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NSDL/NSTA Web Seminar:

Chemistry Comes Alive II: Sticky Molecules and Folding Proteins

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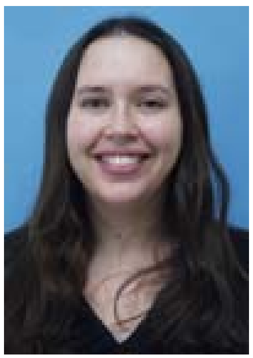
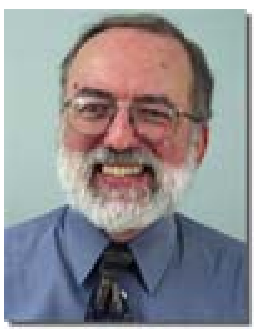
Tuesday, October 23, 2007

Today's NSDL Experts



Dr. Lynn Diener, Outreach Specialist, ChemEd Digital Library, University of Wisconsin-Madison



Dr. John Moore, W. T. Lippincott Professor of Chemistry at the University of Wisconsin-Madison and director of the Institute for Chemical Education (ICE)

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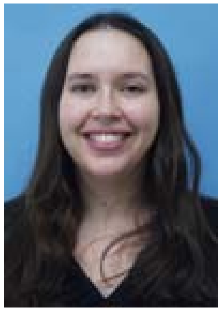
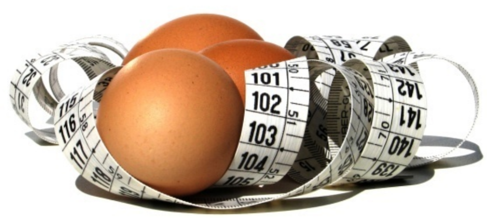
Special Guest

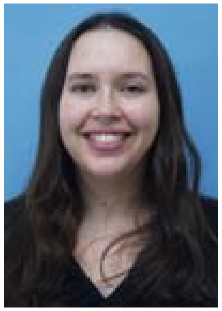
Jon Holmes, Associate Editor for the Journal of Chemical Education, University of Wisconsin-Madison



Today we will explore hydrophobicity and the chemistry of proteins using selected *JCE* resources

- *JCE* articles
- Classroom Activity
- Featured Molecules
- Multimedia problems
- Video





Proteins are …

A. Polymers
B. Carbohydrates
C. Without covalent bonds
D. Free of the element sulfur
E. A and D

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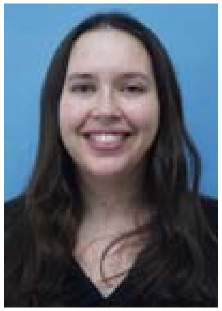
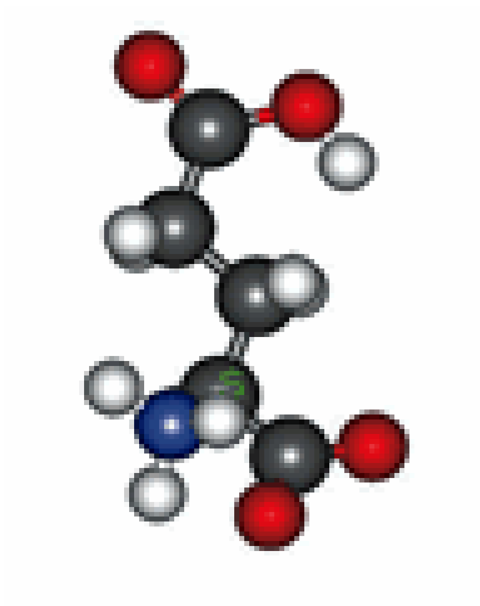
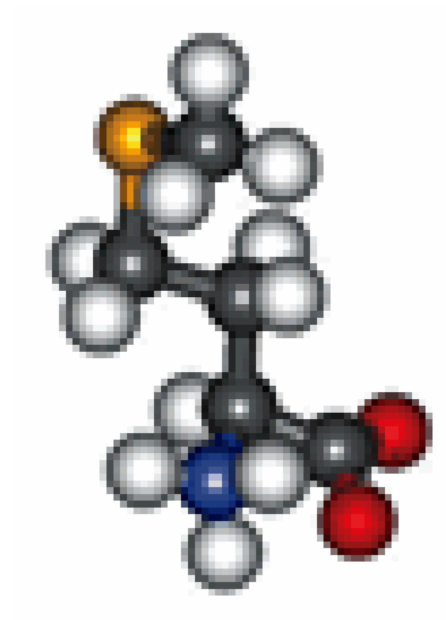


Polymers

Proteins are polymers of amino acids.



(S)-glutamic acid



(S)-methionine

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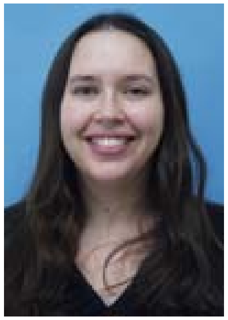
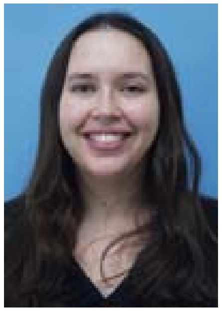


Where can you start if you need background information on a topic you need to teach?

Search for topics of interest using the *JCE* Index

http://www.jce.divched.org/

http://nsdl.org



To teach students about the importance of hydrophobicity in protein folding, I need to understand it

Information • Textbooks • Media • Resources

The Real Reason Why Oil and Water Don't Mix

Todd P. Silverstein*
Chemistry Department, Willamette University, Salem, OR 97301

Background

Most introductory chemistry textbooks include in their discussion of solubility and miscibility the famous rule of thumb, "like dissolves like". The converse of this rule, that nonpolar solutes are insoluble in polar solvents, is often referred to as the hydrophobic effect. This effect forms the basis for many important chemical phenomena: the cleaning action of soaps and detergents, the influence of surfactants on surface tension, the formation of biological membranes, and the stabilization of protein structure are all based in large part on the hydrophobicity of nonpolar groups. In their explanation of the hydrophobic effect, introductory chemistry textbooks often rely primarily on the concepts of enthalpy and intermolecular forces. Because the solution process is generally discussed after enthalpy, but before entropy or free energy, authors are left with little choice but to emphasize enthalpy over entropy when explaining the thermodynamic basis of "like dissolves like" and the hydrophobic effect.

mechanical analysis of the hydrophobic effect. Somehow the ideas stressed in these papers and many others have been largely overlooked in introductory and organic chemistry textbooks.[1] In this paper I will describe the scope of the problem, present thermodynamic data along with a generally accepted model that explains the hydrophobic effect, and recommend how textbook authors should approach the problem.

Discussion

First consider the discussion of the immiscibility of octane and water quoted above. The choice of octane as solute is fortuitous because dissolving octane in water is, as these authors propose, slightly endothermic. However, this is not the main reason why octane does not spontaneously dissolve in water. In fact, dissolving smaller hydrocarbons such as ethane, propane, butane, and pentane in water is actually an *exothermic* process (see Table 1). Even for hexane,

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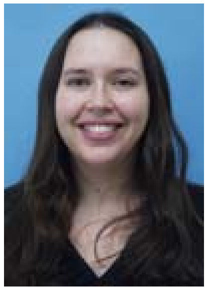
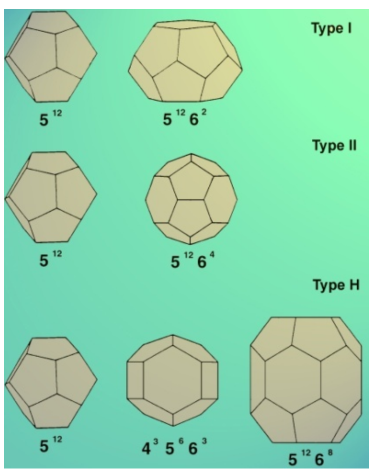
The main reason why hexane does not dissolve in water is

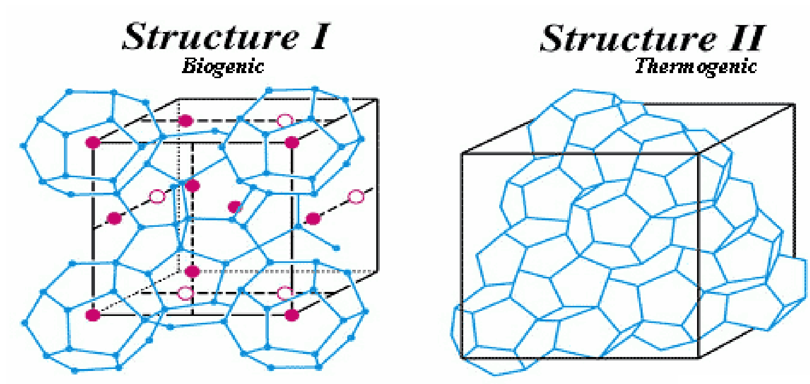
A. The process is endothermic (enthalpy effect is unfavorable)
B. There is no hydrogen bonding between hexane and water
C. There is increased order in the aqueous phase (entropy effect is unfavorable)



Decreased Entropy

- Water molecules form a distorted ice-like structure to surround the non-polar solute.
- Non-polar solute is prohibited from free movement, in a water “cage”.





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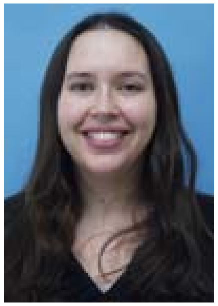

JCE online search turns up more information

In the Laboratory

Synthesis and Self-Assembly of the "Tennis Ball" Dimer and Subsequent Encapsulation of Methane W

An Advanced Organic Chemistry Laboratory Experiment

Fraser Hof, Liam C. Palmer, and Julius Rebek Jr.*
Department of Chemistry and the Skaggs Institute for Chemical Biology, The Scripps Research Institute, La Jolla, CA, 92037-1000; *jrebek@scripps.edu

Research: Science and Education

Advanced Chemistry Classroom and Laboratory

edited by
Joseph J. BelBruno
Dartmouth College
Hanover, NH 03755

Hydrophobic Solvation: Aqueous Methane Solutions

Oliver Konrad
Universität Hamburg, Institut für Physikalische Chemie, Martin-Luther-King Platz 6, D-20146 Hamburg, Germany

Timm Lankau*
Department of Chemistry, Room 303, National Tsing Hua University, 101 KuangFu Road Sec. 2, Hsinchu 300, Taiwan;

In the Laboratory

Gas Clathrate Hydrates Experiment for High School Projects and Undergraduate Laboratories W

Melissa R. Prado, Annie Pham, Robert E. Ferazzi, Kimberly Edwards, and Kenneth C. Janda*
Department of Chemistry, University of California, Irvine, Irvine, CA 92697; *kcjanda@uci.edu

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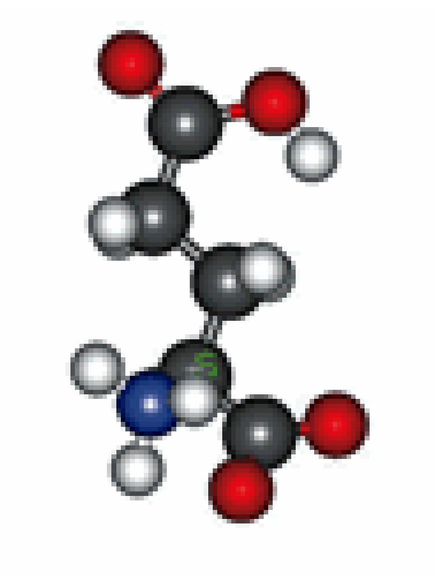
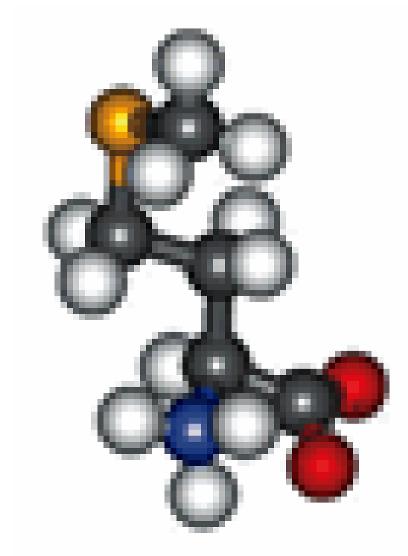
Which amino acid side chain will be more soluble in water? Stamp your answer

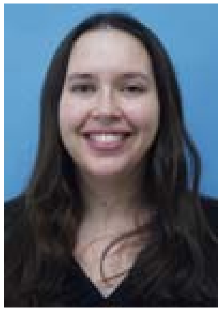




Gray=Carbon White=Hydrogen

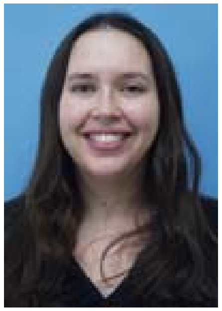
Red=Oxygen Yellow=Sulfur

Blue=Nitrogen



Featured Molecules

- Molecules can be manipulated.
- Students can get a sense of their three-dimensional structures.
- Crystal structure of α-(1→3)-galactosyltransferase (GTB)



Protein Folding

- Aqueous Solution
- Hydrophobic/non-polar side chains will fold away from the water.
- Hydrophilic/polar side chains will fold to be near the water.

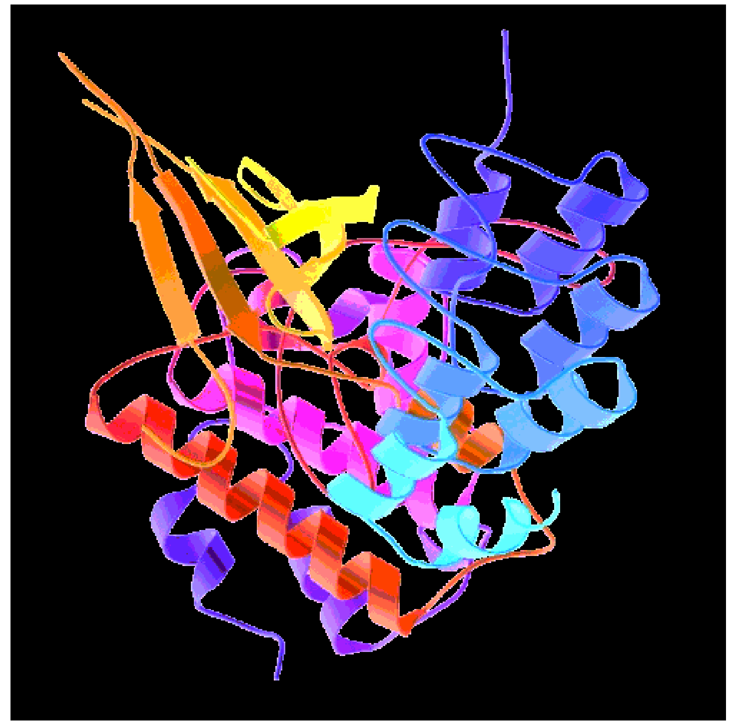
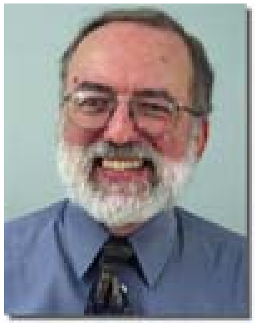


Image Credit: Peng laboratory
http://folding.uchc.edu/Research.htm

If you placed an unfolded protein in hexane, what would you expect to happen?

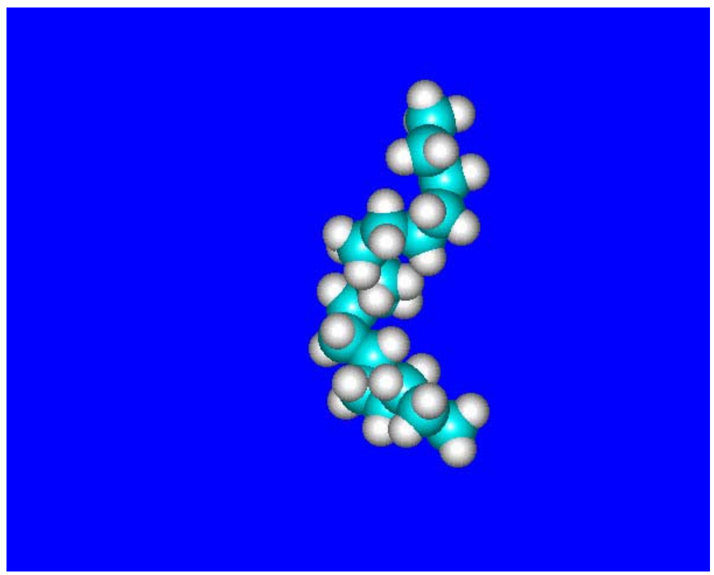
A. It would fold the normal way.
B. It would not fold at all.
C. It would fold in a different way—with more hydrophilic/polar side chains in the center of the structure and more hydrophobic/non-polar side chains on the outside.



How can I help my students understand protein folding?

Chemistry Comes Alive videos

– Alkanes in Motion video



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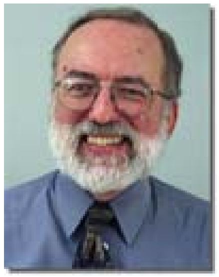
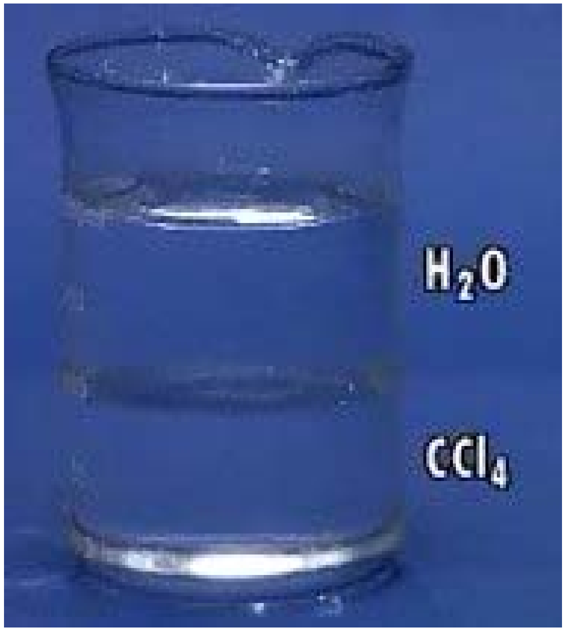
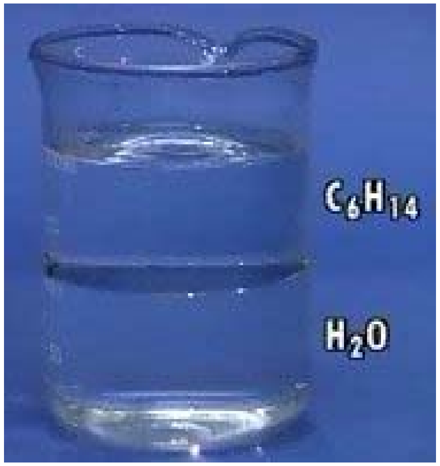


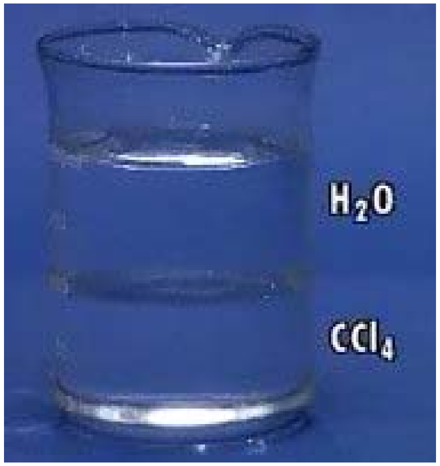
Multimedia problems

- Your students can work their way through problems designed to educate.
- Floating Squares problem teaches students about polarity.
- Floating squares video



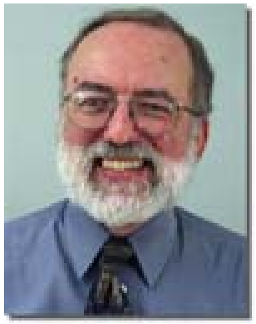
What do these two pictures suggest about the densities of the three liquids?





Which liquid has the highest density?
Stamp your answer

Water	CCl_4	C_6H_{14}



A hands-on option in the *JCE*

Classroom activities

- Colorful lather printing
- Magic sand (hydrophobic sand)

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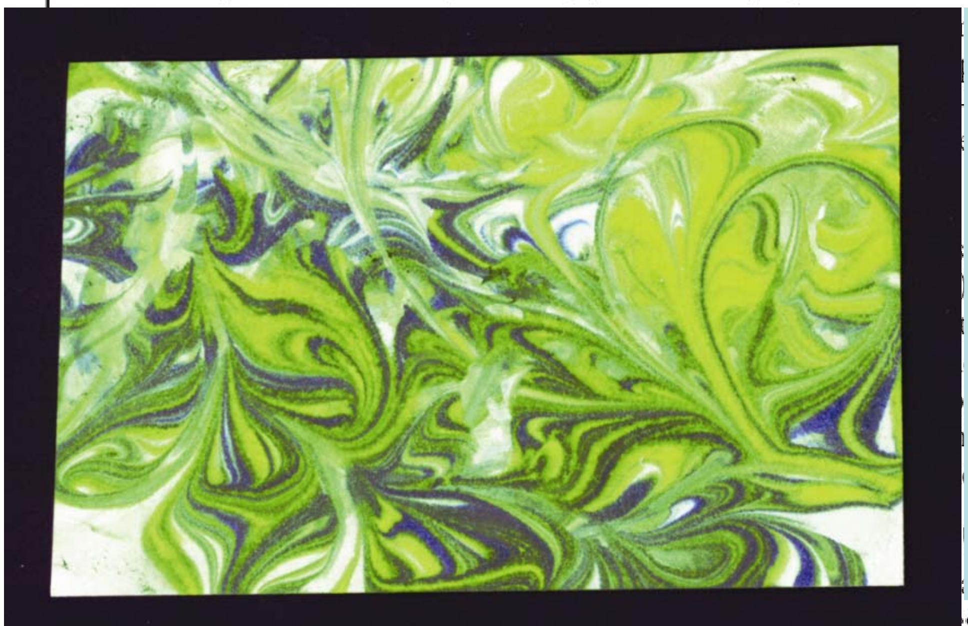
Colorful Lather Printing

Susan A. S. Hershberger,* Matt Nance, Arlyne M. Sarquis, and Lynn M. Hogue
Center for Chemistry Education, Miami University, Middletown, OH 45042; *hershbss@muohio.edu*



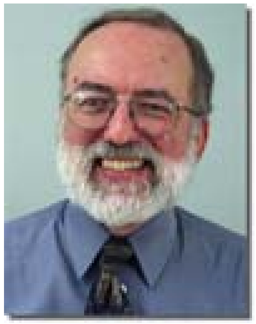
- Use shaving cream and food coloring to create art like this
- Students have fun learning about polarity and hydrophobicity

…s and, in particular, a discussion of foams as colloids. The careers of consumer product chemists *(1)* and the chemistry of other consumer products may also be relevant. Paper marbling is an ancient art, so the Activity can be effectively integrated with art or history lessons.

About the Activity

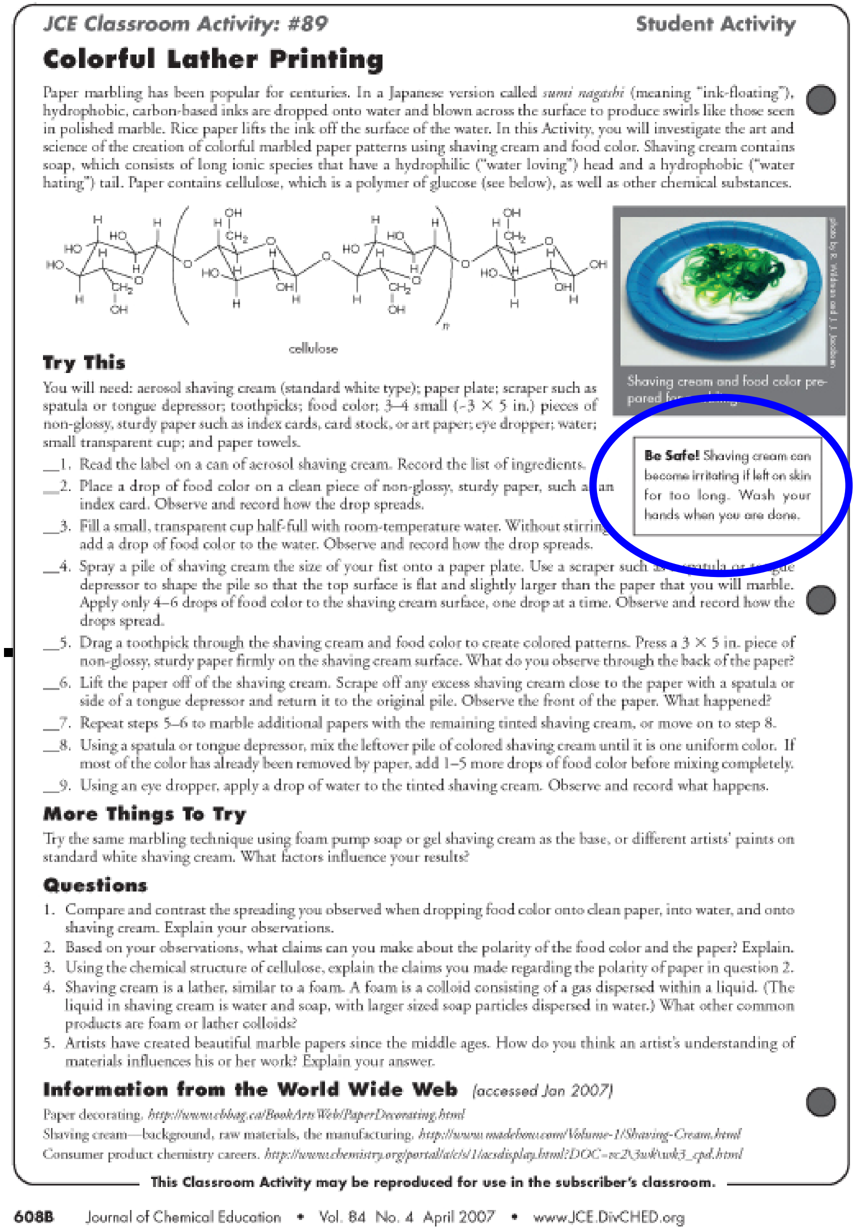
Activities that foster creativity as students learn chemistry concepts are popular among educators who believe that "fun, discovery, and creativity" should be part of the exploration of chemistry *(2)*. In this Activity, students first observe how food color spreads into water, paper, and shaving cream (which contains both polar and nonpolar components) and then observe the affinity that paper (cellulose) has for polar substances.

When a water drop is added to the surface of shaving cream tinted with food color, the color instantaneously disappears in the lather at the point of contact. The effect is similar to the demonstration where black pepper floating on the surface of water immediately spreads when soap or detergent contacts the water. Soaps and other surfactants are



Safety Matters

- All *JCE* classroom activities include safety considerations.
- For this activity shaving cream can irritate skin, so wash it off after use.



JCE Classroom Activity: #89 **Student Activity**

Colorful Lather Printing

Paper marbling has been popular for centuries. In a Japanese version called *sumi nagashi* (meaning "ink-floating"), hydrophobic, carbon-based inks are dropped onto water and blown across the surface to produce swirls like those seen in polished marble. Rice paper lifts the ink off the surface of the water. In this Activity, you will investigate the art and science of the creation of colorful marbled paper patterns using shaving cream and food color. Shaving cream contains soap, which consists of long ionic species that have a hydrophilic ("water loving") head and a hydrophobic ("water hating") tail. Paper contains cellulose, which is a polymer of glucose (see below), as well as other chemical substances.

cellulose

Shaving cream and food color pre-pared for marbling.

Try This

You will need: aerosol shaving cream (standard white type); paper plate; scraper such as spatula or tongue depressor; toothpicks; food color; 3–4 small (~3 × 5 in.) pieces of non-glossy, sturdy paper such as index cards, card stock, or art paper; eye dropper; water; small transparent cup; and paper towels.

Be Safe! Shaving cream can become irritating if left on skin for too long. Wash your hands when you are done.

__1. Read the label on a can of aerosol shaving cream. Record the list of ingredients.
__2. Place a drop of food color on a clean piece of non-glossy, sturdy paper, such as an index card. Observe and record how the drop spreads.
__3. Fill a small, transparent cup half-full with room-temperature water. Without stirring, add a drop of food color to the water. Observe and record how the drop spreads.
__4. Spray a pile of shaving cream the size of your fist onto a paper plate. Use a scraper such as a spatula or tongue depressor to shape the pile so that the top surface is flat and slightly larger than the paper that you will marble. Apply only 4–6 drops of food color to the shaving cream surface, one drop at a time. Observe and record how the drops spread.
__5. Drag a toothpick through the shaving cream and food color to create colored patterns. Press a 3 × 5 in. piece of non-glossy, sturdy paper firmly on the shaving cream surface. What do you observe through the back of the paper?
__6. Lift the paper off of the shaving cream. Scrape off any excess shaving cream close to the paper with a spatula or side of a tongue depressor and return it to the original pile. Observe the front of the paper. What happened?
__7. Repeat steps 5–6 to marble additional papers with the remaining tinted shaving cream, or move on to step 8.
__8. Using a spatula or tongue depressor, mix the leftover pile of colored shaving cream until it is one uniform color. If most of the color has already been removed by paper, add 1–5 more drops of food color before mixing completely.
__9. Using an eye dropper, apply a drop of water to the tinted shaving cream. Observe and record what happens.

More Things To Try

Try the same marbling technique using foam pump soap or gel shaving cream as the base, or different artists' paints on standard white shaving cream. What factors influence your results?

Questions

1. Compare and contrast the spreading you observed when dropping food color onto clean paper, into water, and onto shaving cream. Explain your observations.
2. Based on your observations, what claims can you make about the polarity of the food color and the paper? Explain.
3. Using the chemical structure of cellulose, explain the claims you made regarding the polarity of paper in question 2.
4. Shaving cream is a lather, similar to a foam. A foam is a colloid consisting of a gas dispersed within a liquid. (The liquid in shaving cream is water and soap, with larger sized soap particles dispersed in water.) What other common products are foam or lather colloids?
5. Artists have created beautiful marble papers since the middle ages. How do you think an artist's understanding of materials influences his or her work? Explain your answer.

Information from the World Wide Web *(accessed Jan 2007)*

Paper decorating. *http://www.cbbag.ca/BookArtsWeb/PaperDecorating.html*
Shaving cream—background, raw materials, the manufacturing. *http://www.madehow.com/Volume-1/Shaving-Cream.html*
Consumer product chemistry careers. *http://www.chemistry.org/portal/a/c/s/1/acsdisplay.html?DOC=vc2\3wk\wk3_cpd.html*

Colorful Lather Printing

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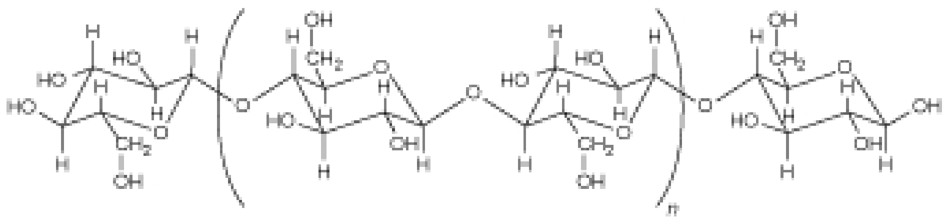
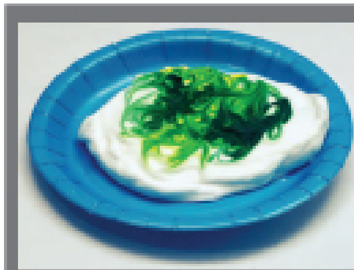


cellulose



Shaving cream and food color prepared for marbling.

Try This

You will need: aerosol shaving cream (standard white type); paper plate; scraper such as spatula or tongue depressor; toothpicks; food color; 3–4 small (~3 × 5 in.) pieces of non-glossy, sturdy paper such as index cards, card stock, or art paper; eye dropper; water; small transparent cup; and paper towels.

Be Safe! Shaving cream can become irritating if left on skin [redacted]

__1. Read the label on a can of aerosol shaving cream. Record the list of ingredients.

[redacted]

__4. Spray a pile of shaving cream the size of your fist onto a paper plate. Use a scraper such as a spatula or tongue depressor to shape the pile so that the top surface is flat and slightly larger than the paper that you will marble. Apply only 4–6 drops of food color to the shaving cream surface, one drop at a time. Observe and record how the drops spread.

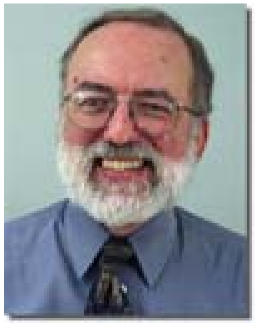
__5. Drag a toothpick through the shaving cream and food color to create colored patterns. Press a 3 × 5 in. piece of non-glossy, sturdy paper firmly on the shaving cream surface. What do you observe through the back of the paper?

__6. Lift the paper off of the shaving cream. Scrape off any excess shaving cream close to the paper with a spatula or side of a tongue depressor and return it to the original pile. Observe the front of the paper. What happened?

[redacted]

__8. Using a spatula or tongue depressor, mix the leftover pile of colored shaving cream until it is one uniform color. If most of the color has already been removed by paper, add 1–5 more drops of food color before mixing completely.

__9. Using an eye dropper, apply a drop of water to the tinted shaving cream. Observe and record what happens.



Does the paper contain polar substances?
Stamp your answer

Yes	No

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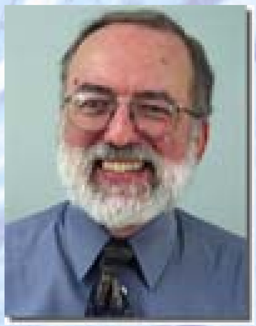
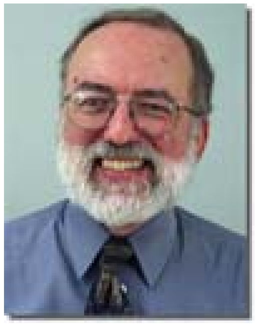


More about the activity

- The Colorful Lather Printing activity allows students to draw their own conclusions.
- They start by experimenting with water and food color and end up experimenting with water and lather.



Magic Sand

- Unlike regular sand, Magic Sand is hydrophobic.
- The Magic Sand classroom activity guides students through a hands-on exploration of this fascinating material.

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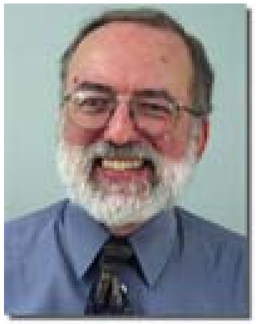
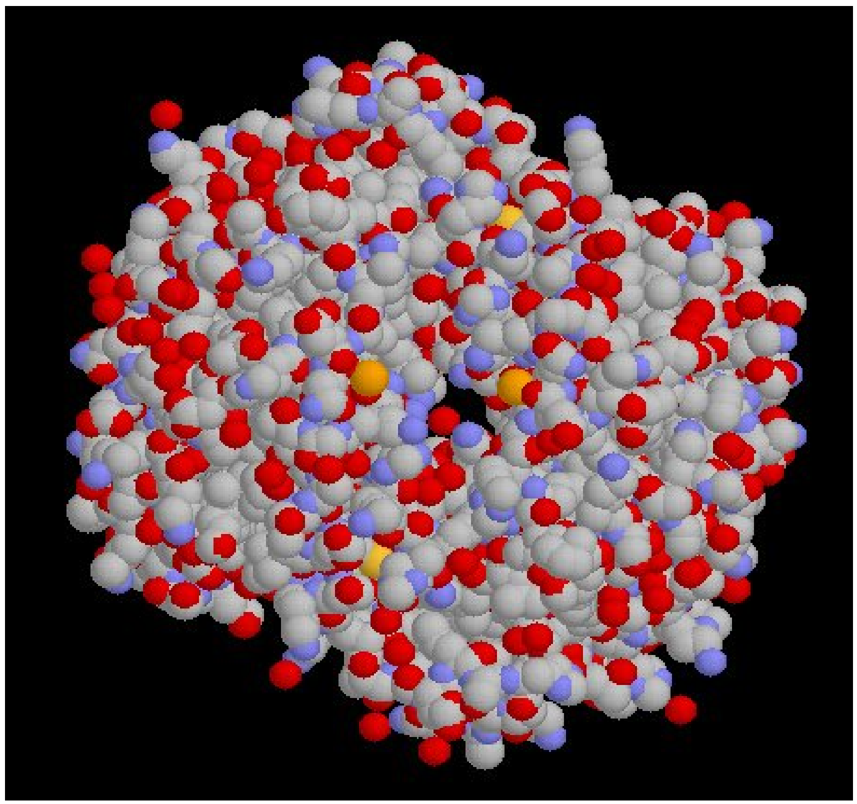


A useful tutorial (not yet part of the library)

Biomolecules Tutorial



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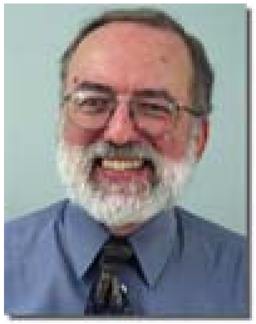
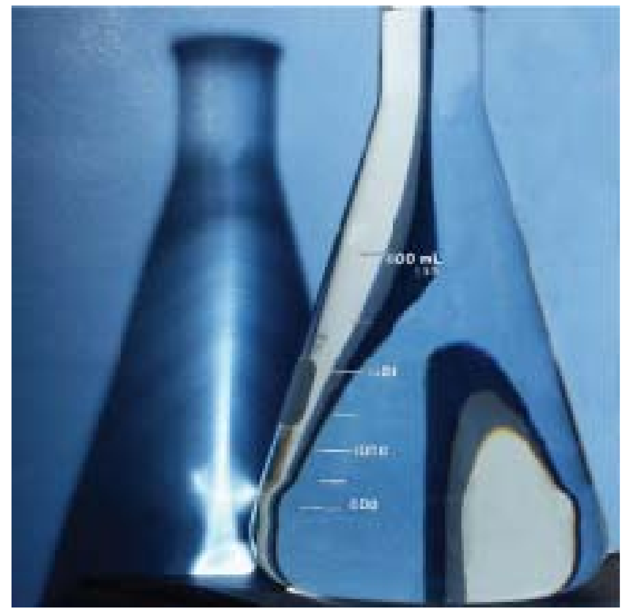
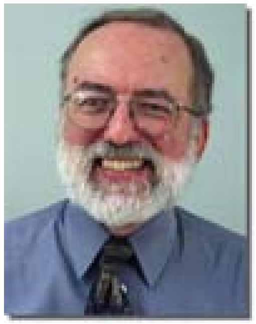


Chemical Education Digital Library (ChemEd DL)…

is starting with resources from the *JCE* DLib, building on resources from the ACS Education Division and ChemCollective project, and will grow from there.





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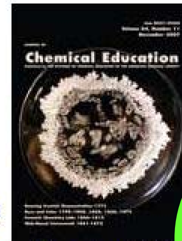

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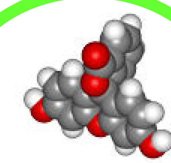
Featured Molecules
Molecular Models of Dyes



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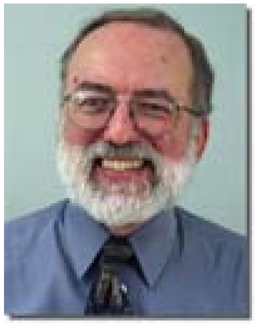

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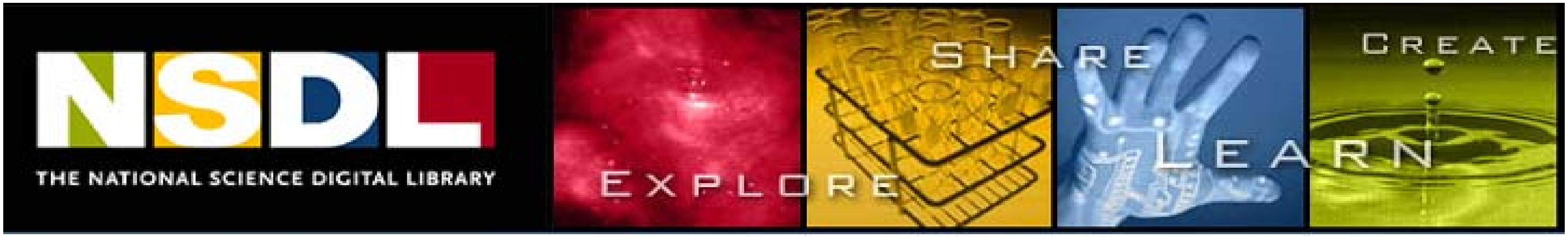

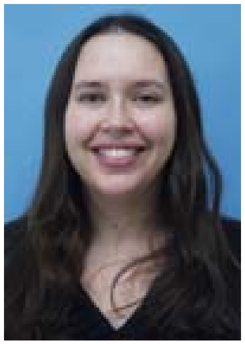

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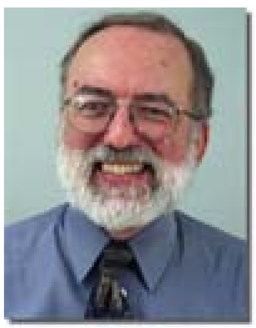

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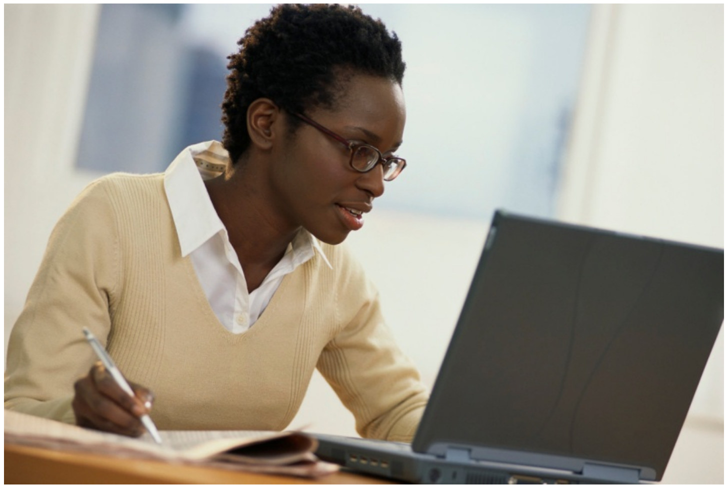

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