A Model of Matter: Part 2

Last week, we began thinking about a model of matter that would explain our observations of matter and its changes. We suggested you try this activity with your students:

Ask your students to draw a diagram and explain how water disappears from a puddle.

- What happens?
- Where does the water go?
- Why?

A disappearing puddle is a change we've all observed. Let's see if we can explain it using the model of matter we proposed last week: *'tiny particles in motion'*.

Let's assume the puddle is about 1m (100cm) across and about 25 cm deep. The puddle consists of billions of tiny particles. Democritus called them *atomon*; we call them molecules. (Actually, a puddle the size we have assumed would contain approximately $7x10^{27}$ molecules; that's a 7 followed by 27 zeros.)

Water drop

The molecules exert a force of attraction on each other. This force of attraction helps keep the molecules of water in a sample of liquid water together. The attraction among molecules of water makes sense if you think about a drop of water hanging on the tip of a medicine dropper. If the molecules did not stick together, the drop would not form, and the water would come out of the dropper in a *very* thin stream.

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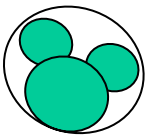
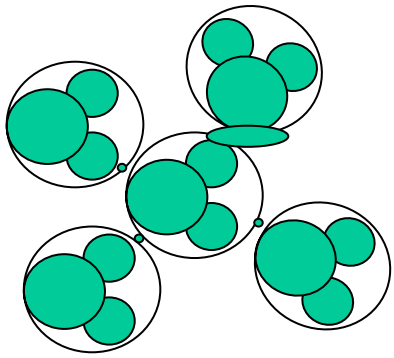
The diagrams below show how we believe the water molecule looks and how a group of water molecules are arranged in water. The dots represent the forces of attraction.



One water molecule



A group of water molecules held together by force of attraction.

The molecules are in motion. Not all have the same speed. Some are moving faster than others.[1]

So, how do we explain the evaporation of water from the puddle? If one of the fastest moving molecules is at the surface of the puddle, it can overcome the attractive forces the water molecules have for each other. The speedy molecule is able to break away from the pack and escape into the air. The water molecule becomes water vapor and joins the other water molecules in the air. This process occurs over and over again at the surface of the liquid water.

Some liquids such as isopropyl alcohol (rubbing alcohol) evaporate a lot faster than water. If the molecules of alcohol are moving at approximately the same speeds as the molecules of water in the puddle, how do you explain the faster rate of evaporation?

Alcohol drop

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It's in the *attraction* the molecules have for each other. The intermolecular forces in isopropyl alcohol are considerably less than the intermolecular forces in water, so the alcohol molecules do not need to be moving as fast to escape from the liquid.

Coming up

Next week we'll look further into these fast-moving molecules. In the meantime, consider this:

> You have noticed that puddles dry up faster when the weather is warm than when it is cooler.
>
> - How do you explain that?

What do the New York State standards say?

In the Elementary Core Curriculum, Standard 3, The Physical Setting,

Major Understanding states:

- *3.1a Matter takes up space and has mass. Two objects cannot occupy the same place at the same time.*
- *3.1c Objects have properties that can be observed, described and/or measured: length, width, volume, size, shape, mass or weight, temperature, flexibility, reflectiveness of light.*
- *3.1f Objects and/or materials can be sorted or classified according to their properties.*
- *3.2b Temperature can affect the state of matter of a substance.*
- *3.2c Changes in the properties or materials of objects can be observed and described.*

In the Intermediate Core Curriculum, Standard 3, The Physical Setting,

Major Understanding states:

- *3.1a Substances have characteristic properties. Some of these properties include color, odor, phase at room temperature, density, solubility, heat and electrical conductivity, hardness, and boiling and freezing points.*

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- *3.1d the motion of particles helps to explain the phases (states) of matter as well as changes from one phase to another. The phase in which matter exists depends on the attractive forces among particles.*
- *3.3b Atoms and molecules are perpetually in motion. The greater the temperature, the greater the motion.*
- *3.3a All matter is made up of atoms. Atoms are far too small to see with a light microscope.*
- *3.3c Atoms may join together in well-defined molecules or may be arranged in regular geometric patterns.*

[1]The average speed of a water molecule in ice is about 615m/sec. In boiling water, the average speed is about 720m/sec. The molecules of water are moving pretty fast. The speed of sound at 50^0 C is about 362m/sec, so the water molecules are moving faster than the speed of sound! (http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/phase.html)

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