**VANDERBILT STUDENT VOLUNTEERS FOR SCIENCE**

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**The Science of Magic**

**Vanderbilt Children’s Hospital Seacrest Studios/ Next Steps Lesson**

**Lesson written by: Eric Lu and Patricia Tellinghuisen**

**Some ideas taken from Steve Spangler’s workshop**

# LESSON OUTLINE

1. **Disappearing Water**
   1. You will make water disappear using sodium polyacrylate.

# Turning Water into Grape Juice

* 1. You will change the color of water to resemble that of grape juice.

# Magic Milk Colors

* 1. You illustrate hydrophobic vs hydrophilic interactions.

# Table Cloth

* 1. You will illustrate the effects of inertia.

1. **Surface Tension**
   1. You will use surface tension to hold water in an upside down jar.
2. **Disappearing Crystals** 
   1. You will illustrate that the refractive index of an object can be used to make it invisible.

# MATERIALS

**Pre-Lesson Setup**

**1.** Place two spoon-fulls of sodium polyacrylate in one of the opaque cups.

# Before beginning the lesson, introduce yourself as a magician and welcome the kids to your magic show! If you have a cape, a top hat, or a wand, please use it!

1. **Disappearing Water Materials**
   * Sodium Polyacrylate
   * Water
   * Three Opaque Cups

# Procedure

1. Place the three cups, face up, next to each other.
2. Ask for a volunteer from the audience. Make sure that volunteer is willing to get wet and not wearing any medical equipment that could be harmed by water.
3. Tell students that you’re going to add water into a random cup.
4. Pour some water (around 50ml) into the cup containing the sodium polyacrylate. You should now have two empty cups and one cup with water/sodium polyacrylate.
5. Mix up the locations of the cups; when mixing the cups, do not go so fast that the kids can’t follow your movements (you want them to keep track of the cup).
6. Have the volunteer (or the audience) pick the cup he/she thinks contains the water.
7. Hold the chosen cup over the volunteer’s head and invert the cup. Nothing should fall out since the sodium polyacrylate absorbed the water. At this point, the kids should be astounded because they expected the water to fall out.
8. Have the volunteer (or audience) pick another cup and repeat step 7 until all cups have been picked

***Ask Students:*** Where did the water go?

***The Science:*** Scientific explanations for specific grade levels.

**Pre-K to 3nd grade:** Explain that the cup you poured the water into contained a powder that can absorb lots of water. When the power absorbs water, it turns into a gel that stays inside the cup. This allows you to tip the cup over without spilling the water. This powder is used in dippers and in movies to make fake snow. *Kids are not exposed to scientific names in school until the 4th grade, so mentioning scientific name will needlessly confuse them.*

**4th – 5th grade:** Add that the power is called “polyacrylate” and that it can absorb 200-300 times its weight in water.

**6th – 9th grade:** Add that sodium polyacrylate is a polymer, which is a large molecule made out of linking together lots of smaller molecules.

**10th – 12th grade:** Add that sodium polyacrylate has a lot of negatively charged carboxylic acid groups on it, which allows it to bind to the positively charged hydrogen in water molecules. *Students are first exposed to functional groups and their interactions in 10th grade chemistry classes. Thus, adding this to the explanation should help them relate the lesson to what they’re learning in school.*

*\*This lesson can also be done with insta-snow. The principle is the same, except that you’ll frame it in the context of turning water into snow.*

# Turning Water into Grape juice and back to Water Lesson set up

**1.** To set up the lesson, add two drops of NaOH to a cup containing distilled water. Add two drops of phenolphthalein to a second cup. Add three drops of HCl to a third cup. Make sure all cups are clear.

***Ask Students:*** Do you think it’s possible to turn water into grape juice?

1. Turn water into grape juice by pouring the water containing the NaOH into the cup containing the phenolphthalein. The solution should turn a deep pink.
2. Turn the grape juice back into water by pouring it into the cup containing the HCl. The solution should become clear.

*You can make the lesson more interactive by asking for a volunteer from the audience to pour the water. This also convinces the kids that you’re not doing anything to the water as you’re pouring it.*

**The Science:** Scientific explanations for specific grade levels.

**Pre-K to 3rd grade:** The second cup and the third cup were not empty. The first cup contained water and a special liquid that changes color when mixed with the liquid in the second cup. The third cup contained a liquid that can reverse this color change. *This lesson is scientifically more complicated than the previous lessons, so the basic explanation may seem too simple to the volunteer, but children will find it satisfactory.*

**4th grade – 6th grade:**

Add that that the water in the first cup was basic. The liquid in the second cup is called an indicator, which is something that changes color based on the whether its environment is acidic or basic. The indicator we are using turns pink in basic environments and stay clear in acidic environments.

Because the water in the first cup was basic, when it was added to the indicator, it turned the indicator pink. The third cup contained an acid, which turned the indicator back to clear.

**7th – 12th grade:**

Add the chemical names of the base, acid and indicator. The base is called sodium hydroxide; the acid is called hydrochloric acid; the indicator is called phenolphthalein. Explain the lesson in terms of pH instead of using the terms “acidic and basic.” The NaOH solution has a pH of 11, and the HCl solution has a pH of 2. Phenolphthalein will change color when the pH reaches above 9.5.

# Magic Milk Colors Materials:

* + Whole Milk
  + Q-tip
  + Dish soap
  + Plastic Plate
  + Food coloring

**Procedure: \***Before beginning, make sure that none of the kids are allergic to milk.

1. Pour enough milk into the plastic plate to completely cover the bottom to the depth of about 1/4 inch.
2. Add drops of each of the four colors of food coloring—red, yellow, green, and blue—to the milk. You can make any design with the food coloring. To make the lesson more interactive, you can ask for a member of the audience to come up and make the design.
3. Place a drop of liquid dish soap on one end of the cotton swab. Place the soapy end of the cotton swab into the milk. You should see a burst of color!

**The Science:** Scientific explanations based on grade level.

**Pre-K to 4th grade:** Soap and milk don’t like each other, so when they’re mixed, they try to get as far away from each other as possible. When the soap and the milk move away from each other, it carries the food coloring along, making all of the colors you see.

**5th to 12th grade:** Add that milk is mostly water. Soap is hydrophobic, which means that it tends to push away substances containing water, when when it is added into the milk, it pushed the milk away.

# Table Cloth

# Materials

* + Tablecloth
  + Silverware (fork, spoon, plate, cup)

1. Place a tablecloth on the table. Make sure it is flat and free of wrinkles.
2. Arrange plates, silverware and cups on the table.
3. Grasp the tablecloth with both hands and Position yourself so that you are at about the midpoint of the edge of the tablecloth you'll be pulling.
4. Very quickly, pull the tablecloth straight towards the floor.

**The Science:** Scientific explanations based on grade level

**All grades levels can be given the same explanation**: A man named Sir Isaac Newton figured out the law of inertia, which states that objects don't want to change how fast they're going, and that hey will only speed up or slow down if something pushes or pulls them. The dishes start out standing still. They don't want to move because of inertia. If you pull the tablecloth slowly, it pulls on the dishes for a long time and they will speed up and move along with it. If the tablecloth pulls on the dishes very quickly, it does not move the dishes as much.

**V. Surface Tension**

Fill the glass jar with water and cover it with a card. Have one of your braver students or friends stand under the jar as you turn it over above his or her head. Note the amazement on the faces of your audience, but it's nothing like you'll see in a minute when you pull the card away from the overturned jar and dump the water on your unsuspecting—but hey, what happened? Hope you don't mind a few screams. Who's next? Think you can do it again? Of course you can. It's a science experiment!

There are 2 parts to this activity. DON’T MESS UP AND GET CONFUSED WITH WHICH ONE GETS THE CARD REMOVED!

1. Jar of water plus card

Fill the glass jar with water and cover it with a card. Hold jar over plastic bin. Invert jar (slowly) while holding on to card. Carefully remove hand from card.

The card remains “attached” to the jar, and the water stays in the jar.

(Optional: Have one of your braver students or friends stand under the jar as you turn it over above his or her head.)

1. Jar of water with screen insert. Plus card

Hold the jar up so that students cannot see the mesh inside the jar lid. Pour water into jar until it is full. Put card over opening and turn upside down. Remove hand from card – the card should stay “attached” to jar.

THEN, carefully remove card – water will stay in jar! Pour water out of jar, to show there was no cover. Then show students the mesh, and repeat at each student’s table

WHY?

**Classroom Secrets:**

There are three primary concepts that you’ll want to convey to your students during this demonstration.

* **The properties of air**: Air is the most common gas on earth. It consists of about 78% nitrogen, 21% Oxygen, and 1% other gases such as carbon dioxide, carbon monoxide, hydrogen, helium, neon, krypton, methane, and xenon. Air exhibits elastic properties. It can be squeezed smaller (compressed) and expanded (decompressed).
* **Air Pressure**: The atmosphere exerts about 15 pounds of pressure per square inch of surface at sea level. Because it’s a gas, it not only pushes down, but also upwards and sideways. The card remains in place because the air pressure is pushing upwards harder than the water is pushing downward.
* **Surface Tension**: The surface of a liquid behaves as if it has a thin membrane stretched over it. A force called cohesion, which is the attraction of like molecules to each other, causes this effect. The surface tension “membrane” is always trying to contract, which explains why falling droplets of water are spherical or ball shaped.

1. Egg In A Bottle

If you just set the egg (hard boiled) on the bottle, its diameter is too large for it to slip inside. The pressure of the air inside and outside of the bottle is the same, so the only force that would cause the egg to enter the bottle is gravity. Gravity isn't sufficient to pull the egg inside the bottle.

When you change the temperature of the air inside the bottle, you change the pressure of the air inside the bottle. If you have a constant volume of air and heat it, the pressure of the air increases. If you cool the air, the pressure decreases. If you can lower the pressure inside the bottle enough, the air pressure outside the bottle will push the egg into the container.

It's easy to see how the pressure changes when you chill the bottle, but why is the egg pushed into the bottle when heat is applied? When you drop burning paper into the bottle, the paper will burn until the oxygen is consumed (or the paper is consumed, whichever comes first). Combustion heats the air in the bottle, increasing the air pressure. The heated air pushes the egg out of the way, making it appear to jump on the mouth of the bottle. As the air cools, the egg settles down and seals the mouth of the bottle. Now there is less air in the bottle than when you started, so it exerts less pressure. When the temperature inside and outside the bottle is the same, there is enough positive pressure outside the bottle to push the egg inside.

**How to Get the Egg Out**

You can get the egg out by increasing the pressure inside the bottle so that it is higher than the pressure of the air outside of the bottle. Roll the egg around so it is situated with the small end resting in the mouth of the bottle. Tilt the bottle just enough so you can blow air inside the bottle. Roll the egg over the opening before you take your mouth away. Hold the bottle upside down and watch the egg 'fall' out of the bottle. Alternatively, you can apply negative pressure to the bottle by sucking the air out, but then you risk choking on an egg, so that's not a good plan.

**VI Blowing Out a Candle**

Place a lit candle behind an object that is taller and wider (but not too much) than the candle. Blow towards the object at the level the candle is. The flame will go out. If a lit candle is not allowed, use a ping pong ball. The ball will move.

The air current divides on hitting the bottle, clings to the sides, and joins up again behind the bottle with its strength hardly reduced. It forms an eddy which hits the flame. You can put out a lighted candle placed behind two bottles in this way, if you have a good blow.

1. **Disappearing Crystals**

The Water Gel balls are made from a polymer that absorbs water. Materials of this type are said to be hydrophilic, water loving, and absorb water just as a dry sponge might if dropped into a pail of water. When placed into water, the crystals will absorb water and swell to several hundred times their original size.

Show the students the small dehydrated crystal, and tell them that the ball grew from this when it was put into water for 1 day.

Give each pair a water gel ball and a glass marble (in a 1oz cup) and a jar of water.

Ask students to describe the water gel ball and the marble.

Tell students to put **the marble** into the jar of water.

Ask students if they can see the marble? (yes)

Explain – refractive index of water and glass are different so that the light waves are bent when they enter the marble.

Now put the water gel ball into the water. Can you see it? (No)

Explain – these gel balls are made up almost entirely of water (99%). So the refractive index of water and the ball is the same. It is difficult to see the spheres in water because light rays are not bent when they travel between two substances with the same indices of refraction.

Ask students what they could do to make the water gel ball appear visible?

What happens when you put a beam of laser light thru the water plus water gel ball? (the laser shows a path through the gel).

What happens when you put food coloring into the water? Add a single drop of red food coloring, swirl the water around, and show the students that you can now see the water gel ball