Kitchen Science

*Visit **www.homebaking.org** for glossary, lessons, power points, and more!*

Find Out:

- Apply scientific procedures and principles that effect food preparation in using the kitchen as a laboratory.
- Hypothesize, experiment and measure how varying temperatures, preparation method, equipment and ingredients affects outcome.

Purpose:

- Students will work together to develop a procedure for testing a question and hypothesis related to food preparation.
- Scientific terms and methods will be reviewed and applied in a commonplace setting, the kitchen.
- Participants will measure the results of their experiments and prepare written and/or oral presentations.

McRel Standards: Achieve national education standards, www.mcrel.org

Language Arts--Writing-1.11; 4.4; 4.5; 4.6; 4.8
Reading-7.1; 7.4
Listening and Speaking –8.7
Viewing: 9.6

Mathematics—1.1; 1.2; 3.1; 4.1; 4.4; 4.8; 6.4; 6.6; 9.1

Sciences— Life Sciences 6.3; 6.4
Physical sciences 9.7
Nature of Science 12.5; 13.3 and 13.6 (Food Sciences)

Life Work—Behavioral Studies1.5; 2.7; 3.1; 3.3; 3.8

Choose:

- **Leavening:** Measure the effects of temperature, mixture of ingredients and methodology on C02 production in chemical and yeast mixtures and the volume of beaten egg whites used as the leavening in a product.
- **Mixtures, Solutions and Emulsions**: Discover the differences with edible experiments.

Plan:

- Use the following guidelines, ideas and recipes to assist teams in conducting an experiment using common kitchen ingredients and equipment.
- Review the Scientific Method steps outlined in the Leavening section as a guideline for how to plan the experiments.
- Select how you would like the teams to report their results—in writing, orally or in a display.

Do: Great Science Experiments

I. Leavening: Chemical, Fermentation and Physical Methods
II. How Solids and Liquids Mix: Mixtures, Solutions and Emulsions

I. Leavening. Chemical, Fermentation and Physical Methods

Steps for a Great Science Experiment.

Step 1: Get an Idea. This can be hard. Think of something you enjoy and then begin to ask how what sciences are used to make it happen. The kitchen is a great place to start. There is science in any food preparation task. Chemical and physical changes, bacteria and fungus at work—even packaging and sensory preferences are sciences.

In baking, many baked products rely on leavening to "lighten" the end product. Three common types of leavening include: Chemical (baking soda, baking powder, cream of tartar), yeast fermentation and air suspended in the batter through beaten egg whites.

Step 2. Define the problem. What do you want to find out? For example, in baking, you might ask "What is the purpose of using a certain ingredient, method or temperature? "What will happen if…?"

Choose one factor or condition that you will intentionally change *(independent variable)* that will influence the result *(dependant variable).*

For example:	**Independent Variable**	**Dependent variable**
	A. Temperature	Baking powder batter reaction
	B. Yeast in mixtures	Yeast fermentation
	C. Egg white temperature	Volume of beaten egg whites

Your experiment will also need one or more variables called ***controlled variables*** that are not changed throughout the experiment. You must use controls in order to truly know which variable affected the outcome of your experiment. If you vary two factors at once, you will not know which variable had the most effect.

Examples of controlled variables:

A. Baking powder is reacts to produce CO2 gas which lightens or "leavens" many baked goods. Baking powder is "double acting." Half its reaction is due to moistening the batter and causing the acidic agent to react with the alkaline agent. The other half occurs when the batter reaches a certain temperature. To find that temperature, the amount of baking powder and liquid it is mixed with must remain constant and the temperature changed to find when the second reaction will occur.

B. Yeast is a living, microscopic organism—a fungus—that when mixed with water that is not too hot and certain other ingredients will grow in a fermentation process. The fermentation process releases carbon dioxide that will leaven or "raise" a dough or batter. Other ingredients in yeast and water mixtures have an effect on the rate of fermentation. To observe this, you would need to control the amount and type of

yeast used, the temperature at which the experiment is conducted, and the volume of water in the mixtures.

C. Recipes frequently instruct you to have the **egg whites** at room temperature before beating them. What will happen if the egg whites are beaten cold? The mixing tools (bowl, beaters) will need to be at the same temperature, the same volume of egg whites used and the mixing period timed to see what differences occur in volume between refrigerated egg whites and room temperature egg whites.

Step 3: Research

Look up information about your topic and your variables. This information will later be used to write your report. Use at least three different sources including books, magazines, Internet, interviews, encyclopedias. Be sure to write down information for your Bibliography.

For leavening Internet research:

Home Baking Association--www.homebaking.org
American Egg Board—www.aeb.org
Clabber Girl—www.clabbergirl.com
Fleischmann's Yeast-www.breadworld.com
Red Star Yeast Corporation—www.redstaryeast.com
Sarah Phillips, Baker--Baking911.com

Other resources:

A Baker's Dozen Lessons Home Baking Association, 2006. www.homebaking.org
Baking for Success. Home Baking Association. Video/lessons. 1998. www.homebaking.org
Cooking Wizardry for Kids. Margaret Kenda and Phyllis S. Williams. Barron's Educational Series. 1990.
Rising to the Occasion. Fleischmann's Yeast/National 4-H Council. 1999. www.breadworld.com
See for Yourself. More than 100 Experiments for Science Fairs and Projects. Vicki Cobb. 2001. Scholastic Inc.
The Science of Yeast.--www.redstaryeast.com.

TIP: Don't forget to check the Family & Consumer Sciences classroom!
Refer to Chapter 14—"Leavening Agents and Baked Goods" from ***Food Science and You*** by Kay Mehas and Sharon Rodgers.

Step 4: Hypothesis.

The hypothesis is a special kind of prediction that forecasts how one variable will affect a second variable. A hypothesis should be written as an if/then statement.
Example:

A. If a batter containing baking powder is mixed with cool (72 degree F.) ingredients, then it will not loose volume before it can be baked and the end product will have more volume.
B. If active dry yeast is mixed with water and salt then it will not ferment as well as when combined with flour or sugar initially.
C. If egg whites are used directly from the refrigerator then they will not provide as much volume to lighten or leaven a batter.

Step 5: Test and Experiment

- Write a list of materials needed to perform the experiment.
- Write your procedure—a list of numbered, detailed directions that tells
- every step of your experiment. Another person should be able to pick up your written procedure and perform the same experiment without your assistance.
- Prepare a chart or grid to note your observations and collect data. Your
- data should be expressed as ***quantitative*** data—numerical values. This will allow you to graph your results.
- Note ***qualitative*** observations too! These are what the investigator experiences with their senses while observing.

For example:

A. Note temperature of ingredients (use a probe food thermometer available at most stores that sell kitchen equipment) in degrees F.
B. Note the temperatures: of refrigerated ingredients, room temperature and liquids used in mixtures, such as with yeast.
C. Measure ingredients on a scale or liquids in milliliters so each mixture contains the same amount of ingredients.
D. Measure the height of a batter, mixture or finished product in centimeters using a grease-free stick or probe measure.
E. Time all mixing procedures in seconds, using the same speed on a mixer and same length of time for accurate comparisons.
F. Yeast fermentation may be observed by preparing one package (7 gm/1/4 oz.) active dry yeast with one cup 105 degree F. water in one of three or four clean, 16 oz. soft drink bottles. A funnel may help you add the ingredients the variable ingredients.
   Add one teaspoon of an independent variable (salt, sugar, flour, oil) in each bottle containing the water and yeast mixture. Mix.
   Attach one balloon (use the same size on each bottle), securing with a small rubber band at the bottle neck. Label each bottle according to its contents.
   Record the time of each observation—maybe every 10 minutes for one to two hours.

Step 6: Organize Data and Make Conclusions

- Record your results in full—make charts, graphs, and diagrams, using a computer or graph paper.
- Label and title all charts, graphs and diagrams for interpretive ease.
- Analyze the results and form a conclusion.
- Tell whether your conclusion supported your hypothesis.

Step 7: Write your report.
Use paragraph form and the six traits of good writing:

- Tell what you wanted to accomplish (problem, variables and hypothesis)
- How you did it (procedure—all steps of the scientific method)
- What you discovered (project results and research)
- Acknowledgements and bibliography

Step 8: Visual Display.
A visual display is summary of your project. Use eye-catching colors, words, graphs and pictures, but not too cluttered. It's the scientific content that's important.

For example: **Left Panel**	**Center Panel**	**Right Panel**
Problem	Title	Results
Hypothesis	Illustrations/Photos	Conclusions
Variables	Graphs/Charts	Acknowledgements
Procedure		

Standard Recipe for Leavening Experiment A and C

Ann's Butter Cake recipe will work well in either the baking powder or egg white experiments.
Be sure… the mixing bowl and ingredients are the same temperature for both halves.
… to mix at the same speed and for the same amount of time for each half.

Ann's Yellow Butter Cake
1 cup margarine or butter
2 cups sugar
3 cups all-purpose flour, sifted
4 teaspoons baking powder
4 eggs, separated
1 teaspoon vanilla
1 cup milk

1. In a large mixing bowl, cream butter. Add sugar and blend until fluffy. In a separate bowl, sift flour together with baking powder; set aside.
2. Separate egg yolks from egg whites in two separate bowls. Add egg yolks to butter mixture, then add vanilla. Alternately add milk with sifted flour mixture. Mix until batter is smooth. Beat egg whites until they are stiff; fold into batter.
3. Pour into three greased and floured two, 9-inch X 1 ½ -inch pans. Bake at 350 degrees F for approximately 30 minutes (start checking the cake at 20 to 25 minutes; do not over bake).

Source: The Clabber Girl Recipe Book, "RECIPES TO WARM THE HEART"—www.clabbergirl.com

Example A. For baking powder leavening experiment:
Divide Ann's Yellow Butter Cake recipe in half.

- Make one half of the recipe using room temperature (72 degrees F) milk.
- Make second half of batter using hot (180 degrees F) milk.
- Measure batter temperature and volume of each half before baking.
- After baking, measure and note differences in volume, texture etc.

Example C. For egg-white leavening experiment:

Option 1: Divide Ann's Yellow Butter Cake recipe in half.

- Make one half the batters with egg whites that are at room temperature before beating. Measure the volume of the beaten egg whites before folding into
- the cake.
- For second half, use cold egg whites. Measure volume of beaten egg whites.
- Measure the height of each baked cake. Note any other differences between the two.

Option 2: Conduct a similar test with

Individual Strawberry Meringues Makes 20 meringues

3 egg whites, room temperature
1/4 cup strawberries, frozen
1/2 cup white sugar
1/4 cup premium shredded coconut
1/4 teaspoon almond extract

1. Preheat oven to 325°F. Cover cookie sheet with parchment paper. In medium size bowl, beat egg whites until stiff peaks form. Use food processor to shred frozen strawberries or cut into small pieces. Quickly fold shredded strawberries and remaining ingredients into egg whites. With a tablespoon, drop on to cookie sheet.
2. Bake for 10-15 minutes or just until meringues begin to brown on top. Turn oven off and leave meringues in oven for several hours or overnight to dry out. Serve alone or with fresh strawberries**.**

More on meringues and leavening with eggs the American Egg Board, www.aeb.org

II. Liquids and Solids in Mixtures, Solutions and Emulsions.

Explore how liquid and solid ingredients mix—or will not mix—together.

Terms:

Mixtures: Two or more substances that have been combined. The substances are ***not*** chemically attached as they are in a compound. The substances keep some of their physical properties. They are different from solutions in part because they do not last—they will separate slowly.

- **Heterogeneous mixture**: The individual substances can be recognized by sight. The mixture is not uniform in makeup—for example, an oil and vinegar salad dressing. Other mixtures include egg salad, pizza, soups.

Example to try:

Orange Vinaigrette Makes about 1/2 cup.

5 tablespoons rice or red wine vinegar
2 tablespoons frozen orange juice concentrate
1 tablespoon sunflower or vegetable oil
1 teaspoon dried oregano, crushed
1/8 teaspoon salt

Combine all ingredients and mix well. May be made 2-3 days ahead, keep refrigerated. Shake before serving over greens—especially good on spinach salad!

Source: National Sunflower Association—www.sunflowernsa.com

- A **suspension** is a mixture that will separate very slowly. Suspensions are very important in cooking and baking. A suspension may be mixed for a long time (creaming sugar and butter for cookies; flour and water for bread) or making nuts into nut butter. The long mixing time helps keeps the ingredients in suspension.

  If heated (flour and milk heated to thicken pudding or sauce), or baked (dough or

batter) the suspension becomes thicker or even solid.

Examples to try:

Homemade Nut Butter--is a mixture in suspension. It can be made from almost any nut or oil seed such as roasted sunflower kernels and soy nuts. Long mixing helps it stay in suspension to spread—over time it will separate.

Instructions: Using a food processor, grind 1 to 2 cups nuts (peanuts, cashews, walnuts, roasted sunflower kernels, pecans, almonds), for one to 3 or 4 minutes. The more oil there is in a nut, the smoother the butter will be. Some nuts will make a somewhat grainy butter. 1 cup nuts makes about ½ cup butter. Store in a sealed container in the refrigerator. Warm to spread.

Option: Toast the nuts before processing: Spread on baking sheet; bake at 400 degrees F. 5 minutes.

Pot O' Gold Cheese Sauce Makes about 1 ¼ cups

2 tablespoons butter or margarine
2 tablespoons all purpose flour
¼ teaspoon salt
1 cup milk
1 cup shredded Cheddar cheese

1. Melt the butter in a 1-quart saucepan over low heat. Stir in flour and salt. Cook over medium heat, stirring all the time, until smooth and bubbly. Take from heat.
2. Stir milk into flour mixture. Heat to boiling, stirring all the time. Boil 1 minute, stirring all the time. Stir in cheese until it is melted. Serve over tortilla chips, veggies or as a dip for bread sticks.

Source: Gold Medal Flour—www.bettycrocker.com

Cherry-Crowned Cocoa Pudding Makes 6 servings

1 cup sugar
1/2 cup cocoa
1/3 cup all-purpose biscuit baking mix
2 cups milk
1 cup water
Canned cherry pie filling, chilled

1. Stir together sugar, cocoa and baking mix in medium saucepan. Stir in milk. Cook over medium heat, stirring constantly, until mixture comes to full boil; remove from heat.
2. Pour into dessert dishes. Press plastic wrap directly onto surface. Refrigerate several hours or until set. Garnish with cherry pie filling. (Source: Hershey Foods)

More chocolate science at Chocolate Manufacturers Association www.chocolateusa.org

- A **solution** is a **homogeneous mixture** when one substance is dissolved in another. It is not the same as a mixture because it is the same in every part when a sample is taken. Salt mixed with water or a syrup of sugar and water are examples.

Example to try:

Stir ½ teaspoon salt into ½ cup warm water until the salt disappears. The salt is no longer visible, but can be tasted. The salt has not changed chemically—its molecules have just disappeared into the water. If you boil the water to evaporate it, the salt will reappear.

More on salt science: www.mortonsalt.com

A **supersaturated solution** forms when you heat a liquid, increasing its ability to dissolve a solid substance. Boiling water will hold much more salt—or sugar—than cold water. When the solution cools, it will still remain in solution—a supersaturated solution. It is an unstable solution—hard shaking, adding more crystals or letting the solvent (water) evaporate will cause extra crystals to settle out.

Examples to try:

Maple Syrup

1 ¾ cup white sugar
¼ cup brown sugar
1 cup water
½ teaspoon vanilla extract
½ teaspoon maple flavoring

1. In a saucepan, combine the sugars and water. Bring to a boil and boil 1 minute. Cool slightly. Add the flavorings.
2. Cover the saucepan for a few minutes while syrup cools to help prevent syrup from forming crystals later in storage.

Rock Candy: Prepare the Maple Syrup without the flavorings and stir in ***2 cups MORE white sugar***, stirring and heating until it dissolves. If desired, put a few drops of food coloring into the solution. Skip step 2.
To observe and form Rock Candy Crystals: Suspend a clean white string, weighted at one end with a heavy metal washer in the center of a clean one-quart wide-mouth canning jar. Wrap the string around a pencil or piece of dowel rod and place it across the mouth of the jar. Roll the string around the pencil so that the metal weight is almost touching the bottom of the jar. Pour the sugar syrup solution into the jar. Crystals will begin to form in 1 hour and continue for several days. If a layer forms on the surface of the mixture, break it so evaporation may continue. Enjoy the simplest of all candy!
Source: Home Baking Association—www.homebaking.org/
Super Sugar Science at The Sugar Association www.sugar.org

- An **emulsion** is a suspension of a liquid within another liquid. The ***emulsifier*** is the ingredient that holds them in suspension. An egg yolk or silken tofu will both hold oil and vinegar in suspension because they contain the emulsifier lecithin. An example is mayonnaise or salad dressing.

Example to try:

Caesar Salad Dressing Makes 1 cups

½ cup vegetable oil
4 oz. firm silken tofu*
1 tablespoons white or rice vinegar
1 tablespoon lemon juice
2 teaspoons Dijon mustard
1 teaspoon lemon pepper
1/8 teaspoon salt or Worcestershire sauce

1. In a food processor or blender whirl the tofu, vinegar, lemon juice, mustard, sugar and salt until well combined.
2. Drizzle in the oil while blending until smooth. Store in a sealed container in the refrigerator.

*Silken tofu is widely available in supermarket produce aisles.
Nutrient information: 1 tablespoon (15 g) provides: (similar to light mayo)

Calories	54	Fiber	0 g	Protein	0.4g	Sodium	30 mg	Total fat	6 g	Potassium	6 mg
Sat. fat	1 g	Carbohydrate	0 g	Cholesterol	0 mg						

Other resources:

A Baker's Dozen Lessons for Better Baking. DVD format 2006. www.homebaking.org
Baking for Success. www.homebaking.org (Focaccia, brownies and corn bread history/science)
Baking 9-1-1. Sarah Phillips. 2003. www.baking911.com
Cooking Wizardry for Kids. Margaret Kenda and Phyllis S. Williams. Barron's Ed. Series. 1990.
Rising to the Occasion. Fleischmann's Yeast/National 4-H Council. 1999. www.breadworld.com
See for Yourself. More than 100 Experiments for Science Fairs and Projects. Vicki Cobb. 2001. Scholastic Inc.
The Science of Yeast.--www.redstaryeast.com
What Einstein Told His Cook. Robert L. Wolke. 2002. W.W. Norton & Co. New York www.wwnorton.com