From the Kitchen to the Classroom….
Ideas and Lessons for the Science Teacher.
By John B. Snodgrass

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Overview:

In many ways the kitchen can be considered the chemistry laboratory of the home. Within its confines many complex chemical reactions occur on a daily basis such as the denaturing of proteins, the conversion of starch to sugar, and the incorporation of that sugar into favorite recipes. The results of these experiments are eagerly awaited and judgment is passed rivaling the grading scale of the toughest chemistry teacher. Because the kitchen is familiar to all students, it may prove useful for the science teacher to use it as a resource to provide interesting, informative, and rigorous activities for his or her students. If the teacher is convinced that hands-on science activities have educational value, the kitchen also might be the place to look because of the plethora of products and possibilities contained within its confines. I am convinced that educational experiences for all ages, including middle school students can be developed using kitchen science.

Rational

In my capacity as a science teacher for gifted students in the Pittsburgh Public Schools, I have many occasions to employ hands-on science activities in my classes. The Pittsburgh Middle Gifted Center, where I work, serves upwards of 50 public, private and parochial students within the city of Pittsburgh. Any one student visits the center once a week for four one-hour sessions in a variety of subjects. It is my charge to provide an educational experience for my 7th and 8th grade students that is unique, enriching, and beyond what they study at their home schools. With that in mind, the lessons below are written for use in my science classes and are, in my opinion, informative, rigorous, and unique. They are also written for sharing with fellow, interested teachers.

Using the kitchen is a familiar reference point; the inquiring science teacher will find much information that is relevant and valuable in motivating students. In the narrative that follows many hands-on science activities are presented that have a kitchen connection. In the first section, for example, teachers can find activities centered on corn. Corn is an important grain and in its many guises can be used to provide interesting activities and exercises for interested students. Popcorn, corn oil, cornstarch, corn syrup, and corn flakes are explored and a brief history of corn and popcorn is provided. In addition to corn, there is a section on acid-base indicators. Ph and pOH are examined and a table of indicators from strong acid to strong base is furnished, as well as an activity in which students can make their own universal indicator using red cabbage. Water is indispensable to the cook and some of its unique features are explored. Who doesn’t like ice cream? Techniques in making ice cream are given and students will have an activity in which they can make their own ice cream. Polymers are briefly discussed and students can try their hands at exploring sodium polyacrylate and creating guar gum slime. There is also a section in which questions are presented for interesting classroom discussion.

Objectives:

Students will participate in the presented activities, demonstrations and discussions of kitchen science. Explanations and activities as presented are intended for 7th and 8th grade students. An annotated reading list for teachers and students is provided, as are the science standards adopted by the Pittsburgh Public Schools in the Appendix. The standards that apply in each activity are also listed by their respective numbers. This paper is written to be teacher-friendly. With this in mind, I have organized the material in an ersatz cookbook. Demonstrations that serve a motivational function are termed appetizers or desserts and more involved activities or lab exercises are listed under main courses. A demonstration usually takes from 10 to 15 minutes of a class period and lab exercises about one class period (one hour). If the reader can gain any use from these contents, please avail of any part or parts thereof.

Strategies:

Many of the topics discussed below include their history, explanations of the chemistry underlying the reactions, specific materials needed by teachers and students, and insights gained by performing of the experiments and demonstrations. Whether hands-on activities, demonstrations, or discussion, the topics have been carefully chosen to interest and meet the science needs of middle school students.

Classroom Activities:

All about Corn

Corn or maize is native to the American continent. Paleobotanical and archeological findings indicate that wild corn not much different in botanical properties with modern corn existed in Southern Mexico about 5000 years ago. Corn was a staple grain for Native Americans for many centuries prior to arrival of European explorers. Corn in the popcorn form is a familiar kitchen snack that holds a wealth of potential for the interested teacher. It has a colorful, long history and valid educational value. Popcorn has been known and used by humans for thousands of years. It probably originated in Mexico as evidenced by multiple thousands- year-old pollen found 200 feet below Mexico City, which is indistinguishable from modern corn pollen. At about 5600 years old, small ears of popcorn found in Bat Cave New Mexico in 1948 and 1950, represent the oldest popcorn ears discovered. Grains of popcorn that still pop have been found in tombs on the east coast of Peru. These grains are estimated to be about 1000 years old. A maize god is represented on a funeral urn found in Mexico dating from about 300 A.D. Ancient popcorn poppers, shallow vessels with a hole on the top and a single handle date from the same time. 800-year-old kernels of popped corn exposed when desert winds blow away sand from ancient burial mounds have also been found. By the time European settlers arrived in the Americas, over 700 types of popcorn were in use by virtually all Native American Tribes. Natives tried to sell popcorn to the crew of Christopher Columbus. Cortez was first introduced to popcorn when he invaded Mexico in 1519. The Aztecs used popcorn for food, ornamentation, and ceremonial headdresses. Early French explorers in the 1600's noted that the Iroquois in the Great Lakes region popped popcorn and even made a popcorn soup. English colonists were given a deerskin bag filled with popcorn at the first Thanksgiving Feast at Plymouth Massachusetts.[1] Popcorn snacks were brought to meetings with English colonists as goodwill tokens. Since that time popcorn has become a familiar favorite among children and adults alike.

Mechanics of corn popping:

When asked why popcorn pops, my 7th and 8th grade students offer various hypotheses. Eventually someone usually volunteers the idea that popcorn pops because of water turning to steam and exploding the hard shell surrounding the kernel. This is certainly part of the story but the exact details of the popcorn pop are not completely understood. The most likely sequence of events that unfold as the oil surrounding the kernel heats is that the starch- protein matrix inside the kernel absorbs water, expands as it cooks, and with the aid of the tremendous pressure developed as water turns to steam, explodes the kernel's shell. When popcorn is popped in the classroom in a beaker, condensed water readily collects on the beaker walls as the popcorn pops. The ideal water content of a viable popcorn kernel ranges from 11 to 14 percent [2]

Popcorn: A Main Course

Ingredients (Materials):

Popping corn, One Hotplate per two students, Stopwatch, Aluminum foil, one 1000 ml beaker per two students, Graph paper, one ruler per student, Cooking oil, Popcorn seasonings (optional)

Classroom Activity using popcorn: (Standards # 1, 5, 6, 9}

I have found that students are likely to respond positively to any activity, which involves popping corn. One easy investigation involves comparing the volume difference between unpopped and popped corn. A more involved investigation allows students to count kernels popped in fifteen second intervals and to make a graph of # of pops versus time. Materials required are one hotplate per two students, a 1000 ml beaker, cooking oil, a timer, aluminum foil, safety goggles, graph paper, lab sheet, and a pencil. The hotplate is turned to a medium heat and the 1000 ml beaker is placed on it. A small amount of cooking oil is added and 2 test kernels. An aluminum foil lid is fashioned for the beaker. Students are instructed to monitor the system until at least one of the kernels pops. At this time about 200 to 250 kernels are dumped in the beaker. I have found that a film can canister holds just the right number of kernels. The foil lid is replaced, the system shaken, and timing begun. Students are instructed to count the number of kernels that pop in fifteen-second time intervals until most kernels pop. Students should be reminded not to try to pop every kernel as this might result in a burnt batch.

Results:

Students can construct a graph with time in seconds on the X-axis and # of pops on the Y-axis. This exercise is valuable because students learn the value of a best-fit line in expressing results. Typically, there will be a scattering of data that is best expressed in a bell curve. A discussion of results can lead to Ludwig Boltzmann's seminal work concerning the behavior of gas molecules in a closed container. Over a century ago Boltzmann solved mathematically a problem that had baffled scientists. In any closed container containing a gas, what is the speed or kinetic energy of any molecule at any given time? Since there are literally trillions of molecules in even the smallest container, to describe the behavior of any one particle is a daunting task indeed. What Boltzmann did to solve the problem was to develop a statistical method which dealt with average kinetic energies of all particles rather than single molecules. In other words in any container a few of the molecules at any give instant are moving slowly (low kinetic energy) a few are moving very fast (high kinetic energy) and most are somewhere in the middle. Popcorn popping follows this pattern. A few pop quickly, a few very slowly, and most somewhere between. In both cases the bell curve applies. Statistical models for many phenomena in our world can be constructed using the bell curve. For example, intelligence, height, weight, and shoe size of large populations of people chosen randomly show a normal or bell-shaped distribution as do any randomly distributed phenomena. As a side note, if student wish to eat the popcorn I will permit it if normal precautions are taken such as making sure that the popping beakers are only used for that purpose and that stringent cleanliness is observed. Other safety considerations include requiring that students wear eye protection and that they exercise care around the hotplates.

More Classroom activities involving corn: Appetizers and Desserts.

Density Gradients using Corn Oil: (Standards # 2, 6)

Ingredients:

Glass containers such as graduated cylinders, Corn oil, various liquids of varying density such as acetone, alcohol, corn syrup, water, etc.

Classroom Activity:

Just as corn has other uses in the kitchen besides popping, so too there are other uses in the classroom. Corn oil can be used in investigations on density. Since it has a density less than water, that is a density less that one, it can be used in a density gradient. Water can be added to a glass graduated cylinder and corn oil can be carefully added next. If done properly, the corn oil will rest on the water surface without mixing. Other liquids with varying densities such as alcohol, and acetone, can be carefully added to the mix. With a little experimentation students can find objects that float in one liquid but sink in a less dense one. These objects can be added one at a time and a density column with various objects floating in it can be created.

A Corn Syrup Dessert: (Standards # 1, 5, 6)

Ingredients:

Corn syrup, light box or source of backlit light, polarized filters

Classroom Activity utilizing corn syrup:

Corn syrup has been produced in large quantities in the United States since the mid 19th century. It is made by breaking down starch molecules, which occur abundantly in corn, into glucose units by acids, fungal, bacterial, or malt enzymes. Glucose or its double-unit entity, maltose, can be produced in any proportion by regulating the degree of breakdown of the glycogen molecules. The more complete the digestion, the sweeter the syrup. The long chains of undigested glycogen give corn syrup its viscosity and help prevent the crystallization of other sugars in baked goods [3]. This makes corn syrup valued in baking products. Corn syrup also has interesting optical properties. If corn syrup (Karo is one type) is placed between polarizing filters, a brilliant display of light is seen as the polarizers are rotated. One way to show this is to place a light source such as a light box behind one large polarized filter. The teacher next to me has a large backlit screen like those used by doctors to examine x-rays that she lets me borrow. Large polarizers are available from science suppliers such as Edmund Scientific. The bottle of Karo syrup is then placed in front of the polarizer. The light is turned on and a second polarizer is placed in front of the syrup and rotated. A complete spectrum of colors is produced. Students may be given individual polarizers if the teacher has enough to do it this way. The teacher can then place one large polarized sheet between the light and the corn syrup and the students can turn their own polarizers.

Three Cornstarch Appetizers: (Standards # 2, 5)

Ingredients:

Cornstarch, transparent plastic cups, water, a round can with a tight-fitting lid, one candle, a thistle tube or funnel, matches

Classroom Activity: A Thixotropic construction-employing cornstarch:

Cornstarch has at least two attributes that make it attractive to the science teacher. One is that because the starch molecule is composed of water-resistant long-chained polymers, it can be mixed with water to produce an interesting substance that interacts with, but does not combine with the added water[4]. The other attribute of cornstarch useful to the science teacher is that it can pose an explosion hazard under the right conditions. To test the first attribute, cornstarch is added to a 400 ml beaker to about the 300 ml level. Water is added slowly and the mixture is stirred until a consistency of thick paint is attained. If the surface is struck sharply with a finger, the surface can't be penetrated. The entire system quivers but resists penetration proportional to the intensity of the strike. When the finger is placed lightly on the surface, it can penetrate into the mixture if light pressure is used. If the finger is withdrawn slowly, very little or none of the mixture sticks to it. The cornstarch-water mixture is classed as thixotropic. That is, the mixture remains a gel when undisturbed but assumes a liquid state when placed under isothermal stress. Paint is a classic example of a thixotropic substance.

Classroom Activity: A Cornstarch Dust Explosion:

Dry cornstarch can also pose an explosion hazard. Grain elevator workers and coal miners across the country are well aware of the explosion hazard of dust. A single kernel of corn or one lump of coal is relatively hard to ignite. If those same lumps are crushed into dust and blown into a confined area, they pose an explosion hazard because of the increased surface area of the combustible material[5]. This can be demonstrated to students by obtaining a metal can with a tight-fitting lid. A thoroughly cleaned paint can possessing a lid will do. Punch several ventilation holes around the bottom of the can and place a funnel with its wide end up and narrow end attached to a rubber hose on the bottom of the can. A hole should be drilled large enough to accommodate the hose, which should lead 2 to 3 feet from the can. A candle with a height approximately equal to the funnel system is also placed in the bottom of the can. One or two tablespoons of cornstarch (teachers can experiment to determine the optimum amount) are spooned into the top of the funnel. The candle is lit and the lid is carefully placed as firmly as possible on the can. Students are more impressed if they realize that the lid is so tight that it can only be removed by prying with a screwdriver. If the ventilation is adequate, the candle should stay lit. The instructor should then step back and blow forcefully into the hose attached to the funnel. Almost immediately the lid is blown several feet into the air by a large fireball generated by the igniting cornstarch. Anyone in a 10 to 15 foot diameter will feel the intense heat generated by the fireball. This is a very popular demonstration that vividly illustrates the effect of surface area on combustion. The demonstration can also be performed with the lid off. Students should be told to watch for the dust cloud formation just before ignition. Safety considerations are obvious as fire is involved. Students must be reminded of the dangers of dust in confined spaces and warned that this is only a teacher demonstration!

A Cornflake Appetizer: (Standards # 2, 3, 5)

Ingredients:

Total cornflakes, one or two magnets from a computer hard drive, one petri dish, water, one clear plastic cup, an overhead projector

Classroom activity with cornflakes:

Most students are familiar with Total cornflakes. This cereal's market claim is that it supplies virtually every daily nutrient and vitamin needed by an adult. This claim includes iron, a nutrient needed for hemoglobin function among other things. What students are often surprised to learn is that the iron is present in its free, elemental form and with a strong magnet can be removed from the cereal. I obtained such a magnet from Flinn Scientific for about 5 dollars. They say that these magnets are salvaged from computer hard disk drives. At any rate, they are strong! I purchased a pair and discovered that when attached to each other, the magnets were virtually impossible to separate by merely pulling on them. Actually, twisting and pulling can separate them. I wrapped them in electrical tape because unwrapped they had the nasty tendency to pinch my fingers and produce painful blisters. The Total demonstration consists of placing 2 or 3 flakes in a petri dish filled ½ to ¾ full of water. If the magnet is brought near to one of the flakes, it will cause the flake to move. With a little practice, a person can move the flakes at will around the petri dish. The petri dish may be placed on an overhead projector and the demonstration can be shown to the entire class. If students still are not convinced that free iron is present, a handful of flakes can be crushed in some water on a clear plastic cup. By running the strong magnet up and down the side of the glass it is possible to separate out a spot of iron from the flakes [6]. As a cautionary note, magnets should not be placed near any magnetic tapes or disks. This includes a wallet that may contain a bank or credit card.

Acid and base Indicators

Indicators are substances that change color in the presence of an acid or a base. They are usually weak acids and often are organic. There are indicators that are specific for acids (tea changes from dark to light when an acid such as lemon is added) and bases (see table below.) The table below is provided so that teachers can select indicators based upon their particular needs. A universal indicator will show color changes through the entire pH range. Red cabbage can provide a close approximation of a universal indicator and will be discussed a little later in the paper.

Acids taste sour and turn blue litmus red. Acids often interact with metals to produce hydrogen gas. A base has a bitter taste and turns red litmus blue, and feels slippery (as in handling a bar of soap). The strength of an acid can be measured to the extent that it produces hydrogen ions or adds a proton to water to produce the hydronium ion (H_3O^+). The value for pH is the negative logarithm of the hydronium ion concentration. The value for pOH or the hydroxyl ion concentration in an aqueous solution is the negative logarithm of the hydroxyl ion concentration. Pure, distilled water which is neither an acid or a base has a pH of 7. When an acid is added, the hydronium ion concentration becomes larger and the pH value becomes less than 7. When a base is added, the hydroxyl ion concentration increases and the pH becomes greater that 7. Strong acids can have a pH of 1 or 2 and a strong base a pH of 12 or higher [7]. The table below is provided to aid the teacher in selecting indicators from strong acids to strong bases. Indicators are available from any number of supply houses including Flinn Scientific, Science Kit and Boreal Laboratories, and Sargeant-Welch.

A Table of Acid-Base Indicators

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ACID-BASE INDICATORS [8]

Indicators	Acid Color	PH Range	Base Color
Methyl Violet	Yellow	0.0 – 1.6	Blue
Malachite Green	Yellow	0.2 – 1.8	Blue-green
Cresol red	Red	1.0 – 2.0	Yellow
Thymol blue	Red	1.2 – 2.8	Yellow
Benzopurpurin 4B	Violet	1.2 – 3.8	Red
Orange IV	Red	1.4 – 2.6	Yellow
Phyloxine B	Colorless	2.1 – 4.1	Pink
2,4-Dinitrophenol	Colorless	2.8 – 4.0	Yellow

Methyl yellow	Red	2.9 – 4.0	Yellow
Bromophenol blue	Yellow	3.0 – 4.6	Blue-violet
Congo red	Blue	3.1 – 4.9	Red
Methyl orange	Red	3.2 – 4.4	Yellow
Bromocresol green	Yellow	4.0 – 5.6	Blue
Alpha-Naphthyl red	Red	4.0 – 5.7	Yellow
Methyl red	Red	4.8 – 6.0	Yellow
Litmus	Red	5.0 – 7.0	Blue
Bromocresol purple	Yellow	5.2 – 6.8	Violet
4-Nitrophenol	Colorless	5.4 – 6.6	Yellow
Bromothymol blue	Yellow	6.0 – 7.6	Blue
Phenol red	Yellow	6.4 – 8.0	Red
Brilliant yellow	Yellow	6.6 – 7.9	Orange
Cresol red	Yellow	7.0 – 8.0	Red
Metacresol purple	Yellow	7.4 – 9.0	Violet
2,6Divanillyldenecyclohexanone	Yellow	7.8 – 9.4	Red
Thymol blue	Yellow	8.0 – 9.6	Blue
Phenolphthalein	Colorless	8.3 – 10.0	Dark pink
Ethyl bis (2,4-dinitrophenyl acetate	Colorless	8.4 – 9.6	Blue
Thymolphthalein	Colorless	9.4 – 10.6	Blue
Alizarin yellow R	Yellow	10.0 – 12.0	Red
Malachite green hydrochloride	Green-blue	10.2 – 12.5	Colorless
Methyl blue	Blue	10.6 – 13.4	Pale violet

Sodium indigosulphonate	Blue	11.4 – 13.0	Yellow
Orange G	Yellow	11.5 – 14.0	Pink
2,4,6-Trinitrotoluene	Colorless	11.7 – 12.8	Orange
1,3,5-Tinitrobenzene	Colorless	12.0 – 14.0	Orange

A Main Course in which RED CABBAGE is used as an Acid-Base Indicator (Standards # 1, 2, 5, 6,7)

Ingredients:

Fresh red cabbage leaves, one blender, water, various household solutions including ginger ale, cola, lemon juice or fresh lemons, vinegar, Milk of Magnesia, baking soda, Windex, dishwashing liquid, Drano, soap, Borax, Spic and Span

Classroom Activity: Red Cabbage Indicator

The leaves of the red cabbage yield a universal indicator that show a color change from strong acid to strong base. Two or three red cabbage leaves yield sufficient indicator for several classes. The indicator is made by placing the leaves in a blender and by adding a cup or two of water. The slurry of water and cabbage leaves can be boiled and filtered to yield a dark-purple liquid. This liquid can be diluted with distilled water. At a pH of 7 (neutral) `the color is light purple. In strong acids such as lemon or grapefruit juice the color is dark red. Weak vinegar turns the indicator orange. A weak base (pH of 8 or 9) turns the indicator green. A strong base turns the indicator yellow. If the instructor has a blender, some distilled water, and a head of red cabbage, an interesting activity can be carried out in the classroom. Small amounts of household products such as ginger ale, cola, lemon juice, vinegar, Milk of Magnesia, Baking soda, Windex, dishwashing liquid, Drano, soap, Borax, Spic and Span, etc. can be tested and students can determine the relative acidic and basic nature of the substances.

An alternative method of preparing red cabbage indicator is to place a red cabbage head chopped into several pieces into a 4 L beaker or large pot. Enough distilled water to cover just ½ of the cabbage is added to the container. Cover the container and heat to boiling. As the water boils, the cabbage can be pressed into the solution. The cabbage should be well cooked and the solution filtered. Buffer solutions of 2, 4, 6, 8, 10, and 12 should be prepared. If one drop of the indicator gives a distinct color change to each of the buffer solutions, it is ready to use. Boiling of the indicator solution will give more intense colors. The solution may be stored in a refrigerator for several weeks. The solution can be frozen for long-term storage.

All about Water:

What About Water? A discussion.

Water is one if not the most important chemicals found in the kitchen and for this reason, students should be made aware of some of its properties. Water is aptly termed the universal solvent because so many materials dissolve in it. This is nowhere more true than in the kitchen. All foods have some water content. Water contains dissolved nutrients, can cook, preserve, and improve the taste of foods, and serve as the substrate in which countless chemical reactions occur. Water is one of the few substances that exist in solid, liquid, and gas stages in a relatively narrow temperature range. In spite of its importance in food preparation, and indeed, life, middle school students often display a remarkable lack of knowledge concerning its properties. I like to ask students the following questions: *If you want to bring a pot of water to the boiling point, which method of heating is the most energy-efficient?* A. Turn the heat as high as possible. B. Turn the heat to some medium value. C. Turn the heat to its lowest setting and bring the water to a gradual boiling point? *Once the water boils, what setting is best in terms of energy expenditure, to keep the water boiling?* A. Keep the heat on its highest setting. B. Use a medium setting. C. Use the lowest heat setting so that the water barely boils [9]. The lab exercise below will make the answers more obvious. Water also shows interesting properties when it freezes. Universally, substances contract as they cool. This makes sense when the kinetic molecular nature of matter is considered. Cooling is marked by a decrease in kinetic energy of molecules in the substance. Less kinetic energy means that the molecules can crowd closer, i.e. the density increases. Water is no different until 4 degrees Celsius is reached. At this temperature a molecular realignment occurs in water that results in the molecules actually occupying more space than at higher temperatures. When ice is formed at the freezing point, the ice is less dense than the water from which it was formed. This means that ice floats instead of sinking. The implications for life on this planet resulting from ice floating are staggering. If ice did not float, deep lakes and oceans would clog with ice that would not melt in summer. Before long, life would be locked in ice and, in all likelihood, would be in extreme danger of extinction. The freezing point of water is also a sliding scale. The ordinary freezing point is zero degrees Celsius. The addition of chemicals such as salt or calcium chloride, or ethylene glycol can depress the freezing point and make ice melt at lower temperatures.

Classroom Activity: A Boiling Curve for Water: A Revealing Main Course. (Standards # 1, 2, 5, 6, 9)

Ingredients: (all quantities are for two students) ***one*** 400 ml beaker, one thermometer, one glass stirring rod, timer, salt, hotplate, graph paper. One blender per class is optional.

Classroom Activity: A Boiling Curve for Water

Much of the discussion on water above can be contained in one rather elegant lab exercise. Materials needed are one 400 ml beaker, one thermometer, one glass stirring rod, a timing device, ice, salt, and a hotplate. A good blender is useful to crush ice into watery slurry. One student described it as an ice slushy. Salt is added to the mixture. Each student team is given approximately 200 ml of the slurry. They record the temperature, which is typically in the minus 3 to 5 degree Celsius range because of the freezing point depression of the salt. The beaker containing the ice slush is then placed on a preheated hotplate. Students are directed to stir vigorously with a stirring rod and record the temperature of the mixture at 30- second intervals. They are also directed to note the point when the slush has completely melted. Stirring can be made more occasional as the water is heated to the boiling point. Temperatures are still recorded every 30 seconds. When the water reaches a rolling boil, students are instructed to note this time by starring it on the data table. Temperatures are recorded for 3 or 4 intervals after boiling begins. Data expression is in the form of a graph with time in seconds on the X-axis and temperature in degrees Celsius on the Y-axis. The graph of the data should have three distinct regions. The first is that region before the ice melts. The curve should be flat to this point. The heat energy poured into the system does not show up as an increase in temperature because the heat energy is being used to break the crystalline ice structure. This zone is termed the **latent heat of fusion**. After the ice melts, the temperature rises exponentially. In reference to the question earlier about how to heat water, it makes sense to pour in as much heat as possible to raise the temperature as fast as possible in light of the exponential rise in temperature. The third graph region occurs when the water reaches a rolling boil. The line once again levels off and the temperature remains constant at about 100 degrees Celsius. This zone is termed the **latent heat of fusion.** The heat energy is being utilized to turn water into water vapor. In light of this it makes sense to turn the heat down to just keep the water boiling because the temperature will remain the same as long as there is enough heat to keep the water boiling (Epstein). In short this is a very instructive lab exercise that is simple in execution but replete with information useful to the science student and to the would-be cook. In a later section, the ability to suppress the freezing point of water will serve well in making and exploring the teaching potential of ice cream.

Water revisited as a solvent and the use of water with soap.

Without question water is an excellent solvent. Washing of dishes and pots and pans would be severely compromised if not impossible without water. Plain water, however, has its limitations. For one thing it does not do a good job on grease or oil. Oil is less dense than water and floats on its surface. It also does not mix with water, instead forming globules that resist mixing. In order to make water more effective in attacking grease and oil, a few things must be known about water. Water contains two elements, hydrogen and oxygen. Two hydrogen atoms combine with one oxygen atom for the formula, H_2O. The hydrogen atoms arrange themselves in such a way that a 105 degree angle is made with the oxygen atom. This arrangement gives the water molecule a polar charge. The hydrogen ends have a slight positive charge and the oxygen center has a slight negative charge. The water molecule, because of this bipolar charge, is attracted to particles of opposite charge. In fact, water molecules also have an attraction for each other; the hydrogen ends being attracted to the oxygen centers. This results in water forming clusters accounting for surface tension and a tendency to disassociate from non-polar molecules such as fats [10]. The secret in attacking fats effectively with water is to make the fat a polar liquid that will attract the water molecules, which will then surround the fat molecules and disperse them. This can be accomplished by using soap.

Soap has been used for thousands of years. The ancient Mesopotamians in the fifth millennium BC probably noticed that ashes from campfires mixed with animal fat had grease- cutting capabilities [11]. Soap is essentially animal fat mixed with a basic substance such as ashes or lye (sodium hydroxide). At the molecular level the positive sodium ion from the base combines with a fatty acid molecule at its negative end. When the soap is mixed with greasy water, the fatty acids orient themselves with their negative ends out and their tails buried in the fatty globules. In the watery environment, the sodium ions dissociate from the fatty acids. This leaves a negative charge on the fatty acid that attract the hydrogen complexes on the water molecules. This is repeated literally billions of times along the fat globules, which results in their being surrounded or emulsified by the water. In this way the fat is broken up in very small units that can be rinsed away down the drain. Dish- washing liquids use synthetic materials that accomplish the same thing as soap. They also contain surfactants that help break the surface tension of water by breaking up the hydrogen-oxygen complexes that water forms. In the industry they refer to this as making water "wetter". The smaller water complexes are then more effective in combining with the vulnerable fatty acid negative ends.

A Water Appetizer: Surface Tension (Standards # 1, 2, 6)

Ingredients:

One plastic container per two students, toothpicks, paperclips, and dishwashing liquid

Water’s surface tension can easily be shown by filling a container with water and by floating a paper clip on its surface. I use a plastic container that holds about three liters. A toothpick is dipped in dishwashing liquid and a small portion of dishwashing liquid is introduced into the tank by touching the surface with the detergent end of the toothpick. The paperclip will immediately sink because the surface tension of the water has been destroyed by the surfactants of the detergent. Until the water is changed in the tank, no more paperclips can be floated. One student claimed that he had caused several water striders (these are small spider-like creatures) on a quiet part of a stream to sink using this technique. I have seen these small insects in streams many times. They do rely on surface tension to stay afloat and if one looks closely, the indentations that their little legs make on the water surface can be seen. What the student says makes a certain amount of sense, but I have never tried it myself.

Classroom Discussion: Ice Cream

Ice cream is the dessert of choice of many people as implied in the statistic that the average American eats 15 quarts of ice cream every year. The making of this popular dessert can be accomplished relatively easily in the science classroom and in examining the process; students can incorporate a great deal of chemistry and physics. Ice cream consists of at least four phases that have important functions in ice cream and can be examined under the microscope. There is a liquid phase consisting of dissolved sugars, salts, and milk proteins. These prevent the mixture from freezing into a solid block of ice and give the ice cream its flavor and nutritional value. There are solid ice crystals consisting of pure water and globules of milk fat that in good ice cream are very small and well distributed in the mixture. The ice crystals trap the other ingredients in the spaces between them and thus serve as a stabilizer. The milk fat lends smoothness and body. A fourth phase is air cells that are somewhat larger than the ice crystals. The air cells interrupt the solid and liquid phases making the mixture lighter and smoother. Sometimes there is a fifth phase, which consists of lactose molecules that if present in large quantities can give the ice cream a gritty texture. The objective in making good ice cream is to combine the first four phases in proper proportions and to limit as much as possible the fifth phase. [12]

Making ice cream requires three distinct steps. Step one is concocting the mixture by combining the ingredients and cooking them. Step two is cooling the mixture below the freezing point of water and the thorough mixing of the ingredients. Step three is the hardening phase in which the ice cream attains the proper consistency associated with ice cream. If all goes right, a tasty, fine-textured ice cream will result from your classroom efforts. The ingredients and procedure that follows is intended for two students. The interested teacher can assemble materials appropriate to his own classroom needs.

*Classroom Activity***:** *Making Ice Cream in the classroom (Standards # 2, 5, 8)*

Materials: 1-tablespoon sugar
½ cup half & half, whole milk, or 2 percent milk
¼ teaspoon vanilla
6 tablespoons rock salt
1 pint-size zip-loc bag
1 gallon-size zip-loc bag
Crushed ice

Making Ice Cream:

The sugar, milk, and vanilla mixture can be prepared the night before by heating the mixture the night before or can be mixed in the classroom by the students if so desired.. Cleanliness is very important and only new baggies and clean utensils should be used. In class the students can fill the gallon bag ½ full of ice and the rock salt. They can then add the sugar, milk, and vanilla mixtures to the small baggie, seal it, and place it in the larger baggie. Students can then shake and pass the large baggie back and forth in order to thoroughly agitate it for five to ten minutes. The system then can be allowed to stand undisturbed for another five minutes. This allows the ice cream to harden. The small baggie can then be removed, wiped dry, and opened. Students can then enjoy their treat. This is a very simple way to prepare ice cream but it does incorporate the three steps required as mentioned above. Of course, flavors can be added and modifications can be tried. At worst the teacher will have a pint-sized mess on his hands. Care should be exercised in agitating the bag as salt water can enter if the baggie containing the ingredients is pierced. At best the activity will be an excellent demonstration of kitchen chemistry in action.

Science Appetizers Utilizing Ion Exchanges (Standards # 2, 5)

THE ELECTRIC PICKLE:

Ingredients: One outlet cord, 2 screws about 1-½ inches long, one kosher dill pickle, electric outlet

When I drive home from work, I enjoy listening to interviews on the Public Radio program, Fresh Air. One day a scientist was describing a silly experiment involving a pickle and an electric current. He claimed that a kosher dill pickle could be made to glow if plugged into an electric socket. Naturally, I had to try it myself. Here's how I made it work. Obtain an electrical cord with the plug attached. A cord clipped from an old appliance that is of no further use will do nicely. Strip one to two inches of the insulation from the ends of the two wires that make up the cord. Each bare end of the wire is then wrapped around two separate one and one-half screws. The wires are separated enough so that each screw can be inserted into opposite ends of a fat, kosher pickle. The lights in the room are extinguished and the cord is plugged into an electrical outlet. Within a few seconds, the pickle begins to steam and suddenly begins glowing with a greenish-yellow light. Students love this demonstration. The pickle can be used two or three times but I usually discard it after one trial. Since there is probably a migration of metal ions in the pickle during the demonstration, it is not a good idea to eat it. The pickle becomes very hot when plugged in and I find it helpful to bridge it across a 400 ml beaker mouth. Students should be cautioned that there is a danger of electric shock and that they should never try it themselves unless a responsible adult is present.

An Appetizer Utilizing a Polymer ….Sodium Polyacrylate (Standards # 1, 2, 3, 4, 5, 8)

*Ingredients***:** sodium polyacrylate, food coloring, transparent plastic cups or small beakers, Baggies, Huggie diapers, salt

In my teaching I have found that students like the unexpected demonstration that strains their credulity. Such a demonstration is one in which Sodium Polyacrylate is used. Sodium polyacrylate is a polymer that is prepared when sodium acrylate and acrylic acid are combined (geocities). The resulting polymer has cross-links capable of absorbing tremendous amounts of water. The manufacturer claims the crystal will absorb 800 times its weight in distilled water and 300 times its weight in tap water. It is a fluffy white crystal that has very low toxicity and can be obtained from Flinn Scientific or from such stores as K-Mart and Wal-Mart under the name of Water Grabber. Cutting open Huggies extra-absorbent diapers can also obtain yield the polymer.[13] These diapers allow much longer change intervals because they hold so much moisture. For my demonstrations I like to have students add 100 ml of water to a small sandwich baggie. They can also add food coloring if they like. I then have the students file by my demonstration table and I add about ¼th teaspoon of sodium polyacrylate to their baggie. There is an immediate reaction in which the water is completely absorbed as the students watch. They can even add more water and it too will be absorbed. I caution them not to pour this mixture down the drain as it could cause a severe blockage. A small amount of table salt stirred vigorously into the polymer causes it to liquefy, however. A class discussion of its possible uses in addition to diapers usually follows the demonstration. One use in the kitchen is in the absorbent pads that are placed under packaged meat to prevent leaks.

Another Polymer Appetizer… Guar Gum (Standards # 1, 2, 3, 8)

Guar gum is a light yellow powder derived from the endosperm of the guar plant. Most guar is grown as a cattle feed in India and Pakistan with some also grown in Texas. [14] Guar gum makes an excellent thickening agent and as such is added to gravies, ice cream, and pet foods. It is an excellent polymer for the classroom because of its ease of preparation, low toxicity, and quick setting time.

Materials: Guar gum. This is available from Flinn Scientific Inc. P.O. Box 219, Batavia, IL 60510. Phone: 1-800-452-1261.

Sodium Tetraborate or Borax. This is also available from Flinn or in laundry section of grocery store. Graduated cylinder, food coloring, water,(distilled is preferred although tap water will work), Baggies, small measuring spoon, plastic micropipettes or eyedroppers.

*Procedure for making guar gum slime***:**

Prior to class prepare a saturated solution of borax by adding more borax than will dissolve in one to two hundred milliliters of water. This will be an adequate supply to easily make more than 100 batches of slime. Students should add 100 ml of water to a baggie. If you are using tap water, do not use water below room temp. (about 25 degrees Celsius). Water that is too cold makes for slower polymerization. After adding the water to the Baggie, students can use food coloring to color the water to suit their taste. Spoon about 1/8th teaspoon of guar gum into the Baggie containing the now colored water. Advise students to quickly mix the guar gum with the water by gently kneading the water-gum mixture. If there is a delay in mixing, the mixture gets lumpy. One micropipette squeeze of the saturated borax solution is now added to the Baggie. The borax forms the polymer by cross-linking the guar gum solution. Students should knead the solution and polymerization will occur. Within a few minutes, a really good slime is formed. Students may remove the slime and pass it from hand to hand, etc.

Classroom Discussion Topics (Standards # 1, 2, 3, 4, 7, 8)

Sometimes students can gain a great deal of information and satisfaction by discussing certain selected topics. Since everyone eats, there is no shortage of discussion topics originating in the kitchen. The vast majority of students probably have no idea where the food they eat originates. They may vaguely refer to farms or orchards, but most of our experience and knowledge of food origins begins and ends with the supermarket or cafeteria. We take it for granted that our food supplies are safe to eat and reasonably clean. Recently, however these assumptions have been called into question.

Question One: What is mad cow disease and what can be done to prevent getting it?

Mad Cow Disease or Bovine Spongiform Encephalopathy was first diagnosed in cows in 1986. It is a progressive, debilitating disease of cows in which their motor functions such as walking and eating deteriorate fairly rapidly. The examination of the infected animal's brain reveals spongy areas where healthy brain tissue should be. The disease has been found mainly in Great Britain with a few infected animals in Europe. Sheep have a similar disease called Scrapie that has been known since the 1800's. This disease, however, seems to be specific to sheep and not transmittable to beef or humans. Bovine Spongiform Encephalopathy is probably contracted by cows eating feed that has ground-up waste animal tissue from slaughtered, infected cows. Under law this practice has been banned in countries in Europe and the United States. BSE, or Bovine Spongiform Encephalopathy, was not thought to be a threat to humans until cases of human infection started to show up in Great Britain in 1989. In humans the disease is called Creutzfeldt-Jacob disease (CJD). In humans the disease is also progressive as the victim suffers memory loss and brain damage over a few months. Eventually the infected person can no longer see, speak, or feed himself. Sometimes the disease is referred to as "Altzheimer's on fast- forward." Variant CJD is a new form of the disease infecting mostly younger people with an average age of death of under thirty years. The disease also takes longer to kill the infected person, about two years, and involves hallucinations and other psychiatric features not found in CJD. Since its diagnosis in 1989, over 100 persons have died of CJD and Variant CJD, mostly in Great Britain. There is no vaccine or cure for the disease, and the only way to prevent it appears to be to stop producing cattle feed contaminated with animal byproducts.[15] As a sidelight to this discussion it should be noted that even though the disease has not been confirmed in the United States, there still is a risk of infection. Hundreds of small feed producers in the U. S. continue to mix animal byproducts with their feed, even though it is against the law. Government inspectors are few in number compared to the feed-producers and until all operations are made safe, we are at risk. One thing that may be preventing the introduction of the disease is that cattle are slaughtered at a much younger age in the United States than in Great Britain. Some suspect that younger cattle have not had the time to develop the disease to the point where it would be a threat to humans. [16]

Discussion Question 2: What is Foot and Mouth Disease and why is so much fuss being made of it?

Foot and mouth disease is a highly contagious viral infection of cattle, sheep, pigs, and goats. An infected animal develops blisters on the mouth and feet as well as weight loss. The disease also weakens the animal and can cause miscarriages and reduced milk production in goats and cows. It is spread by direct contact, through food, and even soil that the animal has come in contact with. The United States has not had a confirmed case of foot and mouth disease since 1929 and intends to keep it that way. Customs officials employ sniffing dogs, questioning of travelers as to food products they might be carrying, and disinfectants to prevent the spread of the virus to the shores of the U. S. The disease has been mainly found in Great Britain with a few isolated cases in France and Holland. Foot and mouth does not affect humans but the fact that it does blemish livestock makes consumers uneasy. The newly formed European Union or E. U. is especially sensitivity to any hint of the disease. They have banned imports of livestock and meat products from Great Britain and have forced large scale slaughtering of animals even suspected of carrying the disease. It is suspected that the disease was introduced to Britain by contaminated swine food imported from China.[17]

Discussion Question 3: What is E. coli and why should we worry about it?

The name E. coli includes dozens of bacterial species that are found in the intestinal tracts of animals, humans included. Most are harmless to humans. In reality, even the harmless serve a useful function by taking up space that might be used by harmful bacteria in their absence. Beneficial intestinal E. coli helps to digest food and to synthesize vitamins for their host organisms. One species, labeled E. coli 0157:H7 is a virulent variation and causes sickness and even death in many cases in humans. It produces a toxin that can cause intestinal bleeding, diarrhea , and gastric distress. If the toxin enters the blood stream, it can destroy internal organs such as the kidneys. Brain lesions are also reported in E. coli 0157:H7 infections. The most vulnerable to E. coli 0157:H7 infections are the very young and those whose immune systems are compromised such as transplant recipients and AIDS victims. One way that meat can become contaminated with E. coli 0157:H7 is if intestinal wastes come in contact with it. This can happen in slaughterhouses or by handling by infected persons. Contamination can occur with as few as five bacteria and bacteria can survive for several weeks on contaminated surfaces such as counter tops and chopping blocks. Children's' petting zoos and the handling of animals has also been implicated in contamination. Thorough cooking of meat affords the best protection although bacterial infections also occur on foods other than meat such as salad bars. The FDA has approved the irradiation of foods and this may afford some protection for consumers. Better sanitation techniques in the slaughterhouses, restaurants, and in the home offer good defenses against this pathogen.[18]

Notes: This section lists those sources that I used for much of my research.

1. http://www.popcorn.org/encyclopedia/epanhist.cfm….a good history of popcorn

2. McGee, pg. 241….how popcorn pops.

3. ibid, pg. 395 …about corn syrup.

4. McGee, pg. 336… about cornstarch.

5. McFall, pg. 36…dust as an explosion hazard.

6. Bilash, Gross, and Koob, Volume II, pg. 9. about very strong magnets.

7. Acids and Bases, Microsoft Encarta Encyclopedia .

8. http://www.ucdsb.on.ca/tiss/stretton/chem1/data11.htm This is the source of the indicator table.

9. Epstein, pg. 215… Thinking Physics is Gedanken Physics!

10. McGee, pg. 600… soap.

11. http://www.cleaning101.com/cleaning/history/ History of soap.

12. McGee, pg. 25… about ice cream.

13. http://www.geocities.com/CapeCanaveral/Cockpit/8107/superabsorbe.html… super-absorbers.

14. http://www.westtexasguar.com/ …guar gum facts.

15. http://www.mad-cow.org/dec99_news_late.html …A good source of mad cow information.

16. Schlosser, pg. 202. …mad cow disease.

17. http://www.guardian.co.uk/theissues/article/0,6512,441031,00.html … foot and mouth disease source.

18. Schlosser, pg. 201. E. Coli.

Works Cited

Becker, Bob, Twenty Demonstrations Guaranteed to Knock Your Socks Off. 2 Vols. Flinn Scientific, Inc., 1997. Totaling 40 demonstrations in 2 volumes, there are several chemistry demonstrations utilizing kitchen materials and science.

Bilash II, Boris, Gross, George R., and Koob, John K. A Demo a Day, 2 Vols. Flinn Scientific, Inc., 1998.

Doherty, Paul, and Rathjen, Don, ed. Science Snackbook, The Exploratorium, 1991.Stwertka, Albert. A Guide to the Elements. Oxford University Press, Inc., 1998.

Freier, G. D. and Anderson, F.J. A Demonstration Handbook for Physics. American Association of Physics Teachers. 1996. Many good demonstrations and ideas including kitchen science are found in this volume.

Hillman, Howard, Kitchen Science Houghton Mifflin Company, 1981, 1989. This book is organized in a question/answer format. Some sample questions: Why are dull knives more dangerous than sharp ones? What causes a fish to develop a fish odor? Are eggs essential in making hollandaise? Can I make my own baking powder? The author covers quite a bit of kitchen science in a readable, easily understandable format.

http://www.ucdsb.on.ca/tiss/stretton/chem1/data11.htm This is a good source for learning about acid base indicators. The table of acid base indicators used in the narrative came from this website.

http://www.geocities.com/Capecanaveral/Cockpit/8107/superabsorbe.html Sodium Polyacrylate or Superabsorber is discussed in some detail.

http://www.westtexasguar.com/ This website is a good source of information about guar and its uses.

http://www.popcorn.org/encyclopedia/epanhist.cfm This is a good place to look for students and teachers. Everything one would want to know about popcorn is arranged in an entertaining and easy to use format.

http://www.cleaning101.com/cleaning/history/ This is a website that is a good source of soap history.

http://www.geocities.com/CapeCanaveral/Cockpit/8107/superabsorbe.html Everything you wanted to know about super-absorbing polymers but were afraid to ask.

http://www.mad-cow.org/dec99_news_late.html This is a website that is an excellent source of information on mad cow disease.

http://www.guardian.co.uk/theissues/article/0,6512,441031,00.html This website discusses foot and mouth disease from many angles.

McFall, Christie, Wonders of Dust, Dodd, Mead & Company, New York, 1980. This is a highly readable book that reveals much about dust.

McGee, Harold. On Food and Cooking: The Science and Lore of the Kitchen. Fireside. 1984. Numbering 684 pages in the paperback edition, this book is as thoroughly researched examination of kitchen science that one is likely to encounter. History and chemistry of foods as well as recipes and cooking advice is given in a reader-friendly format. If one book were to be selected on kitchen science, this would be the one.

McGee, Harold, The Curious Cook: More Kitchen Science and Lore. Macmillan, 1990. Taking up where he left off in On Food and Cooking, McKee serves up more information on the science of cooking. Much of the book is devoted to sauces such as béarnaise, hollandaise, mayonnaise, and beurre blanc. The author also discusses food and health and the physiology of taste. This is a highly readable book.

Schlosser, Eric. Fast Food Nation…the dark side of the all-american meal. Houghton Mifflin Company. 2001. In regards to the commercial preparation of fast food, Mr. Schlosser has done his homework. The author presents a convincing argument that the fast food industry has changed not only American eating habits but has altered the entire culture… for the worse! His treatment of E. coli 0157:H7 will make you think twice before you eat your next hamburger or chicken sandwich.

Shaw, Mike, A Plethora of Polymers, Science Kit and Boreal Laboratories.1998.

Reading List for Students:

Braman, Arlette N., Bosson, Jo-Ellen, Kids Around the World Cook!: The Best Foods and Recipes from Many Lands, John Wiley & Sons. 2000. Young readers develop an appreciation for other cultures by learning to cook their native dishes.

Cole, Joanna, Degan, Bruce, The Magic School Bus Gets Baked in a Cake: A Book about Kitchen Chemistry, Scholastic Trade. 1995. Kids find themselves inside a cake and learn about mixtures and reactions that occur when ingredients are combined.

Cunningham, Marion, Lisker, Emily, Cooking With Children: 15 Lessons for Children, Age 7 and Up, Who Really Want to Learn to Cook, Knopf. 1995. This book provides adults and children with an opportunity to work together to prepare dishes.

Dooley, Norah, Thornton, Peter, J. Everybody Bakes Bread, Lerner Pub. Group. 1995. In a friendly, international neighborhood, the main character, Carrie, learns to bake 7 types of bread favored by various ethnic groups.

Goss, Gary, Dyer, Jane, Blue Moon Soup: A Family Cookbook, Little Brown & Co. 1999. This is a book for kids and grown-ups alike. Such dishes as Likity Split Pea Soup, Polka Dot Soup, Broccoli Soup au Gratin, and Ch-Ch-Chili are just a few of the recipes that will appeal to all palates.

Harbison, Elizabeth M., Harbison, John, Loaves of Fun: A History of Bread With Activities from Around the World, Chicago Review Pr. 1997. The author provides a history of bread and 24 recipes and five activities relating to bread making. This is a book that studies food as a part of culture.

Kenda, Margaret, Williams, Phyllis S, Sawyer, Phyllis A., Cooking Wizardry for Kids, Barrons Juveniles. 1990. This book offers a dazzling collection of experiments, art projects, and recipes for kitchen fun. The illustrations are especially good.

Priceman, Marjorie, How to make an Apple Pie and See the World, Dragonfly. 1996. The reader travels around the world to gather and to see how the ingredients for an apple pie are prepared. The reader then prepares an apple pie. Yum, yum! The illustrations and storyline are just right.

Vezza, Diane Simone, Greenstein, Susan, Passport on a Plate: A Round-The_World Cookbook for Children, Simon & Schuster. 1997. Kids can travel around the world with more that 100 recipes from all over the world. Each recipe is rated from one to four utensils for level of difficulty and the amount of adult supervision required to prepare the item.

Pittsburgh Public Schools Science and Technology Standards

The Pittsburgh Public Schools has adopted the following Science Technology Standards:

1. All students explain how scientific principles of chemical, physical, and biological phenomena have developed and relate them to real world situations.

2. All students demonstrate knowledge of basic concepts and principles of physical, chemical, biological, and earth sciences.

3. All students use and master materials, tools, and processes of major technologies which are applied in economic and civic life.

4. All students explain the relationships among science, technology, and society.

5. All students construct and evaluate scientific and technological systems using models to explain or predict results.

6. All students develop and apply skills of observation, data collection, analysis, pattern recognition, prediction, and scientific reasoning in designing and conducting experiments and solving technological problems.

7. All students evaluate advantages, disadvantages, and ethical implications associated with the impact of science and technology on current and future life.

8. All students evaluate the impact on current and future life of the development and use of varied energy forms, natural and synthetic materials. And production and processing of food and other agricultural products.

9. All students demonstrate basic computer literacy, including word processing, software applications, and the ability to access the global information infrastructure, using current technology.

Materials List

Disposable Items:

Popping corn, aluminum foil, graph paper, corn oil, acetone, alcohol, corn syrup, cornstarch, transparent plastic cups, candle, funnel, matches, Total cornflakes, petri dish, red cabbage, blender, ginger ale, cola, lemon, vinegar, baking soda, Windex, dishwashing liquid, Drano, Borax, Spic and Span, salt, toothpicks, paperclips, sugar, milk, cream, or half & half, vanilla extract, Zip-loc baggies (Pint or quart size), gallon size Zip-loc baggies, kosher dill pickles, sodium polyacrylate, food coloring, Huggie diapers, guar gum, disposable plastic berol pipettes,

Equipment or reusable materials:

Hotplates timer, thermometers, 1000 ml beaker, light box, polarized filters, a round can with a tight-fitting lid, computer hard drive magnets, overhead projector, 400 ml beakers,

glass stirring rods, electric cord, 2 screws approximately 1 to 2 inches long, graduated cylinders, small measuring spoon