

TRICK #1: The Disappearing Milk Trick

Teacher's Guide

Overview of the Trick:

An apparently empty blue 12-oz drinking glass is sitting on the table. The Magician pours what appears to be milk into the glass. After a few seconds, he tips the glass upside down and demonstrates that the milk has “disappeared”.

How the Trick Works:

(Do not reveal this to students until after they have explored the properties of the Magic Granules for themselves and have proposed their own explanation for the trick.)

Before performing the trick, the Magician adds “magic powder” to the bottom of the glass. The “magic powder” is actually a chemical similar to that used in super-absorbent baby diapers to keep the baby “dry”. As the chemical absorbs water, the mixture forms a gel, which does not pour out when the glass is turned upside down. The color of the glass helps prevent the audience from observing the gel in the glass.



Lesson Focus: Properties of Super Absorbent Polymers

Lesson Synopsis: Students explore the properties of super absorbent polymers and infer the basis of the observed magic trick. They devise a method to quantify the water-holding capacity of a super absorbent polymer and apply it to their sample. In **What's Going On Here?** students are introduced to the science of super absorbent polymers and are challenged to create a new product using them.

Related National Science Education Standards:

Content Standard B (Physical Science):

As a result of their activities in grades 5-8, all students should develop an understanding of **Properties and Changes in Properties of Matter**.

Fundamental concepts and principles that underlie this standard include:

A substance has characteristic properties...

Content Standard E (Science and Technology):

As a result of activities in grades 5-8, all students should develop **Abilities of Technological Design**, including the ability to **Design a Solution or Product**.

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Related Benchmarks from Benchmarks for Science Literacy:

Section IB (Scientific Inquiry):

By the end of 8th grade, students should know that:

What people expect to observe affects what they actually do observe.

Section 8B (Materials and Manufacturing):

By the end of 8th grade, students should know that:

The choice of materials for a job depends on their properties and on how they interact with other materials.

Section 9B (Symbolic Relationships):

By the end of 8th grade, students should know that:

Graphs can show a variety of possible relationships between two variables.

Glossary:

- ★ **polymer** A substance consisting of long chains of repeating subunits, which may be cross-linked.
- ★ **super absorbent** Capable of absorbing an unusual amount of water or liquid.
- ★ **polyacrylamide** A type of super absorbent polymer. Among its numerous uses is use as a soil additive or soil substitute to reduce the need for watering plants.
- ★ **sodium polyacrylate** A super absorbent polymer used in super absorbent diapers.

Important Science Concepts:

1. Some substances form a gel when combined with water.
2. Some chemical substances, called polymers, consist of long chains of repeating subunits.

Materials for Each Inquiry Team:

Materials for the Initial Exploration:

- ★ Goggles
- ★ Water
- ★ 3 12-oz clear cups/team
Measuring Cups and Spoons, or Graduated Cylinders
- ★ Sample of "Magic Granules" (polyacrylamide or a related polymer, sold in garden centers and some craft shops as Aqua Crystals, Hydro Gel, Soil Moist, etc.)

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Suggested Materials for Further Exploration:

- ★ Other Liquids (cooking oil, etc.)
- ★ Salt, Sugar (for mixing solutions)
- ★ Potting Soil, Seeds
- ★ Super Absorbent Diapers
- ★ Sodium Polyacrylate (available from chemical supply houses)
- ★ Distilled Water
- ★ Balance or Postal Scale

Safety Precautions:

- ★ Have students use goggles to protect their eyes against splashes and eye contact.
- ★ Remind students that eating and drinking is not allowed during their inquiry.
- ★ Using a granular form of the polymers is safer than using powdered polymer because polymer powder can irritate eyes and nasal passages. If powder is used, avoid inhalation and eye contact.
- ★ Exercise caution in “dissecting” dry super absorbent diapers. Inhalation of particles can cause respiratory irritation.

Procedure:

Engagement: Show the video of the **Disappearing Water Magic Trick**. Have students brainstorm in their **Inquiry Journals** possible explanations for the trick.

Exploration, Explanation, and Extension: see **Student Handout**

Evaluation:

1. Have students propose a new use for super absorbent polymers (other than in super-absorbent diapers or as a soil additive/replacement), create an advertisement for their new product, and orally explain their proposal. (See **What's Going On Here?** handout.)
2. Have students design a new “magic trick” using super absorbent granules.

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Ideas for Further Exploration:

Students might consider one or more of the following questions:

1. Does the polymer absorb liquids other than water? (**Math Connection:** Calculate the polymer's absorption capacity for various liquids and solutions.)
2. What happens if salt, baking soda, or sugar, is sprinkled directly on the gel?
3. If the gel is allowed to dry out, will it swell again when water is added?
4. Does the amount of liquid absorbed by a given amount of granules depend on the type of solution or its concentration? (**Math Connection:** Make a graph relating the amount of solution absorbed to the solute concentration of the solution.)
5. Does the time required for complete absorption depend on the type, concentration, or temperature of the liquid? (**Math Connection:** Make a graph relating the amount of liquid absorbed to time elapsed.)
6. How would mixing granules with soil affect seed germination or plant growth? (**Math Connection:** Graph the growth of seedlings grown with and without mixing the polymer into the soil.)
7. How do different brands of super-absorbent diapers compare in terms of their absorbency? (To be fair, test them with a 0.09% salt solution as simulated urine, rather than using tap water.)
8. How do the granules in super-absorbent diapers compare in their absorbency to those sold at garden centers? (Use caution in "dissecting" a diaper to avoid inhaling small particles!)

Additional Background Information for Teachers:

Both polyacrylamides and polyacrylates are substances that form long chains of repeated subunits when placed in water. Polyacrylates tend to absorb a greater amount of distilled water than of tap water (which contains various dissolved substances) or other liquids. Polyacrylamides tend to swell more than polyacrylates and are less affected by solutes in the water.

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References:

- ★ **A Plastic that "Grows", Experiment of the Month**, National Plastics Center & Museum, May 1997, available online at <http://npcm.plastics.com/slimystuff4.html>
- ★ **What is Sodium Polyacrylate Good For, Besides Toys?, Experiment of the Month**, National Plastics Center & Museum, June 1997, available online at <http://npcm.plastics.com/slimystuff5.html>
- ★ **More About Those Diapers!, Experiment of the Month**, National Plastics Center & Museum, July 1997, available online at <http://npcm.plastics.com/slimystuff6.html>
- ★ **Yet Another Super Absorbent Plastic!, Experiment of the Month**, National Plastics Center & Museum, August 1997, available online at <http://npcm.plastics.com/slimystuff7.html>
- ★ **Homemade Night Sky or Ocean, Experiment of the Month**, National Plastics Center & Museum, October 2000, available online at http://npcm.plastics.com/exp_of_the_month.html
- ★ **The Absorbing Story of the Thirsty Polymer, ChemMatters**, October 1999, pp. 3-5, available online at http://tungsten.acs.org:80/ncw/cm_oct99.pdf
- ★ **Polymers, WonderNet**, American Chemical Society, available online at <http://www.acs.org/wondernet/activities/past/polymers/polymers.html>

TRICK #1: The Disappearing Milk Trick

Student Handout

Materials for Each Inquiry Team:

For Exploration:

- ★ Goggles
- ★ Sample of “Magic Granules”
- ★ Water
- ★ 3 12-oz Clear Cups
- ★ Measuring Cups and Spoons or Graduated Cylinders

For Extension:

- ★ Balance or Postal Scale



Exploration:

1. To one cup, add 8 ounces (240 ml) of water. To a second cup, add 1 teaspoon (5 ml) of Magic Granules. In the third cup, mix 1 teaspoon (5 ml) of the magic granules with 8 ounces (240 ml) of water.
2. Observe the contents of the cups over the next 5 minutes.
3. Compare the granules, the water, and the mixture in terms of their properties. (Consider texture, volume, appearance, etc.)

Explanation:

Based on your observations, revise your proposed explanation for how the trick was done, if needed. After you complete the **Extension**, see **What’s Going On Here?** for more information.

Extension:

Use equipment available for measuring volume (measuring cups and spoons or graduated cylinders) and mass/weight (balance or postal scale) to devise a method to measure the maximum water-absorbing capacity of 1 teaspoon (5 ml) of dry granules. (Hints: How long will you give the granules to absorb water? How will you know whether the gel could still absorb even more water? How will you compare the final amount of gel to the amount of granules you started with? Compare the volumes? Compare the weights or masses?) Use your method to estimate the amount of granules needed to absorb 8 ounces (240 ml) of water. Use your data to describe the water-holding capacity of the granules in general terms. (“It expands to ___ times its original volume.” “It absorbs ___ times its weight in water.”)

TRICK #1: What's Going On Here?

Student Handout

Super Absorbent Polymers

In this trick, the magician knew that we would expect the milk to pour out when he tipped the glass. Milk pours, right?

What if we mix something into the milk? What happens if we mix in powdered drink mix, or sugar, or a small amount of sand? It still pours, right?

The “magic granules” used in this trick are a type of “super absorbent polymer” (PAH-lee-mer) that absorbs water and swells. The jelly-like combination of the polymer and the milk remained in the glass even when it was tipped. It was this unexpected property of this unfamiliar substance that made the trick a success.

The Magic Granules you used in your inquiry were similar to what the Magician used, only in granular form, for safety. (Powder can be inhaled and cause irritation of the nasal passages.) Now that you are familiar with a super absorbent polymer's water-absorbing property, let's talk about some of their uses. In agriculture and the plant nursery industry, granules of a super absorbent polymer called polyacrylamide (polly-uh-KRILL-oh-myde) are mixed with soil or used alone to greatly reduce the frequency with which plants must be watered. As plant roots take in water, the swollen polyacrylate particles shrink, but they can swell again when more water is added. This cycle of shrinking and swelling has been observed to be able to continue for years!

A less-absorbent polymer called polyacrylate (polly-AK-cree-late) is used in some disposable diapers advertised as super absorbent. Product engineers decided to use the less-absorbent polyacrylate rather than polyacrylamide so that the diaper could only absorb so much and only get so big.

A firefighter in Florida noticed that a used super-absorbent diaper was the only object that survived a dumpster fire unburned and got the idea to use polyacrylate gel to spray houses in the path of forest fires. It worked! The fire-retardant is now marketed under the trade name of Barricade.

Engineering Challenge: Water-absorbent polymers are used in numerous other products, including soft contact lenses, hair gels, and dressings for burns. Can you think of another use of water-absorbent polymers? Name your proposed product and create a poster advertising it.