Be the Molecule, Be the Parcel:
Kinesthetic Activities for Teaching Atmospheric Science Concepts

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The Little Shop of Physics specializes in techniques of interactive engagement. Our school science programs allow students to experience, hands-on, over 100 science stations that cover a wide range of science topics.

Our approach is not just engaging, it is effective. Students learn complex concepts by exploring, by experimenting, with very little formal guidance.

Key to the success of many of our experiment stations is kinesthetic experience: Students interact, physically, with the equipment. They feel the change in temperature of air when compressed, they feel the extra pressure in the bottle. They feel the change in resistance of a generator when it is connected to different light bulbs.

We are adapting this kinesthetic approach to a range of different activities in which students explore macroscopic behavior of systems by modeling small scale interactions. This poster explains some of these activities.

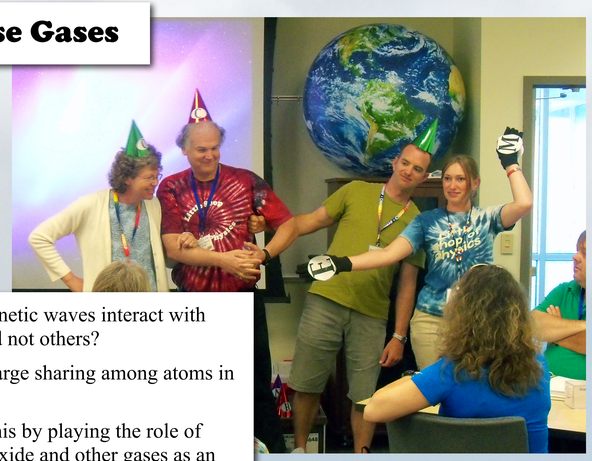
Greenhouse Effect

When photons of long wavelength strike the atmosphere, they are absorbed and re-radiated.

Net result: A warmer earth.

Students simulate this by playing the role of photons that interact with the atmosphere.

Greenhouse Gases

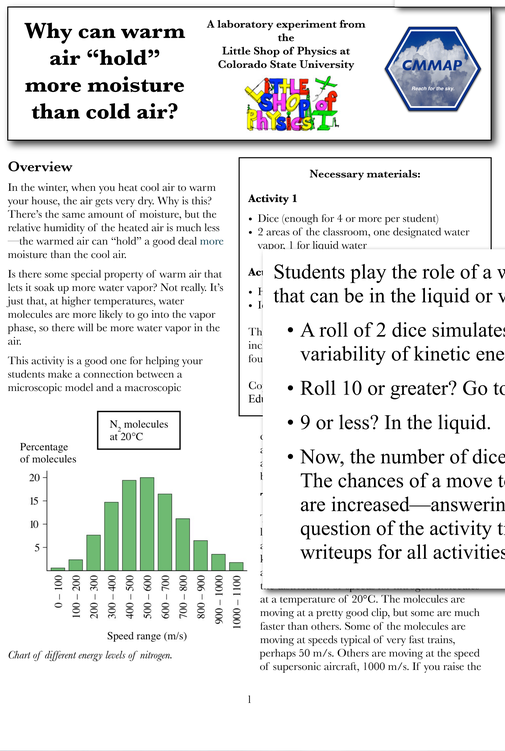


Why do electromagnetic waves interact with some molecules and not others?

It has to do with charge sharing among atoms in the molecules.

Students simulate this by playing the role of atoms in carbon dioxide and other gases as an electromagnetic wave passes.

Vapor Pressure



Why can warm air "hold" more moisture than cold air?

A laboratory experiment from the Little Shop of Physics at Colorado State University

CMMAP

Overview

In the winter, when you heat cool air to warm your house, the air gets very dry. Why is this? There's the same amount of moisture, but the relative humidity of the heated air is much less—the warmed air can "hold" a good deal more moisture than the cool air.

Is there some special property of warm air that lets it soak up more water vapor? Not really. It's just that, at higher temperatures, water molecules are more likely to go into the vapor phase, so there will be more water vapor in the air.

This activity is a good one for helping your students make a connection between a microscopic model and a macroscopic

Necessary materials:

Activity 1

- Dice (enough for 4 or more per student)
- 2 areas of the classroom, one designated water vapor, 1 for liquid water

N_2 molecules at 20°C

Percentage of molecules

0 – 100, 100 – 200, 200 – 300, 300 – 400, 400 – 500, 500 – 600, 600 – 700, 700 – 800, 800 – 900, 900 – 1000, 1000 – 1100

Speed range (m/s)

Chart of different energy levels of nitrogen.

at a temperature of 20°C. The molecules are moving at a pretty good clip, but some are much faster than others. Some of the molecules are moving at speeds typical of very fast trains, perhaps 50 m/s. Others are moving at the speed of supersonic aircraft, 1000 m/s. If you raise the

1

Students play the role of a water molecule that can be in the liquid or vapor phase.

- A roll of 2 dice simulates the random variability of kinetic energy of molecules.
- Roll 10 or greater? Go to the vapor phase.
- 9 or less? In the liquid.
- Now, the number of dice is increased to 3. The chances of a move to the vapor phase are increased—answering the leading question of the activity title. We have such writeups for all activities.

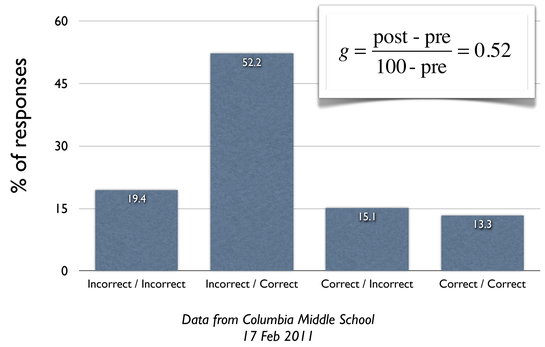
The Way the Wind Blows

In Colorado, sometimes the wind blows from high elevations and low pressures in the mountains to low elevations and high pressures on the plains.

As the air does this, it:

A. cools down.
B. warms up.

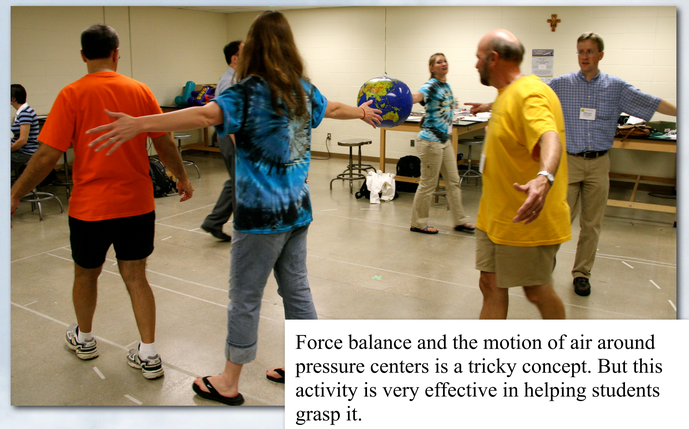
Comparing pre-test / post-test data



Data from Columbia Middle School
17 Feb 2011

Learning gains are significant and durable.

Cyclonic Motion Around a Low



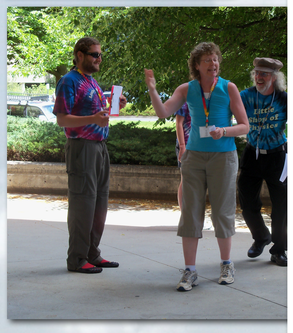
Force balance and the motion of air around pressure centers is a tricky concept. But this activity is very effective in helping students grasp it.

Pressure force points to the center of the low; as student "parcels" move, the Coriolis force kicks in, pushing toward the right.

- Students hold arms to show the direction of the different forces, and move in response.
- Eventually, the forces direct the motion so that students move in a clockwise circle around the low. The slight excess of the pressure force provides the necessary acceleration.

We have approximately 12 activities, with more in development.

Be the Parcel



Students have difficulty understanding the concept of a parcel path, and understanding why certain conditions lead to stability.

We have helped them grasp these processes through this activity. Students proceed as follows:

- Students get a chance to be the parcel. The imagine themselves to be a parcel of air that is slightly warmer than the surface temperature.
- Students move through a simulated profile of temperature vs. height, changing their temperature as they rise at the dry or moist adiabatic lapse rate.
- At each height, they analyze their temperature, and compare it with the environmental temperature, rising further or falling as appropriate.