TERRIFIC SCIENCE
EMPOWERING TEACHERS THROUGH INNOVATION

Experimentell kemi - Perstorp 2019

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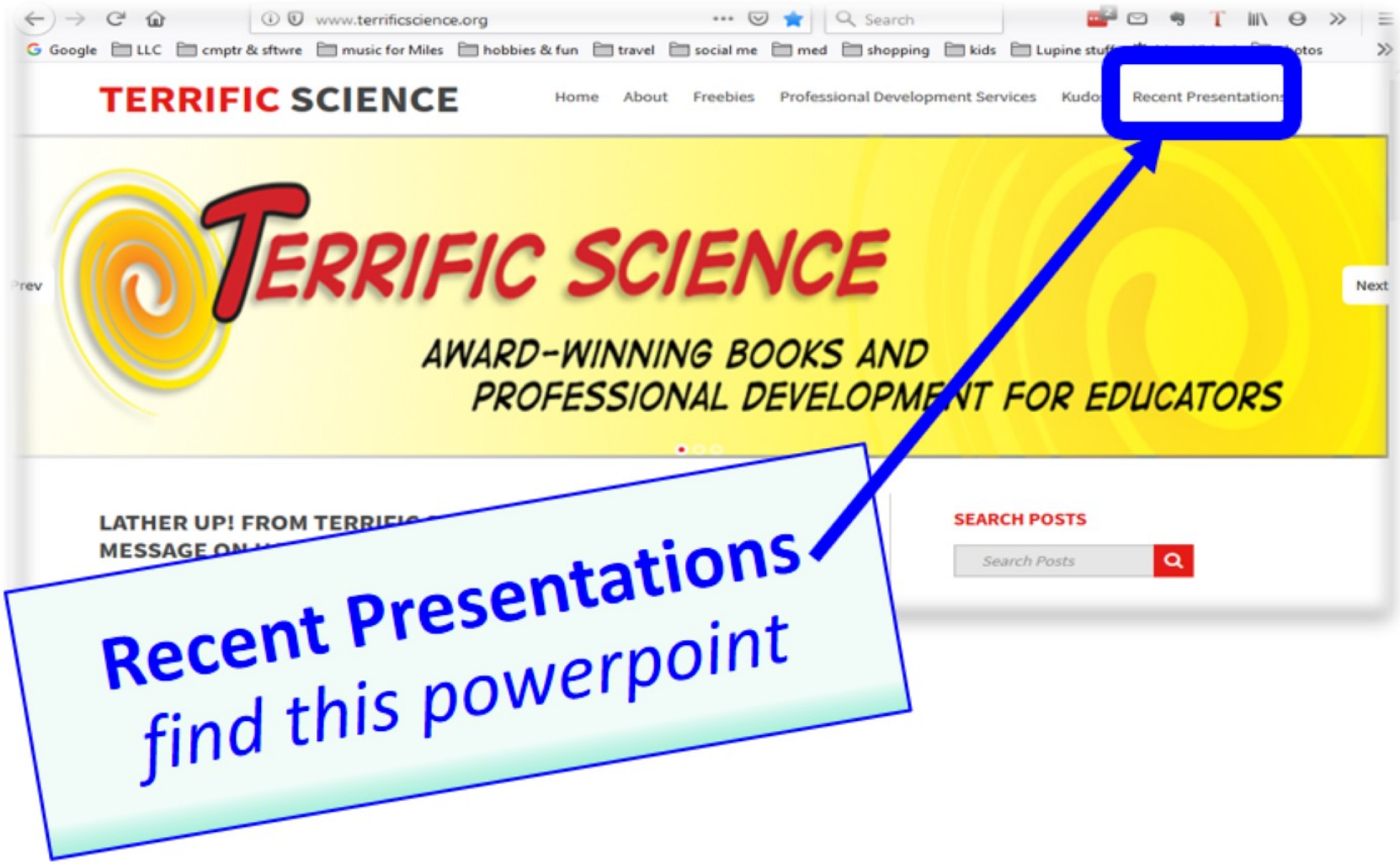
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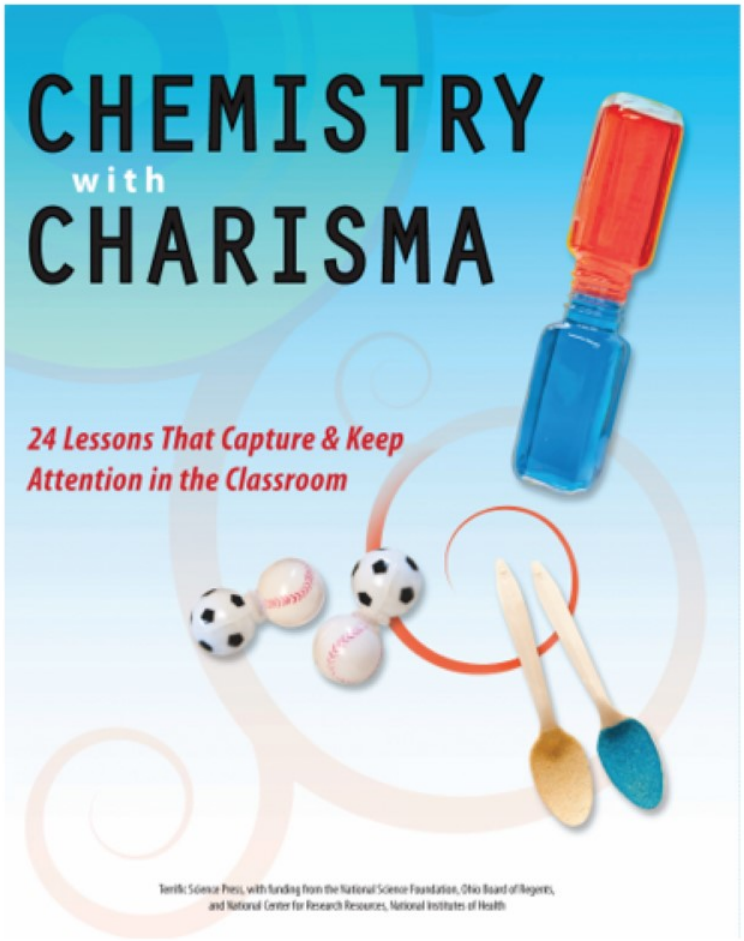
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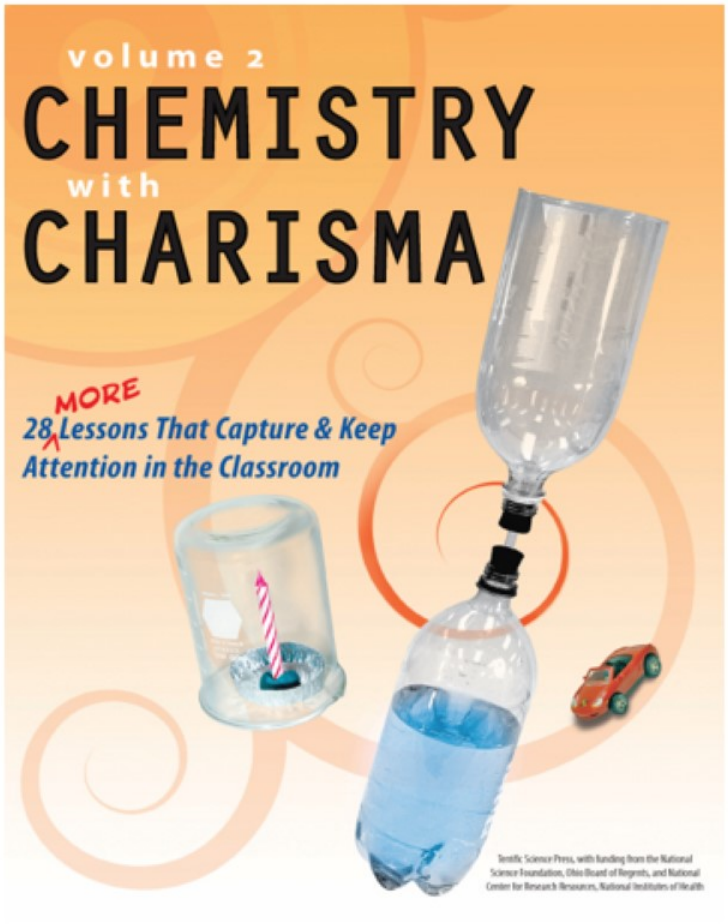
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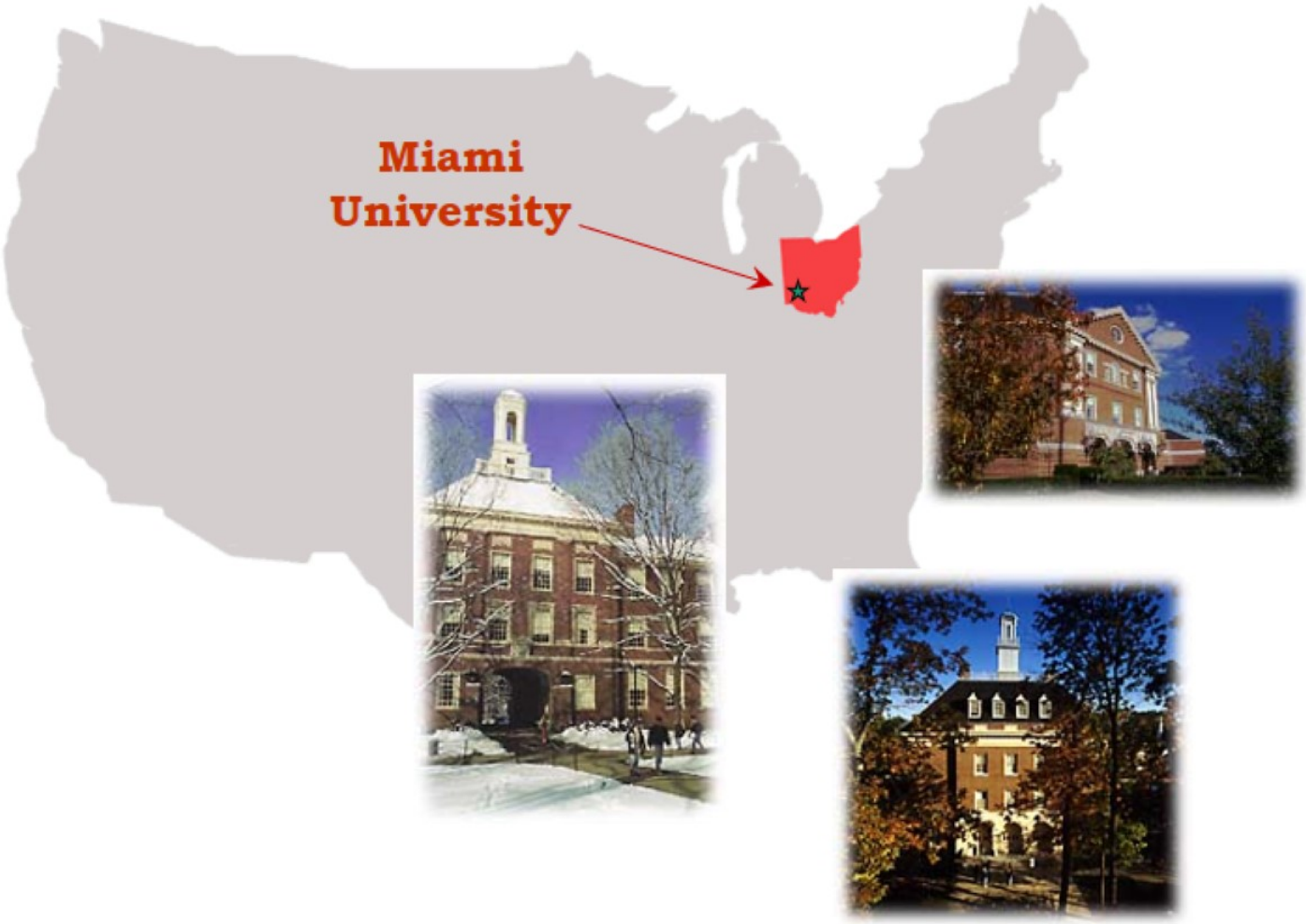
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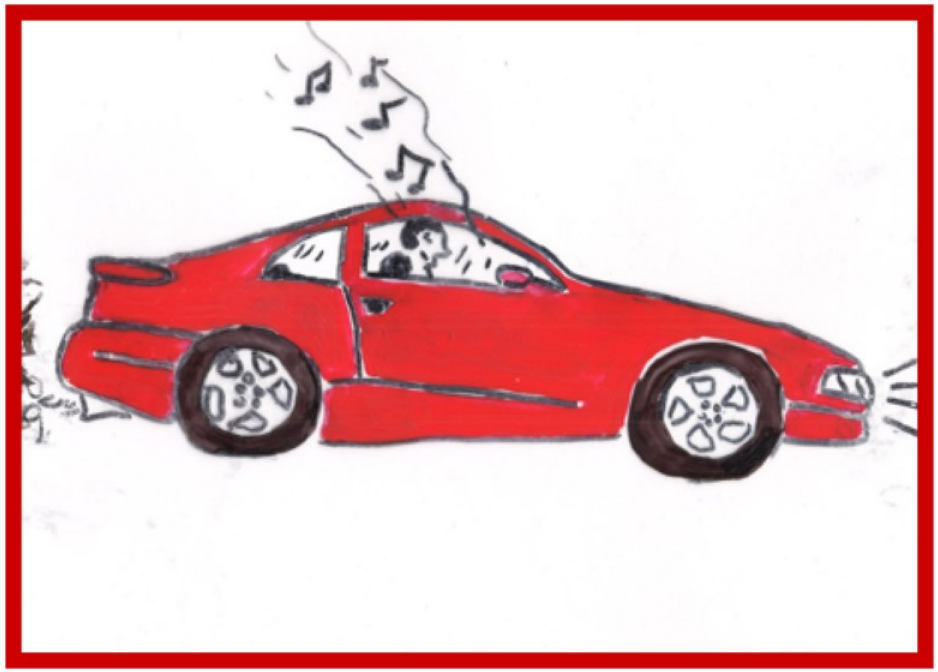
University

Where Would We Be Without Chemistry?



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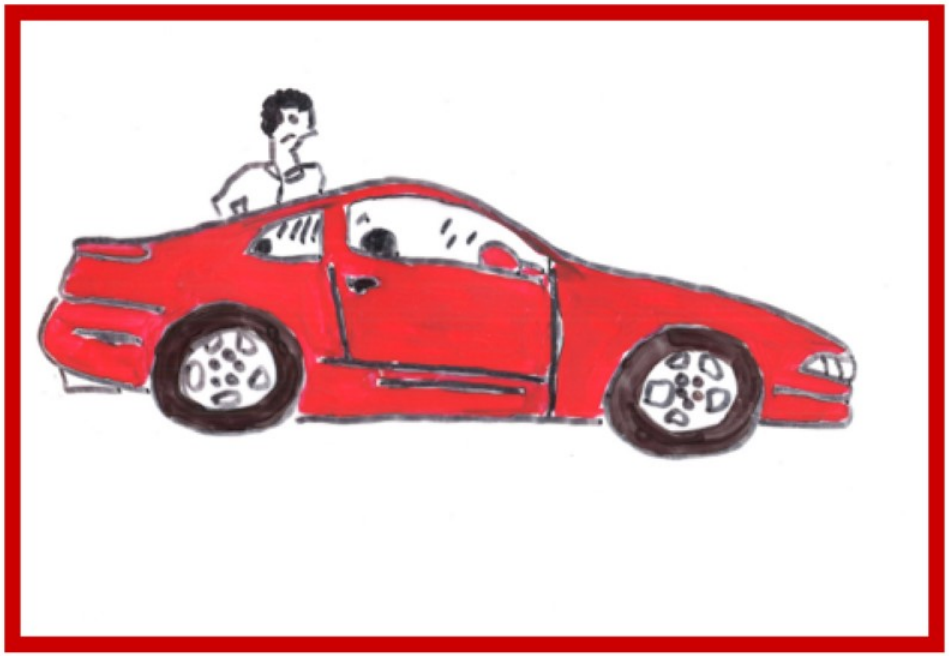
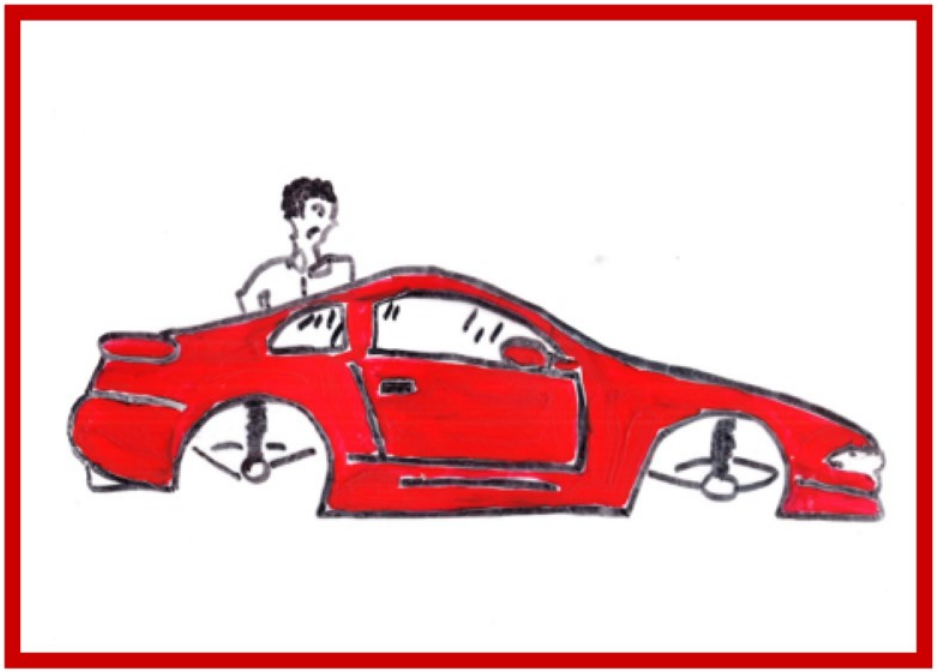


no chemical reactions

Where Would We Be Without Chemistry?

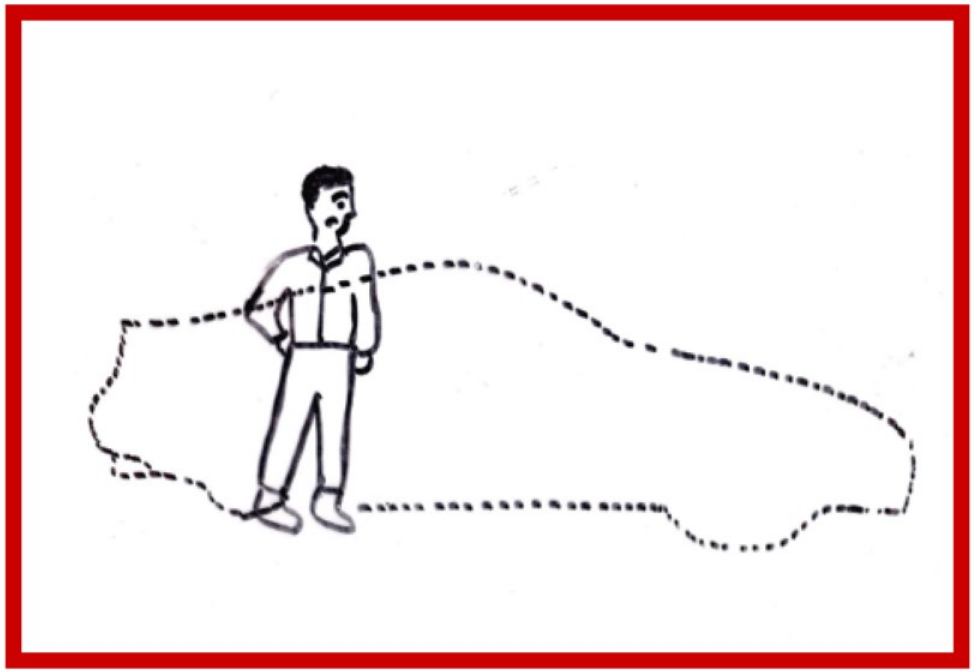


no leather or rubber

Where Would We Be Without Chemistry?

no paint or coatings

Where Would We Be Without Chemistry?



no metals or polymers

Where Would We Be Without Chemistry?

No fabrics

Where Would We Be Without Chemistry?

70 kg male

H_2O	50.1 kg
C	12.6 kg
N	1.8 kg
Ca	1.7 kg
P	.68 kg
K	.25 kg
Na, Mg, Fe, etc	.32 kg

Where Would We Be Without Chemistry?

No you!

TIMSS and PIRLS in Sweden

Chemistry instruction should give students the opportunity to:

- examine information
- communicate
- form an opinion on questions concerning energy, the environment, health, and society
- carry out systematic studies by formulating questions & plan, execute, and evaluate studies)
- use chemistry concepts, models, and theories to describe & explain chemistry in society, nature, and people.

Instruction

Teaching is about negotiation

Critical skills

- Big ideas – planning and referring to
- Provide framework for students to engage in active learning process
- Small group to whole group transitions – claims and evidence discussion
- Non threatening learning environment

Align science instruction with what scientists do

What do scientists do?

How keen are your powers of observation?

The old shell game.

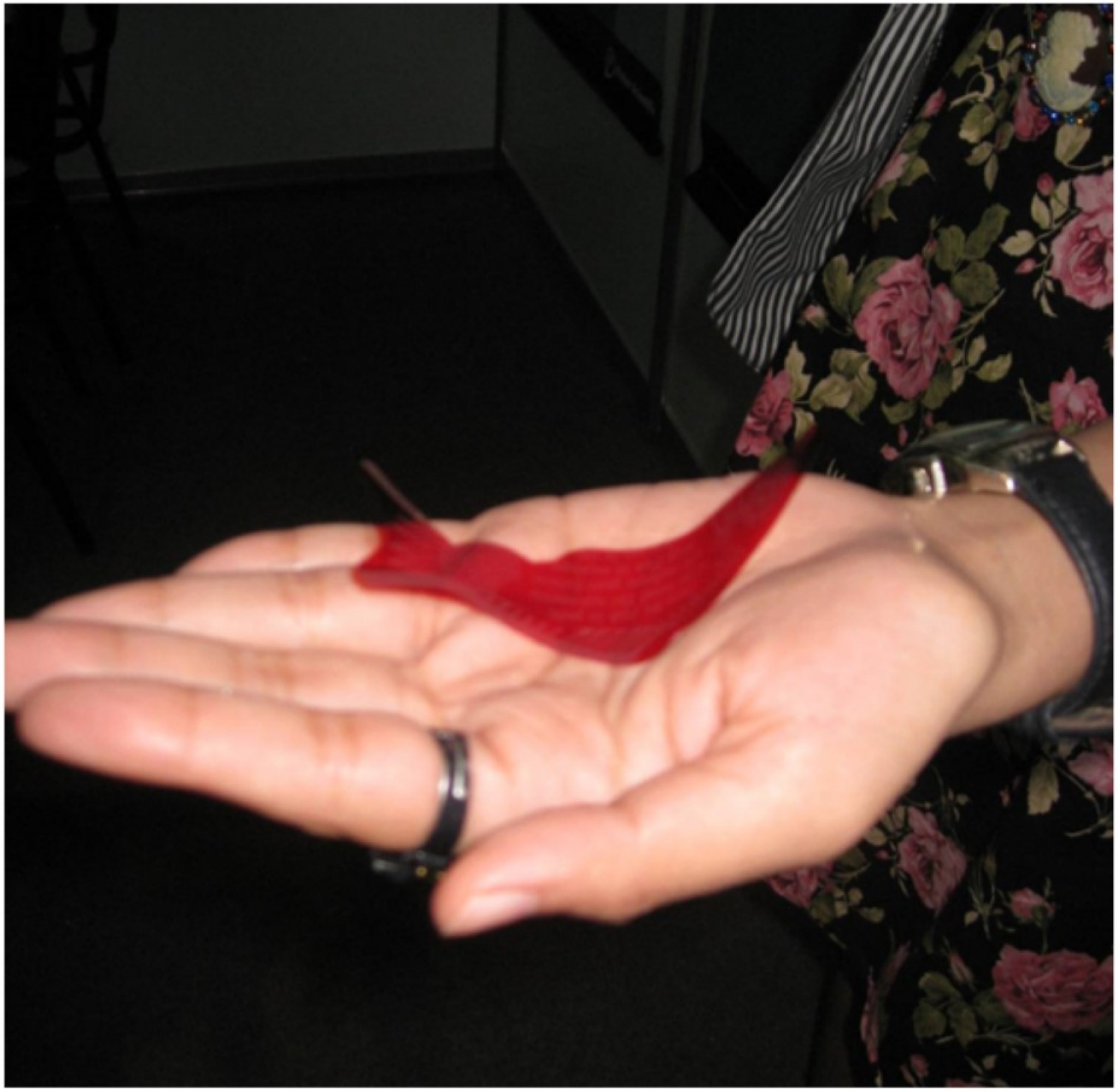
“Super Slurper” (Sodium Polyacrylate): From Entertainment to…

Method

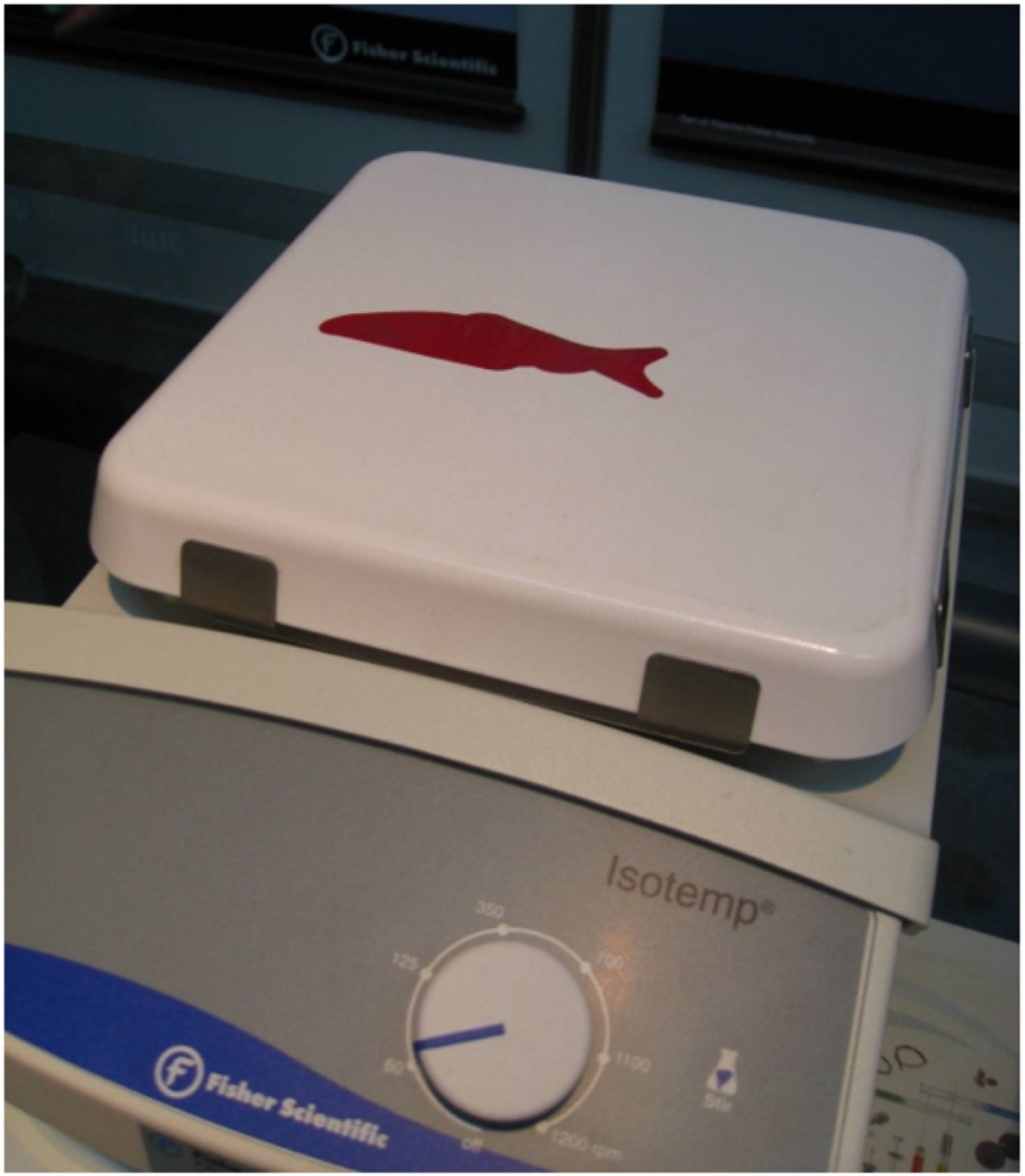
- Students do an activity or observe a demonstration
- Students form testable questions
- Students devise an experiment to answer testable question
- Students make observations and collect data
- Students interpret data to provide evidence
- Students make a claim about the system they are investigating
- Students use evidence to substantiate their claims

Your next challenge:

- make observations
- formulate testable questions
- design an experiment
- collect evidence
- formulate a claim




FORTUNE TELL
MIRACLE FISH


Fisher Scientific
Isotemp®
350
125
700
60
1100
Stir
Fisher Scientific
off
1200 rpm

Hot Stuff:
Investigating Reusable Heat Packs

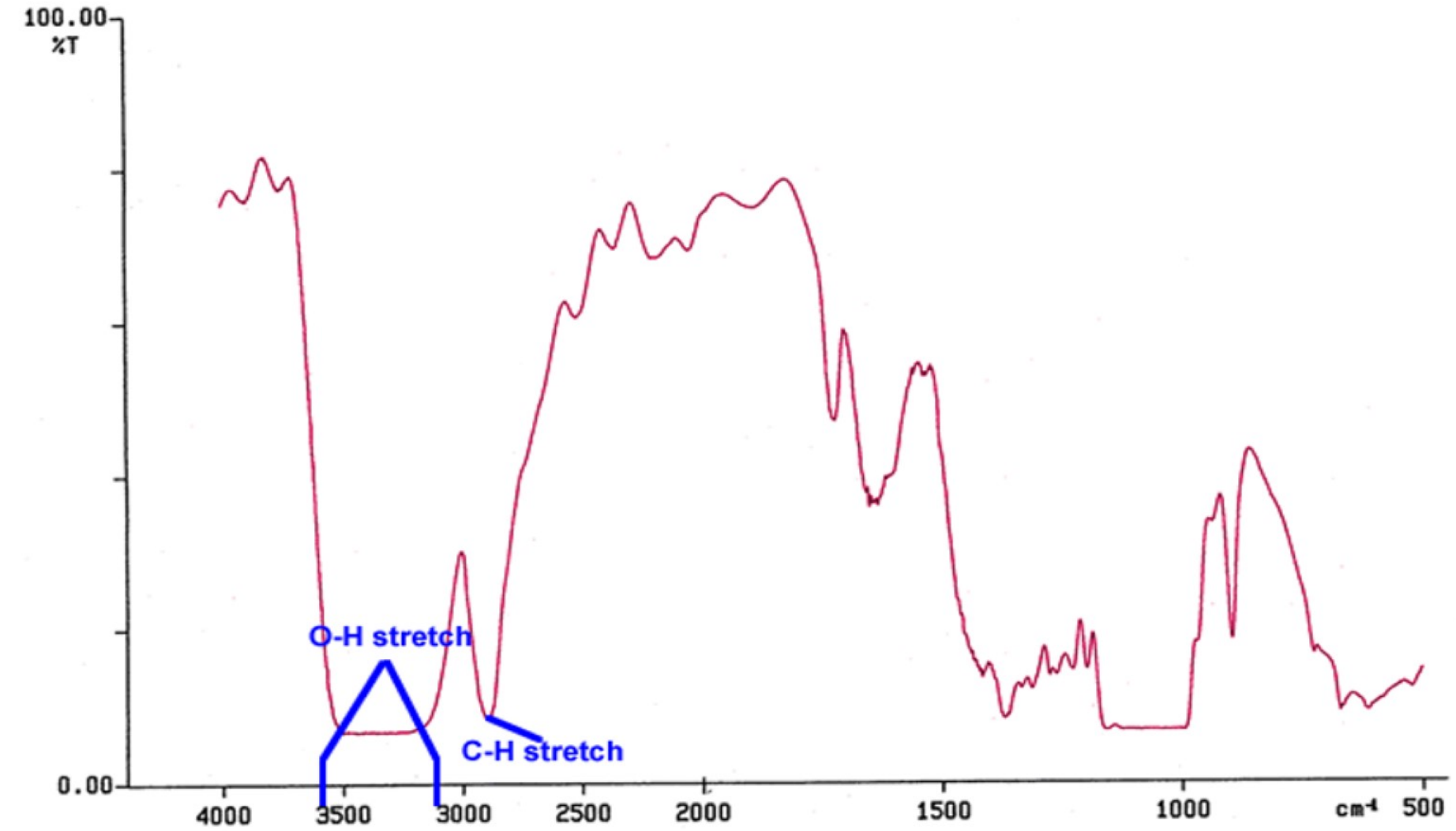
supersaturated sodium acetate solution

Crystallizing the Supersaturated Solution

- How much of the sodium acetate remains in solution after this crystallization process?
- Design an experiment to determine the amount of heat required to recrystallize this solid.

Additional research & literature reveals

Fortune Telling Fish
Non-moisture-resistant cellophane



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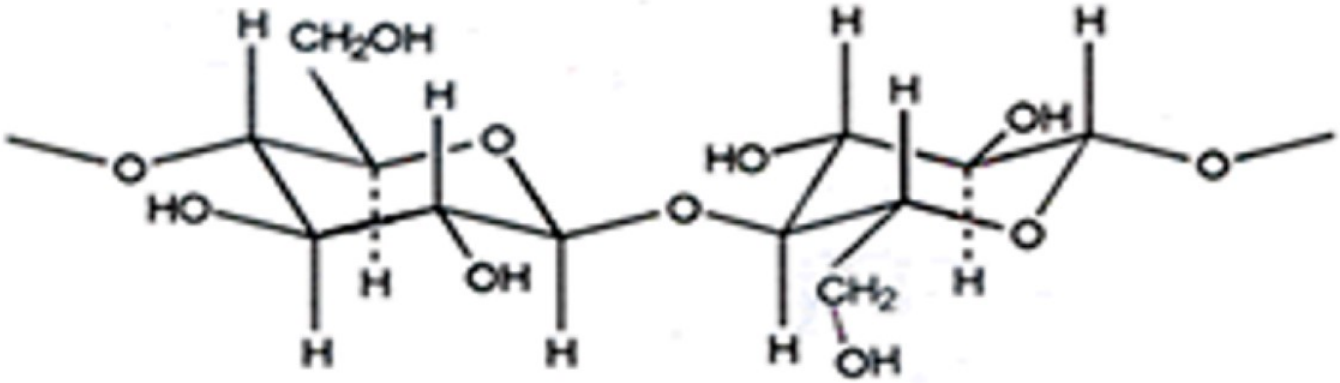
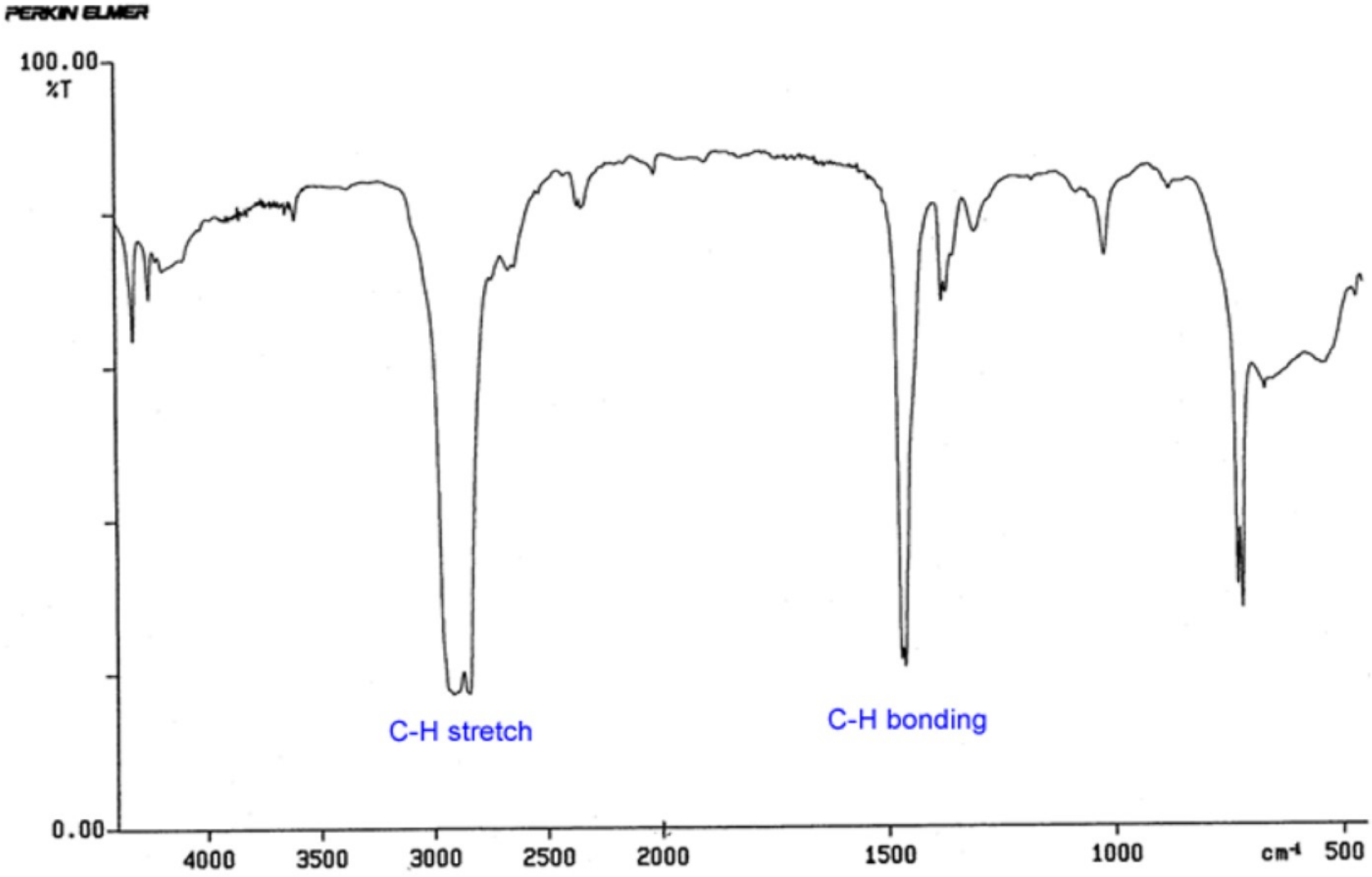
Fourier Transform Infra Red Spectrometer (FTIR)

the fish is made of



Cellulose

Wrapper for Fortune Telling Fish



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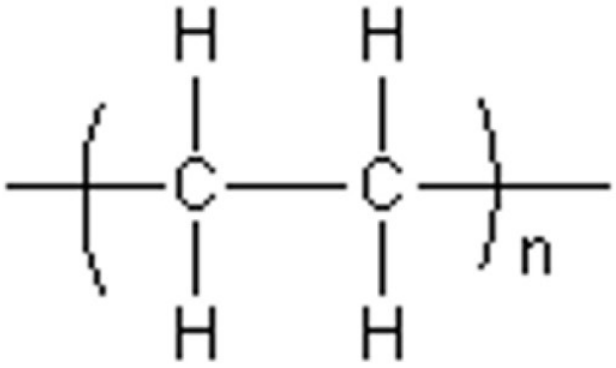


Polyethylene

SCIENCE

Argument-based inquiry

- Testable Questions
- Design appropriate investigations
- Data collection and analysis
- Make a claim
- Evidence

Construction and Critique (practices of science)

Interpreting data

- **"This isn't working!! My results are wrong!"**
  - EVIDENCE is what it is..
  - Even if the results may be unexpected
- **"NOTHING is happening"**
  - No noticeable change is VALUABLE information
- Experiments are repeated many times
  - to check *reliability* of data/observations

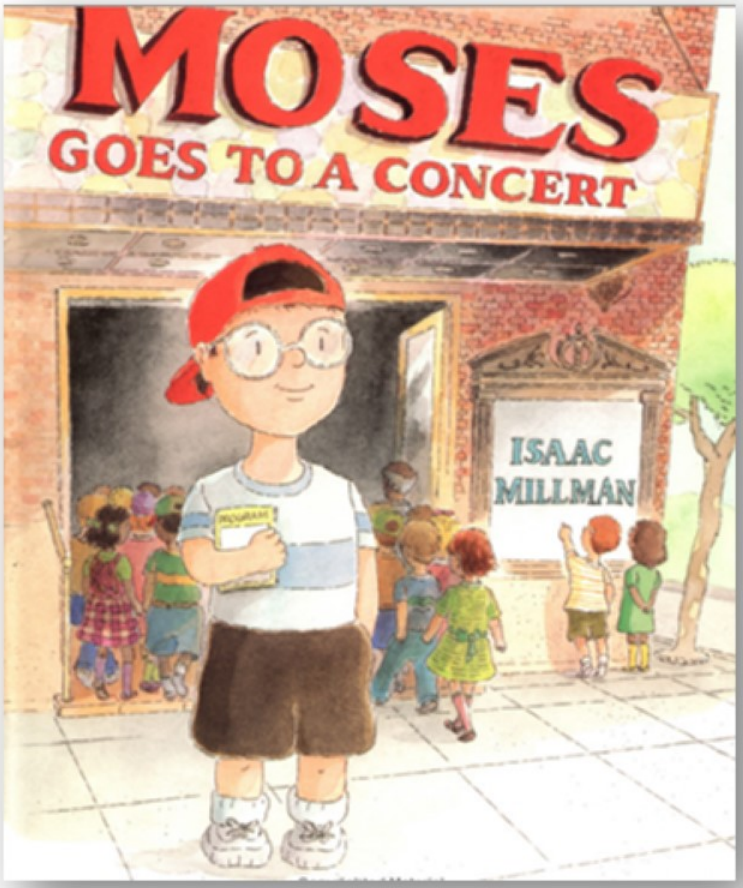
BIG BEN

Gathering Evidence

Testing if the type of hanger affects the results

Testing if the length of the string affects the results

Grade 2 student's claim with substantiating evidence



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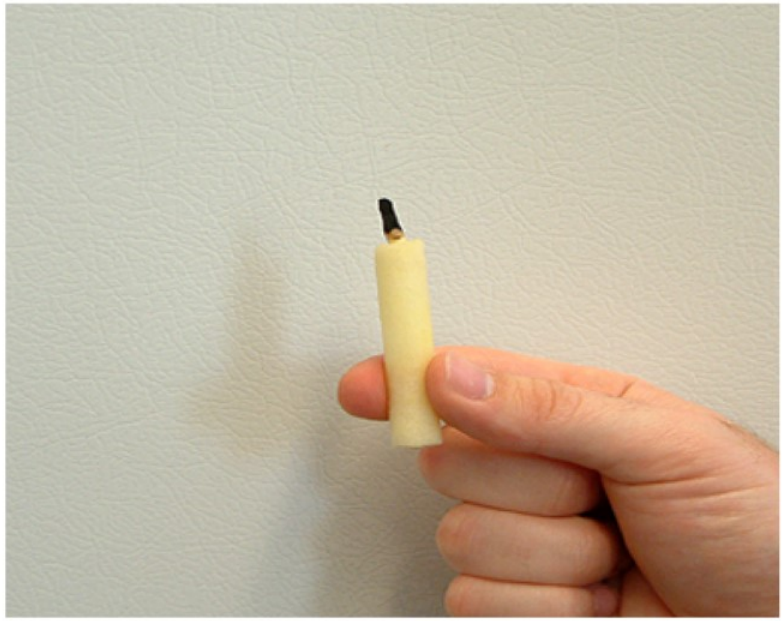
What types of observations?



Qualitative Observations

Quantitative Observations

Discrepant events are only possible if ***prior experience*** *would tell you otherwise*

"Expect the unexpected"

Chinese proverb

Teachers set the perimeters

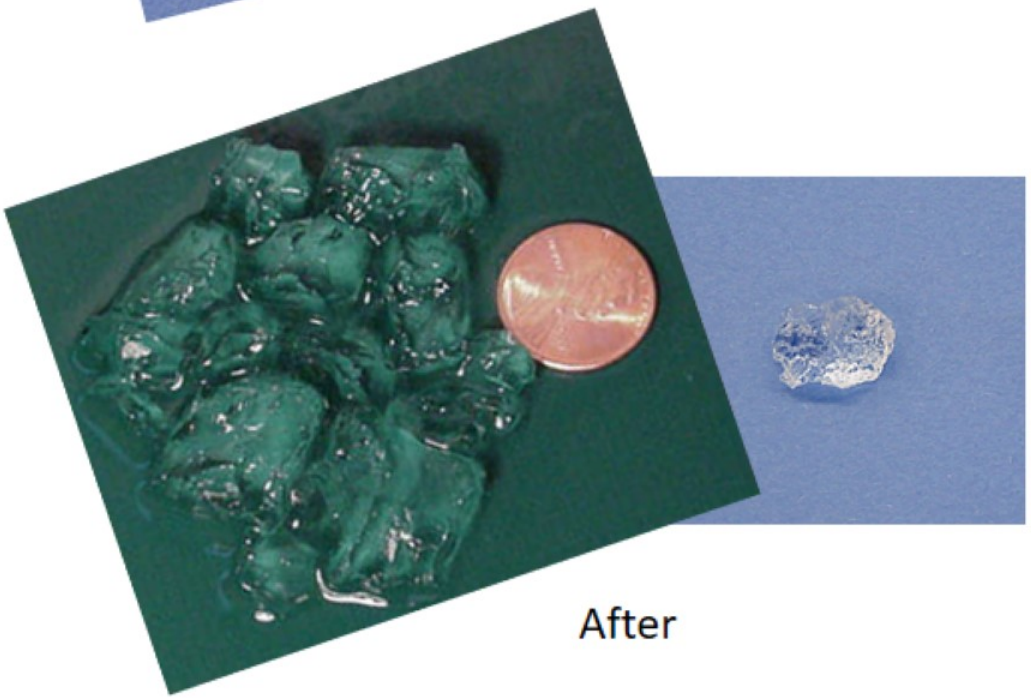
(asking students)

- Is there something you observed about your system that led you to ask this question?
- What materials will you need for your experiment?
- What data will you need to gather in order to answer your question?
- What tools and methods will you use to collect this data?

Magic or Science?

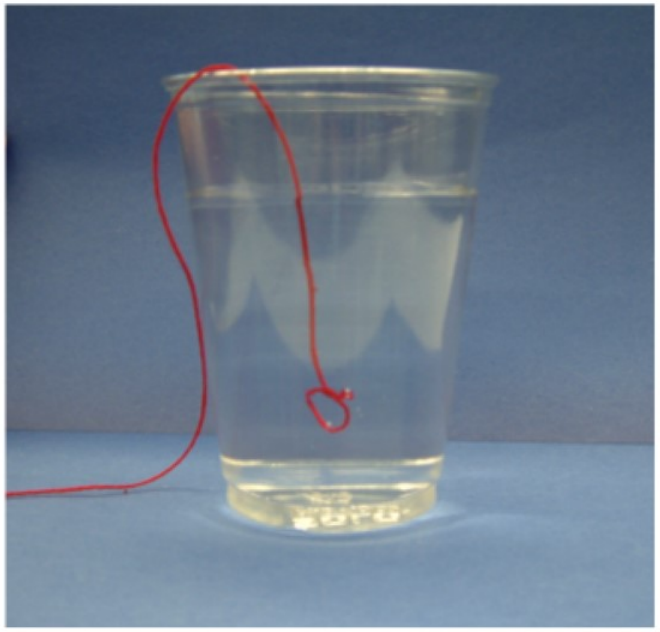
sodium polyacrylamide

Before



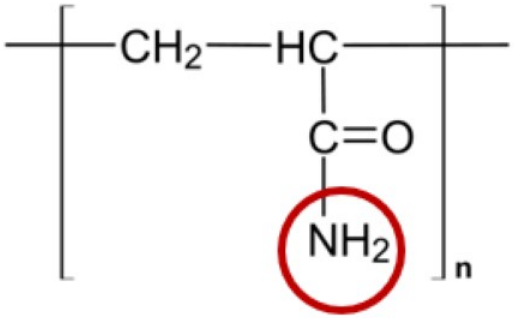
After

Magic or Science?



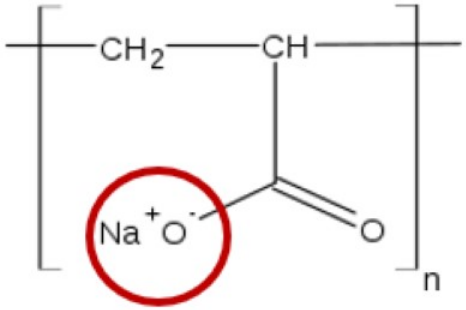
Water saturated polymer has same index of refraction as water

close relatives

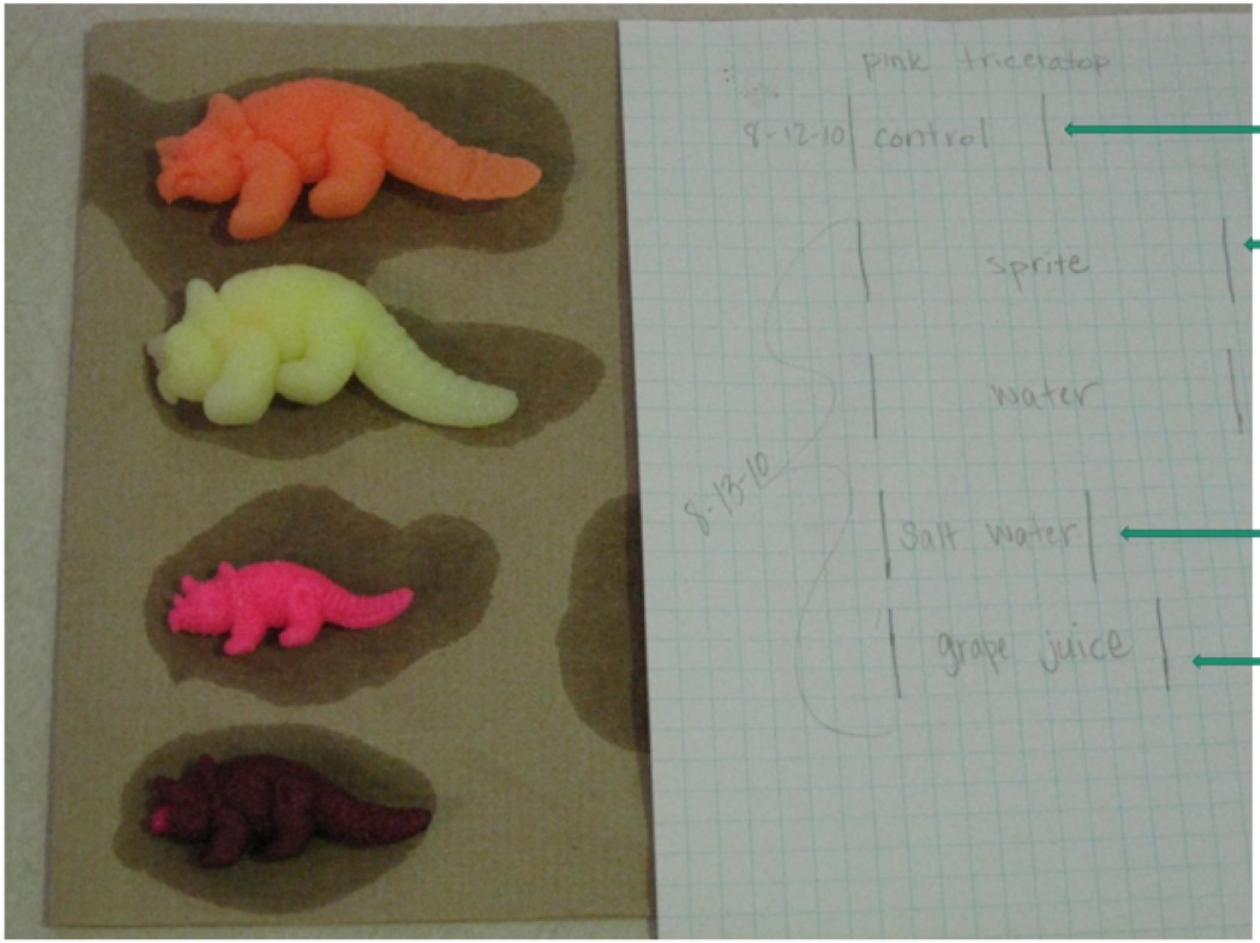


polyacrylamide
Soil Moist

sodium polyacrylate
'Where'd the water go?' demo



Gro-Dinos


pink triceratop
8-12-10 control
sprite
water
8-13-10
salt water
grape juice
control
sprite
water
salt water
grape juice

Reunite the FUN and MENTAL aspects of scientific play !

By combining the fun/hands-on and mental/minds-on aspects of science teaching and learning, we have found that BOTH increased motivation and understanding result.

What do whoopee cushions, potato guns, and exploding straws have in common?

Straws: Science Tools

Work in pairs.
One partner hold a straw.
The other prepare to flick.
Then

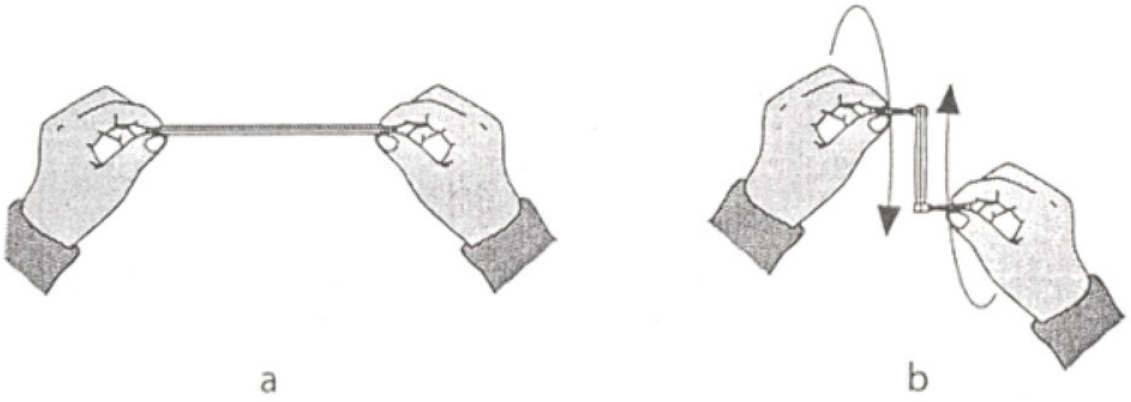
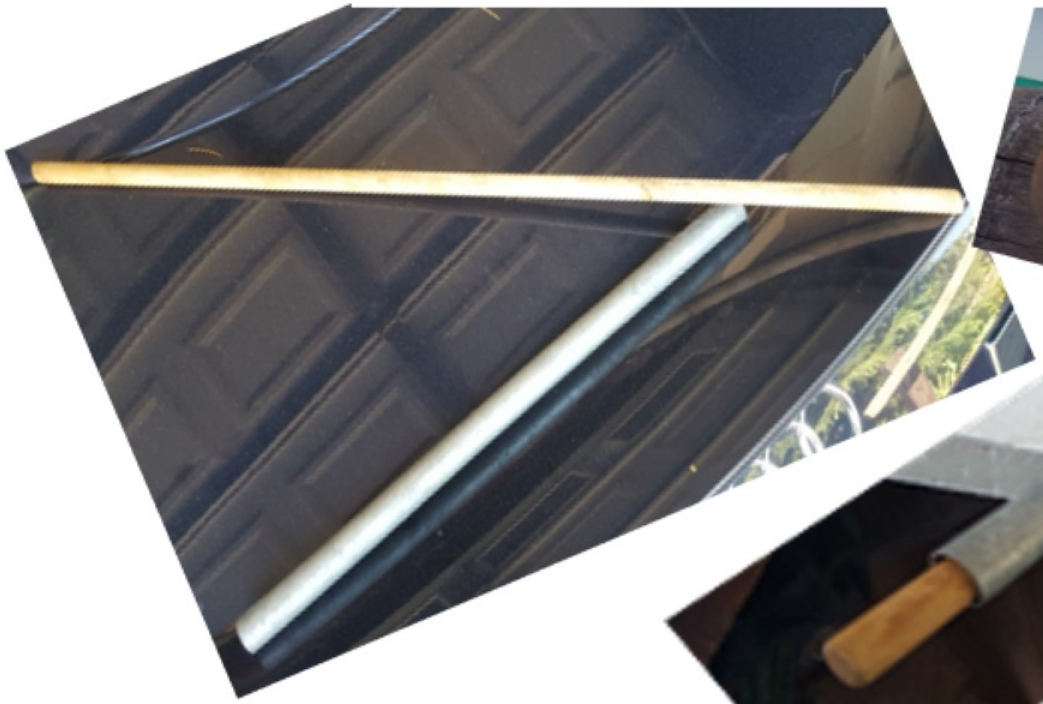
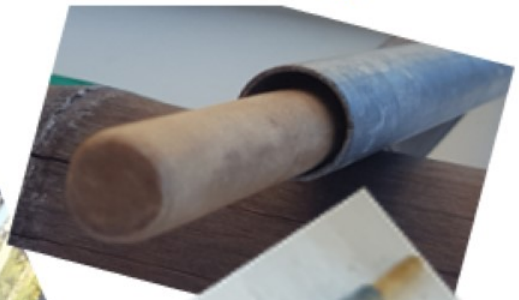


Figure 3: After (a) grasping the straw with both hands, (b) twist one hand over another until about two inches of unrolled straw are left in the middle.

Home-made potato shooter

wooden dowel rod (1cm diameter at least 60cm long)





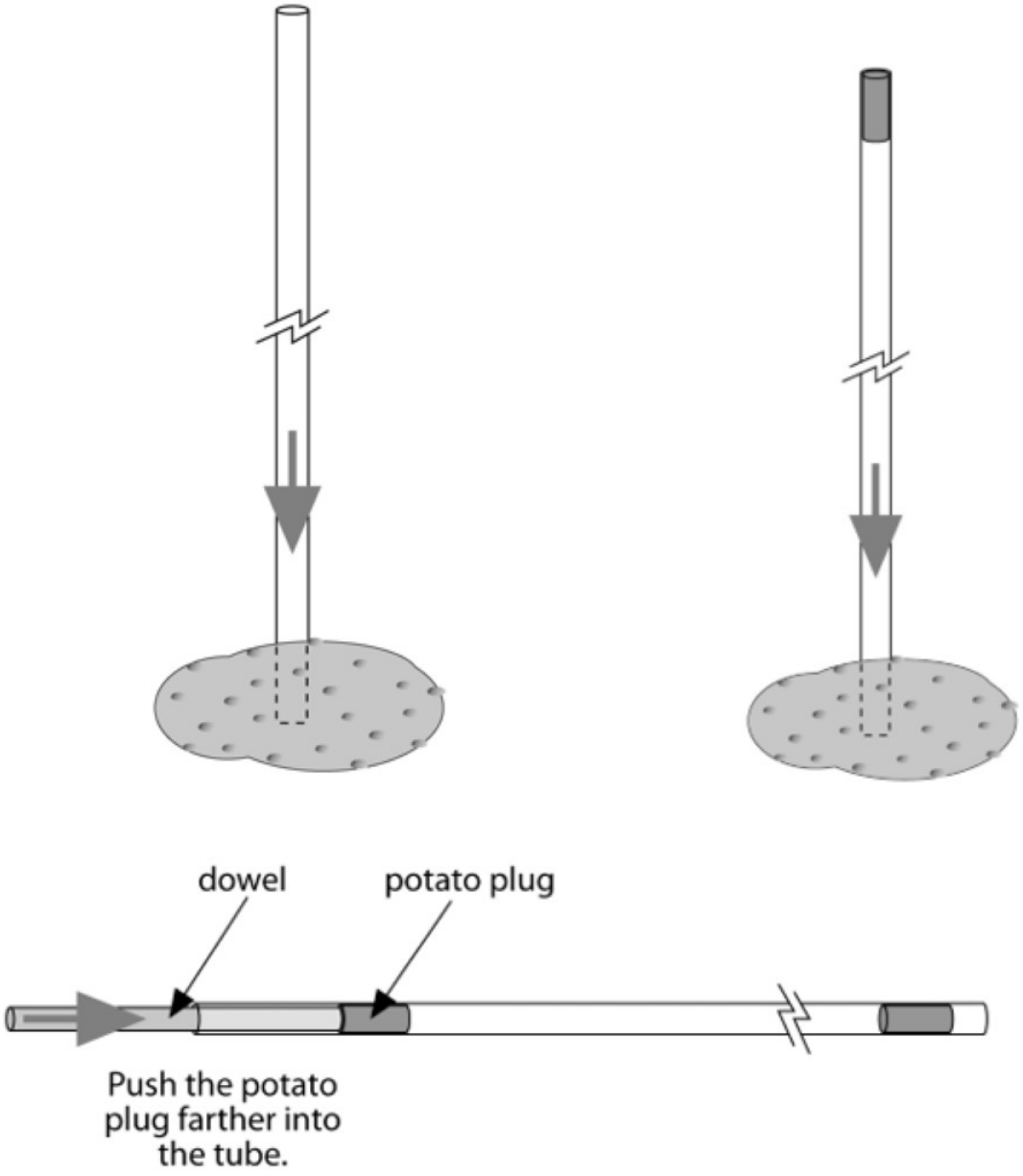
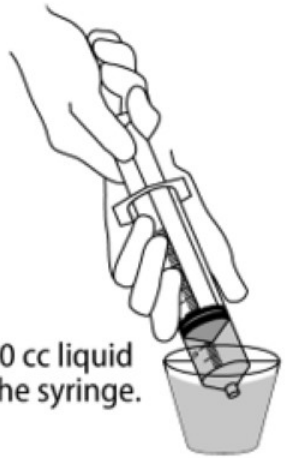


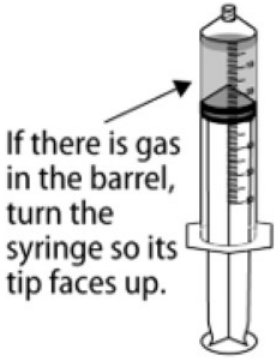
Figure 4: Push the plug 5–6 cm (about 2 inches) into the tube with the dowel.

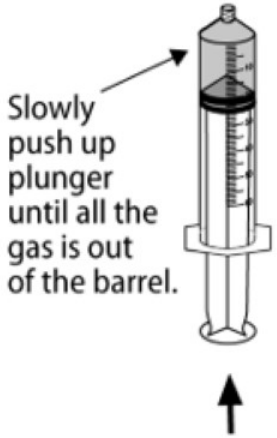
Exploring solids, liquids, & gases in a syringe

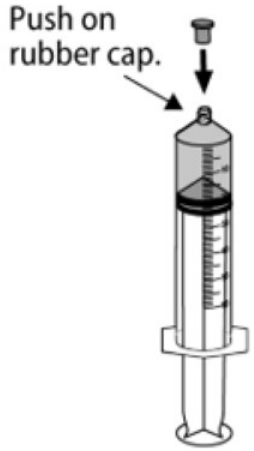
Put the wooden dowel into the syringe.

Next, try water.





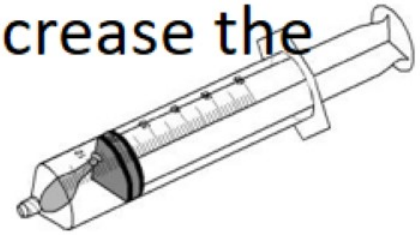




Next we'll look at air

- **Trap** 20 cc air inside a syringe.
  - Make the pressure on the inside less. What happens?
  - Observe as you increase the pressure.

- Put a small, tied-off balloon into the syringe. Close the system. What happens if you decrease the pressure in the syringe?

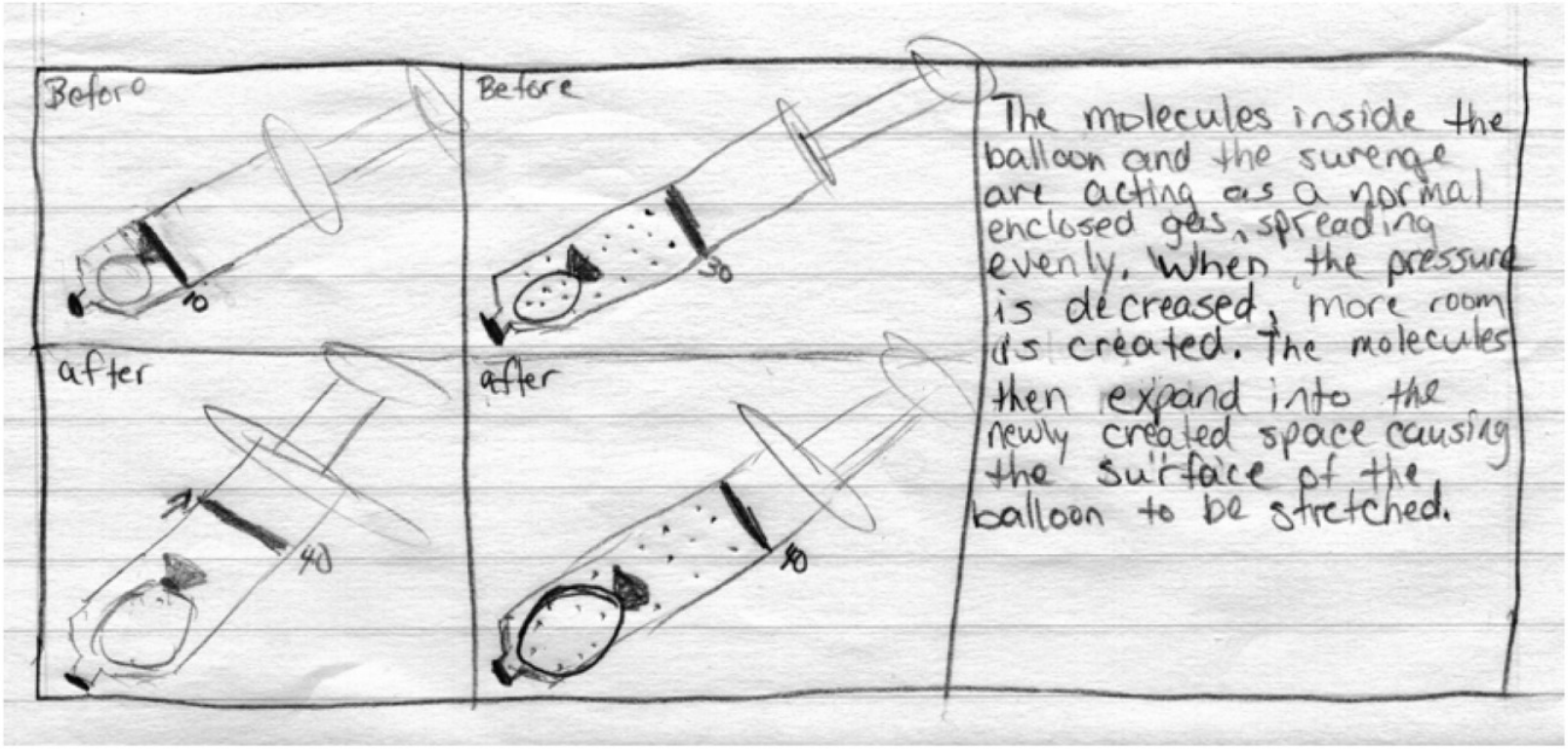


- Repeat the experiment with a marshmallow. What happens?

Marsh Mallow

HS Student's Visualization & Storyboarding

Macroscopic View | **Visualization at molecule level** | **Explanation of model**



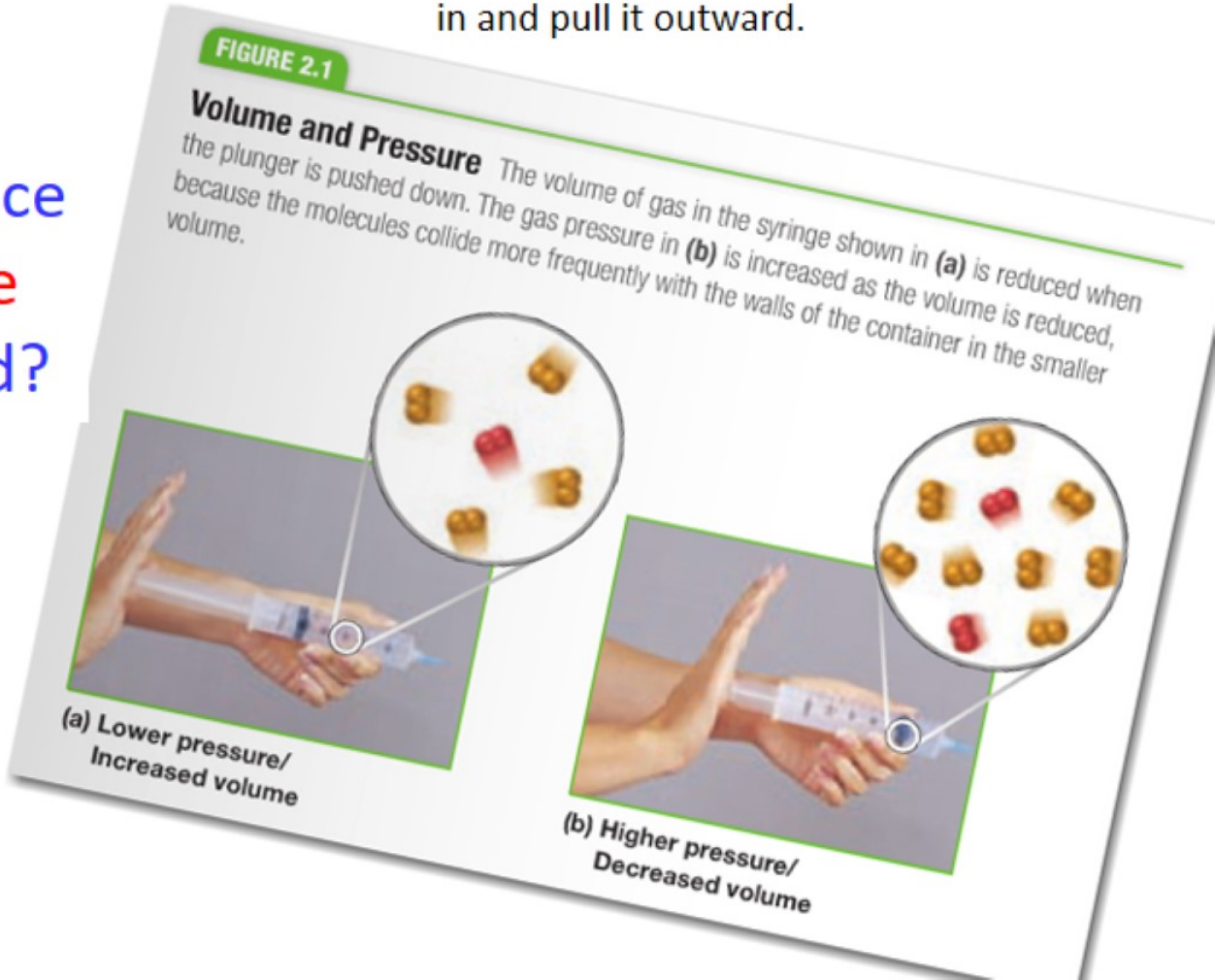
Thank you, Sir Robert William Boyle

(1627-1691)

Trap air inside a syringe.

Observe as you push the plunger in and pull it outward.

What's the evidence that the pressure inside is increased?



Charles Law meets the bubble film

Simple… yet surprising
&
they are doing it!

Placement in your curriculum

- gas laws ($V \alpha T$)

Can you get a hardboiled egg into the bottle?

Ok.. Do it without pushing it with your hands!

What pushed the egg in?

atmospheric pressure

Can you use a raw egg in its shell?

Collecting evidence to understand the system

The System

Procedure:

- Light the candle
- Invert jar or other container
- Quickly lower the mouth of the jar over the candle & into the water
- Observe

Students observe:

- A few bubbles at the very beginning (~40% of the time)
- Water rises into the jar
- The flame goes out
- Water continues to rise even after flame is out

What *testable* questions can you ask?

What *variable would you change* that could allow you to collect information to answer your question?

Group 1

Does increasing the amount of heat affect the results ?

Group 2: testable question

Does the height of the candle change the results?

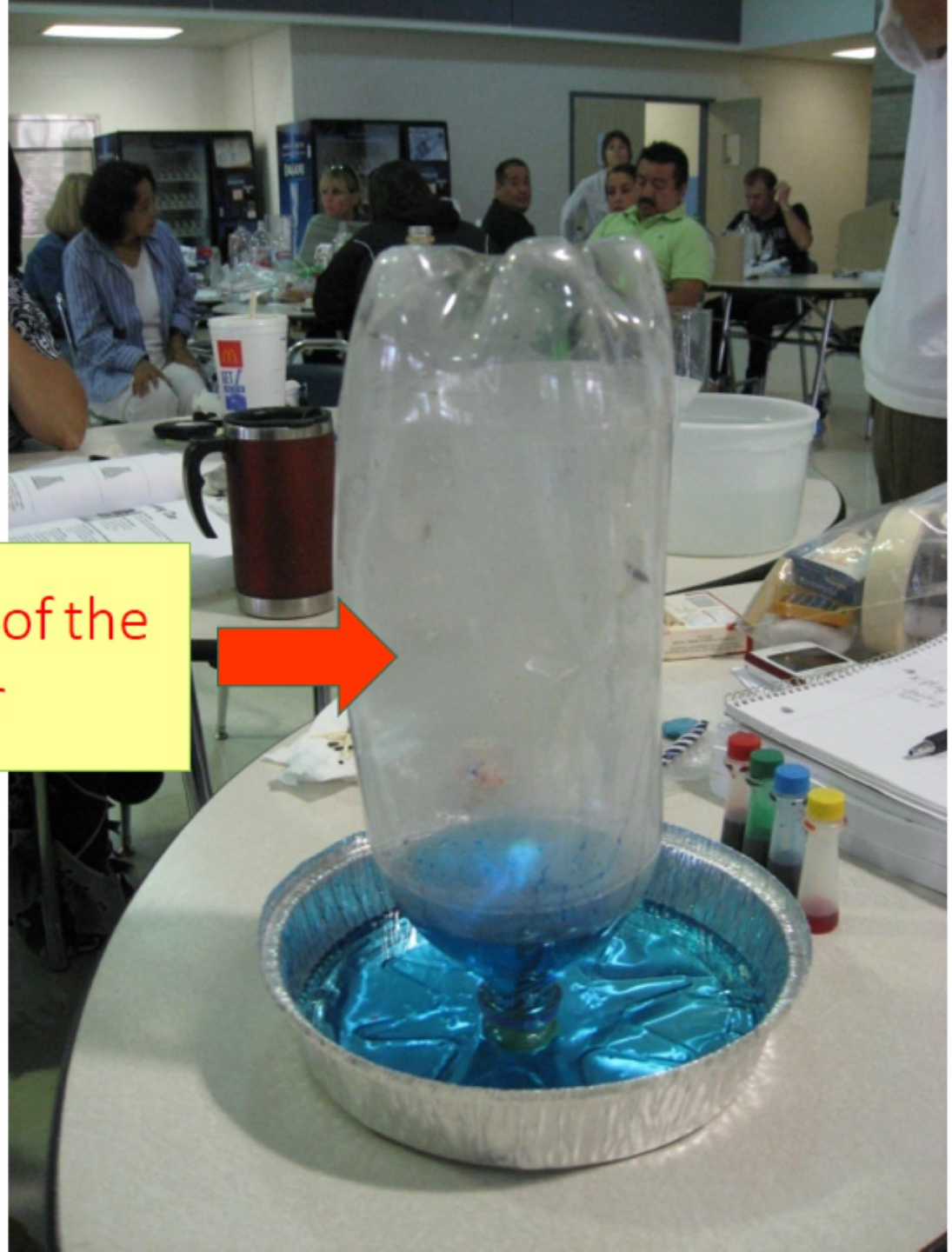

TEXAS
2006
BLOOD DONO

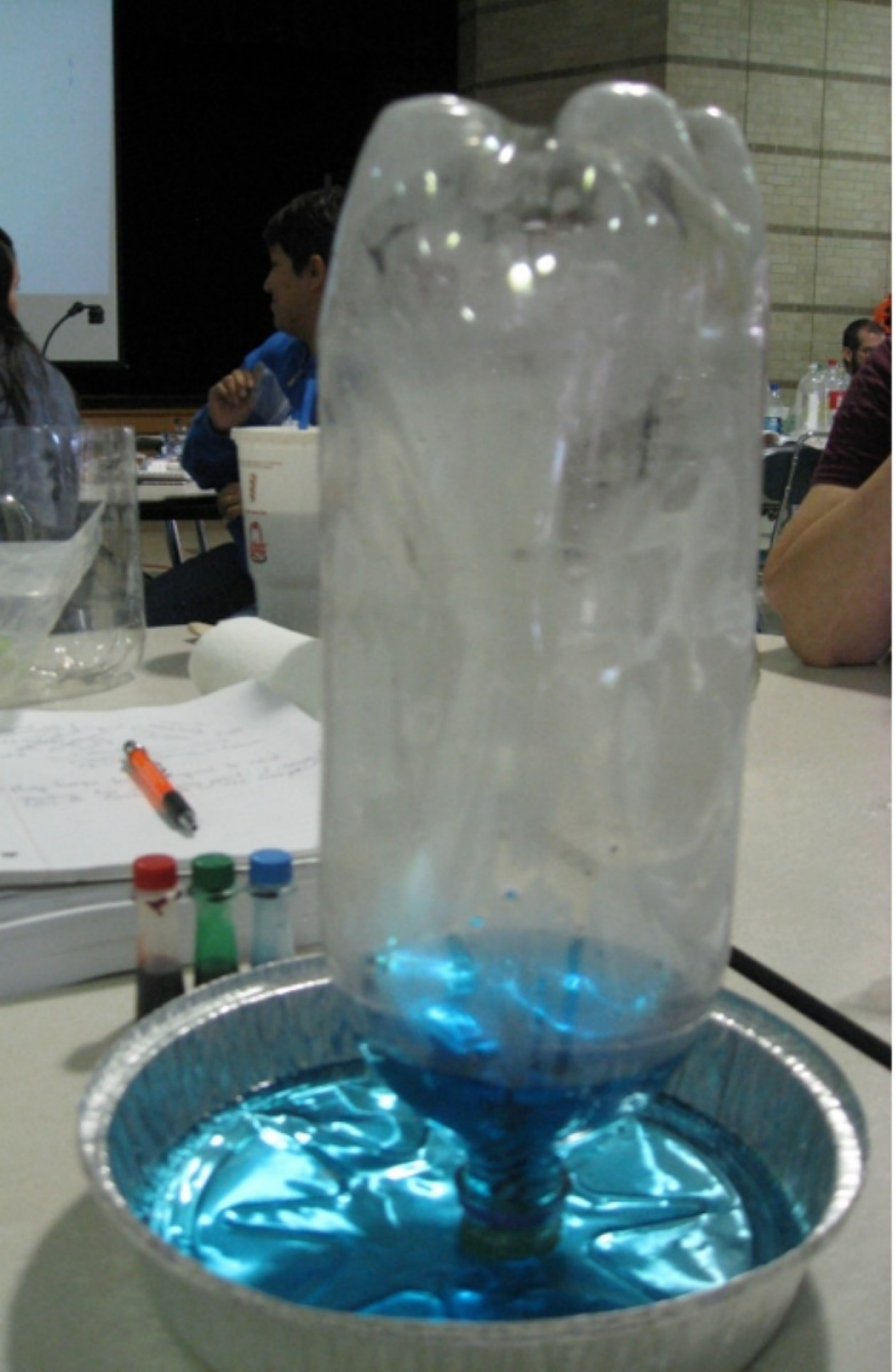
Group 3

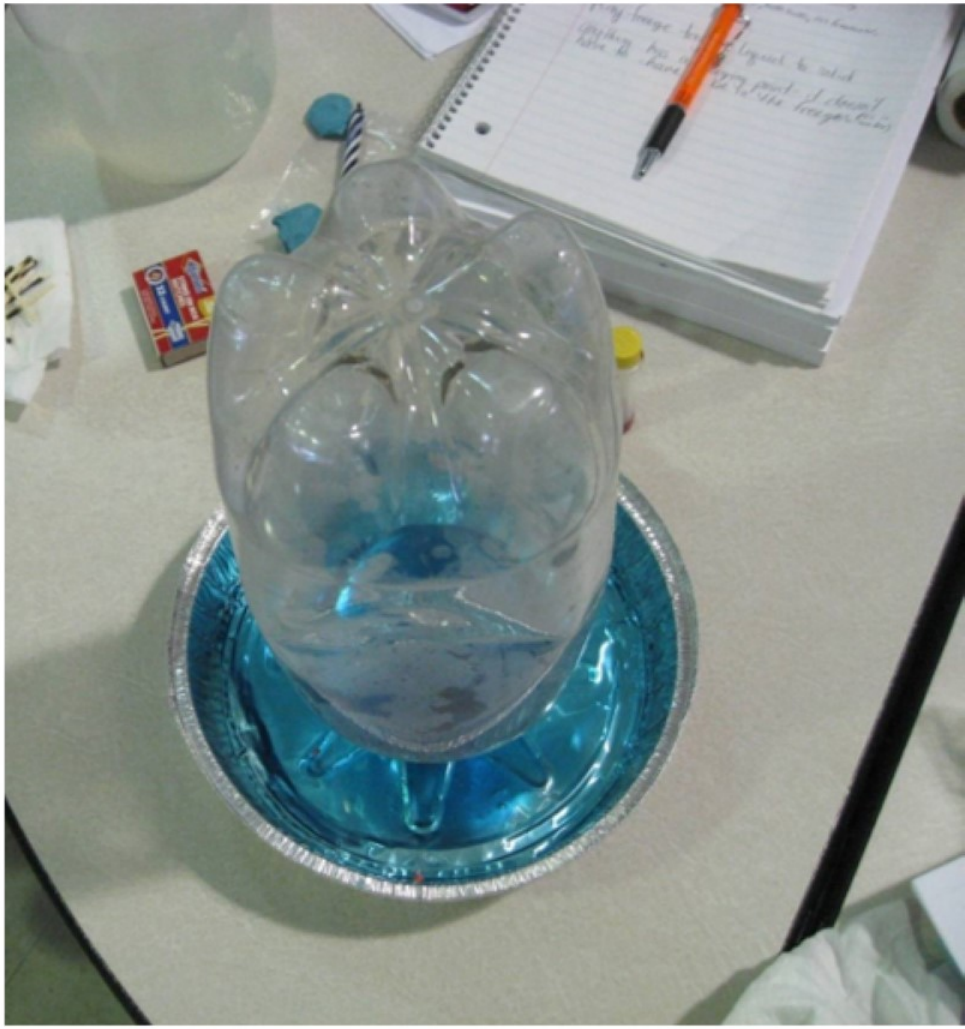
Does a larger bottle affect the results ?

Group 4

Note the sides of the container

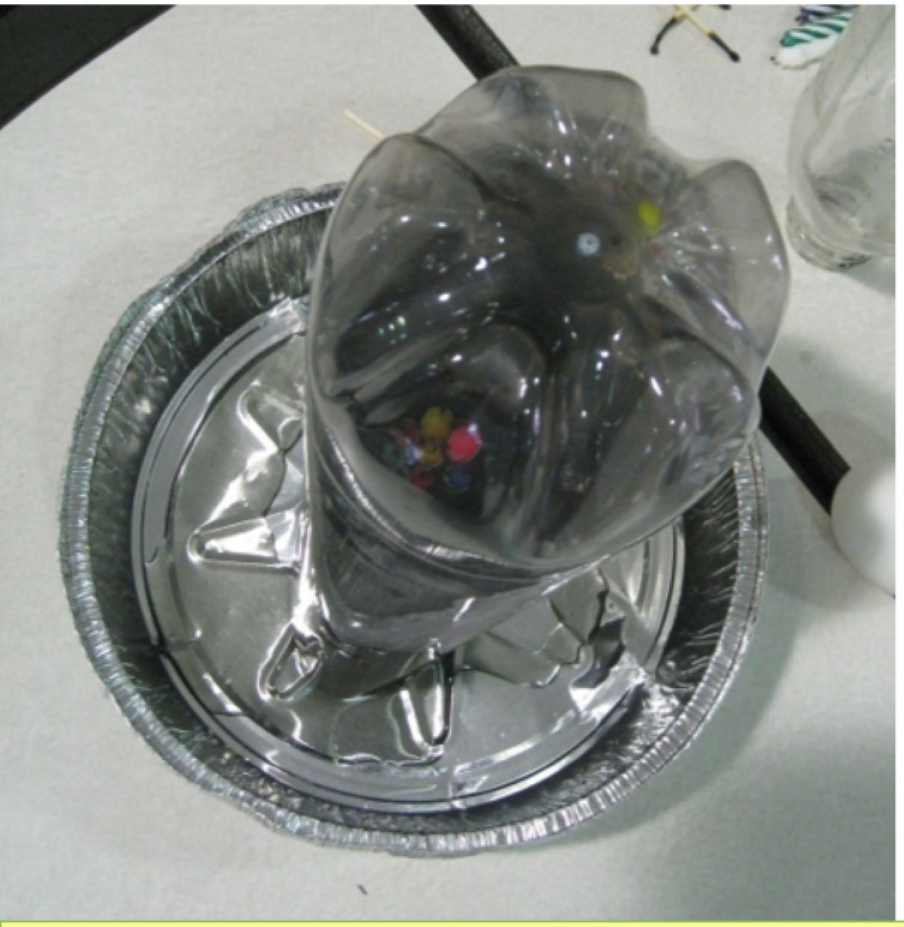






other views

Group 5



Another group tries a similar test

What happens when the warm jar is NOT placed over the candle?

What if the jar is held over the candle for a VERY long time?

Pooling results…

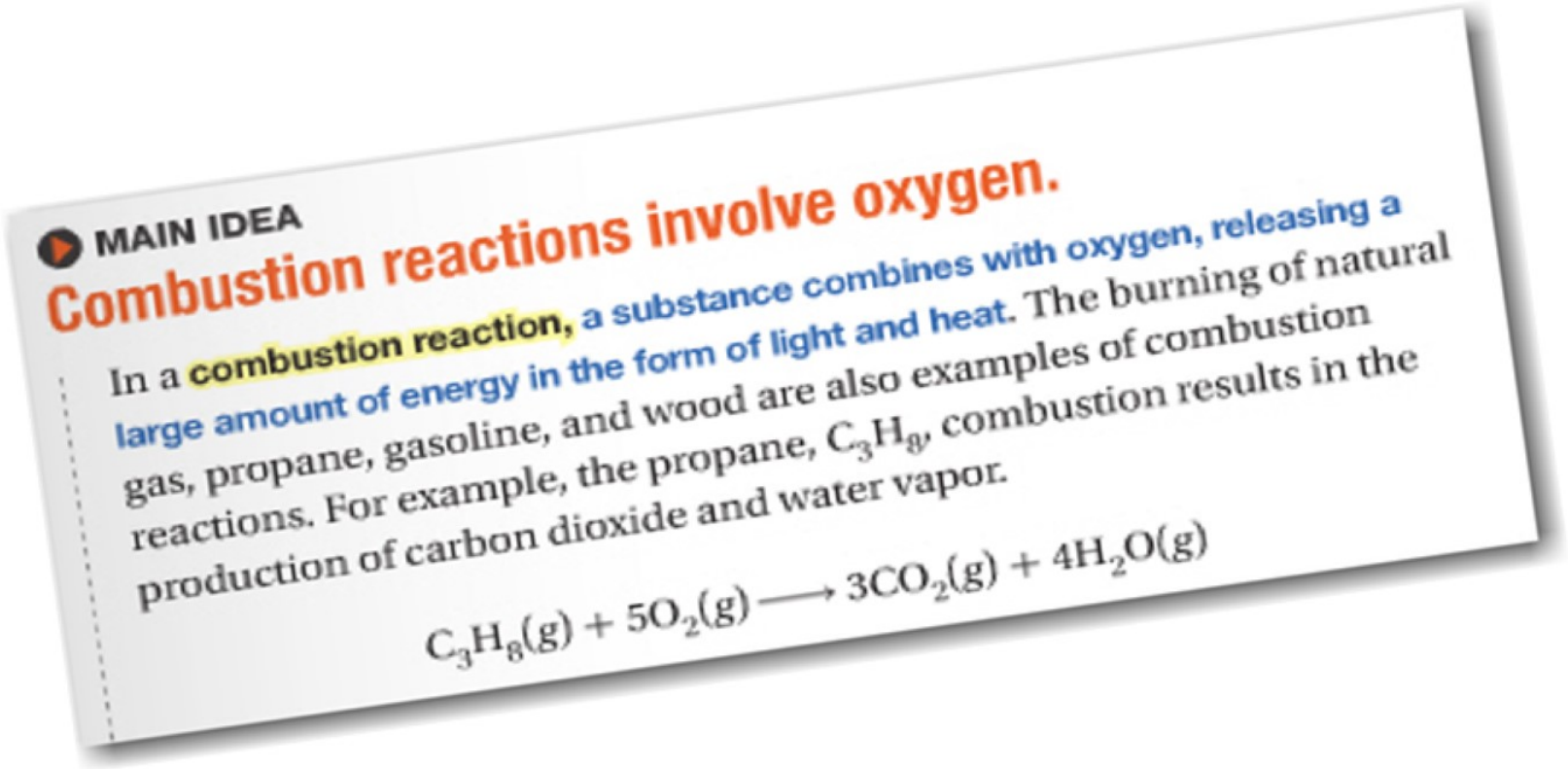
The Sum is Greater than the Parts

- As groups share their claims and evidence with the class, the knowledge base of the class increases.
- As a class, they negotiate meaning from the various studies that were undertaken.
- Formulate more advanced claims as the discussion progresses.

What would most kids say was responsible for the water rising into the container?

the Oxygen was used up…

… but is that the whole story?



MAIN IDEA

Combustion reactions involve oxygen.

In a **combustion reaction,** a substance combines with oxygen, releasing a large amount of energy in the form of light and heat. The burning of natural gas, propane, gasoline, and wood are also examples of combustion reactions. For example, the propane, C_3H_8, combustion results in the production of carbon dioxide and water vapor.

$$C_3H_8(g) + 5O_2(g) \longrightarrow 3CO_2(g) + 4H_2O(g)$$

Combustion of wax

typically paraffin C_nH_{2n+2}

$$C_{17}H_{36}(g) + 26\ O_2(g) \rightarrow 17\ CO_2(g) + 18\ H_2O(g)$$

Moles of gas during reaction:

1 mole(g) + 26 moles(g) → 17 moles(g) + 18 moles(g)

n↑V↑

27 moles(g) reactants 35 moles(g) products

Increase in the gas volume would push the water out of the flask

When the system cools: $18\ H_2O(g) \rightarrow 18H_2O(l)$

Moles of gas once cooled:

1 mole(g) + 26 mole(g) → 17 mole (g) +~~18 mole(l)~~

27 moles(g) reactants → 17 mole(g) products

n↓V↓

n↓P↓

Phases changes make a difference !

1 gram of $H_2O(g)$ occupies about

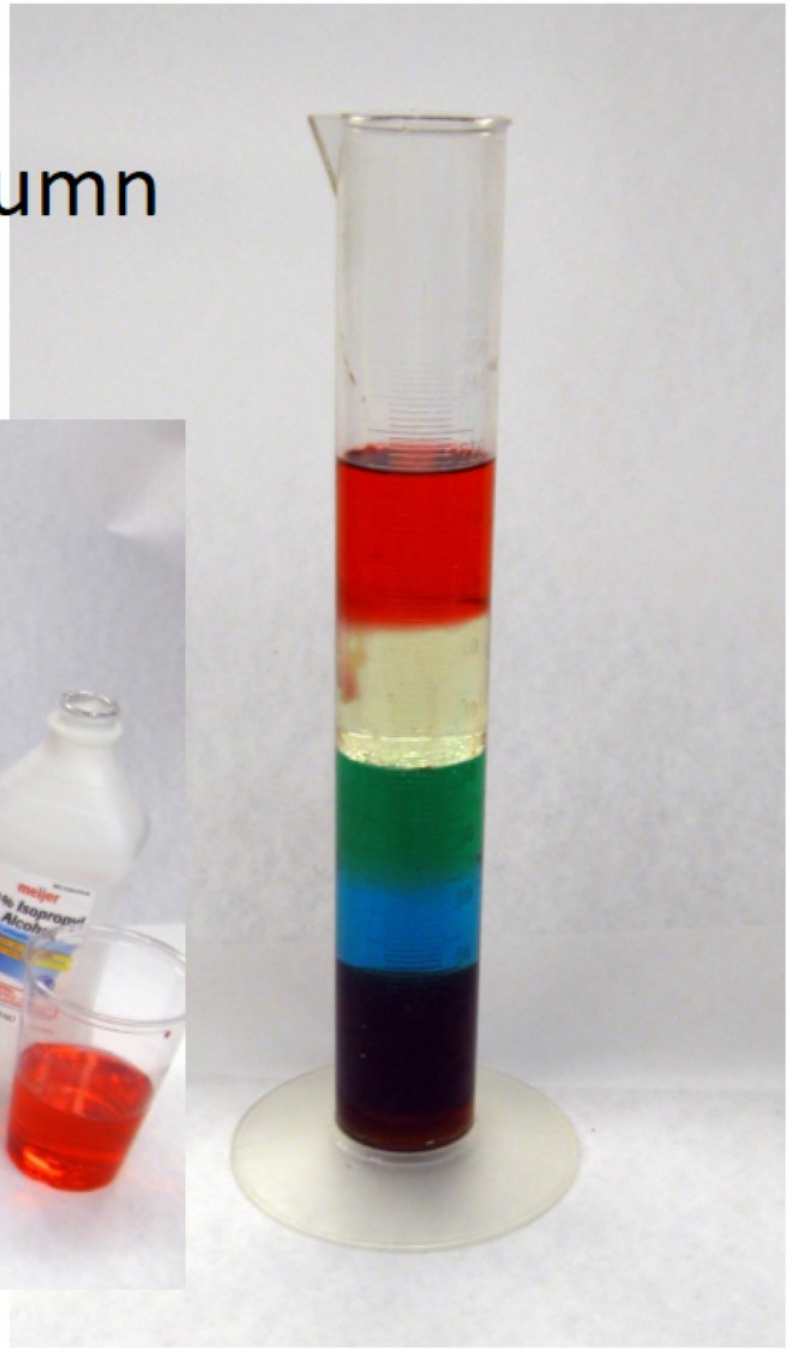
1300 times

the volume of the same mass of $H_2O(l)$! ! ! !

Using chemistry to crush an Al can

A us

Household Density Column

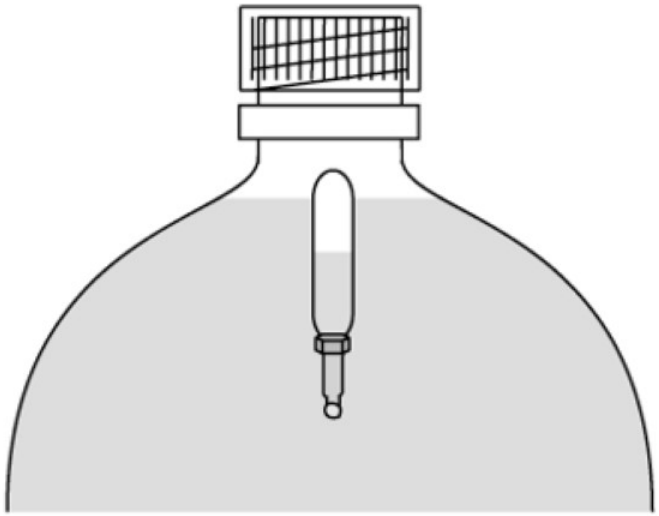


What's happening here?

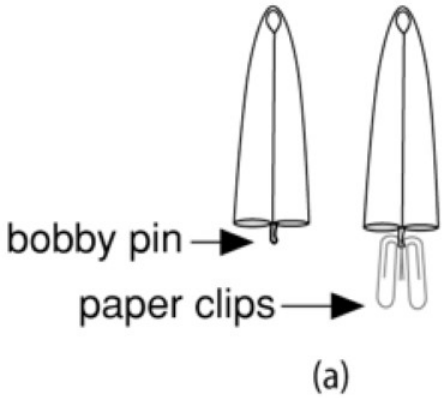
water with red food-coloring

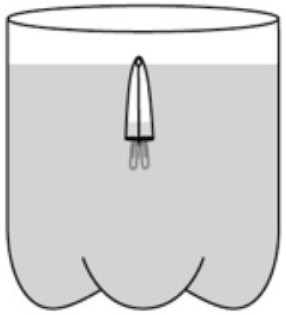
water with blue food-coloring

Cartesian Divers



Beral Pipet

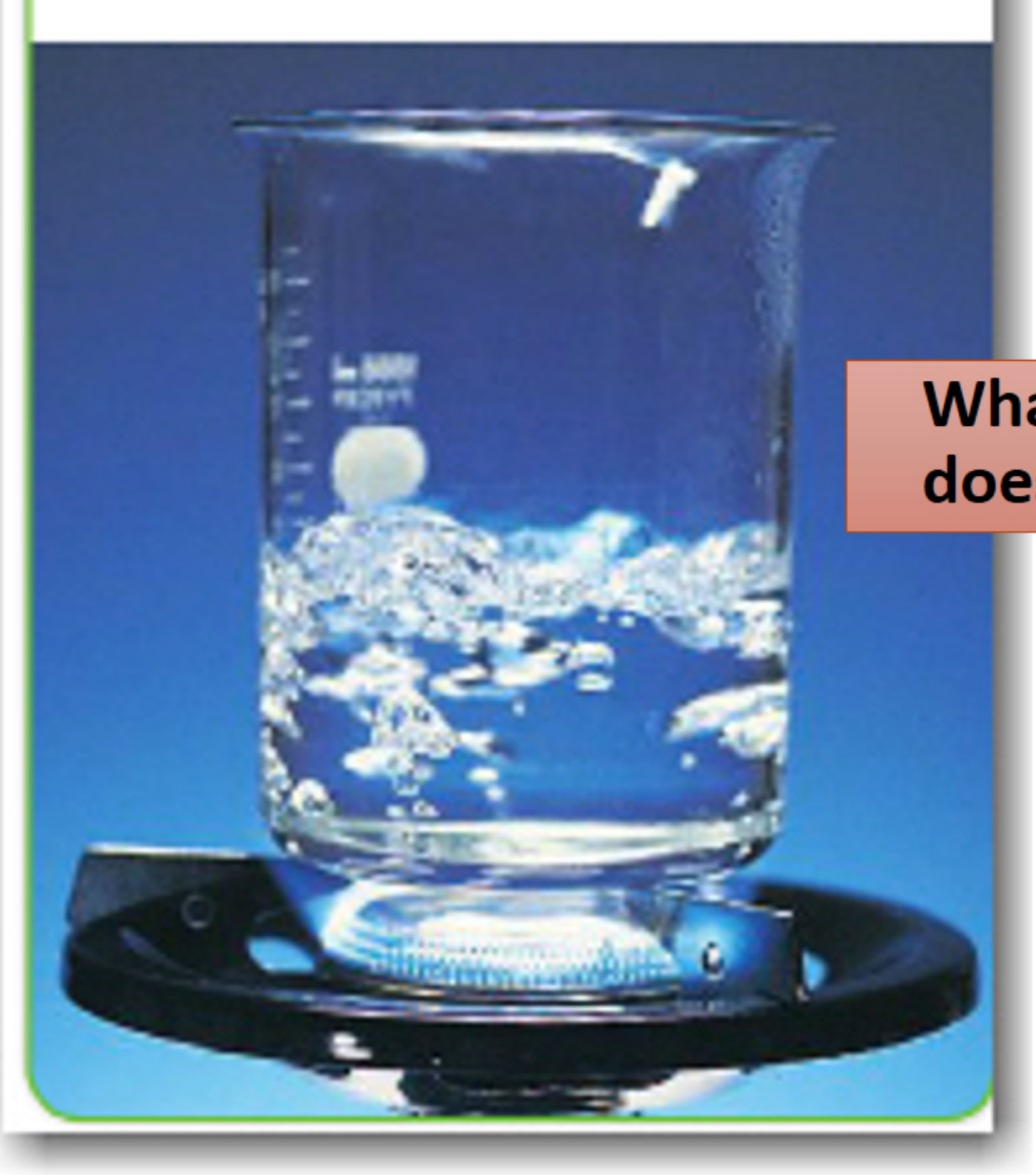




Folded straw

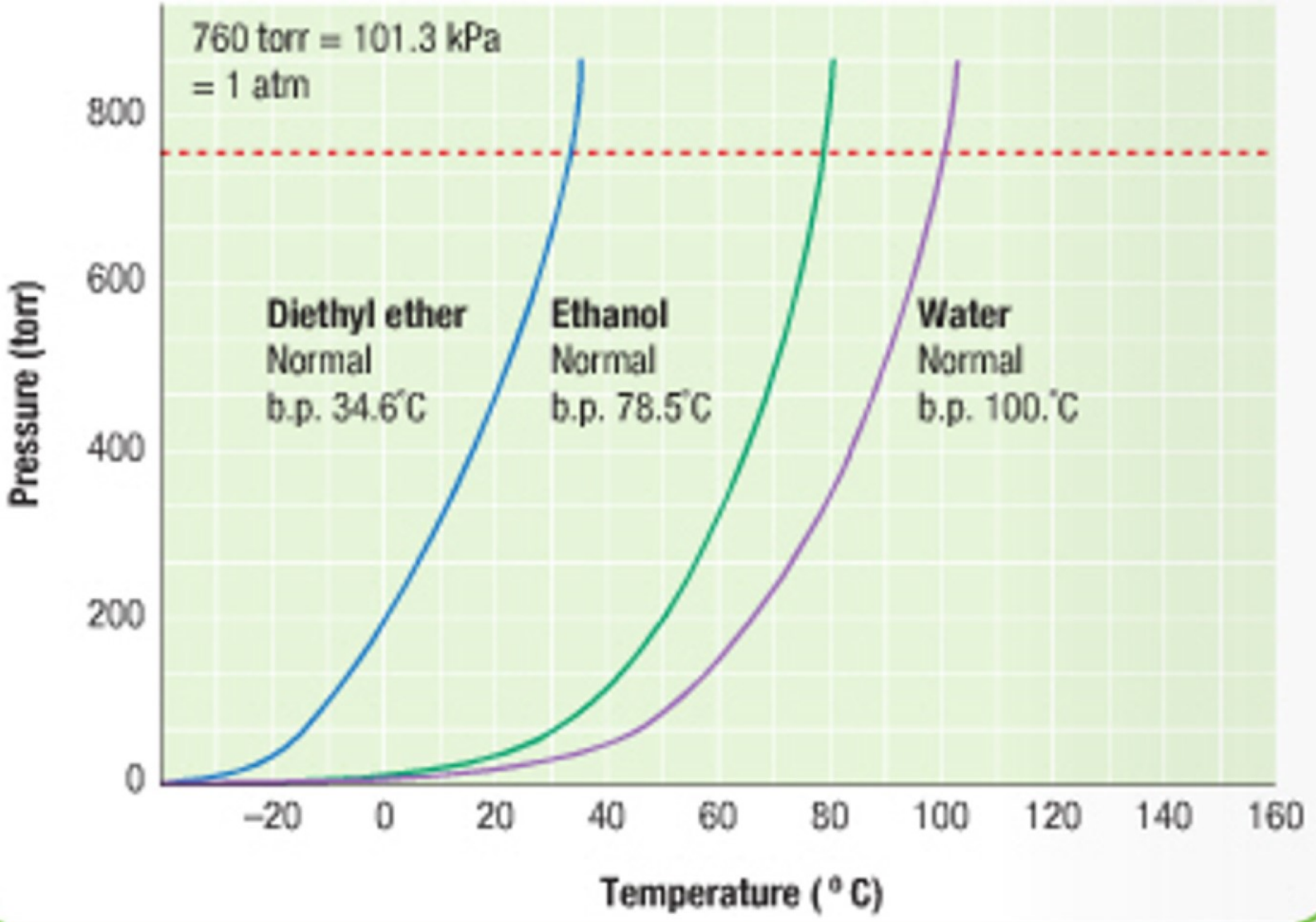
Can you pour a gas?

What's happening to the water?



What temperature does water boil at?

Vapor Pressures of Diethyl Ether, Ethanol, and Water at Various Temperatures



Hand boiler (love meter)

How does it work?

Is this boiling?

base chamber→

Useful, engaging, & fun chemistry tools!

Hand boiler (love meter)

Challenge students to figure out

- the engineering/design of the toy
- the science of the system

Placement in your curriculum

- how gases make pressure
- gas laws ($P \alpha T$)
- what is boiling & what isn't

carefully invert …

keeping ALL of the colored liquid in

the base chamber..

What does the top chamber feel like?

Ice-salt bath

Research Question:

Will an ice cube melt faster in salt water or tap water?

Equipment:

- 2 Styrofoam cups
- Salt water (160 g NaCl / 1 L)
- Thermometers
- Room temperature tap water
- 20 mL ice cubes (made in plastic soufflé cups)

Authentic Research Within the Grasp of High School Students
Annis Hapkiewicz, Okemos High School, Okemos, MI
Journal of Chemistry Education, Vol 76, No. 9, Sept 1999

Speculation:

Ice cube floats higher in salt water which causes the difference in melting rate.

Experiment:

Holding the ice cubes under the surface of the water

Results:

No difference from the initial experiment

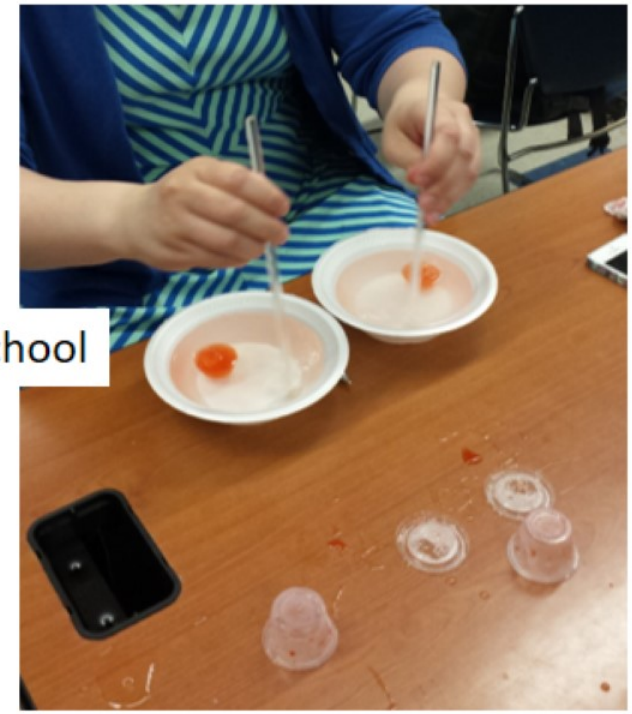
Speculation:

Salt water does not transfer heat as well as tap water.

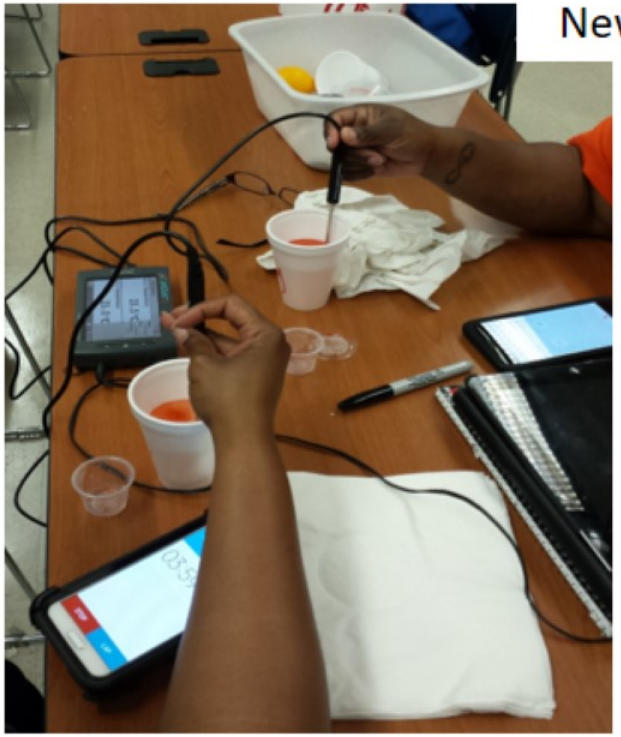
Experiment:

Measure temperature vs time for ice in salt water and ice in tap water

Old School



New School



Results:

Temperature changed more slowly in salt water

Speculation:
Ions in salt causes the ice cube to melt slower

Experiment:
Compare ice cube melting rate in a sugar solution vs tap water

Results: ice cube melted slower in sugar solution

Question: Would stirring the tap water and the salt water during the experiment change the melting rate of the ice cube?

Results: the ice cubes melted at the same rate

Question: Does the size of the container make a difference?

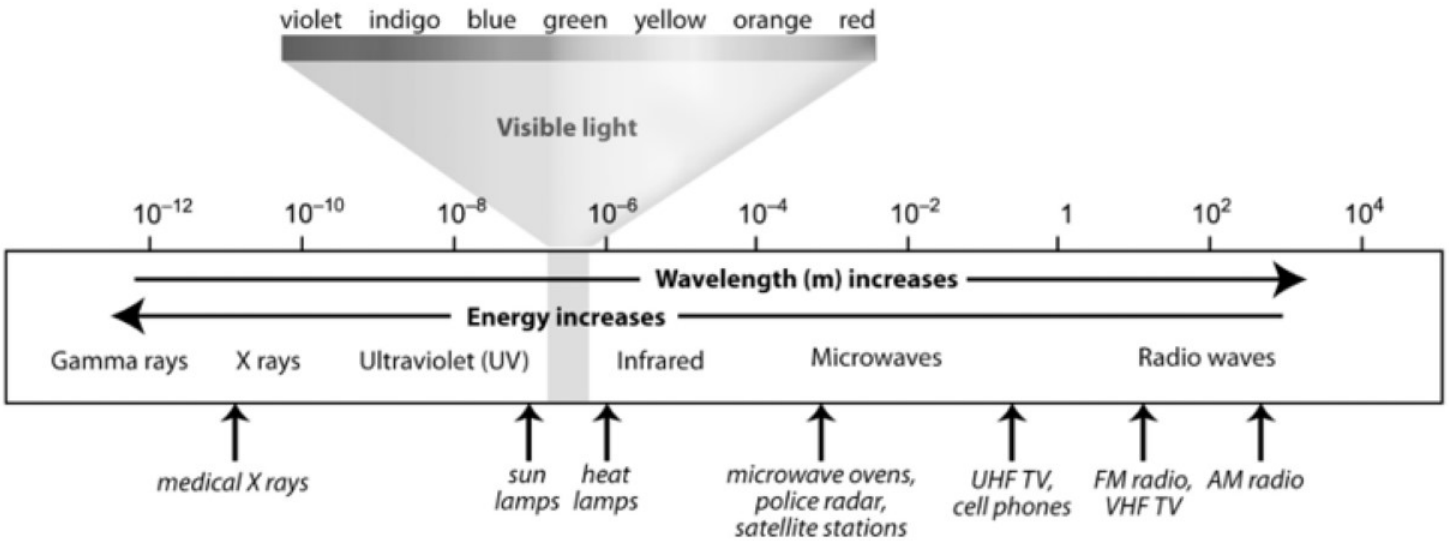
Question: Is there a difference in density of melted ice in salt water vs melted ice room temperature tap water?

Our Questions:
Will an ice cube melt faster in salt water or tap water?

RESULTS
??????????

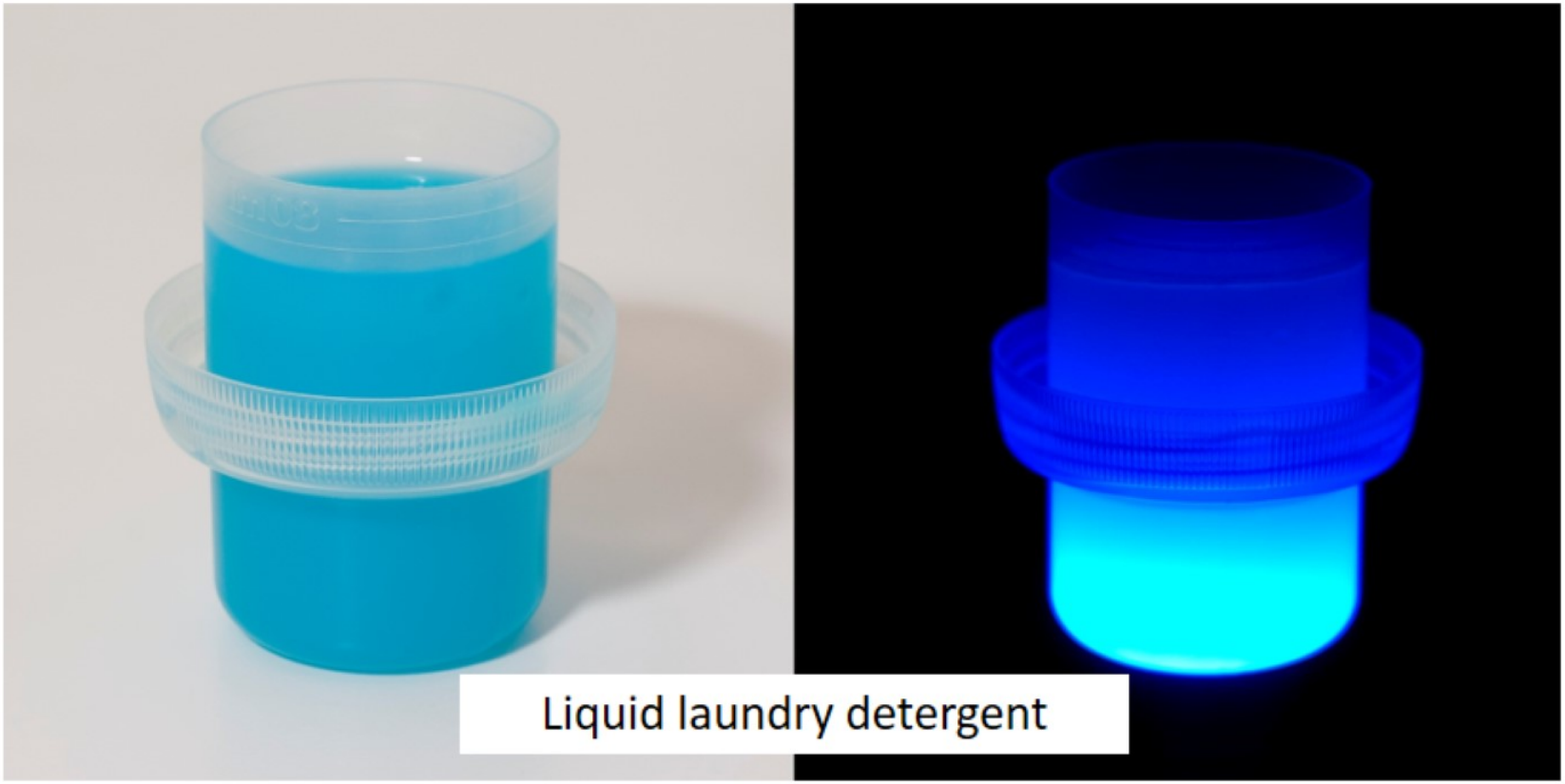
Tap Water

Fluorescence & Phosphorescence


violet indigo blue green yellow orange red
Visible light
10^{-12} 10^{-10} 10^{-8} 10^{-6} 10^{-4} 10^{-2} 1 10^{2} 10^{4}
Wavelength (m) increases
Energy increases
Gamma rays
X rays
Ultraviolet (UV)
Infrared
Microwaves
Radio waves
medical X rays
sun lamps
heat lamps
microwave ovens, police radar, satellite stations
UHF TV, cell phones
FM radio, VHF TV
AM radio

Whiter than white?

absorbs energy in the UV portion of the spectrum and re-emits it in the blue portion of the visible spectrum



Fluorescence
Models that involve role-playing




UV light provides energy to “kick” electrons up to an excited state.
When they return to ground state, energy is given off as light.

Phosphorescence




An intermediate level is available for excited electrons to land before returning to the ground state. Light continues to be given off even after energy source is removed.

phosphorescent vinyl
yet another use

ZnS doped with Cu:
emission occurs at 520 nm

Wavelengths of the LED light:

- **RED** λ = 630 nm
- **GREEN** λ = 525 nm
- **BLUE** λ = 470 nm

a common craft toy

Make observations

Generate testable questions

Formula writing

sodium chloride

Na^{+1} Cl^{-1}

NaCl

Formula writing

magnesium chloride

Mg^{+2} Cl^{-1}

$MgCl_2$

aluminum oxide

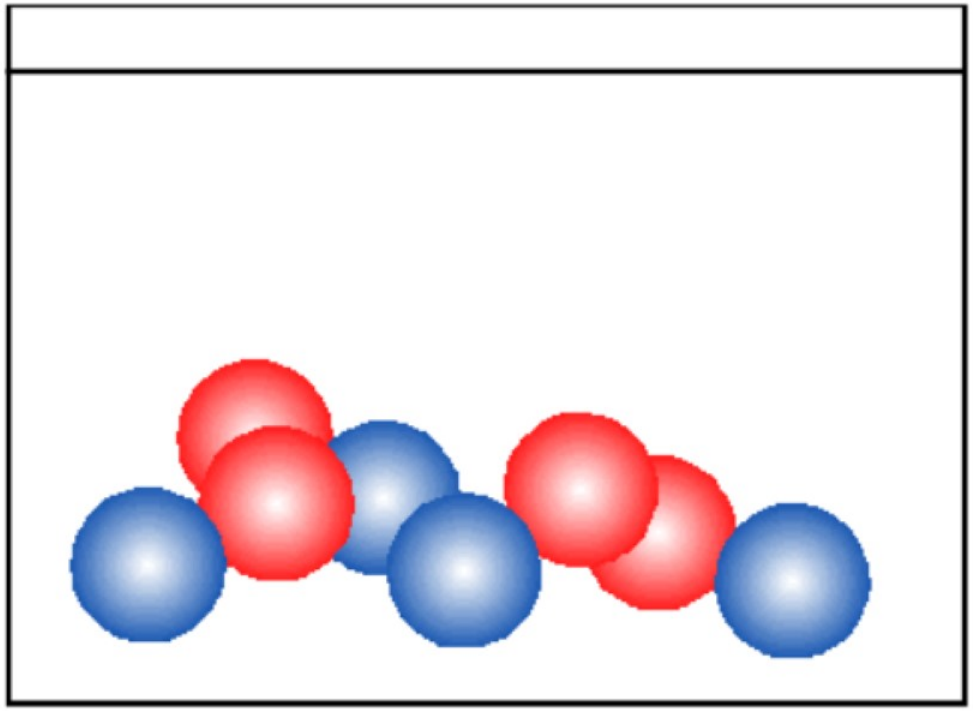
Al^{+3} O^{-2}

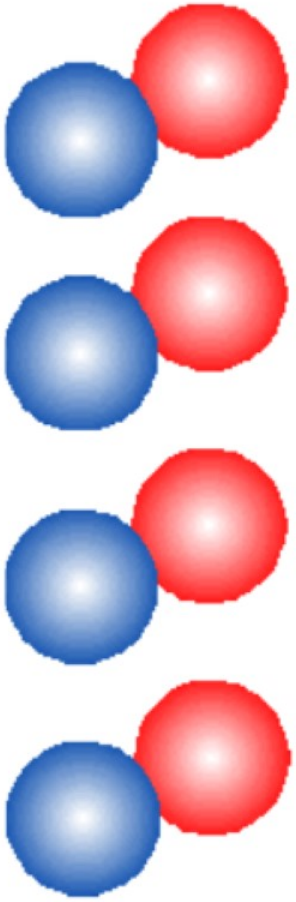
Al_2O_3

Radicals

hydroxide	OH^{-1}
sulfate	SO_4^{-2}
nitrate	NO_3^{-1}

Mixture or Pure Substance?





Pop beads As a Science Tool

?? Element, Compound, or Mixture ??

pure substance

compound

X-Y

Sample B

mixture
of two different elements

Y [monoatomic element]
(X-X) [diatomic molecule]

Sample E

Mixture of 2 compounds

compound (X-Y-X-Y)
and *[its isomer]*
compound (X-X-Y-Y)

Share and Share Alike?

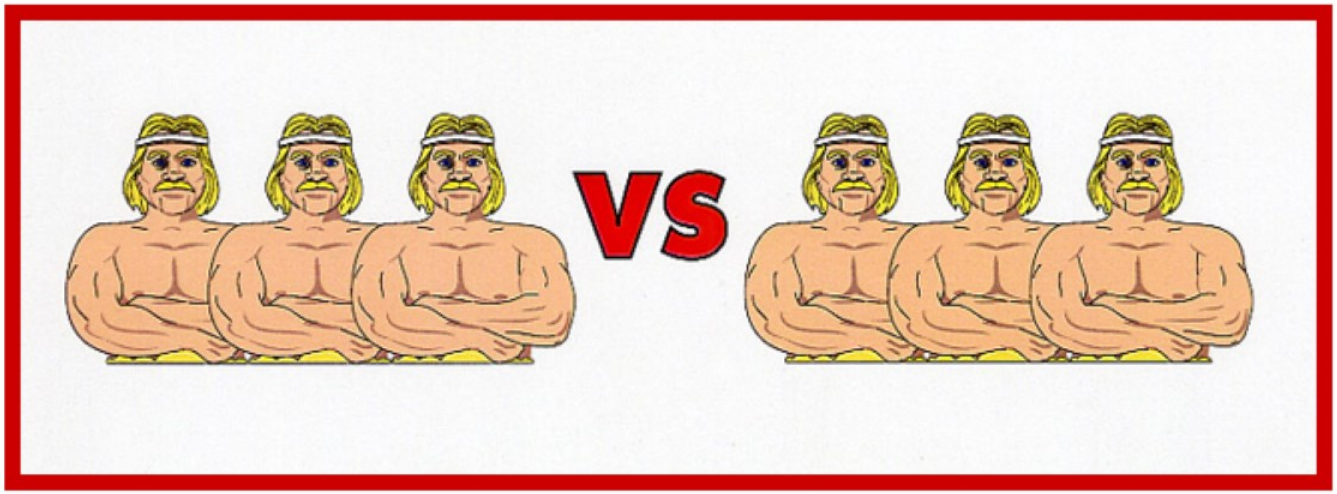
While I was traveling here, I found a large bag containing $1,000,000, so I decided to **share** the money with all of you.

I give each person $5 and keep the rest myself. Did I share?

Yes, just not equally!

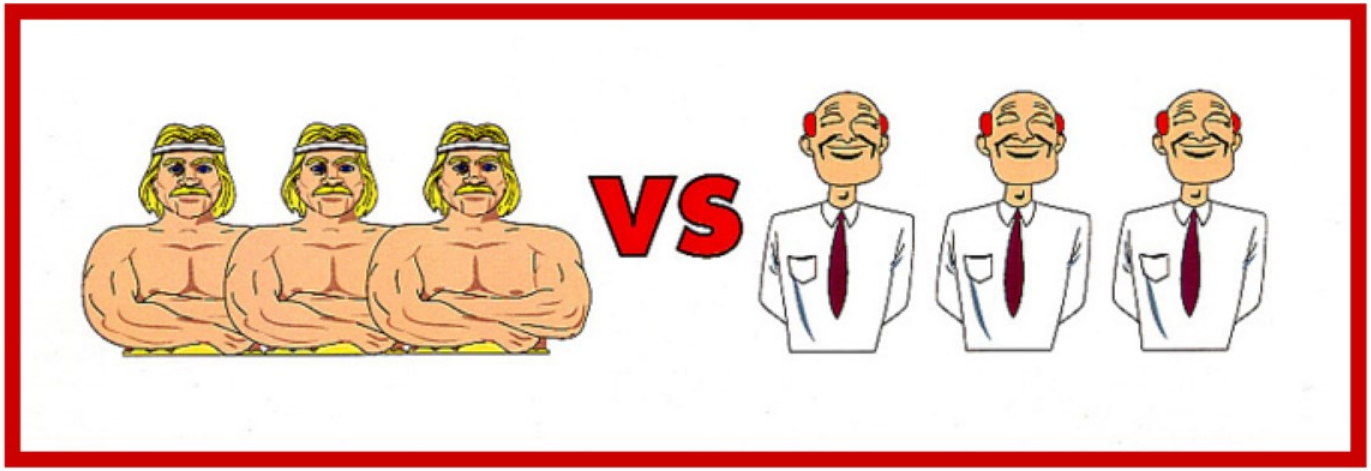
University students demonstrate a pure covalent bond.

Tug of War



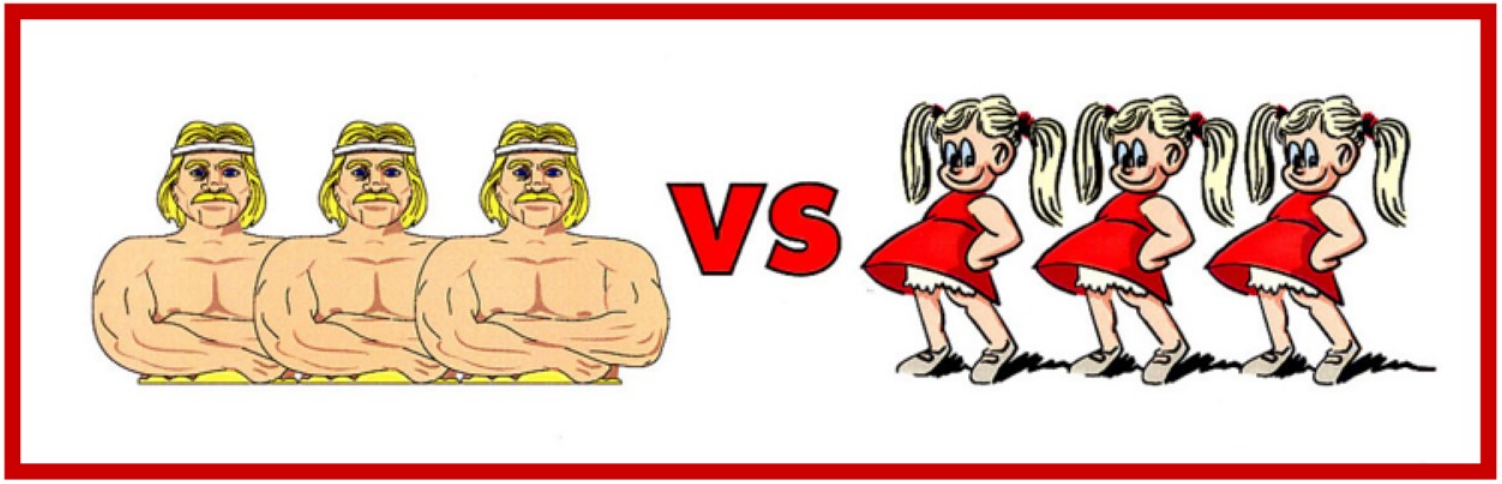
pure covalent

Tug of War



polar covalent

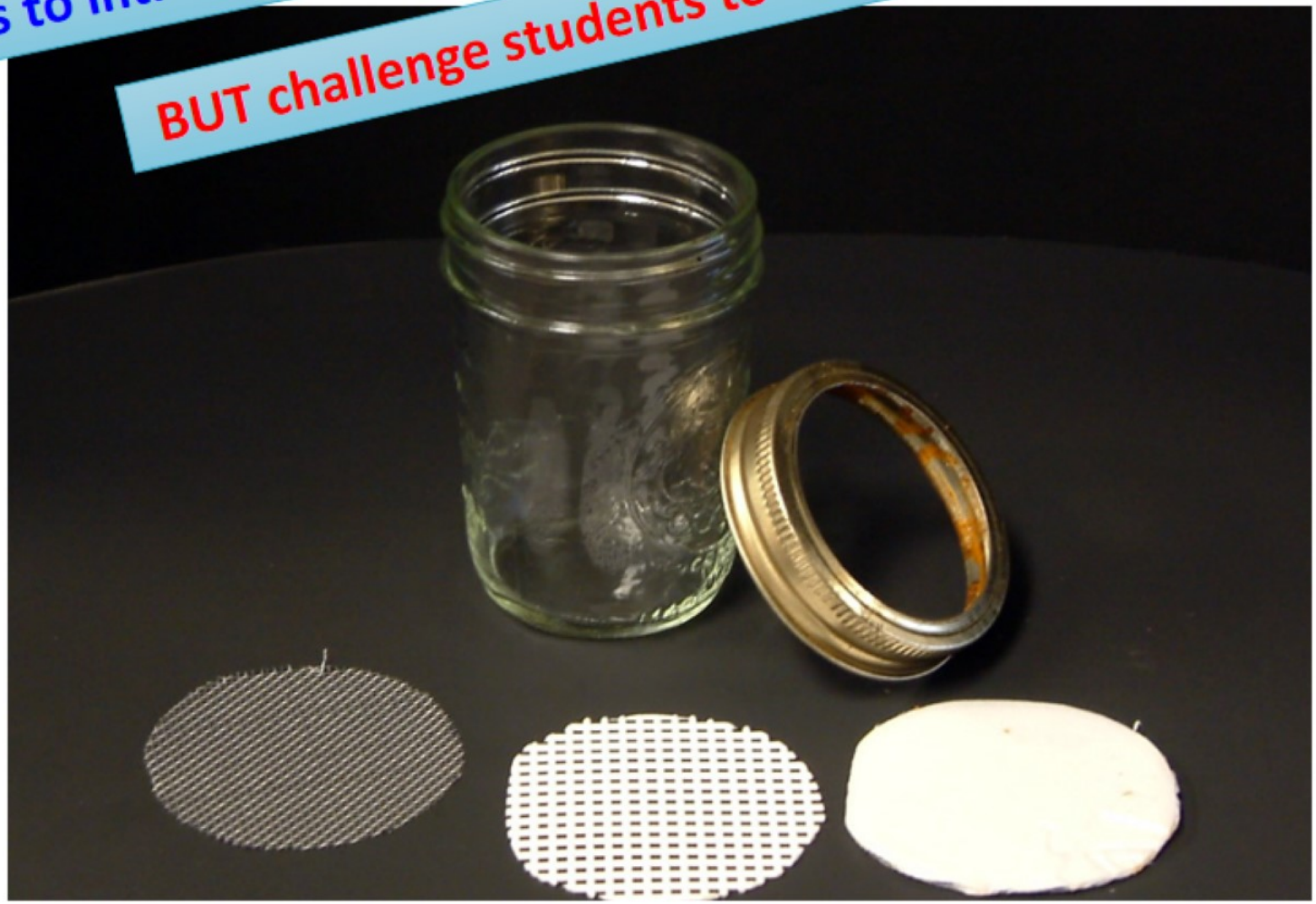
Tug of War



ionic

demos to introduce the phenomena

BUT challenge students to do it when possible



Anti-gravity bottle

Testable questions ?

How big can the hole be?

~1.3 cm in diameter

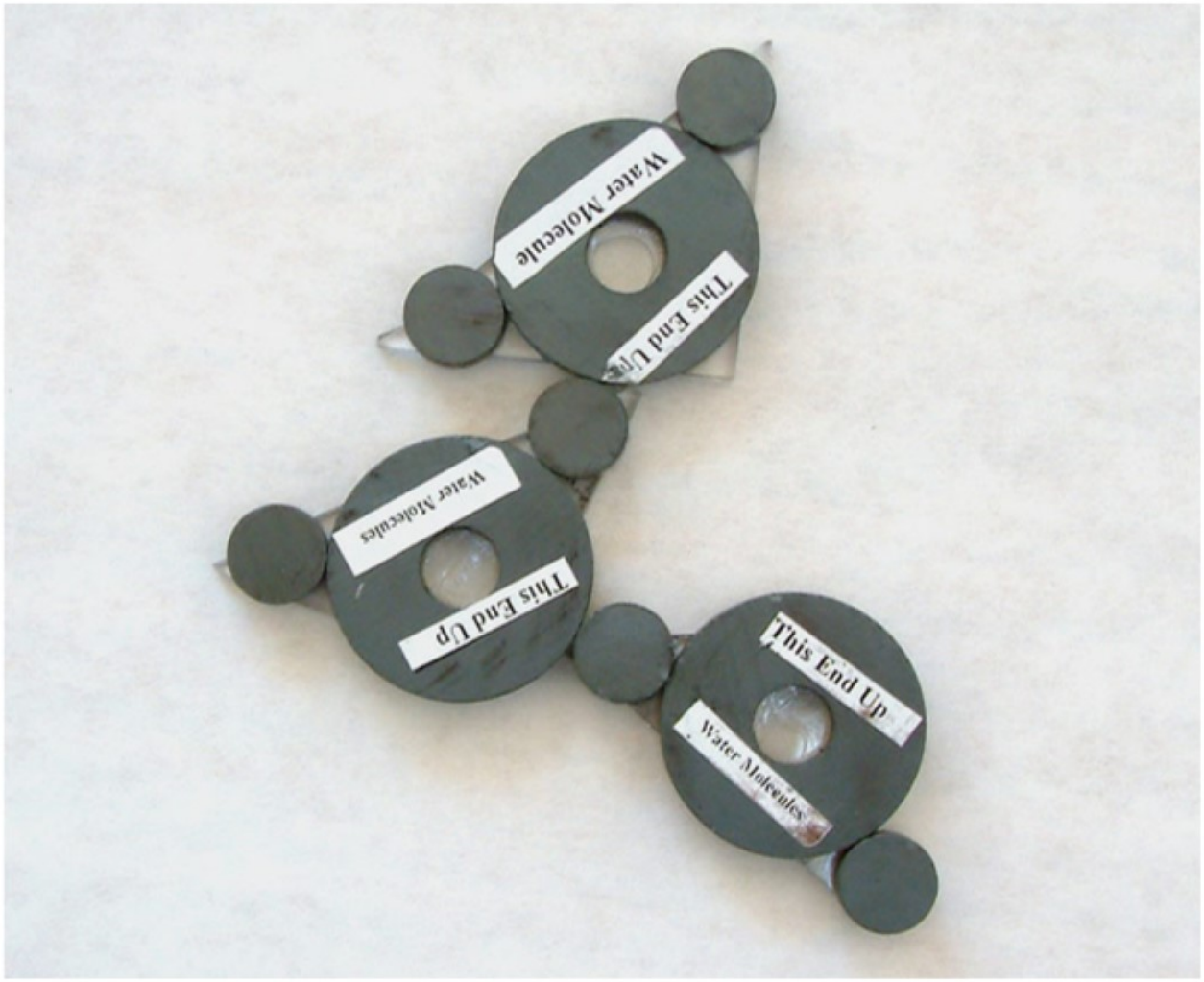
Models as helpful teaching tools…

Water is NOT magnet!

- **Models by their very nature are imperfect representations.**
- **In spite of this, this model provides a helpful way to visualize the behavior of water.**

Modeling the behavior of water

Modeling the behavior of water



Modeling

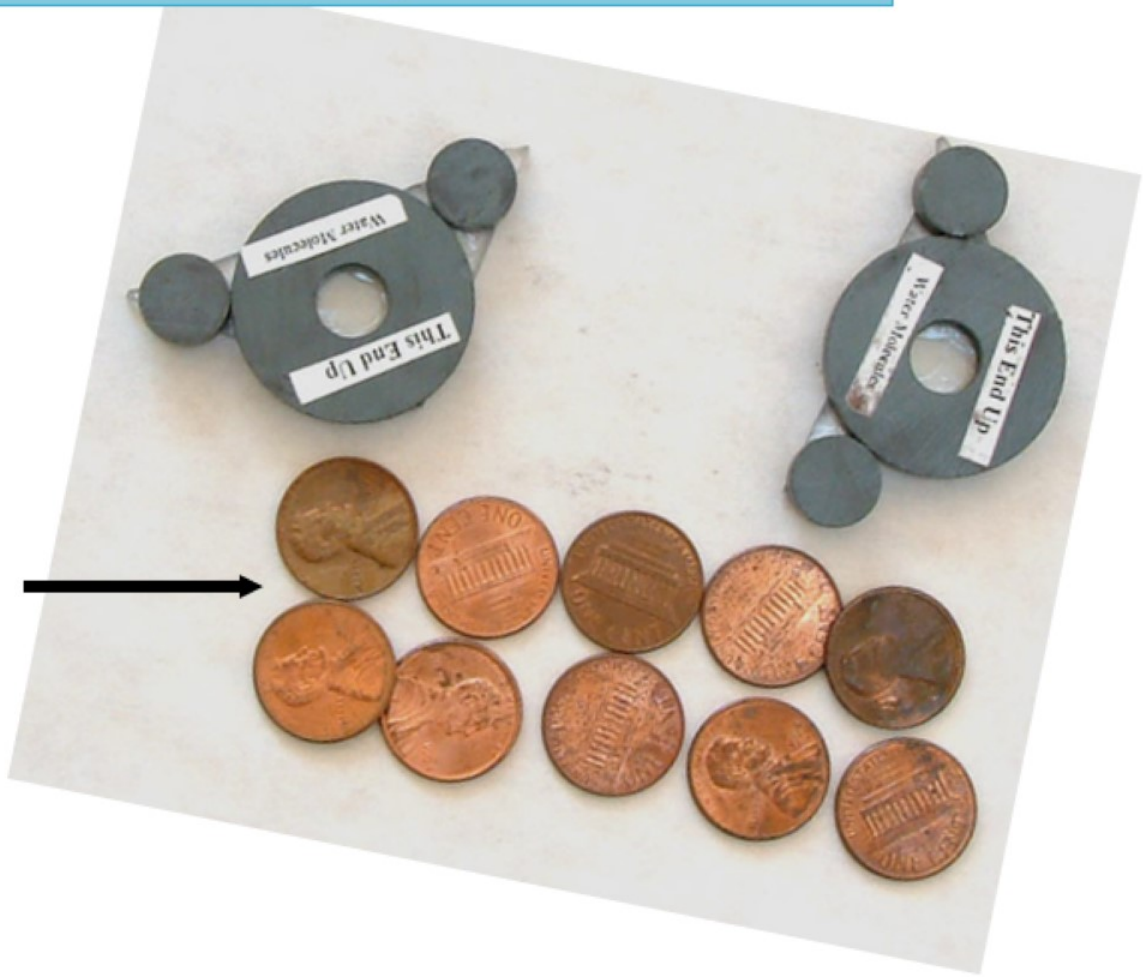
an ionic solid

Dissolving in water

Hydration of the anion

So what about a non-polar solid?

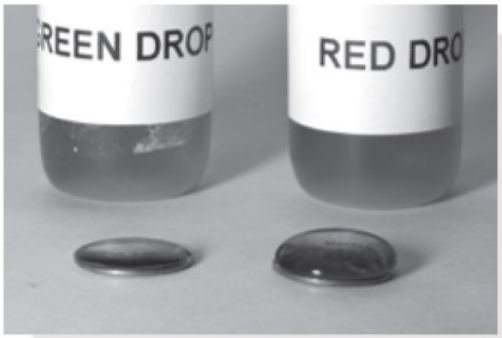
Cu/Zn pennies are used as the nonpolar substance



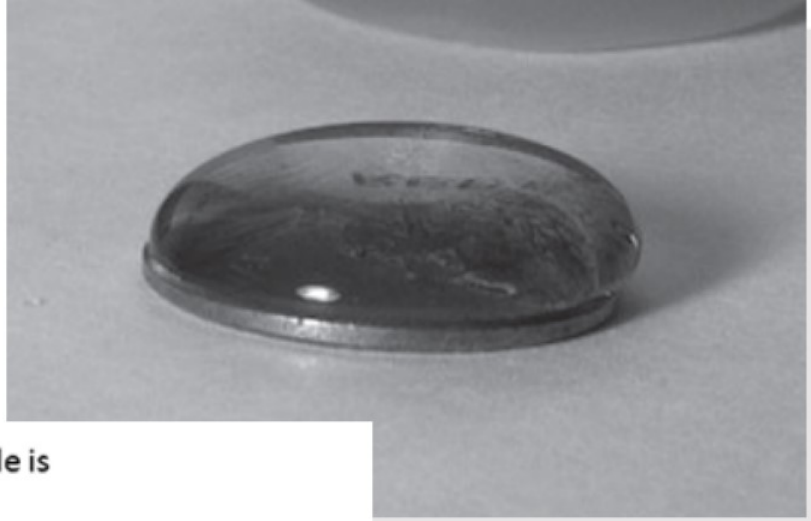
Red drop---Green drop

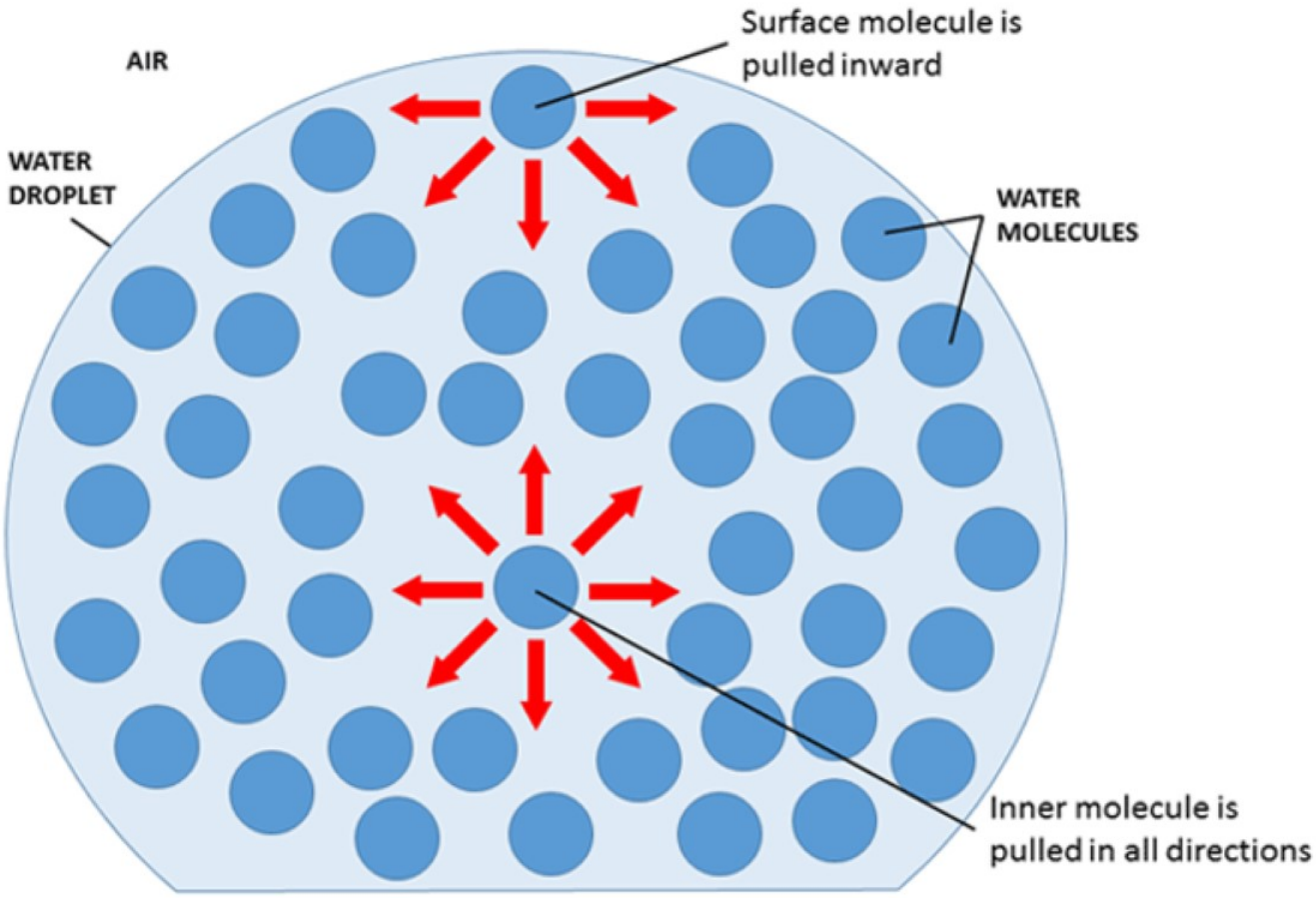
Students experiment to find out:

- Which liquid is colored water?
- What type of chemical was added to the other sample?
- ***We used a surfactant.***

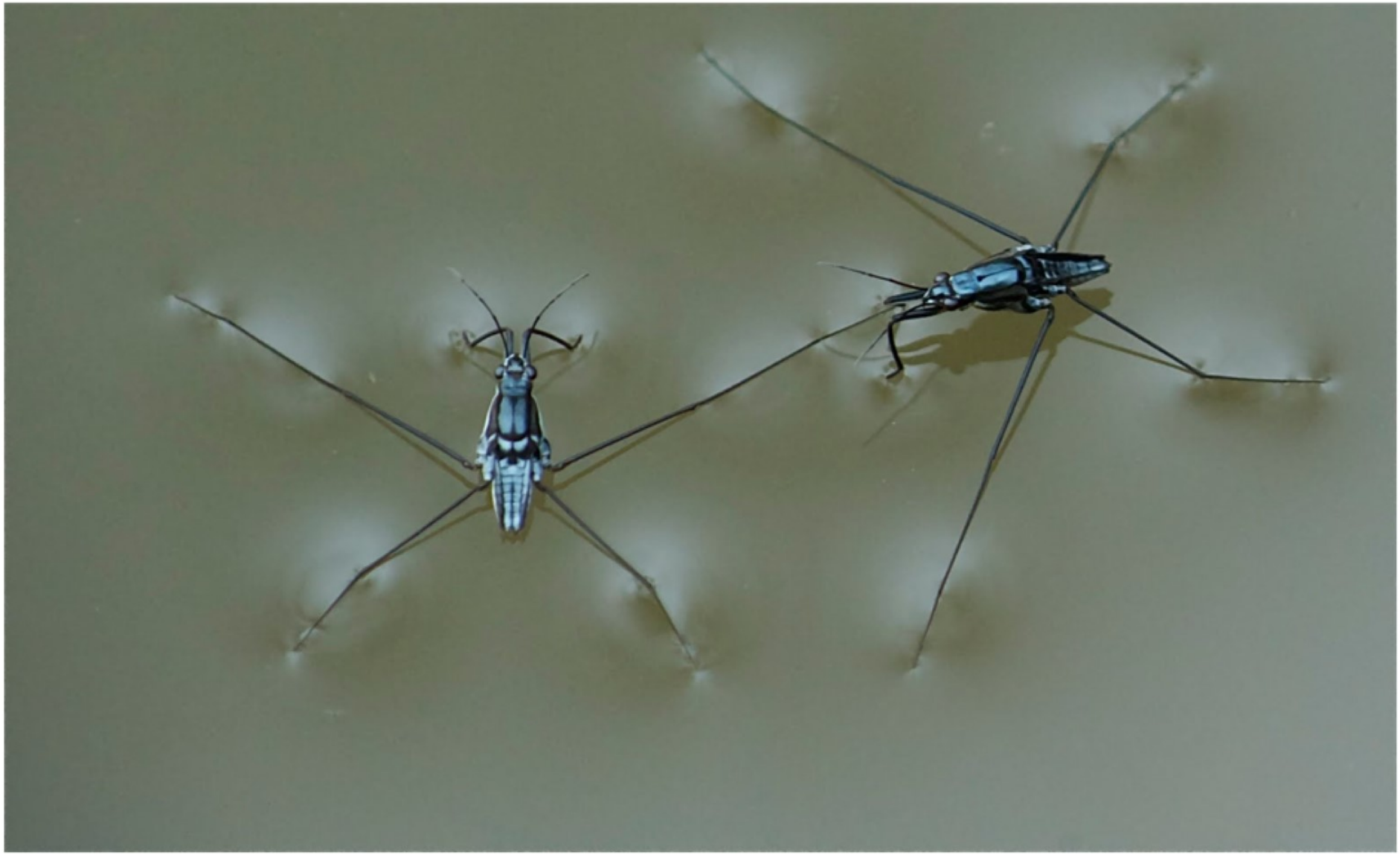


Drops on a coin

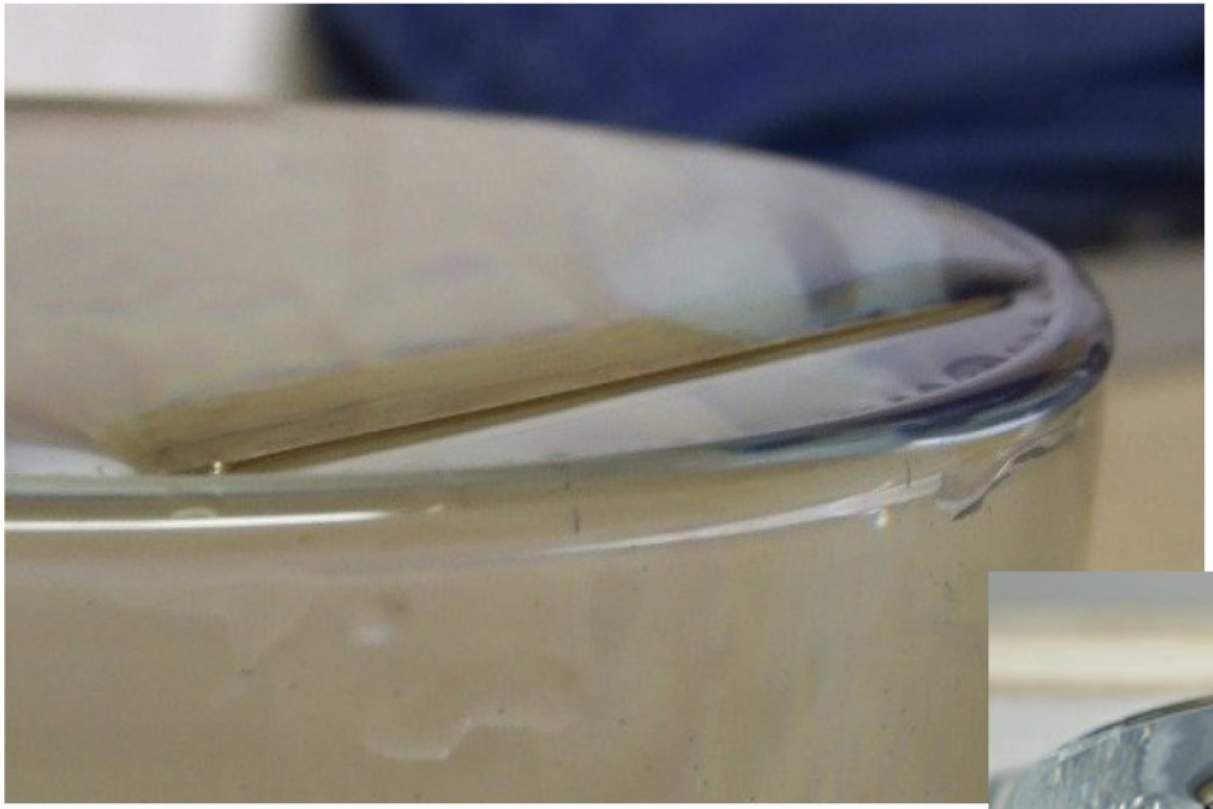


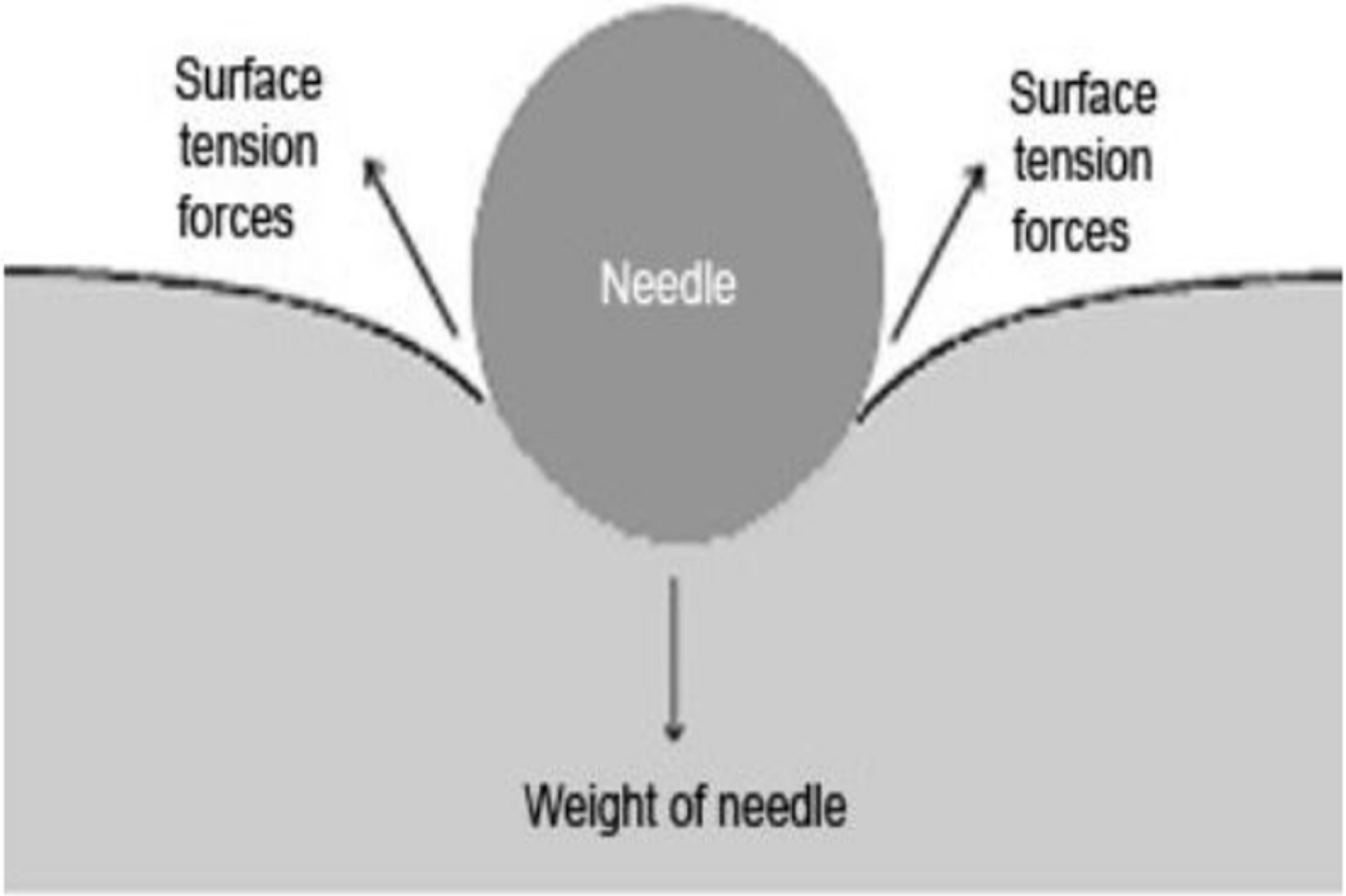


How do they do this?



Can you do this?

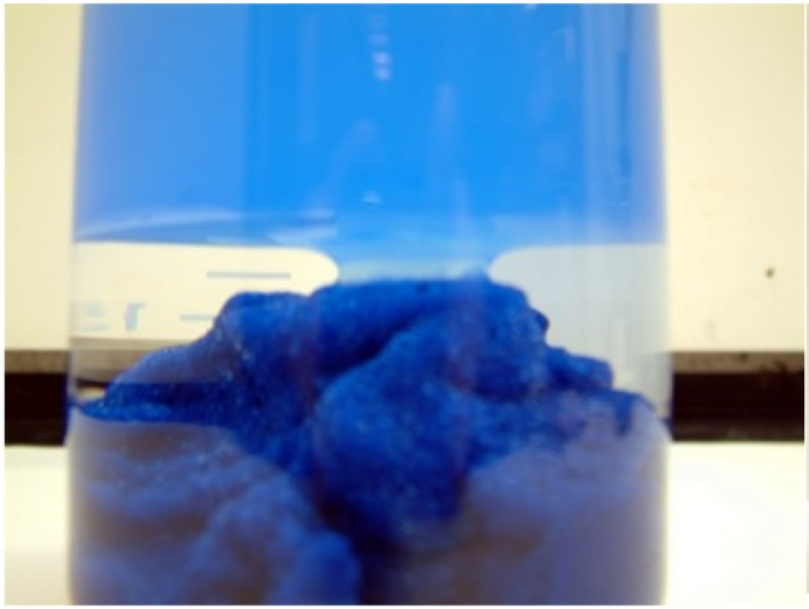



Surface tension forces
Surface tension forces
Needle
Weight of needle

Magic sand

Hydrophobic effect in plants


100ml
KIMAX
80
60
40
20



hexane

water

water

WATER

- The “universal non-solvent”
- Hydrophobic effect

“ Human beings were invented by *water* as a device for transporting itself from one place to another.”

Tom Robbins
Even Cowgirls Get the Blues

Magic Sand: Modeling the Hydrophobic Effect and Reversed-Phase Liquid Chromatography

Ed Vitz, Kutztown University

Journal of Chemical Education

Volume 67, Number 6, June 1990

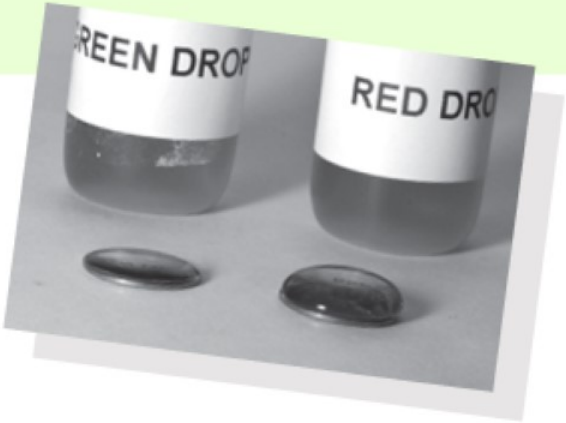
Add 1 drop of water

What is happening?

WHITE SPOT = "cleaned" shaving cream

- It's a surface tension effect…

remember the Green Drop activity



- The surface tension of the drop of water was lowered by the soap in the shaving cream
- As the water spreads over the surface of the shaving cream it pushed the large organic food coloring molecules away.

WHITE SPOT = "cleaned" shaving cream

Testable questions:

- Will this work with other colored liquids?
  - Other organic dyes
    - Methylene blue
    - Tempera
  - Ionic salts in solution
    - Cobalt chlorides solution
    - Copper sulfate solution

FYI.. Ionic salts don't work. The shaving cream remains colored when the water is dropped on it.

"Holeyness of matter"

- ½ fill tube with colored water

- add colorless water to COMPLETELY fill (so the water "domes" at the top) **IMMEDIATELY** cover with your thumb & do **NOT** remove it until I tell you to!!!

- Invert 4 times while observing *(feel sides & look carefully)*

Quiet EVERYONE & listen carefully

"Holeyness of matter"

- ½ fill tube with colored water
- COMPLETELY fill with alcohol **& IMMEDIATELY** cover with your thumb… **do NOT remove your thumb**

! ! ! ! ! ! ! ! ! ! !

- Invert 4 times while observing *(**feel** & **look** carefully)*

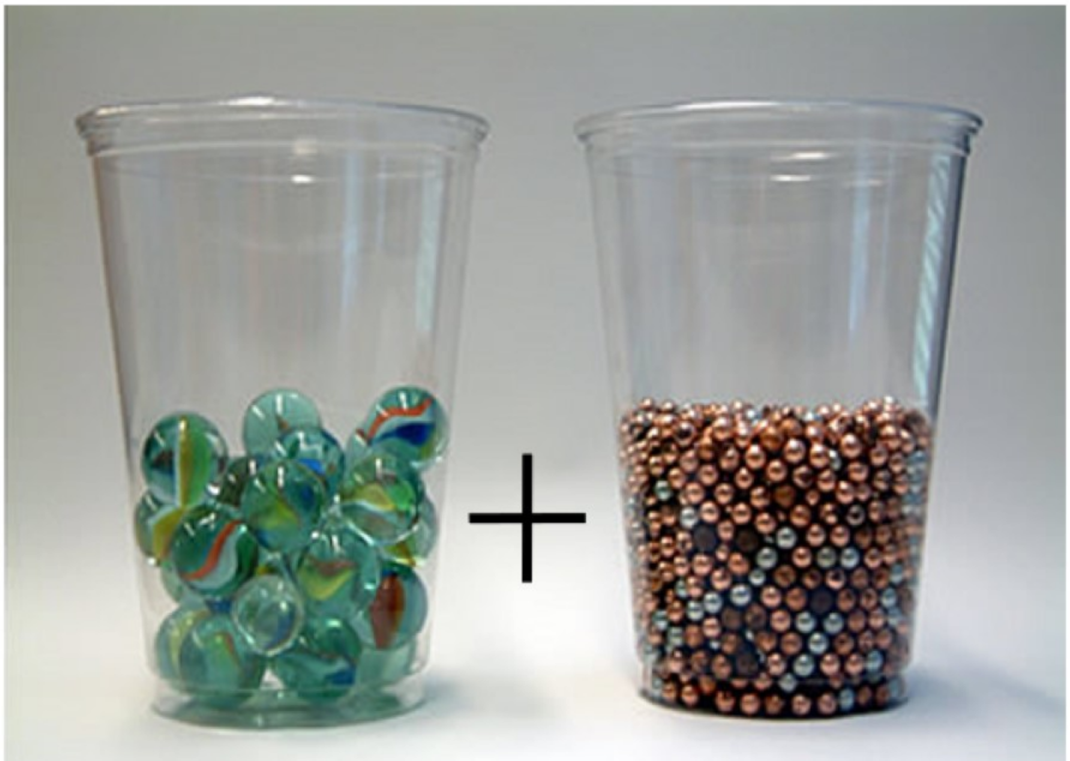
Quiet EVERYONE & listen carefully

50 mL H_2O + 50 mL H_2O = 100 mL H_2O

BUT

50 mL H_2O + 50 mL *alcohol* ≠ 100 mL solution

Modeling to explain



= ?

Modeling to explain

REMEMBER the hand boiler?
Distillation

Before

dye in solution

empty

After

← solid dye

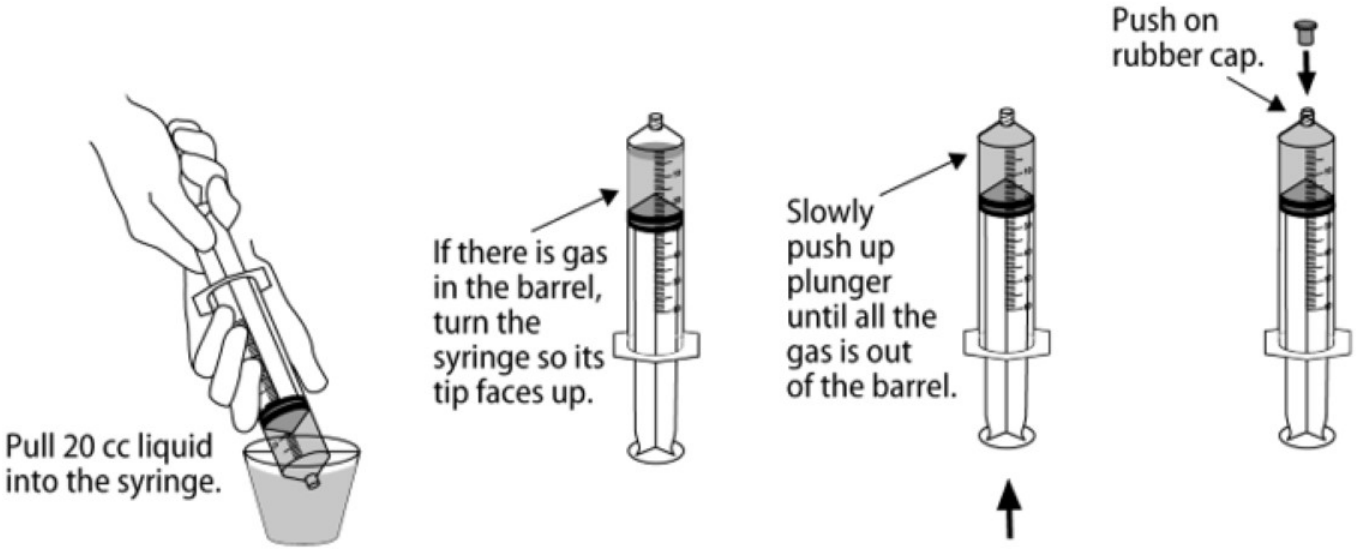
colorless liquid

Separating a mixture

shake

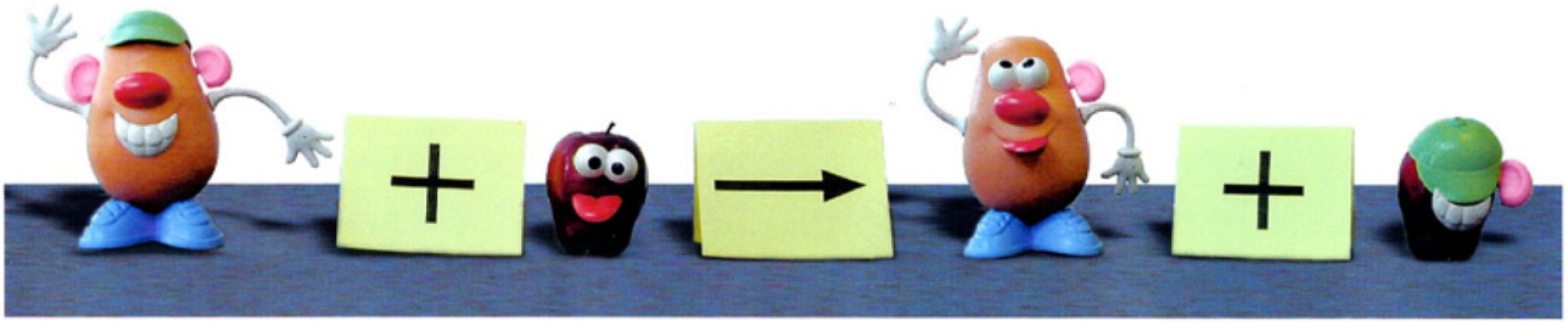
Volume estimate

Student explorations



- pressure changes
- temperature changes
- methyl red indicator (if colorless soda)

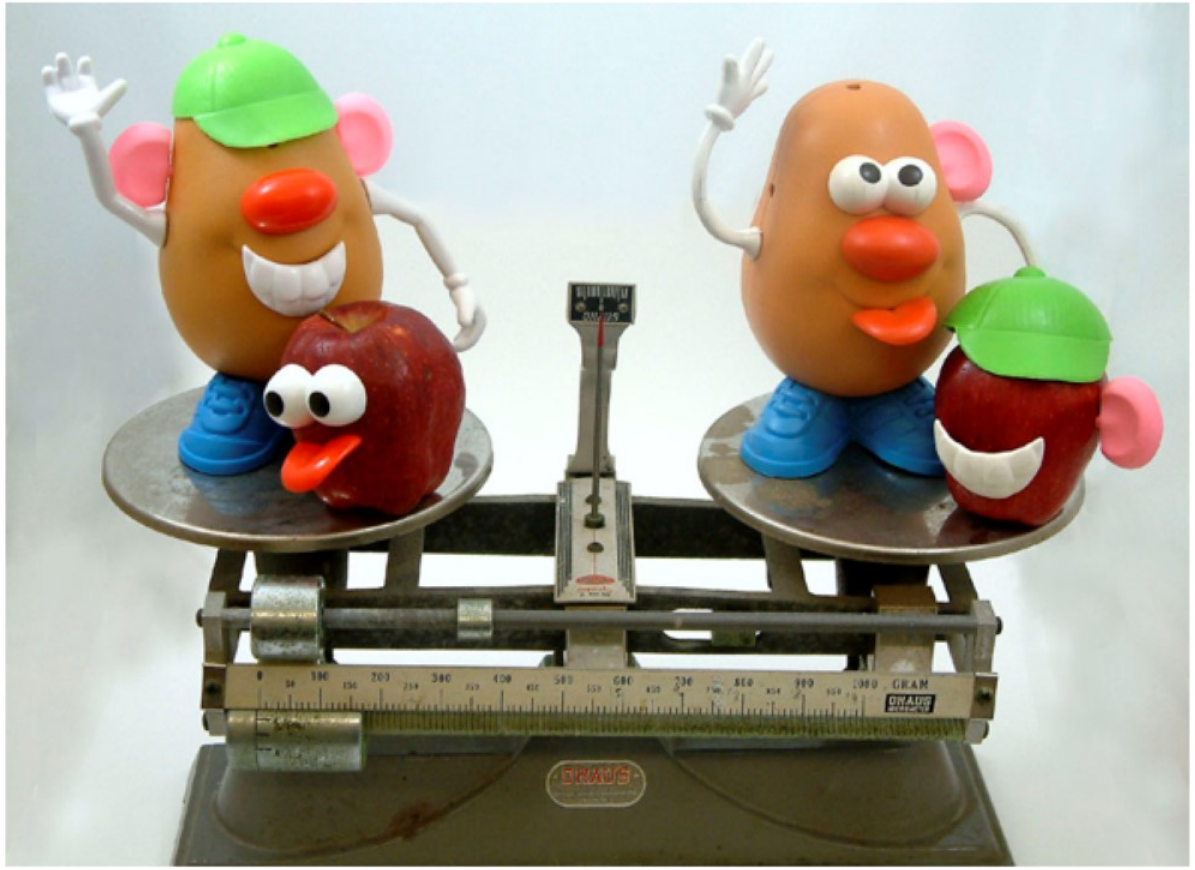
Visualizing a Chemical Reaction



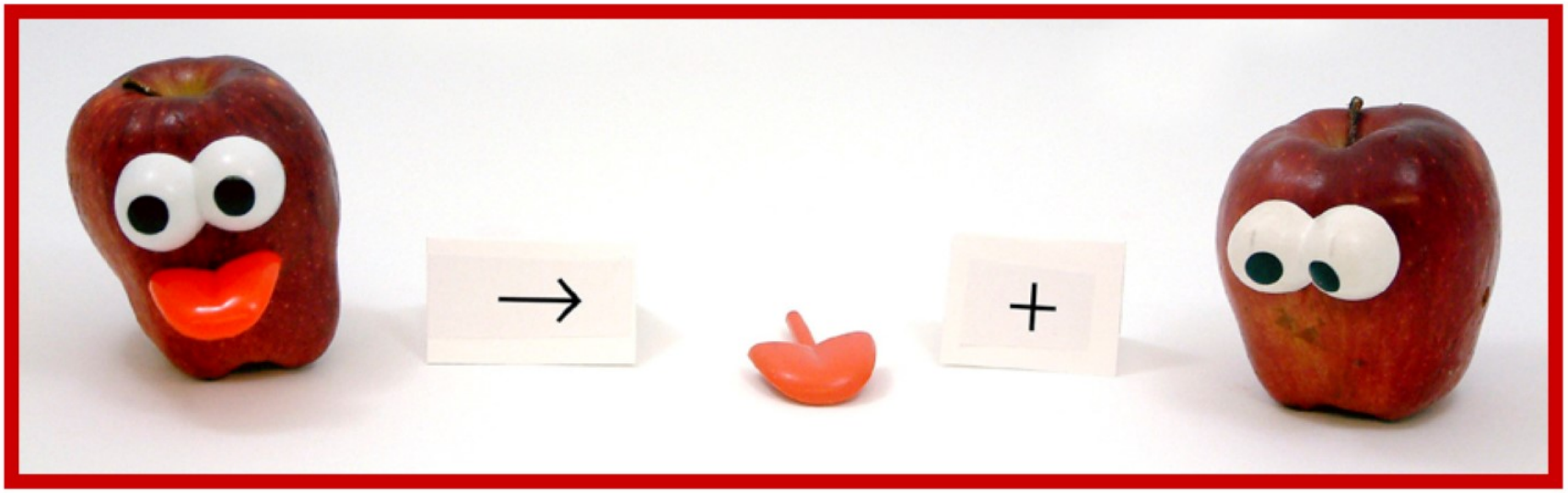
reactants

products

Conservation of Mass

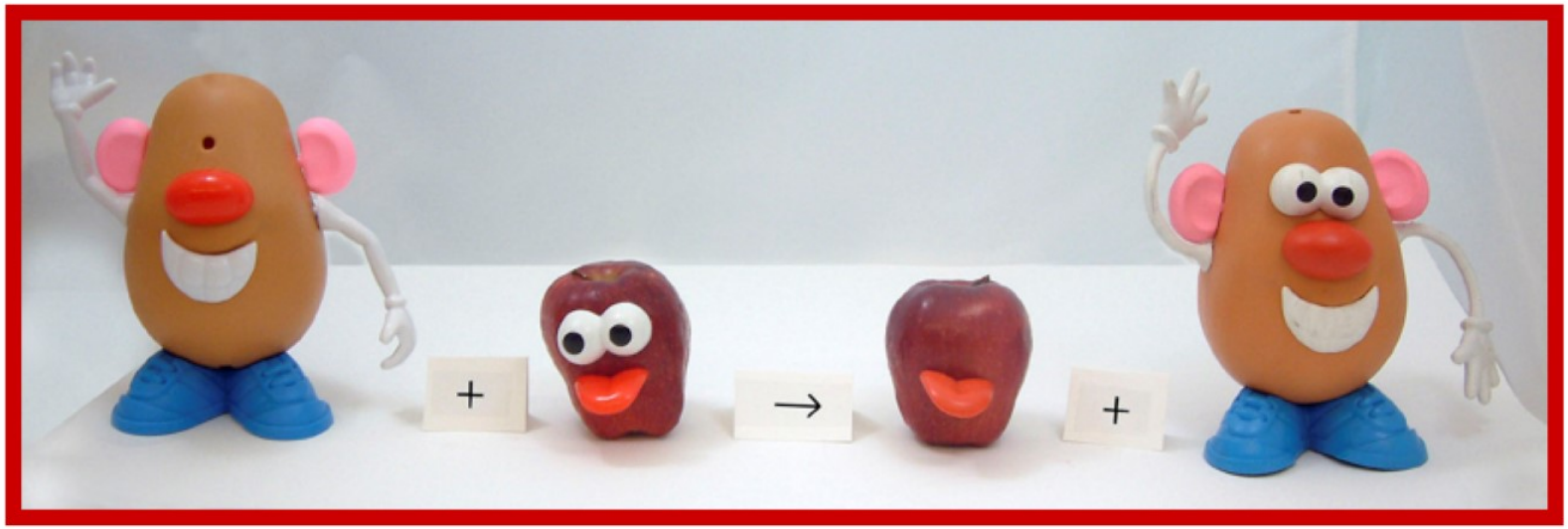


Visualizing a Chemical Reaction



decomposition reaction

Visualizing a Chemical Reaction



single replacement reaction


WATER
10% EPSOM SALT
SOLUTION
UNIVERSAL
INDICATOR
SOLUTION

Pencil assembly

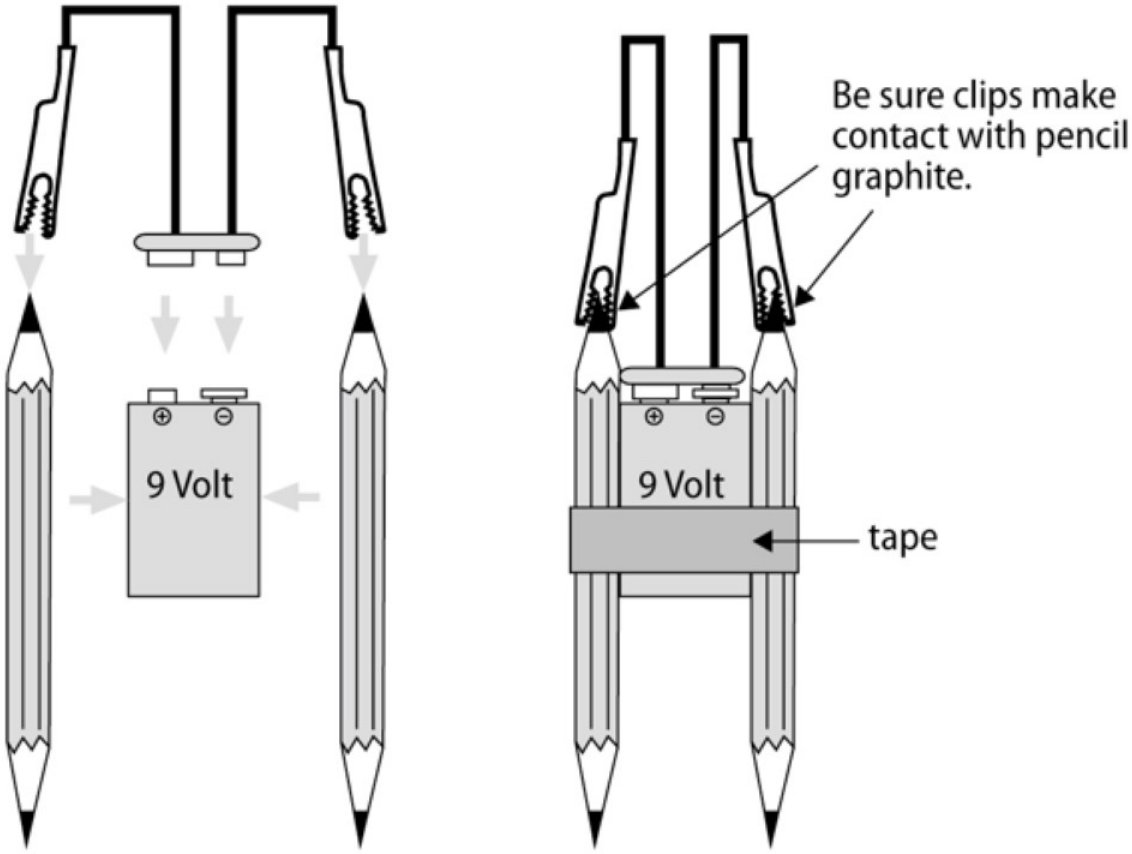
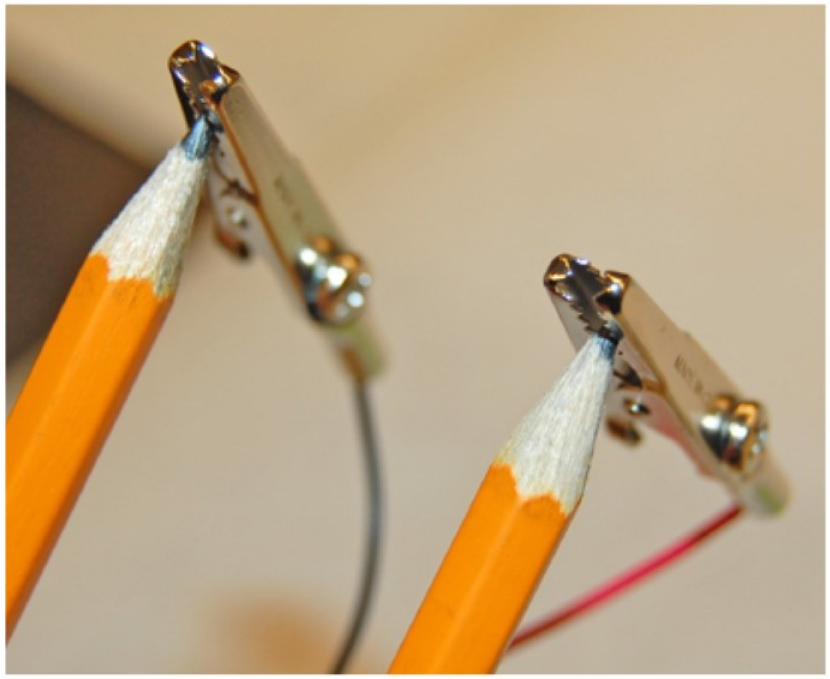
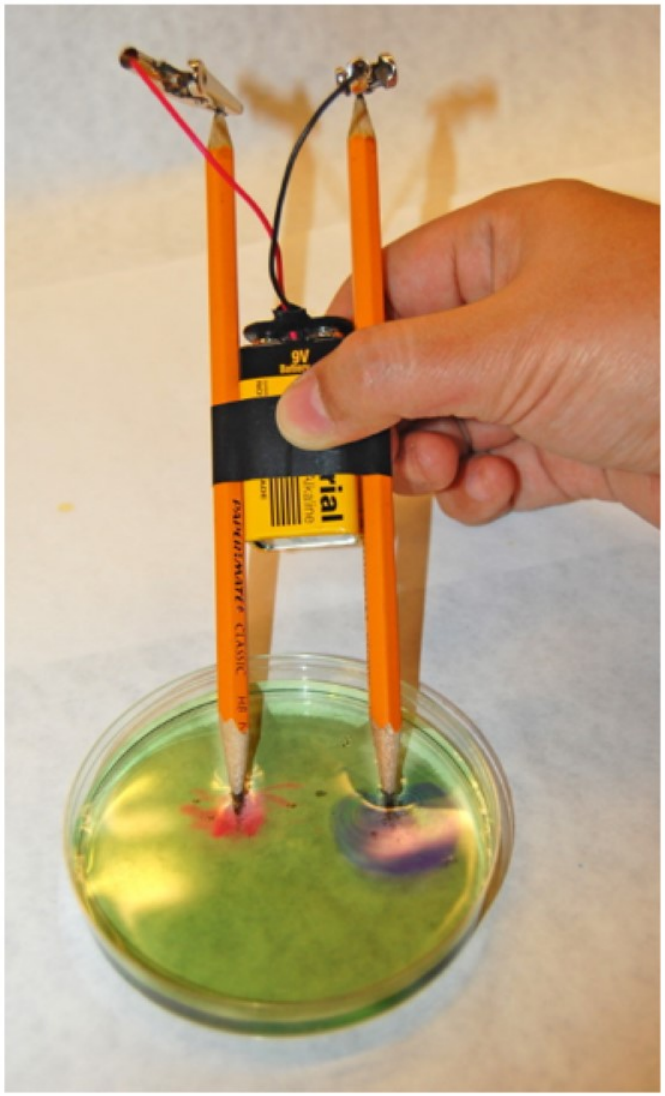


Figure 1: Assemble the pencil electrolysis apparatus.





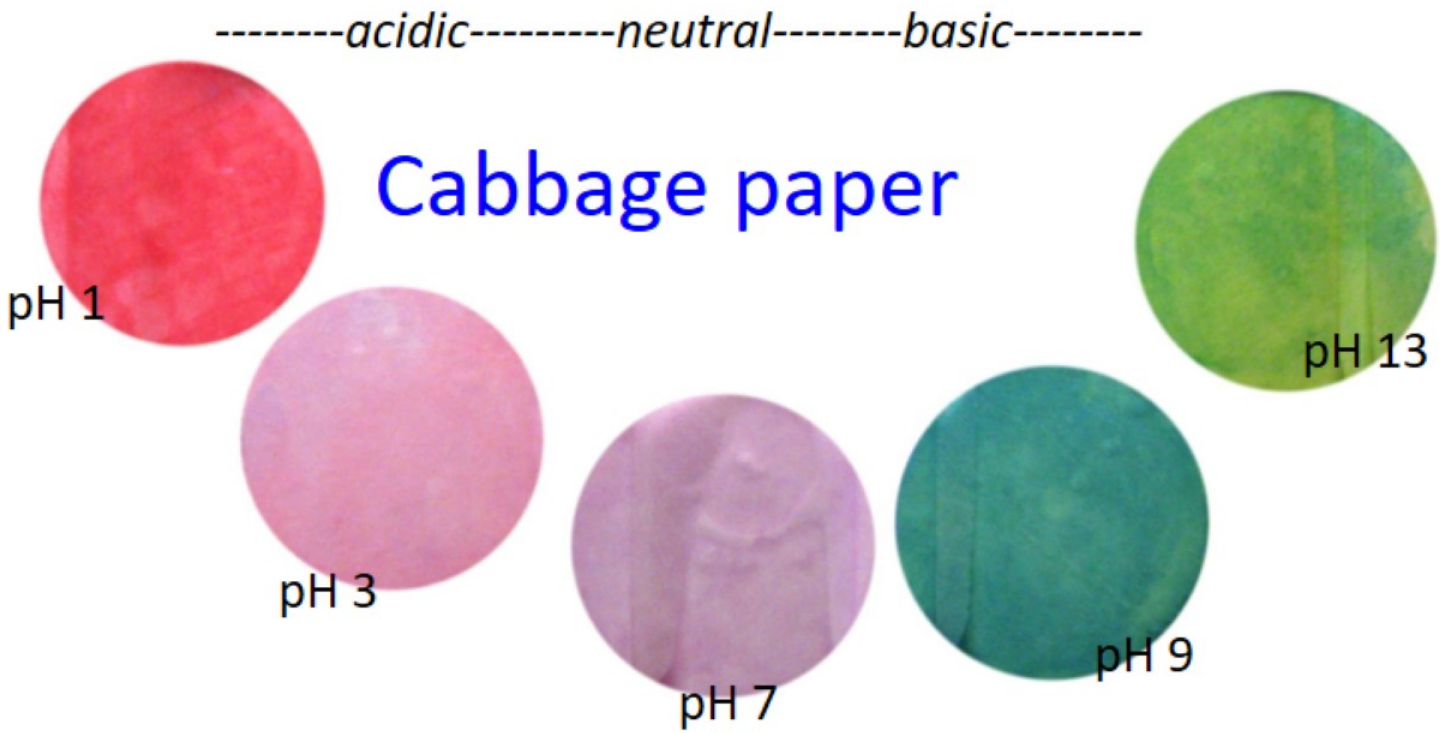

CLASSIC
HB

$$4H_2O(l) + 4e^- \rightarrow 2H_2(g) + 4OH^-(aq)$$

$$2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$$

$$2H_2O(l) \rightarrow 2H_2(g) + O_2(g) + 4H_2O(l)$$

Acid/Base Indicators



Acid/Base Indicators

Chemiluminescence

Your challenge:

- make observations
- formulate testable questions
- design an experiment
- collect evidence
- formulate a claim
- share with your neighbors
- negotiate for understanding
- Authentic writing assignment

A scientist is someone whose curiosity survives education's assault on it.

– Sir Herman Bondi

But we believe:

A scientist is someone whose curiosity is nurtured by education's impact on it.

Someone once said...

A good teacher is...

- 1/3 heart
- 1/3 head
- 1/3 ham