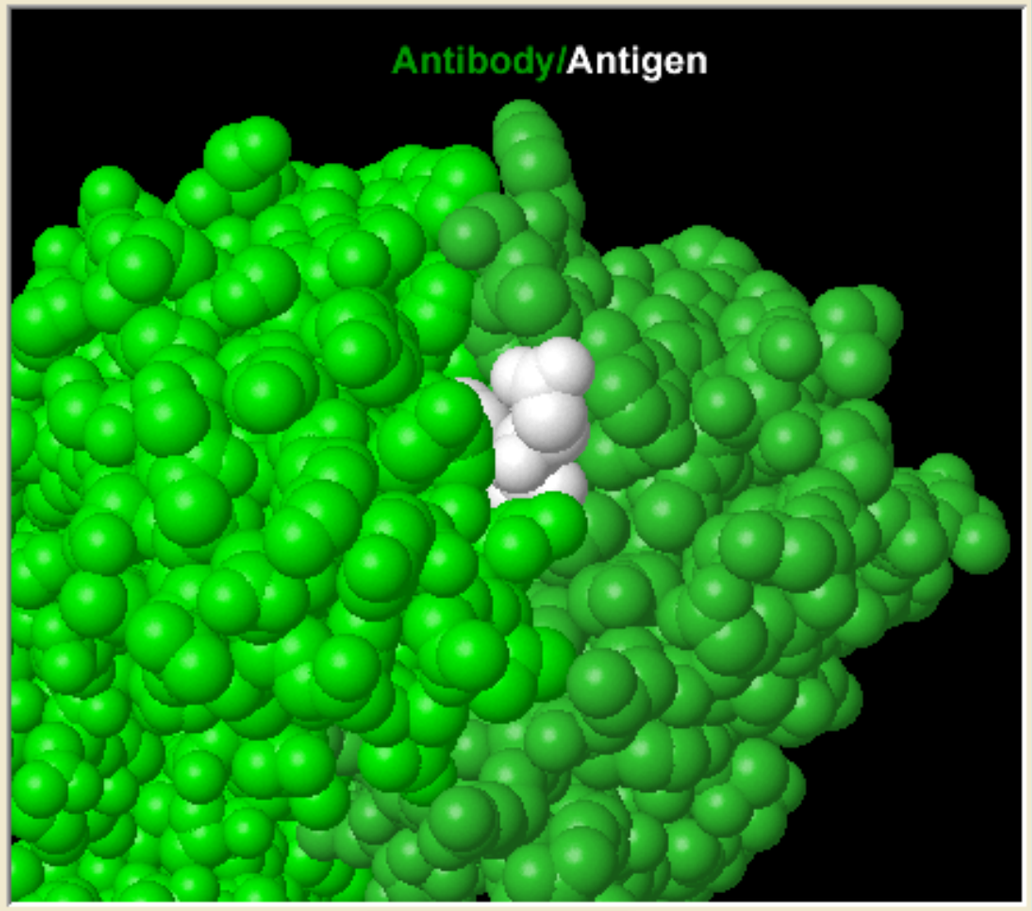
0

100
80
60
40
20
0

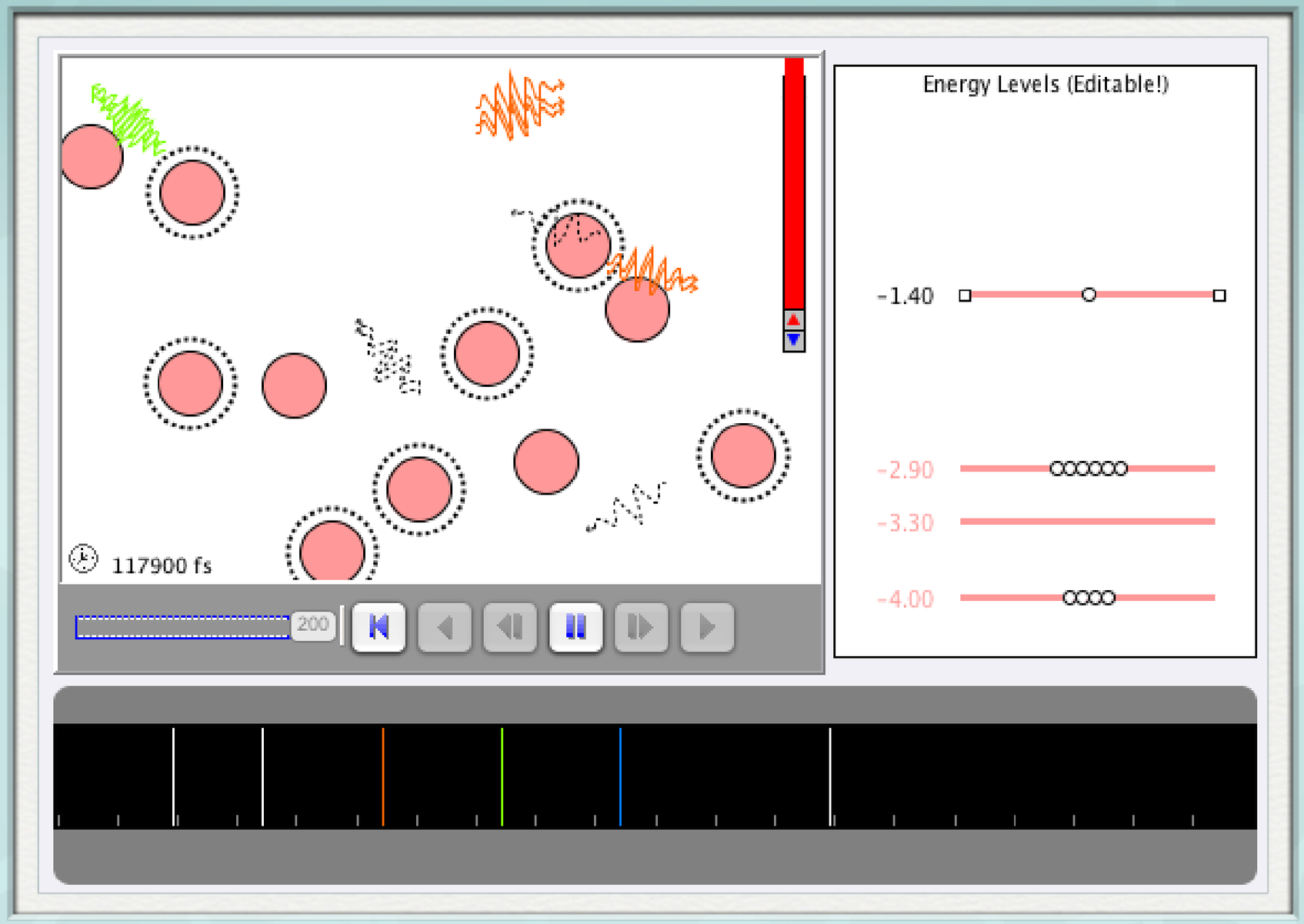
% reaction complete

Chem/Bio - Intermolecular Attractions

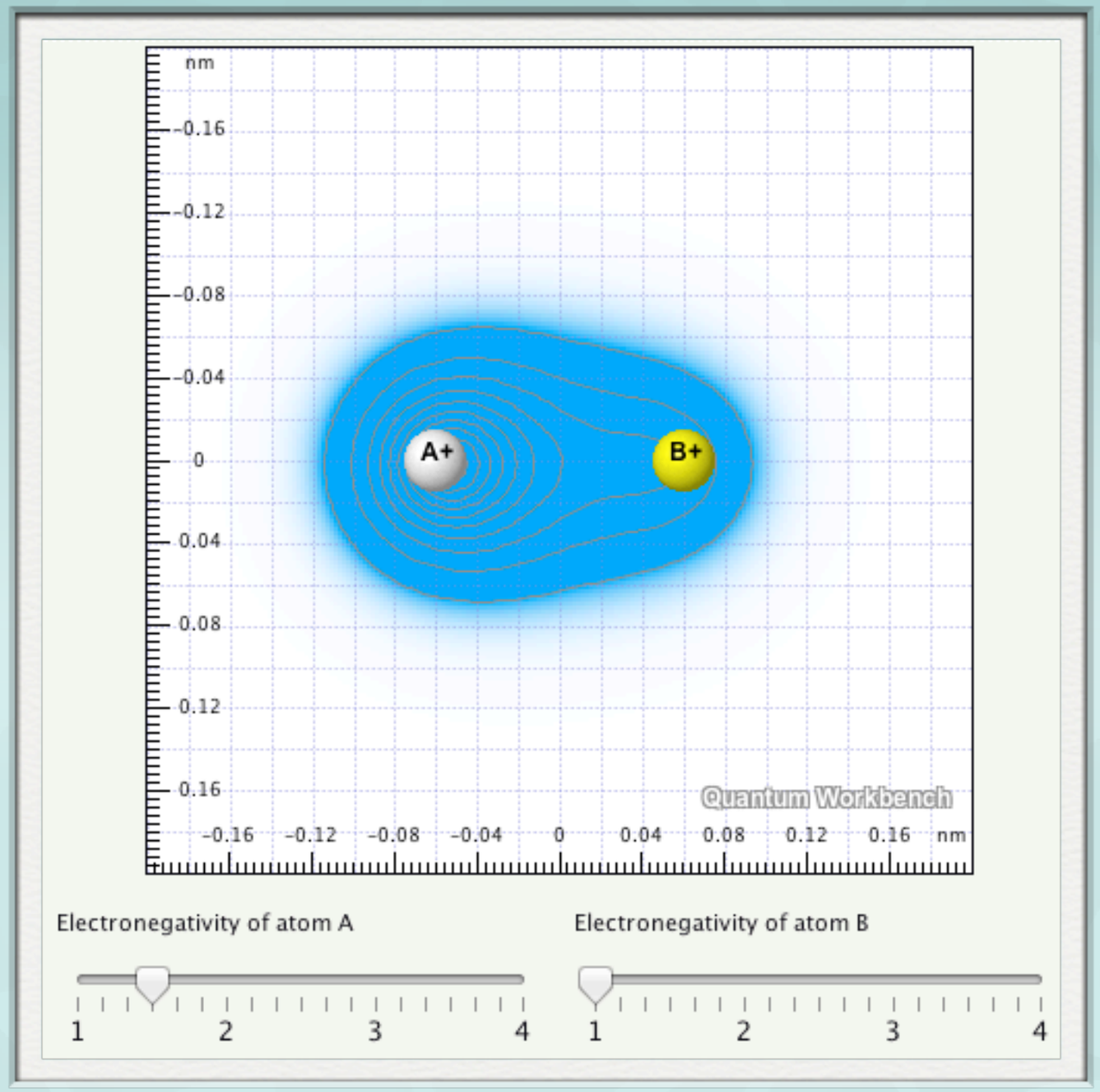




Phys/Chem - Spectroscopy



Quantum Chemistry - Polar Bonds



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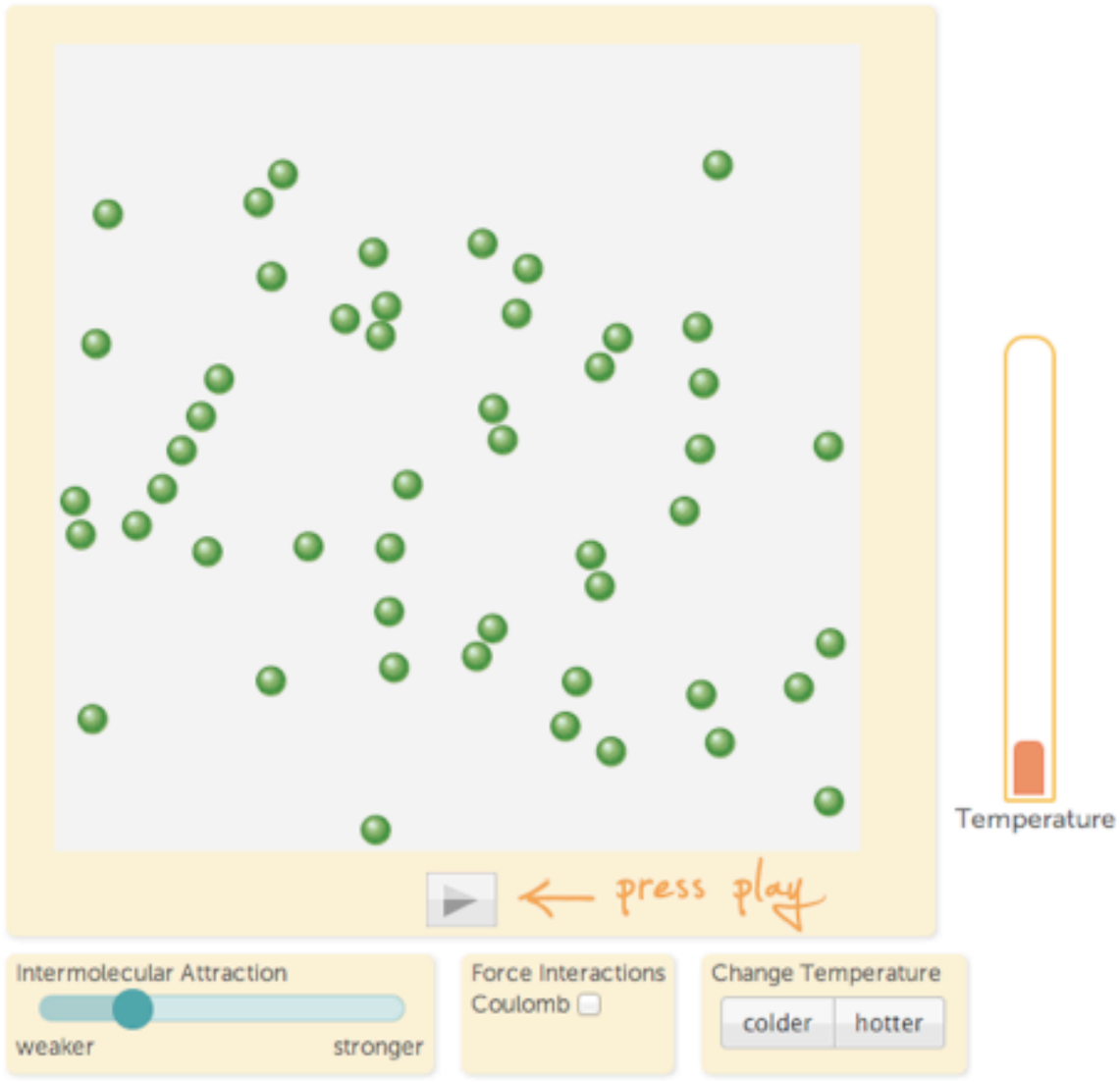
Switch to HTML5/ JavaScript

Atoms. In Your Browser.

Now you can use our award-winning molecular simulations anytime, anywhere.



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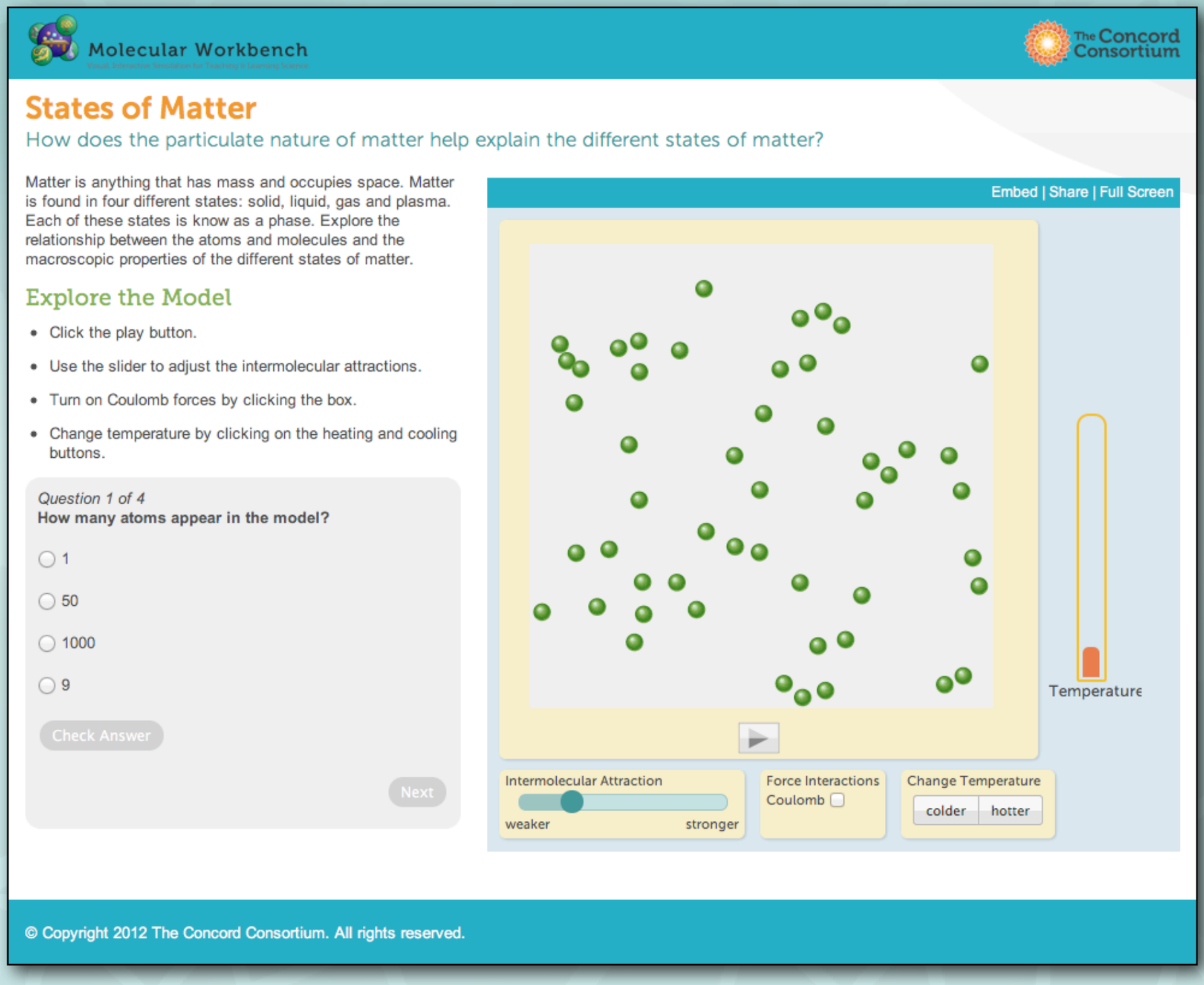
Benefits of the Web Platform



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

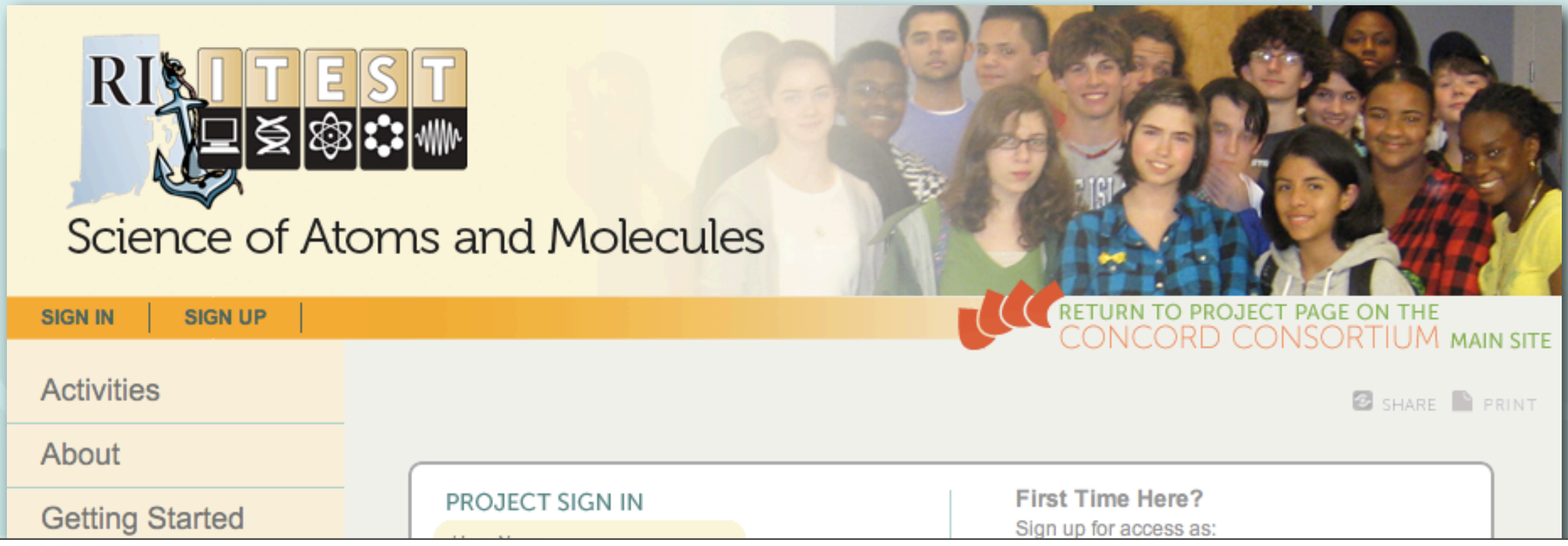
- **Molecular Workbench Application and Database**
  http://mw.concord.org

- **NextGen MW - HTML5 version**
  http://mw.concord.org/nextgen/

- **Various Project portals**
  http://www.concord.org/projects

Previewing Models and Using the Portal

- Go to: http://ri-itest.portal.concord.org
- or http://et.portal.concord.org
- Click on the “Activities” link.
- Click the try button on an activity.



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