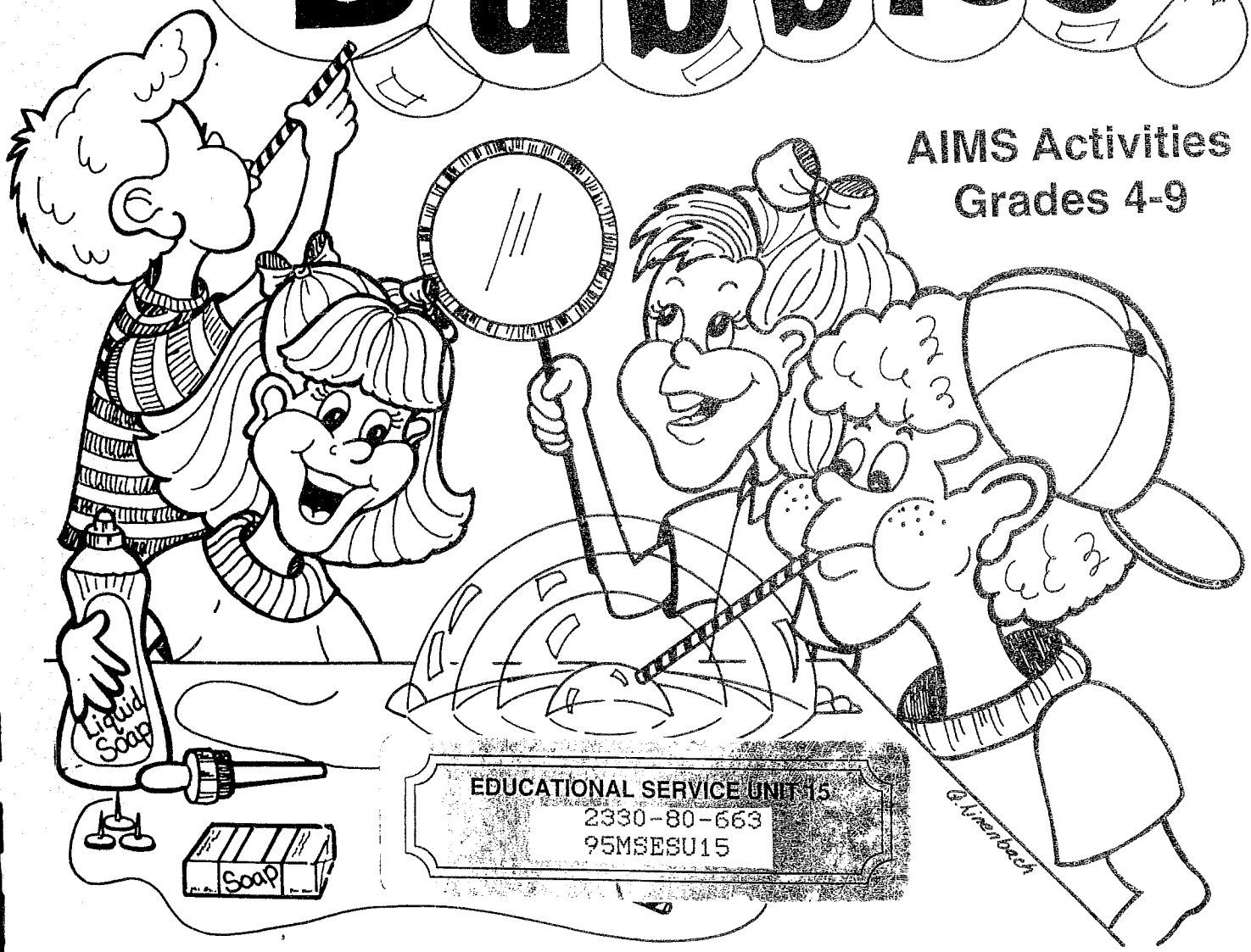
Soap Films and Bubbles

AIMS Activities
Grades 4-9



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Soap Films and Bubbles

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AIMS (**A**ctivities Integrating **M**athematics and **S**cience) began in 1981 with a grant from the National Science Foundation. The non-profit AIMS Education Foundation publishes hands-on instructional materials (books and the monthly AIMS Newsletter) that integrate curricular disciplines such as mathematics, science, language arts, and social studies. The Foundation sponsors a national program of professional development through which educators may gain both an understanding of the AIMS philosophy and expertise in teaching by integrated, hands-on methods.

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Math Skills

	Finding Volume	Measuring Length	Timing	Finding averages	Measuring/Judging angles	Using Ratios	Finding/Using formulas	Finding area	Venn diagram/ Set theory	Working with geometric shape	Patterning	Counting	Sequencing	Using calculators	Graphing	Basic computation ASMD	Plotting coordinates	Using a compass
Whet Your Appetite		✓																
It's a Touchy Subject									✓									
Taking Shape										✓								
Bubble Clusters					✓					✓	✓							
Water Rings		✓																
Macro Molecules											✓	✓						
Pulling Strings		✓					✓	✓				✓	✓	✓				
Stretching Out		✓		✓		✓								✓	✓			
Arching Links											✓							
Thumbtack Sandwich I		✓														✓		
Thumbtack Sandwich II		✓											✓			✓		
A Fork in the Road					✓		✓			✓		✓					✓	
Reflections on Geo-Panes					✓		✓			✓		✓						
Under Pressure					✓													✓
Bubbles Aloft																		
Riding on Air	✓																	
Liquid Rainbows													✓					
Soap Cookbook						✓												
What's the Best Solution?			✓	✓														
Don't Burst My Bubble			✓	✓									✓					
Swell Hemispheres	✓			✓									✓					

Science Processes

	Observing/Classifying	Measuring/Comparing	Collecting/Recording Data	Predicting/Inferring	Identifying/Controlling Variables	Making/Testing Hypotheses	Applying/Generalizing	Interpreting Data
Whet Your Appetite	✓							
It's a Touchy Subject	✓	✓	✓		✓	✓	✓	✓
Taking Shape	✓	✓	✓				✓	
Bubble Clusters	✓		✓				✓	
Water Rings	✓	✓	✓			✓	✓	
Macro Molecules		✓					✓	
Pulling Strings	✓	✓	✓	✓				✓
Stretching Out	✓	✓	✓	✓			✓	
Arching Links	✓	✓	✓		✓		✓	✓
Thumbtack Sandwich I	✓	✓	✓	✓				
Thumbtack Sandwich II	✓	✓	✓	✓				
A Fork in the Road	✓	✓	✓	✓			✓	✓
Reflections on Geo-Panes	✓		✓	✓			✓	✓
Under Pressure	✓	✓	✓			✓	✓	✓
Bubbles Aloft	✓		✓				✓	
Riding on Air	✓	✓	✓	✓			✓	✓
Liquid Rainbows	✓	✓	✓	✓			✓	✓
Soap Cookbook		✓						
What's the Best Solution?			✓		✓	✓	✓	✓
Don't Burst My Bubble	✓		✓	✓	✓		✓	✓
Swell Hemispheres		✓	✓	✓				

INTRODUCTION

Bubbles have long been a favorite preoccupation of children and adults; bubble solutions and blowing tools continue to be popular items on store shelves. Why not use this motivating force to observe and discover what soap films and bubbles can help us learn?

Where will this soap film journey take us? The answer may surprise you as it did me. From simple wonder, we can advance into the world of geometry, physics, and chemistry. We can study classic minimal surface problems posed by mathematicians and scientists over a century ago. We can learn about molecules, surface tension, light waves, air pressure and patterns, all by observing soap films. Math and science come together naturally in this environment.

These activities combine the learning of content along with the use of scientific processes. Without knowledge, we would not know what questions to ask or hypotheses to form. That's why the fact sheets and background information are so important. A selective bibliography is included for those who want to read the primary sources.

I invite you on an educational adventure. Wonder, explore, and say "aaah!" along with your students as you dip your hands in a little soap and water and discover the fascinating world of soap films.

ADVICE

Allow time for some free play and exploration before getting into the serious part of the lesson. Soap films hold a natural attraction for kids of all ages.

Recognize that there will always be a battle between soap film experimenting and finding a dry place to record information.

Have old towels or rags handy for cleanup. A vinegar and water solution will cut the soap film residue left on desks or tables. Vinegar may also be sprinkled directly on the surface to be cleaned.

SUPPLY LIST

This list may assist you in assembling the supplies for the activities you have chosen.

Consumable Items

_____ glue
_____ string or thin yarn
_____ straws
_____ liquid soap such as Dawn or Joy
_____ assorted gumdrops
_____ round toothpicks
_____ 18 or 20 gauge solid core copper wire
_____ plastic wrap
_____ masking tape
_____ cotton thread
_____ wax paper
_____ vinegar
_____ baking soda

Non-consumable Items

_____ metric rulers
_____ calculators
_____ scissors
_____ protractors
_____ compasses
_____ wire cutters
_____ soldering iron and solder
_____ water containers — half gallon milk cartons, liter boxes, tubs, styrofoam or plastic cups, plastic aquariums, etc.
_____ kitchen tools, gadgets with unusual holes, cookie press, cake decorating tubes, strawberry baskets
_____ commercial bubble wands and solution
_____ wool sample
_____ pairs of rings — jar lids, crumpet rings, tuna cans, soft margarine tubs, plastic bracelets
_____ glass or plexiglass plates, 4" × 4"
_____ thumbtacks
_____ plasticine clay
_____ glass quart jars
_____ cleanup rags, old towels
_____ cookie sheets or cafeteria trays
_____ eyedroppers
_____ construction paper, scratch paper
_____ straight pins
_____ sets of small chains 3 feet in length
_____ blank transparencies
_____ watch or clock with secondhand
_____ round plates, saucers, pie plates, or paper plates

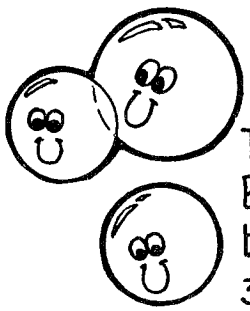
SOAP SOLUTION RECIPES

Many factors contribute to the making of a good soap solution. Consider tap versus distilled water, warm versus cold water, the kind of soap, the additives, and the amount of each ingredient. Cost, also, must be weighed against benefits.

To complicate matters, soaps have various stabilizing additives of their own. Unfortunately, these additives are not listed on the labels so comparison is difficult. Try soaps in different price ranges. Try additives such as sugar, syrup, lemon juice, gelatin, and glycerin. Glycerin is available in drugstores.

Several investigations in this book are devoted to finding the optimum solution. However most bubble experiences do not require a special recipe. Just squirt some liquid dish soap into water, stir and blow.

This collection of ordinary, unusual, and historic recipes has been gleaned from books, magazines, and science museums. Although sophisticated solutions can be created in chemical laboratories, most of the following solutions can be made in your home or school.



BASIC RECIPES

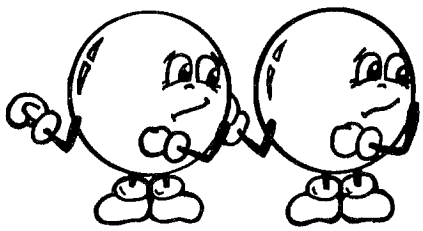
The Exploratorium in San Francisco, site of several Bubble Festivals, recommends this recipe. For best results, let it age at least five days.

3.8 liters	1 gallon	water
175 ml	2/3 cup	Dawn or Joy detergent
15 ml	1 tablespoon	glycerin, optional

(960 ml) 1 quart water	50% distilled water	Tap water
(120 ml) 1/2 cup soap	40% good liquid detergent	1-2% soap
Glycerin, optional	10% glycerin	

2 parts water	3 parts water	5 parts water
3 parts soap	1 part soap	1 part soap
1 part glycerin	3 parts glycerin	1 glycerin

SOMETHING DIFFERENT



60 ml cold water
15 ml unflavored gelatin
Heat to 90 Celsius (almost boiling) in double boiler. After it is dissolved and there are no bubbles, add
9 ml glycerin
3 ml liquid detergent
Stir gently; keep warm while using. Bubbles can be mounted on heavy paper or rolled across smooth surfaces.

Historic Solution

These solutions are more difficult to make but are included for their historic value.

JOSEPH PLATEAU'S SOLUTION (1873)

Sodium oleate is an white powder available from dealers in chemical supplies.

40 oz. distilled water
1 oz. pure sodium oleate
Do not stir but set in a dark place for 24 hours to dissolve.
10 oz. U.S.P. glycerin
Mix by pouring back and forth between two clean containers. Store in a dark place about one week. Siphon off the clear fluid below the scum. To the clear fluid add
2 drops household ammonia
Bottle for use.

CHARLES V. BOYS' SOLUTION (1890)

A variation of Plateau's

Fill a clean stoppered bottle 3/4 full of water. Add 1/40th the water's weight of sodium oleate. It will probably float. Leave in the dark for a day to dissolve. Add pure glycerin to nearly fill the bottle and shake well. Leave the closed bottle in a dark place for about a week. Siphon the clear liquid from the scum. Add one to two drops strong liquid ammonia to every pint of liquid.

To use, put the amount needed into another container. Leave the original stored. Do not return the leftover solution to it. Do not warm or filter. Do not expose to air unnecessarily. (Boy's' solution lasted ten years.)

BUBBLE PERSONALITIES

JOSEPH ANTOINE FERDINAND PLATEAU (1801-1883)

This Belgian spent much of his life studying the surface properties of fluids, despite being completely blind by the age of 42. (His eyes were permanently damaged from looking at the sun during an optics experiment.) The problem of finding the minimum surfaces of three-dimensional figures is now called Plateau's Problem. It is easily done with soap films but was not solved mathematically until 1976. His classic work is entitled Statique experimentale et theorique des liquides soumis aux seules forces moleculaires (Experimental and Theoretical Investigations of the Equilibrium Properties of Liquids Resulting from their Molecular Forces), published in 1873. Much of his research was done at the University of Ghent in Belgium.

CHARLES VERNON BOYS (1855-1944)

Boys was well known for giving lecture-demonstrations throughout England, making the study of bubbles and their properties interesting to children and adults. His book, Soap Bubbles, Their Colors and Forces Which Mold Them, is the classic work on bubbles in the English language.

EIFFEL PLASTERER

Since age 25, this former high school physics teacher and sorghum farmer from Huntington, Indiana has been experimenting with bubbles. He created "Bubbles Concerto", a show combining science and entertainment, and has presented it over 1,400 times since 1932.

Plasterer makes his solutions in concentrated form and then adds two parts water to one part concentrate. One of his concentrates is made from sassafras roots. Of the many soap solutions he has tried, one gave him a bubble that lasted 340 days! This particular bubble was breath-blown to four inches in diameter and kept in a closed jar. It never popped, but slowly lost air until it disappeared. He uses another solution for making giant bubbles that can enclose seven people.

Approaching the age of 90, he still blows bubbles. In April of 1986, he appeared at the Second International Bubble Festival hosted by the Exploratorium in San Francisco.

TOM NODDY

Whether putting on a show in a school, in a prison, at a museum, or on television's "Tonight Show", Tom Noddy from Santa Cruz, California has fascinated people with bubble magic. He blows chains of caterpillar bubbles, square bubbles, bubble families, bubbles inside bubbles, bubble volcanoes, and spinning bubbles to name a few. He became interested in bubbles while saving money for a trip to Europe. Noddy continues to learn from scientists and bubble lovers all over the world.