

Hello Parents & Students!

Welcome to **ChemExplained.com Middle School SCIENCE!** We believe that a science curriculum with experiments should be more than just “fun”—it should be meaningful and educational. Our goal is to help students in middle school uncover the real chemistry behind every experiment.

This manual introduces students to the formal lab report process, covering everything from hypotheses to data-driven conclusions. We’ve also included **What is the Chemistry in this Experiment?** sections with **Final Thoughts** and **Real-Life Applications** for parents to ensure they have all the tools needed to guide their students through the wonders of chemistry.

As you prepare for these lab sessions, here are a few tips on how to use this manual:

- **Before You Begin Each Experiment:** Read Mr. Riz’s pre-lab letter, located in the *Lab Experiment Answer Key* section at the end of this manual. It provides essential context on the chemistry principles behind each experiment, along with great discussion questions to ask your students.
- **Vocabulary Terms:** Throughout this manual, **bolded** terms indicate key concepts that students should recognize and learn for future science courses.
- **Laboratory Balance:** Middle school students should develop proficiency in measuring the mass of substances.
 - When operating the digital balance, confirm the unit is set to **grams (g)**. Please avoid using alternative settings such as ct, dwt, ozt, oz, or gn for these labs.
- **Safety Precautions:** Students should always wear safety glasses and gloves while performing these labs. Wash hands thoroughly after handling any materials. Be mindful of small children and pets in the workspace to ensure their safety and the integrity of the lab.
- **Writing Hypotheses:** Many students find forming a hypothesis challenging. Remind them that a hypothesis is an “educated guess” based on what they think will occur during the lab. We follow two rules in writing hypotheses.
 - **No “I think”:** A hypothesis is stated as a confident, testable prediction rather than an opinion (e.g., write “*the diver will sink*” instead of “*I think the diver might sink*”).
 - **It’s Okay to Be Wrong!** Remind your students that a hypothesis does not have to be “correct” to be successful. If their prediction turns out to be false at the end of the lab, they still successfully completed a scientific test!

- **They're Just Guesses:** Since these are predictions, please accept all reasonable student statements. Some experiments do not require a written hypothesis. In these cases, encourage the student to provide a verbal prediction instead.
- **Recording Observations:** Encourage students to utilize the entire space provided in the OBSERVATIONS section of each report, recording their findings using clear, complete sentences with all words spelled correctly.
- **Questions:** Every lab report features post-lab QUESTIONS, specifically crafted to foster critical thinking and help students analyze their findings more deeply.
 - **IMPORTANT:** While the answers in the back of this manual for QUESTIONS and OBSERVATIONS serve as a thorough guide, they are often more detailed than a typical middle school student response. Use them as a guide and reference for the core concepts rather than a strict length or complexity requirement.
- **A Quick Note on Learning:** You will notice that certain chemicals (like carbon dioxide, CO₂) and core science concepts (such as *polymers, catalysts, density, enzymes, and acids/bases*) reappear across multiple labs. This is entirely by design! We don't believe in just covering a topic once and moving on. By revisiting these terms in different contexts, we help students truly connect with and absorb the material.
- **Academic Progression:** As you move through this manual, you will notice that the science material builds on itself! The labs are arranged to start with foundational concepts and gradually increase in complexity and challenge.
- **Pictures & Illustrations:** The images throughout this manual are included to help students visualize the experiments and connect them to real-world science concepts. Please note that these images are educational models and may not be perfectly realistic; they serve as helpful visual guides to clarify understanding of the material.
- **Real-World Connections:** The *ChemExplained Middle School SCIENCE* manual isn't just about memorizing facts from a textbook—it's about seeing science in action all around you! For every single one of the 36 labs, you'll start with a real-life puzzle or something you see every day at home. Whether you are messing around with density, exploring how gases behave, or tracking how fast a reaction happens, you will use normal, everyday items to figure out how things work. This manual connects regular science concepts to your actual life, so you can see that science isn't just a classroom subject—it's happening in your home, your backyard, and everywhere else in the real world!

Happy experimenting!

Mr. Riz *ChemExplained Curriculum Author*

Middle School SCIENCE Master Lab Equipment and Supplies List

RECOMMENDED Supply Sources

Cornerstone Educational Supply
515 Alleghany Ave.
Lynchburg, VA 24501
Ph: 434-509-4115

Home Science Tools
665 Carbon St.
Billings, MT 59102
Ph: 406-256-0990

[Amazon.com](https://www.amazon.com)

ChemExplained has partnered with **Cornerstone Educational Supply (CES)** to provide parents with an affordable and streamlined way to purchase lab equipment. The items highlighted below come pre-packaged in the **CES Middle School SCIENCE Lab Kit here:** <https://cornerstone-edsupply.com/products/chem-explained-middle-school-supply-lab-kit>

Additional required materials, along with their corresponding lab numbers, are listed below.

Alka-Seltzer tablets - 7, 27

Aluminum can (empty) - 26

Antacid (Tums) - 14

Apple (Red Delicious) - 22

Baking soda - 6, 10, 11, 14, 18, 24, 30

Balloons (latex, 12 in) - 30, 34

Borax - 1

Bottle (2 L, plastic) - 7, 33

Bottle (16 oz, plastic) - 30, 32, 34

Bottle cap (plastic) - 2

Bowl (kitchen) - 14, 18, 20, 23, 26, 31, 34, 35

Bubble solution (w. wand) - 28

Butter - 2

Citric acid (powdered) - 18

Clock (watch) - 4, 22

Clothespin - 9

Coffee filters - 12

Computer - 29

Cookie cutter - 25

Coffee stir sticks - 12, 32

Corn starch - 18, 21

Cotton swabs (Q-tips) - 8, 10

Cream (heavy whipping) - 17

Cutting board - 35

Dish soap (Dawn) - 2, 3, 6, 8, 11, 14, 32

Dry ice - 28

Egg (raw) - 16

Epsom salt - 18

EUDAX kit - 5

Eye dropper - 25, 33

Film canister - 6, 27

Fork (plastic) - 11

Food coloring - 1, 2, 3, 6, 7, 8, 18, 19, 21

Funnel (plastic) - Used with graduated cylinders

Gatorade - 5

Gloves (nitrile) - Used in multiple labs

Gloves (winter, insulated) - 17, 26, 28, 34

Glue (Elmer's, white) - 1

Graduated cylinder (10 mL) - 14, 17, 18, 26, 27

Graduated cylinder (25 mL) - 2, 10, 25

Graduated cylinder (50 mL) - 1, 3, 11, 15

Graduated cylinder (100 mL) - 4, 17, 22, 23, 2, 30

Graduated cylinder (250 mL) - 2, 3, 7, 21, 25, 32

Grapes - 2

Gummy bears - 13

Hair dryer (hand-held) - 10

Hand sanitizer (w. pump) - 10

Honey - 2

Hot pad holder - 26

Hydrogen peroxide (3%) - 32, 35

Hydrogen peroxide (6%) - 3

Ice (cubed or crushed) - 17, 26, 34, 35

Jar (glass, pint-sized) - 31

Jar (glass, quart-sized) - 9

Jelly roll pan - 3, 6, 21, 25, 32, 36
 Knife (kitchen) - 5, 22, 35
 Labels - 13, 14, 15, 16, 22
 Laboratory balance - Used in multiple labs
 Lemons - 5
 Lemon juice - 14, 15, 22
 Lighter (BBQ, long) - 11, 32
 Lighter fluid - 11
 Markers (non-permanent) - 12, 14, 15
 Marker (permanent, black) - 1, 13, 34, 35, 36
 Masking tape - 13, 22, 35
 Measuring cup ($\frac{1}{2}$ c, 1 c) - 3, 9, 12, 14
 Measuring spoons (tbsp, tsp) - 6, 12, 32
 Metal nut or bolt - 2
 Microfiber cloth (soft fabric) - 28
 Microwave oven - 10, 25, 35
 Milk (whole) - 8, 25
 Mineral sunscreen - 36
 Muffin tin - 18
 Olive oil - 18
 Oven mitts - 34
 Paint brush (~1 in) - 10
 Pan (kitchen) - 9, 23
 Paper (white) - 10, 27
 Paper clips - 33
 Paper towels - Used in multiple labs
 Pencils - 12, 14, 20
 Pennies (dull, tarnished) - 15
 Periodic Table - 29
 Pie tin (disposable) - 11
 Plastic bags (Ziplock, qt) - 1, 17, 20, 24, 36
 Plastic bag (Ziplock, gal) - 17
 Plastic cups (clear) - Used in multiple labs
 Plastic bin - 20, 28
 Plastic wrap - 23
 Plate - 8, 23
 Play-Doh - 6
 Potato (medium-sized, raw) - 35
 Raisins - 4
 Red cabbage (chopped) - 14
 Refrigerator - 23
 Rock salt - 17
 Rubbing alcohol (isopropyl) - 2
 Ruler - 12, 13, 33, 35
 Sand (dry) - 11
 Saucepan (kitchen) - 14, 23
 Scissors - 10, 12, 19, 22, 24, 27, 33
 Scotch tape - 12, 27
 Seltzer water - 14
 Sodium acetate trihydrate - 23
 Spatula (chemical) - 23, 36
 Spoons (plastic) - 3, 4, 13, 14, 15, 36
 Spoon (metal) - 1, 9, 16, 18, 19, 21, 23, 25
 Sprite - 4, 14, 22
 Stapler (w. staples) - 19
 Steel wool (fine) - 31
 Stove (kitchen) - 9, 23, 26
 Stopwatch - 27, 35
 Strainer (kitchen) - 14, 25
 Straw (drinking, plastic) - 33
 String (white) - 9
 Sugar (white, granulated) - 9, 17
 Sugar (powdered) - 11
 Sunscreens (commercial) - 36
 Tablecloth/sheet (plastic) - 10, 11
 Table salt - 12, 13, 22
 Taco sauce - 15
 Thermometer - 17, 18, 31, 32
 Titanium dioxide (powder) - 36
 Tongs - 28
 Tray (baking) - 21
 Turmeric (curcumin) - 10
 UV Blacklight flashlight - 36
 UV-Sensitive beads - 36
 Vanilla extract - 17
 Vegetable oil - 2, 7
 Vinegar (white) - 6, 10, 14, 15, 16, 22, 24, 25, 30, 31
 Water (bottled) - 14, 15
 Water (distilled) - 23
 Whisk - 18
 Witch Hazel - 18
 Yeast (dry, active) - 3, 32
 Zinc oxide (USP grade powder)

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LAB #8 - *The Magic Milk Experiment*

PARENTS: This week, our students will be exploring: **The Magic Milk Experiment**, a visually stunning activity that serves as a fantastic introduction to the world of **molecular chemistry**. While it looks like a magic trick, it is actually a demonstration of how different substances interact at a molecular level. Here is a brief look at the science behind the experiment:

1. Surface Tension

Liquid molecules, like those in water and milk, like to stick together. This is called **cohesion**. This process creates a “skin” on the surface called **surface tension**. When we drop food coloring onto the milk, it stays mostly in one place because the surface tension of the milk holds it there.

2. The Role of Soap

Dish soap is a **surfactant**, meaning it is designed to break down **surface tension**. The moment the soap touches the milk, it weakens the **chemical bonds** holding the liquid molecules together. This causes the milk (and the food coloring) to spread out rapidly, creating those vibrant bursts of color.

3. “Hating” and “Loving” Water

Soap is interesting! It is composed of **amphiphilic molecules** that have two different ends:

- **Hydrophilic (Water-loving):** This end wants to link up with water.
- **Hydrophobic (Water-fearing):** This end avoids water and searches for fats and proteins.

A Quick Metaphor You Can Use in Class

“Imagine an amphiphilic molecule is like a person standing between two friends who are arguing and refuse to touch each other (Water and Oil). The molecule holds Water’s hand with its left hand, and Oil’s hand with its right hand, bringing them together so they can move as a group.”

Milk is made of water, vitamins, minerals, and—most importantly for this lab—**fats** and **proteins**. As the soap molecules race around to attach themselves to the fat globules in the milk, they push the food coloring everywhere, creating the swirling patterns the students observe.

The “magic” finally stops once the soap has evenly mixed with the milk and all the fat molecules have been “caught.”

We hope your student enjoys sharing their observations with you!

Mr. Riz

LAB EXPERIMENT #8

The Magic Milk Experiment

Name _____

SAFETY PRECAUTIONS

- Wear safety glasses and gloves during the experiment.
- An adult must be present at all times to provide supervision.
- Don't eat or taste any of the ingredients.
- All spills should be cleaned up immediately.
- Wash your hands with soap and water immediately after performing the experiment.

LEARNING OBJECTIVES

In this experiment, the student will be able to:

- Define the terms: **amphiphilic**, **hydrophobic**, **hydrophilic**, **surfactant**, and **polarity**.
- Observe and describe how food coloring moves in milk when soap is added.
- Explain that soap changes how milk behaves by affecting **surface tension**.
- Identify **surface tension** as a force that holds liquid molecules together.
- Recognize that milk contains **fat**, water, and **proteins** that interact with the soap.
- Compare what happens before and after soap is added.
- Make predictions about what will happen when the soap touches the milk.
- Connect the experiment to real-world uses of soap like cleaning dishes or washing our hands.

EQUIPMENT and SUPPLIES

Milk (whole)	Cotton swabs (Q-tips)	Food coloring
Plate	Paper towels	Dish soap (Dawn)

** Parent Notes*

- *This is a student favorite because it looks like a moving piece of art.*
- *Whole milk works best in this lab because of its higher fat content.*
- *Milk is mostly water, but it also contains tiny droplets of fat and proteins.*
- *Have your student perform this lab 3-4 times. Each time they do the lab it is called a "trial."*

HYPOTHESIS

Fill in the blanks to make your prediction: *If* dish soap is added to the center of the milk and food coloring mixture, *then* _____ *because* _____.

PROCEDURE

Prepare the Liquid Base

1. Pour enough milk into the plate to cover the bottom completely.
2. Let the milk settle for 1–2 minutes until the surface is completely calm.

Introduce the Colors

3. Add 1–2 drops of each food coloring near the center of the milk.
4. *Note: Try not to let the food coloring drops touch each other initially.*

Trigger the Reaction

5. Dip one end of a clean cotton swab into the liquid dish soap.
6. Gently touch the soapy end of the swab to the center of the milk.
7. **CRITICAL:** Do not swirl or stir! Just hold the swab steadily in place and watch the movement.

Record & Clean Up

8. Record your observations in the space provided below.
 9. Slowly pour the mixture down the drain, enjoying the final color swirls, and thoroughly rinse the plate with water.
-

Extension Activities (Going Further)

Extension A: The Water Control

- Perform the exact same experiment using water instead of milk. How does the food coloring behave when the soapy swab touches it? _____

Extension B: Changing the Fat Content

- Repeat the experiment using Half-and-Half.
- Add several drops of food coloring throughout the liquid and test with the soapy swab.

Questions to consider: How are the results similar to whole milk? How are they different?

OBSERVATIONS

Describe what you see, hear, or feel doing this lab.

WHAT IS THE ACTUAL CHEMISTRY IN THIS EXPERIMENT?

This lab might look like magic, but it is actually a beautiful demonstration of **surface tension**, molecular **polarity**, and how **surfactants** (like soap) interact with fats and water.

1. The Power of Surface Tension

Water molecules are highly attracted to one another. They like to stick together tightly, especially at the surface, creating an invisible “skin” called **surface tension**. Because milk is mostly made of water, it also has high surface tension. When you first drop the food coloring onto the milk, the drops stay relatively in place because the surface tension of the milk holds them up and keeps them from spreading out quickly.

2. Enter the Soap (The Surfactant)



Dish soap belongs to a class of chemical compounds called **surfactants** (short for *surface-active agents*). Soap molecules are unique because they are “bilingual” in the chemical world. They are **amphiphilic** (**amphi-** means “both” (just like an *amphibian* lives both on land and in water), and **-philic** means “loving” (like an audiophile loves music). So, *amphiphilic* literally means “**loving both**” according to its Greek roots. Surfactants have two distinct ends:

- **A Hydrophilic Head:** This end loves water and wants to bond with it. (Hydro- means “water.”)
- **A Hydrophobic Tail:** This end hates water and avoids it at all costs, preferring to attach itself to grease, oil, and fat. (-phobic means “fear of.”)

3. Breaking the Surface Tension

The moment the soapy cotton swab touches the center of the plate, two amazing chemical processes happen simultaneously:

- **The Soap Spreads:** The soap molecules immediately try to race across the surface of the liquid. As they do, they break the chemical bonds holding the water molecules together, drastically reducing the surface tension.
- **The Color Chase:** As the surface tension drops at the center, the stronger surface tension around the edges of the plate pulls the milk (and the food coloring riding along with it) outward, creating the initial burst of color.

4. The Molecular Dance (Chasing the Fat)

While the surface tension is breaking, the hydrophobic tails of the soap molecules are frantically searching for a place to hide from the water. They find their sanctuary in the tiny droplets of fat and protein suspended in the milk.

The soap molecules twist, turn, and race through the milk to hook onto these fat molecules. As the soap molecules scramble to surround the fat clusters, they bump into and push the food coloring around. This frantic, microscopic scramble is what causes the spectacular, swirling “moving piece of art” you see on your plate!

QUESTIONS

1. What happened the instant the soap touched the milk? _____

2. Did the swirling motion continue, and if so, for how long? _____

3. How would you describe surface tension? _____

4. An insect that can walk on water is the water strider. What do you think would happen if you were to drop a tiny bit of dish soap near a water strider? _____

REAL-WORLD APPLICATIONS FROM THIS LAB

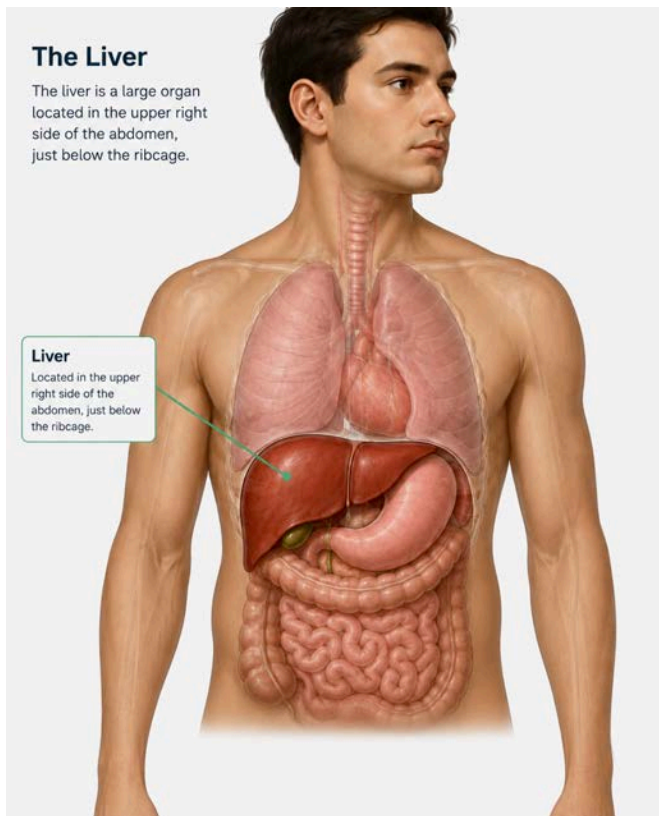
In the lab, the soap’s “**amphiphilic**” nature—having a water-loving head and a fat-loving tail—causes it to chase down the fat droplets in the milk. A molecule that is **amphiphilic** is a special molecule that has two opposite sides—one side loves water, and the other side hates water but loves oil and fat. This exact mechanism is how we keep our world clean!



- **Washing Greasy Dishes:** When you try to clean a greasy bacon pan with just water, the water slides right off because oil and water don’t mix. When you add dish soap, the hydrophobic tails grab onto the grease, and the hydrophilic heads grab onto the rinsing water. This lifts the grease off the plate and allows it to be washed down the drain.

- **How Soap Kills Germs (Handwashing):** Many viruses (like the coronavirus) and bacteria have an outer layer made of lipids (fats). When we wash our hands with soap, the hydrophobic tails of the soap molecules wedge themselves into the germ’s fatty outer shell and break it apart, destroying the virus or bacteria while the water flushes it away.





- **Digestion in the Human Body (Bile Salts):** Our bodies have a natural “dish soap”! When we eat fatty foods like pizza or burgers, our liver produces bile. Bile contains bile salts that act exactly like surfactants. They break large fat globules down into tiny droplets so our digestive enzymes can break them down more easily.

Real-World Applications of Surface Tension

Before the soap is added, the high surface tension of the water/milk acts like an elastic skin, supporting the food coloring. This phenomenon shows up everywhere in nature and engineering.

- **Water Striders and Aquatic Insects:** Water striders rely on the cohesive forces of water molecules to walk across puddles and ponds without sinking. If a pollutant like soap or oil enters their ecosystem, it breaks the surface tension, causing the insects to plunge into the water!
- **FUN FACT** - A water strider's legs are covered by thousands of microscopic, wax-coated hairs. These hairs are **hydrophobic**, meaning they actively repel water. This prevents the legs from getting wet and being pulled under by **capillary action**.





- **Raindrops on a Freshly Waxed Car:**

When a car is freshly waxed, the wax repels water (hydrophobic). Because the water cannot stick to the car's surface, the water molecules stick tightly to *each other* instead. The high surface tension pulls the water into tight, perfect spheres or "beads."

- **The "Tears of Wine" Phenomenon:** If you look closely at a glass of wine, you will see droplets continually crawling up and falling down the sides of the glass. This is caused by the **Marangoni Effect**—the exact same fluid movement seen in the lab when a surface tension gradient is created between the alcohol and the water.



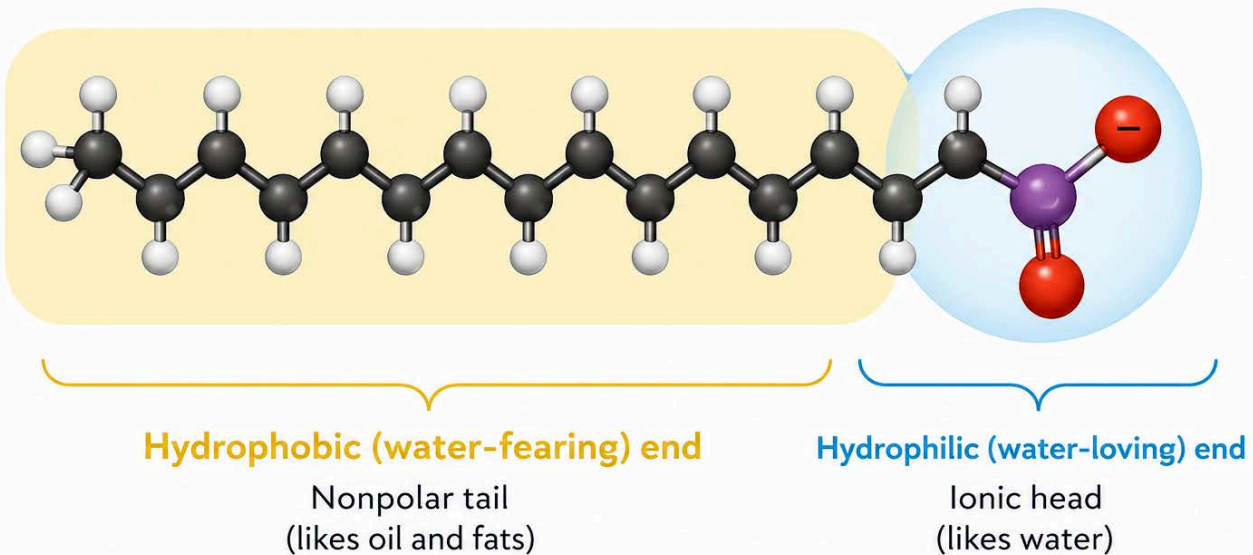
A Great Follow-Up Discussion Prompt for Students:

"If surfactants are so good at breaking surface tension and grabbing oils, what do you think happens to the natural, protective oils on our skin if we use dish soap to wash our hands instead of regular hand soap?"

TEACHER SUMMARY NOTE - The food coloring moved away from the center of the milk because the soap broke the surface tension at the center, and the "elastic skin" of the milk pulled away, carrying the food coloring with it. The colors keep moving until every soap molecule has found a fat molecule, or the surface tension is completely leveled out. The food coloring does not cause the movement; it is an **indicator**. In other words, it's just a "bystander" that gets pushed around by the invisible battle between the soap and the fat. The **hydrophobic** (water-fearing, fat-loving) tails of the soap molecules were searching for fat globules in the milk. They want to bury themselves in the fat to stay away from the water.



A Soap Molecule



The soap molecule has two different ends:
one end **avoids water** and sticks to oil, the other end **loves water** and washes it away!

Many Kinds of Soaps and Detergents



What's the difference?

All soaps and detergents help remove dirt and oil. **Soaps** are often gentler and made from natural fats or oils. **Detergents** are usually stronger cleaners made in labs. Different products are made for different jobs!



LAB QUIZ #8

Name _____

The Magic Milk Experiment

1. Why does food coloring stay mostly in one place when first dropped onto the milk?
 - a. The high surface tension of the water in the milk acts like a skin holding it up.
 - b. The milk is too cold for the food coloring to move.
 - c. The food coloring is too heavy to sink or float.
 - d. The fat in the milk chemically traps the food coloring.
2. What is a surfactant?
 - a. A chemical compound that increases the surface tension of a liquid
 - b. A substance that dissolves completely in fat but hates water
 - c. A type of protein found naturally in whole milk
 - d. A surface-active agent that lowers the surface tension of a liquid
3. What does the word “amphiphilic” literally mean based on its Greek roots?
 - a. Water-fearing
 - b. Loving both
 - c. Living in water
 - d. Breaking apart
4. Which part of the soap molecule actively avoids water and attaches to fats or oils?
 - a. The hydrophobic tail
 - b. The hydrophilic head
 - c. The atomic nucleus
 - d. The water-loving bridge
5. Why does whole milk work better for this experiment than skim milk?
 - a. Skim milk does not have any surface tension.
 - b. Whole milk is thicker, which makes the food coloring change colors.
 - c. Whole milk has a higher fat content for the soap molecules to interact with.
 - d. Skim milk destroys the cotton swab.
6. What is the actual role of the food coloring in this lab?
 - a. It drives the chemical reaction with the soap.
 - b. It breaks down the proteins in the milk.
 - c. It changes the hydrophobic tails into hydrophilic heads.
 - d. It acts as a visual indicator, showing the invisible movement of the liquids.
7. Which of the following statements is not true?
 - a. A water strider’s legs are covered by thousands of microscopic, wax-coated hairs.
 - b. When the soap touched the milk, the colors stopped moving.
 - c. Each time a student performs an experiment it is called a trial.
 - d. Surface tension is like a thin, invisible “elastic skin” on top of the liquid.
8. How do bile salts in the human digestive system relate to dish soap?
 - a. They both protect water striders from sinking in ponds.
 - b. They are both used to clean dishes and pans.
 - c. They both act as surfactants to break down large fat globules into tiny droplets.
 - d. They both create an elastic skin on top of the water.

Lab #8 Answer Keys

OBSERVATIONS

Student statements could read:

After I added soap to the end of the Q-tip, and touched it to the center of the plate of milk, the colors immediately started to move away and swirl! It kept on doing this for a few minutes. It was like a colorful work of art.

QUESTIONS

- 1. The colors immediately moved away from the cotton swab toward the edges of the plate.**
- 2. Yes, the movement continued for several minutes. This is because the soap molecules are physically racing through the milk to find and attach to fat globules.**
- 3. Surface tension is like a thin, invisible “elastic skin” on top of the liquid. It’s caused by the milk molecules clinging tightly to each other because they are polar.**
- 4. The surface tension holding the insect up would vanish instantly. The “skin” would pop like a balloon, and the insect could sink!**

Lab Quiz #8 - 1. a 2. d 3. b 4. a 5. c 6. d 7. b 8. c
