Diffusion of Water with Polymers

Grades: 6-8 and 9-12

Purpose: To investigate the movement of water into and out of a polymer. Gummi® animals are made of gelatin and sugar. Gelatin forms large three-dimensional matrices which give structural support to jellies and jams. Plant spikes and Gro Beasts® are made with polyacrylamide. Water will flow from an area of high concentration to one of low concentration.

Science Standards: Content Standard A: Science as Inquiry; Content Standard B: Physical Science;

Materials: for pairs of students (Students are to pick <u>two</u> different polymers to study: Gummi® Bears, Plant Spikes or Gro Beasts®)

2 - plastic cups (8oz)	2 -aluminum screens (4"x4")
distilled water	centimeter ruler
saturated salt solution	paper towels
electronic balance (optional)	permanent marker

Procedure:
1. Obtain two plastic cups and two different polymers.
2. On the side of each cup, write your name and class period using a permanent marker.
3. Find the mass of each polymer using a balance. Record the information on the lines:
Mass of _____ is _____g Mass of _____is _____g
4. Measure your polymer from top to bottom (length) and from side to side (width) and from front to back (height). Record the centimeters in the data table.
5. Place the polymers in the cups and cover them (1/2 cup full) with distilled or pure water.
6. Place the cup on the counter away from direct sunlight. Let it sit overnight.
7. On the next lab day, gently pour the water over an aluminum screen into a sink. Catch each polymer on a separate screen. While on the screen, measure the height, width, and depth. Record. Blot the screen dry by placing it on a paper towel.
8. Find the mass of each polymer. Do this by placing the entire screen with the polymer on the balance. Record the total mass. Carefully slide the polymer back into the empty cup. Find the mass of the screen alone. Calculate the mass of the polymer. Record.
9. Cover the polymers with saturated salt solution. Let this sit overnight.
10. Find the mass and dimensions of the polymers and record. Calculate the volume.

Data Table for Mass:

Mass in Grams	Polymer One (_____)		Polymer Two (_____)	
	After pure water (day2)	After salt water (day 3)	After pure water (day2)	After salt water (day3)
Mass of screen and Polymer				
- Mass of screen				
= Mass of Polymer				

Data Table for Dimensions in centimeters:

	Polymer One (_____)				Polymer Two (_____)			
	Length	Width	Height	Volume	Length	Width	Height	Volume
Before water								
After pure water								
After salt water								

Conclusions:
1. What happened to the polymers when placed in distilled water? Why?
2. What happened to the polymers when placed in salt water? Why?
3. What do you think would have happened to the polymers if, after the last day, they were again placed in distilled or pure water?
4. Describe how the dimensions of the polymers changed after being placed in the pure water and after being placed in the salt water?
5. Calculate the percent change in mass and percent change in volume after each step of the experiment.
       % change in mass = (final mass - initial mass)/ initial mass x 100
      % change in volume = (final volume - initial volume)/ initial volume x 100
6. Construct a data table to store these calculations.
7. Make a bar graph of the percent changes for mass. Label axes, place a scale on the vertical axis and give a title. Place the data for both polymers on the same graph. USE GRAPH PAPER. If you have a negative value for a percent change, start the vertical axis at a negative number. (For example: -50, -25, 0, 25, 50, 75, 100, etc.)

Percent
Change

This is an example of the axes.

| Water | Salt Water | | Water | Salt Water |
| Polymer #1 | | | Polymer #2 | |
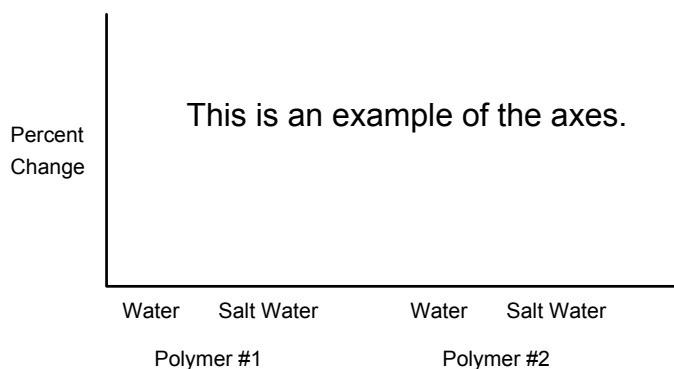
8. Make another bar graph of the percent changes in volume. . Label axes, place a scale on the vertical axis and give a title.
9. Write a paragraph which explains the results of this experiment using the concept of diffusion. Include your data where appropriate to explain your results.

Diffusion of Water with Gummi® Bears

Purpose: To investigate the movement of water into and out of a polymer. Gummi® Bears are made of gelatin and sugar. Gelatin is a polymer that forms large three-dimensional matrices which give structural support to jellies and jams.

Hypotheses: If I place Gummi® Bears in tap water, then the size of the bears will (increase, decrease, remain the same). Circle your answer.
If I place Gummi® Bears in distilled water, then the size of the bears will (increase, decrease, remain the same). Circle your answer.

Materials: for pairs of students

2 - plastic cups (8oz)	2 -aluminum screens (4"x4")
distilled water	2 -centimeter rulers
tap water	paper towels
permanent marker	2 -Gummi® Bears (different colors)
saturated salt solution	

Procedure:
1. Obtain two plastic cups, two different colored Gummi® Bears and two rulers.
2. On the side of each cup, write your name and class period using a permanent marker.
3. Label one cup with "TAP WATER" and the other "DISTILLED WATER".
4. Measure your bear (in cm) from top to bottom (length) and from side to side (width) and from front to back (height). Record the centimeters in the data table. Use decimals.
5. Place the bears in the cups and cover one with distilled and one with tap water.
6. Place the cups on the counter away from direct sunlight. Let them sit overnight.
7. On the next lab day, gently pour the water over an aluminum screen into a sink. Catch each bear on a separate screen. While on the screen, measure the length, width, and height. Record. Blot the screen dry by placing it on a paper towel. BE CAREFUL not to break the bears, they are very fragile.
8. Place the bears back into their correct cups. Cover the bears with saturated salt solution. Let them sit overnight.

9. Find the dimensions of the bears and record. Calculate the volumes (l x w x h).

Data Table for Dimensions in centimeters: (Use decimal numbers.)

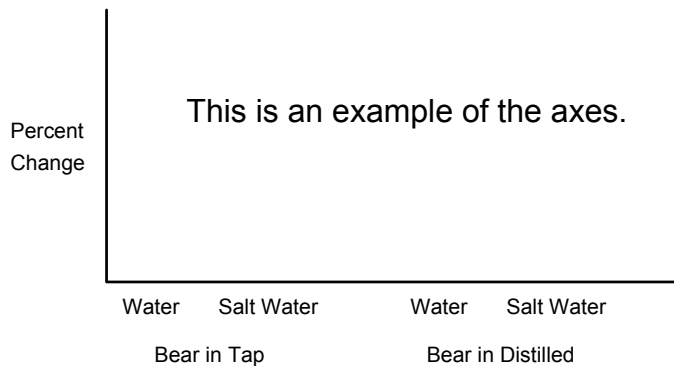|	Gummi® Bear in Tap Water				Gummi® Bear in Distilled Water			
	Length	**Width**	**Height**	**Volume**	**Length**	**Width**	**Height**	**Volume**
Before water								
After water								
After salt sol.								

Conclusions:

1. What happened to the bears when placed in distilled water? Why?
2. What happened to the bears when placed in tap water? Why?
3. What happened to the bears when placed in salt water? Why?
4. What do you think would have happened to the bears if, after the last day, they were again placed in distilled water?
5. Calculate the percent change in volume after each step of the experiment.

   % change in volume = (final volume - initial volume)/ initial volume x 100

6. Place the percentages in the table below:

Bears	% Change in Water	% Change in Salt Water
Tap Water Bear		
Distilled Water Bear		

7. Make a bar graph of the percent changes. Label axes, place a scale on the vertical axis and give a title. Place the data for both bears on the same graph. USE GRAPH PAPER. If you have a negative value for a percent change, start the vertical axis at a negative number. (For example: -50, -25, 0, 25, 50, 75, 100, etc.)

Percent Change

This is an example of the axes.

Water   Salt Water   Water   Salt Water

Bear in Tap   Bear in Distilled

1. 8. Write a paragraph which explains the results of this experiment using the concept of diffusion. Include your data where appropriate to explain your results.

Teacher Notes on Diffusion

(Recommended for Middle Level or High School. The Gummi® Bear Laboratory on Diffusion is intended for younger middle level students where they need more detailed instructions and do not have balances available.)
Diffusion Lab Notes:
- This is a three day lab.
- Volume calculations for plant spikes: Vol.= ½ base x height of triangle x length
- All the polymers for this lab will grow to several times their original size when placed in distilled water for twenty-four hours. The bears and Gro Beasts® will also shrink back to their original size if they are placed in saturated salt solution. The spikes do not release their water in a salt solution environment. Typical plant spike data includes:

Spikes	Dry Mass in grams	1 day in Distilled Water	4 days in Distilled Water	1 day in Salt Water	2 days in Salt Water	3 days in Salt Water
1	.54	4.33	5.68	6.53	6.79	7.31
2	.89	6.10	9.08	10.13	10.98	11.65
3	.50	4.16	5.31	5.99	6.52	6.87

- Gummi® bears work the best since they are small and compact. Worms tend to break when they are enlarged with distilled water.
- If your students observe and record mass changes, the handling of the bears must be gentle since the Gummi® animals get quite flexible and fragile after twenty-four hours in distilled water. The Gro Beasts® and spikes are not that fragile.
- I tried Walgreen brand and Black Forest® brand gummy bears and worms. Both bear brands work well. The Walgreen brand is larger. Other brands just disintegrate.
- Saturated salt water is made from Kosher coarse salt so that it will be clear. Make about one liter of solution for a class. Start with one liter of distilled water and add Kosher coarse salt. Shake until it dissolves. Add more salt and shake. It will take about 360 g or 1 3/4 cup of salt to make the solution saturated. Allow plenty of time for the salt to dissolve. This usually takes overnight! When some salt remains undissolved this indicates saturation.
- Saturated sugar water will also work. This is a bit sticky!
- Have extra gummi animals available for eating at a different time! Do not allow eating during the laboratory.
- It is also possible to see a decrease in size from the original bear placed in saturated salt water. I found a decrease in mass of 41% in 24 hours.
- To introduce the activity and the concept of diffusion, demonstrate the diffusion of a drop of colored dye in water or open a perfume bottle in the room. The molecules move from an area of high concentration to one of lower concentration.
- Plant spikes and Gro Beasts® are not as fragile as bears. These can be used year after year so rinse them well with tap water after the salt water treatment and then dry them out and save them. Let them dry on a surface of plastic wrap as they air dry.

- Plant spikes can be purchased from Educational Innovations, Inc., 151 River Road, Cos Cob, CT 06807 (203-629-6049) or JRM Chemical, Inc., 15663 NEO Parkway, Cleveland, OH 44128, 1-216-475-8488 bulk plant spikes - $46.68 per case + shipping
- Typical Data: (Day Two is after Distilled Water and Day Three is after Salt Water.)
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Polymer	Original mass (g)	Day Two mass (g)	% Change	Day Three mass (g)	% Change
Gummi Bear®	1.7	8.1	376	1.4	-18
Plant Spike	.4	4.0	900	5.4	+1250
Gro Beast®	1.2	51.7	4208	6.9	+475

Polymer	Original volume cm^3	Day Two volume cm^3	% Change	Day Three volume cm^3	% Change
Gummi Bear®	2.31	16.92	632	1.76	-24
Plant Spike	.49	3.5	614	4.95	+910
Gro Beast®	4.7	21.6	3596	29	+517

Written by Mary Harris, Missouri Polymer Ambassador   *Copyright 1996*