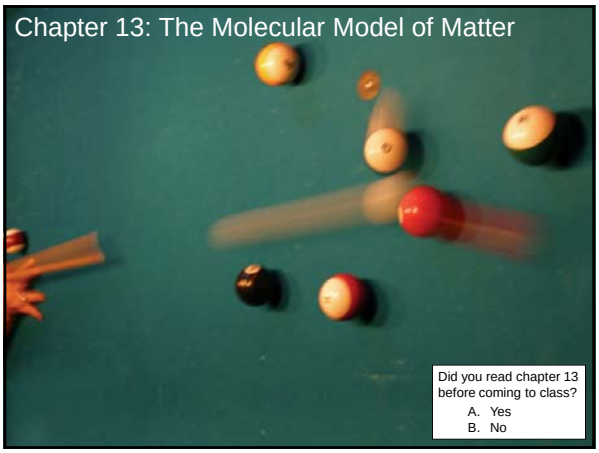
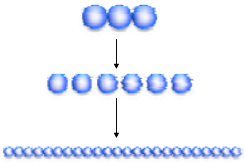
Chapter 13: The Molecular Model of Matter



Did you read chapter 13 before coming to class?

A. Yes
B. No

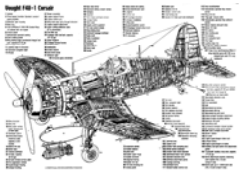
The grand scheme of science



Goal: Understanding (to be able to predict the future)

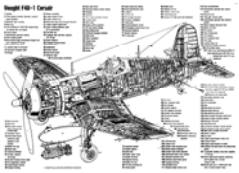
What is a Model?

- A useful analogy we can relate to.
- They are almost never 100% correct.
- Different models are used to describe the same thing at different levels of detail.



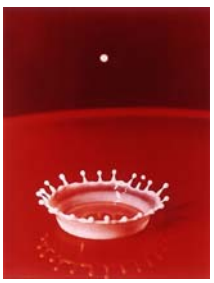
Models of Matter

- Continuous
- Molecular
- Nuclear
  - Solar System (Ch 14)
  - Bohr (Ch 14)
- Wave (Ch 15)
- …



Continuous Model

- The continuous model of matter represents matter as smooth and infinitely divisible. It reflects well what appears to our naked eye, but it lacks explanatory power. Many things remain a mystery as long as we view matter in this way.
  - Example: The milk drop looks continuous, but could we go on cutting it into smaller and smaller pieces indefinitely?



National Geographic

Continuous Model

- Useful in many situations:
  - Fluid dynamics
  - Classical Electrodynamics
- Has many limitations
  - Charge and light come in distinct packets
  - How do changes of state occur
  - Etc.

The Molecular Model

- All matter is made of tiny particles called molecules which are:
  - Too small to see, even with an optical microscope
  - In constant motion
  - Governed by Newton's laws of motion, energy conservation, etc.
- Each different kind of matter has a different kind of molecule

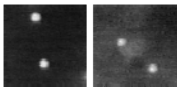
So What?

- Anybody can come up with a theory or model. The proof is in what it can explain and predict.
- So we ask, what can the molecular theory of matter explain and predict?

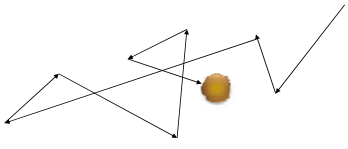
Brownian Motion

- When viewed under a microscope, large particles suspended in a fluid have an erratic, jittery motion.
  - Discovered by Robert Brown in 1827
  - Some kind of "life force"?

Brownian Motion

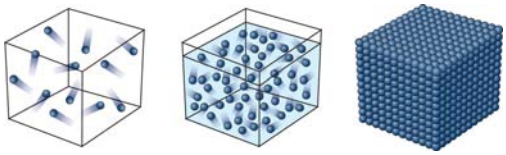


- The erratic, jittery motion of a dust speck in a fluid is strong evidence supporting the molecular model.
  - The speck is colliding randomly by unseen molecules.



States Explained

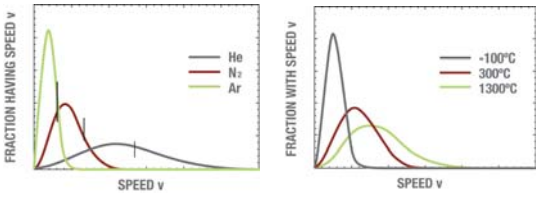
- Solid: The molecules are frozen in place but still vibrate.
- Liquid: The molecules move past each other but still have a weak attraction.
- Gas: The molecules only interact when they collide.
- Plasma: The molecules collide with enough energy to break into charged pieces.

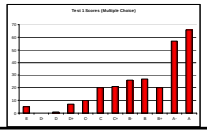


Temperature Explained

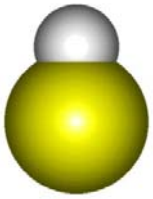
- Temperature is a measure of the average kinetic energy of the molecules.
  - Cold → slowly moving
  - Hot → rapidly moving
  - Absolute zero → motion ceases (-460 F, -273 C)
- Example: At room temperature molecules are moving about 1,000 ft/s

Temperature is a measure of the average kinetic energy of a collection of molecules





Off to the molecular races



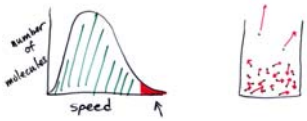
K.E. = $\frac{1}{2}$ mv^2

the same for both NH_3 and HCl

but HCl has about twice the mass

Evaporation Explained

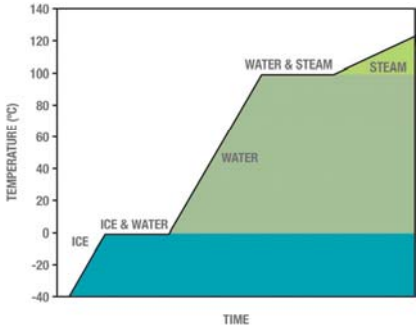
- Temperature is a measure of the average kinetic energy. Some molecules go faster and some go slower. The fast ones escape as a gas even when the average temperature is below boiling.



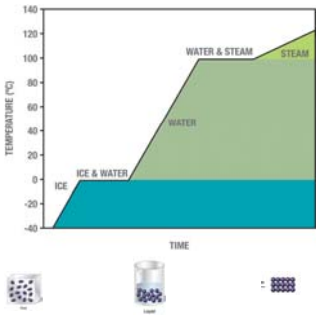
- So why are you so cold when you get out of a swimming pool?
- Why doesn't sweating work in high humidity?

State changes and the molecular model

- Temperature is molecular kinetic energy.
- *Internal energy* includes kinetic plus electrical potential energy from how the molecules are arranged.

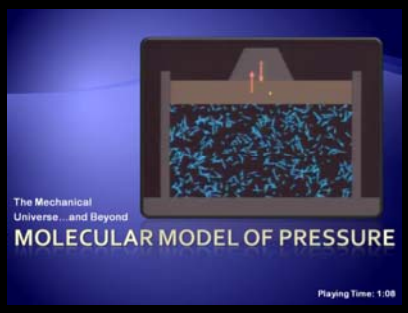


Why does it get warmer when it snows?



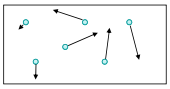
Gas Pressure Explained

- Gas Pressure is caused by molecular collisions with the walls of the container. Like throwing a "bazillian" balls against a wall.
  - Remember Newton's Third Law:
  - The *wall* exerts a force on the *ball*, so the *ball* exerts a force on the *wall*

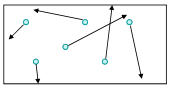


Gas Pressure and Temperature

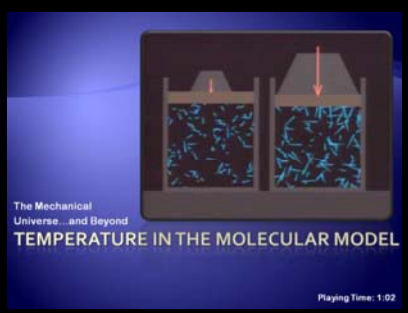
- Gas pressure increases with temperature if the gas cannot expand. The hotter molecules hit the container walls *harder* and *more often* than the cold ones.
  - Example: aerosol can in the fire



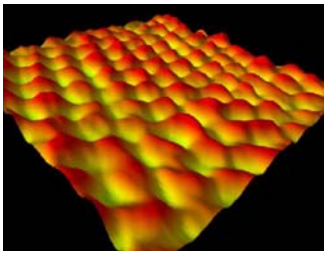
Colder



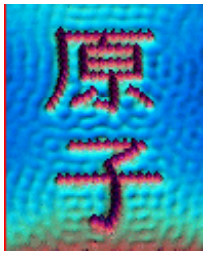
Hotter



Finally, we have actually "seen" atoms using special microscopes

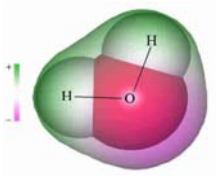


Graphite



Iron on Copper (Gen shi = atom)

A curious behavior of water



Some things we haven't explained

- Where does color come from?
- How are the parts of molecules arranged?
- Why does metal conduct heat well, but wood does not?
- Why does metal conduct electricity, but not wood?