4-H Project Connections
- Cake Decorating
- Foods and Nutrition

4-H Science Abilities:
- Collect Data
- Compare / Contrast
- Interpret / Analyze / Reason

4-H Life Skills:
- Head: Managing—Keeping Records
- Head: Thinking—Critical Thinking
- Head: Thinking—Learning to Learn
- Hands: Working—Self-motivation
- Heart: Relating—Cooperation
- Health: Being—Self-responsibility

National Science Education Standards:

K-4
- Science as Inquiry
  - Employ simple equipment and tools to gather data and extend the senses
  - Use data to construct a reasonable explanation
- Physical Science
  - Properties of Objects and Materials

5-8
- Science as Inquiry
  - Use appropriate tools and techniques to gather, analyze, and interpret data
  - Develop descriptions, explanations, predictions, and models using evidence
  - Think critically and logically to make the relationships between evidence and explanations
- Physical Science
  - Properties and changes of properties in matter

HS
- Science as Inquiry
  - Formulate and revise scientific explanations and models using logic and evidence
  - Recognize and analyze alternative explanations and models
- Physical Science
  - Structure and properties of matter
  - Chemical reactions

The introduction discusses naturally occurring polymers. There are also manufactured polymers, and they are very common. For example, all plastic products are polymers.

STEM Connections

Colorado State University Extension

Connecting Science, Technology, Engineering, and Math concepts to our everyday lives.

Chemistry in the Kitchen

Slime, Gak, and Flubber

Cooking is Chemistry. How can you change the texture of your food by adding different ingredients?

We determine what tastes good on three sensory aspects of food: taste (**gustatory** and **olfactory**), texture, and visual. We won't like food if it looks disgusting or if the texture is weird or gross, even if the taste is superb. Chefs, therefore, aspire to achieve all three aspects, and are experts not only of food but also the chemistry of food.

All matter is made from atoms. Atoms have electrons zipping around the nucleus. Protons and neutrons make up the nucleus. The number of protons determines what kind of atom it is. For example, all oxygen atoms have 8 protons, and all carbon atoms have 6. There are 118 different elements, so protons number between 1 and 118.

Atoms are like LEGOs. The LEGO bricks come in a variety sizes and shapes. Each LEGO piece is like a different **element**—carbon, oxygen, hydrogen, etc. You can't make a helicopter with a single LEGO brick, but you can with a variety of bricks. In a similar manner, the different combinations of atoms form pies, planets, stars, spoons, you, and everything.

Atoms bond together and form **molecule**s. A molecule is two or more bonded atoms. We need to breathe oxygen, and that is formed by two oxygen atoms bonded together. One oxygen atom and two hydrogen atoms bonded together make water. Molecules can also be very big and complex with several thousand atoms, like the proteins in your body.

A **monomer** is a specific molecule that can bond to other similar monomer molecules. A **polymer** is built from repeating chains of that monomer. For example, if you have 100 paperclips, you have 100 individual paperclip monomers. If you attach them into a long chain of 100 paperclips, you have created a paperclip polymer.

Natural polymers are everywhere. Your DNA and chitin, the hard outer covering of insects, are different polymers. Cellulose and polysaccharide are plant polymers. The long strings in celery are cellulose, and starch in potatoes and corn is a polysaccharide.

Different polymers have different properties. The strings in celery are really hard to chew. The monomer molecules line up and bond in an almost unbreakable chain. Starch granules help to make gravy. By isolating the granules and breaking the polymers in starch, you can make lump-free gravy. Lumps happen when the temperature-sensitive polymers are not broken. The monomers in starch don't bind as strongly into those long polymer chains in celery, and can be broken.

You will explore aspects of chemical bonding and breaking with slime, gak, and flubber. You are going compare and contrast them to see how a small change in a **formula** can have a big effect in product.

Age Appropriate:
4th—12th grades

Time Required:
60 minutes

Materials:

For each participant
- 3 zip lock plastic baggies
- 1 label: Slime
- 1 label: Gak
- 1 label: Flubber
- 12"x12" wax paper
- 1 pencil
- 1 data sheet

For every 2 participants

- 3—3oz Dixie cups
- 2 plastic spoons
- 3—9oz clear plastic cups
- 6oz white school glue (Elmers works best)
- 3oz clear glue OR glue gel
- 3 craft sticks (sanitized for edible slime)
- 1 ruler

For the group
- Borax
- Liquid starch
- Water in jugs
- 2 or 3 bowls labeled
- Food color (variety pack)
- 2 or 3 permanent markers

Power Words
- **element**: atoms with the same number of protons
- **formula** (plural formulae): a prescription of chemical ingredients in fixed proportion; a recipe
- **gustatory**: relating to the sense of taste
- **molecule**: a group of atoms bonded together
- **monomer**: a molecule that can be bonded to other identical molecules to form a polymer.
- **olfactory**: relating to the sense of smell
- **polymer**: a substance that has a molecular structure built up chiefly or completely from a large number of similar units (monomers) bonded together

Experience / "What to Do" - Inedible Formulae

- Wash your hands with soap and water.
- Find a partner, and the two of you will need:
  - 1—6oz white glue
  - 1—3oz clear glue
  - 3—plastic cups 
  - 3—paper cups 
  - 3—craft sticks
  - 6—plastic baggies
  - 2—plastic spoons
  - 2—labels: Slime
  - 2—labels: Gak
  - 2—labels: Flubber
  - 2—12"x12" wax paper
- In addition, there are four chemicals for the entire group to share: water, borax powder, food color and liquid starch.
- Only work on the wax paper.
- Each of you will get 3 baggies to make the 3 different formulae. Put 1 label for each polymer on each baggie.
- Each partner will make his/her own polymer. When directed to repeat, make a 2nd baggie of polymer.

Slime:

1. Label a  plastic cup "Borax." Add 4 plastic spoons of borax. Don't use heaping, just slightly rounded spoons.
2. Fill a  paper cup with water, and pour into the borax powder.
3. Mix thoroughly. Only use this spoon for the borax solution.
4. Add 4 full spoons of borax solution into the "Slime" baggie. Add 2 drops of food color and mix.
5. Repeat Step 4 for your partner's "Slime" baggie.
6. Fill the  paper cup with the clear glue.
7. Pour into the  plastic cup using a craft stick to scrap all the glue.
8. Fill the same  paper cup with water. Pour the water into your  plastic cup.
9. Use your craft stick to stir the clear glue and water until thoroughly mixed. You will each use ½ of it.
10. Pour ½ the glue solution into the  paper cup and pour this into your baggie labeled "Slime." Repeat using the other half for partner's slime.
11. Seal the baggie, and double check the seal.
12. Mix the ingredients with your fingertips. Continue to mix until all the liquid is gone. Be patient; it takes about 5 minutes.
13. Dispose of paper cup and craft stick. Set the slime aside.

Gak:

1. Add 4 full spoons of the borax in water into your "Gak" baggie. Add 2 drops of food color and mix.
2. Repeat step 1 for your partner.
3. Fill a new  paper cup with the white glue.
4. Pour into a  clean plastic cup scraping the glue with a clean craft stick.
5. Fill the same  paper cup with water. Pour the water into your  plastic cup.
6. Use your craft stick to stir the white glue and water solution until thoroughly mixed.
7. Pour ½ the glue solution into the  paper cup and pour this into your baggie labeled "Gak." Repeat for partner.
8. Seal the baggie, and double check the seal.
9. Mix the ingredients with your fingertips. Continue to mix until all the liquid is gone. Be patient; it takes about 5 min.
10. Dispose of the paper cup and craft stick. Set the gak aside.

Flubber:

1. Add 4 full spoons of liquid starch to your Flubber baggie. Add 2 drops of food color and mix.
2. Repeat step 1 for your partner.
3. Fill a new  paper cup with the white glue.
4. Pour into a clean  plastic cup scraping the glue with a clean craft stick.
5. Fill the same  paper cup with water. Pour the water into your  plastic cup.
6. Use your craft stick to stir the white glue and water solution until thoroughly mixed.
7. Pour ½ the glue solution into the 3oz Dixie cup, and pour this into your baggie labeled "Flubber." Repeat for partner.
8. Seal the baggie, and double check the seal.
9. Mix the ingredients with your fingertips. Continue to mix until the liquid is gone. Be patient; it takes about 5 min.
10. Dispose of 3oz cup and craft stick.

Data Collection: Directions are on the data sheet.

Share/Reflect/Generalize/Apply: In these three polymers, you only changed one chemical (good science always demands that one variable is changed at a time). Consider the slime, gak, and flubber—what specific chemical was responsible for the different properties that it had? While these formulae are inedible, you can make edible polymers, too. Thinking only about the texture of these substances, do you think that they have sensory appeal? Why or why not? How would you incorporate an edible polymer in one of your dishes? What would the texture be like? Try it.

Career Connections: Chemists can be found in kitchens, laboratories, schools, factories, and shops worldwide. Specific occupations are: chef, confectioner, agriculture, geology, biology, physics, astronomy, high school teachers, energy, manufacturing, fashion (primarily in fabrics), to only name a few.

References: Photos: http://www.ehow.com/how_7457038_make-flubber-liquid-starch.html.

- Drewnowski, A. and Moskowitz, H.R. (1985) Sensory characteristics of foods: new evaluation techniques, The American Journal of Clinical Nutrition 42, p924-931.
- Lesson 3: The Science of Thickening Agents, captured 01/03/2012 at http://www.mycaert.com/.
- Formulae modified from: http://chemistry.about.com/od/slimerecipes/tp/edible-slime-recipes.htm.

Thank you to my Reviewers: Glenda Wentworth, Family and Consumer Science Agent, Eagle County, and Christy Fitzpatrick, Northeast Region 4-H STEM Specialist

This STEM Connection was developed by: Dr. Barbara J. Shaw. To find out more about 4-H STEM activities, contact your local county Extension office. http://www.ext.colostate.edu/cedirectory/countylist.cfm More activity sheets can be found at http://www.colorado4h.org/k12/activity_sheets/activity.php

You and your partner will need 2 pencils, 2 data sheets, and 1 ruler. You will each collect your own data on your polymers. Read the description of each characteristic, and follow those steps. Record your data under the correct column for Slime, Gak, and Flubber.

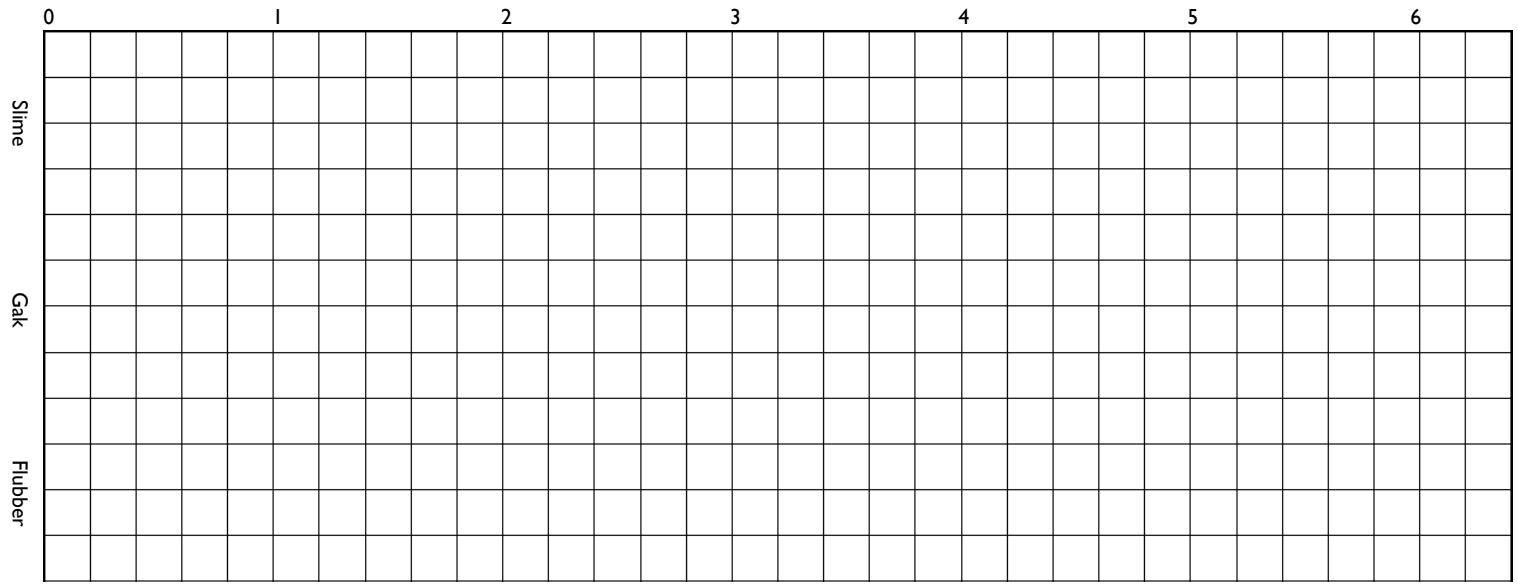
Characteristics of each "formula" Name:

Characteristic	Slime	Gak	Flubber
Ooze Factor (OF): Roll each polymer into a ball and place on a table top. Record the diameter. Do not touch, and time 60 seconds. Record the diameter after 1 minute. How much did your polymer ooze (ending minus beginning measurement)?			
Bounce Factor (BF): Roll the polymer back into a ball. Hold it at the top of a 30 cm (12") ruler and open your hand to drop. Record how high the polymer bounces on the first bounce.			
Bounce Number (BN): Roll the polymer back into a ball. Hold it at the top of a 30 cm (12") ruler and open your hand to drop. Count the number of times the polymer bounces before stopping.			
Slow Stretch (SS): Grasp the polymer with both hands and slowly pull your hands apart. Continue until the polymer breaks. Record the length of the polymer stretched at the breaking point in centimeters.			
Fast Stretch (FS): Grasp the polymer with both hands and jerk your hands apart quickly. Record the length of the polymer stretched at the breaking point in centimeters.			
Squeeze Factor (SF): Place the polymer in the palm of your hand and squeeze. Record the results.			

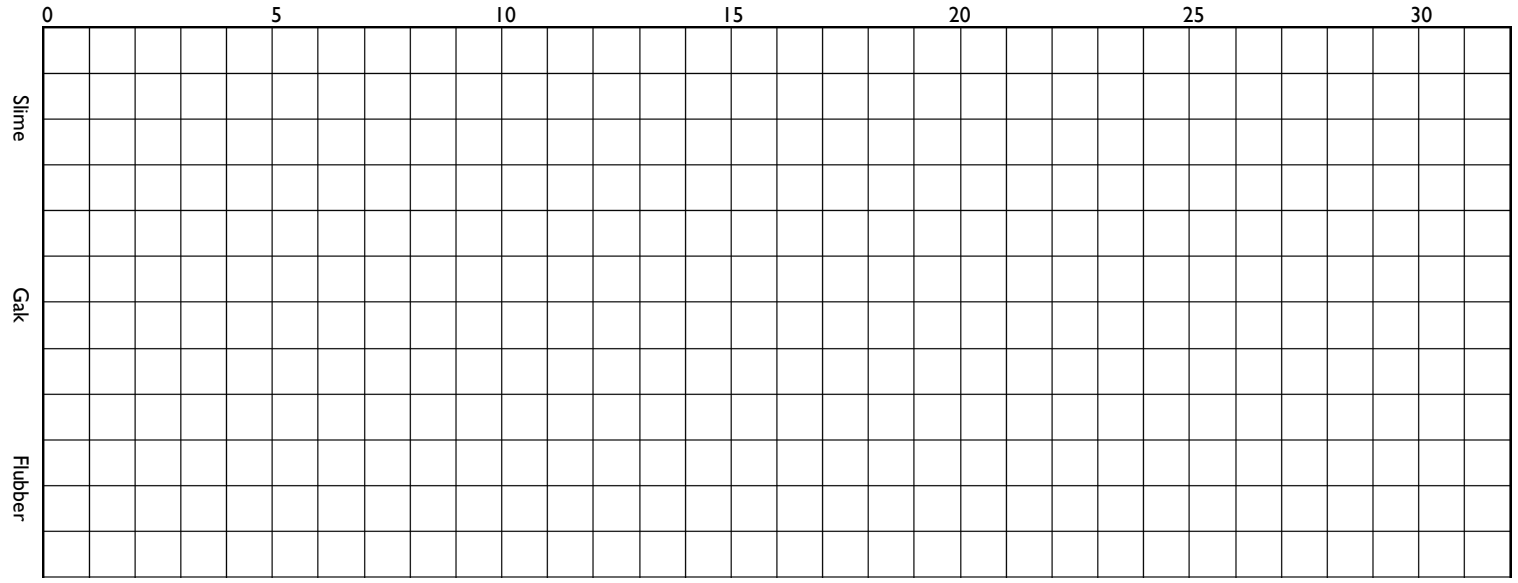
In each inedible formula, you only changed one chemical, and each polymer is distinct. Using the data that you collected, compare and contrast the 3 different formulas of polymers. How are they similar? How are they different? Graph your results on the back of this data sheet.

Graph the results of Ooze Factor, Bounce Factor, and Bounce Number

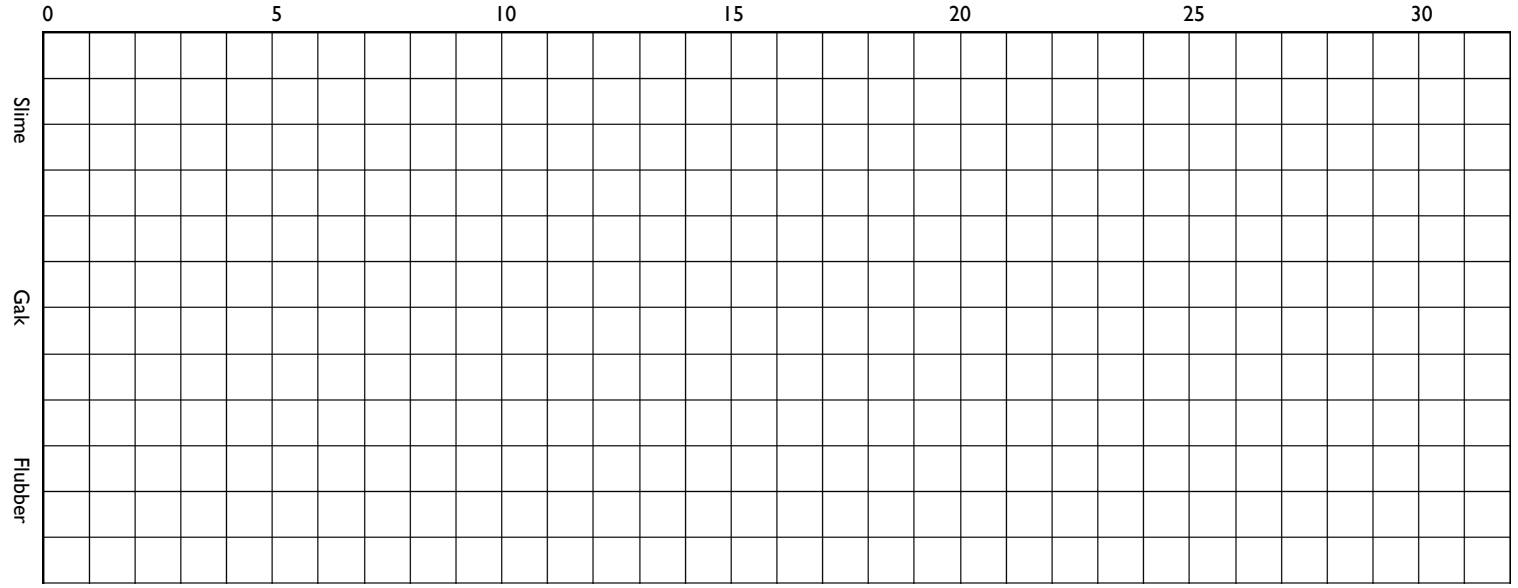
Ooze Factor: Record both the beginning and ending diameter of your polymer ball in centimeters (each line = 2 millimeters; there are 10 millimeters in 1 centimeter)



Bounce Factor: Record the height your polymer ball bounced when dropped from the top of a 30cm ruler (each line = 1cm)



Bounce Number: Record the number of times your polymer ball bounced when dropped from the top of a 30cm ruler (each line = 1 bounce)



Teaching Tips

12 plastic teaspoons = 3oz Dixie cup
4 plastic teaspoons = ~1fluid oz

- **Caution:** These polymers will stick to cloth and can stain natural wood. Be sure to work on plastic surfaces, or only work on the wax paper. If they get embedded into cloth (carpet, upholstery, or clothes) freeze with an ice cube and pick out the frozen pieces. For smaller stains, you can wash with a mild soap and water.
- **Caution:** Food color can stain hands and clothes. Eventually the color will wear off hands. To remove the stains from clothes, use a stain remover product. It should remove the stain completely.
- **Patience is the key:** The polymers are formed by kinetic energy breaking bonds and allowing the long chains of polymer bonds to form. It takes time, and the longer you work the polymer, the better it is. It can take up to 10 minutes to absorb all the liquid, but the result is well worth the effort in the cool factor! These formulae have been tested, and generally take about 5 minutes.
- **Setting up your room for these experiments:** Collect all the supplies. If you are working with younger participants, you may also want to provide the pre-mixed glue solutions (directions are below). The participants need tables, and you need a central location for the shared chemicals: 1—2 boxes of mixed food color, borax powder poured into 2—4 (depending on the number of participants) bowls labeled "Borax" with a permanent marker, liquid starch poured in 2—4 bowls labeled "Starch" (pour when ready to make flubber to avoid spills before then), and 2—4 jugs labeled water (clean milk jugs are perfect). You need several containers of each of these shared chemicals, otherwise there will be a long waiting line. You are pouring the borax and starch into bowls, because the participants measure 4 plastic spoonful of those chemicals, and the bowls are easier to get the spoons full.
- **Can I mix the glue solutions in advance?** Yes, you can prepare the glue solution days or weeks before actually making the polymers. For those of you working with younger participants, this is suggested. The basic recipe for the glue solutions is 1 part glue and 1 part water. If you add 5 cups of glue, you will need to add 5 cups of water. Each participant needs 3 fluid ounces of white glue and 1.5 fluid ounces of clear glue. To make the correct amount of white glue solution, multiple the number of participants x 3, and then add some incase of accidents or spills. To make the correct amount of clear glue solution, multiple the number of participants x 1.5, and then add some incase of accidents or spills. For example, if you are working with 24 participants, you would need 72oz of white glue (9 cups) and 36oz of clear glue (4.5 cups) plus a bit more for spills and accidents. Add the glue into a clean milk jug and add an equal amount of hot water. Close the top and shake the jug to mix. If you are making 1 gallon of glue solution, add half the water you need, mix, and then add the other half. If the jug is too full, you won't be able to mix the glue completely. Be sure to modify this formula to the number of participants you have. You can always make more than you need and store it.
- **Clean-up suggestions:** The easiest way to clean up after making polymers is to use paper towels rather than washing everything. If you are planning on presenting the inedible polymer activity several times, you can reuse the plastic cups, spoons, and bowls. Simply wipe out, allow to dry, and then wipe out again to get the rest of the remaining residue.
- **How do I make translucent slime? How do I make opaque gak?** Basically, your slime and gak will be about as transparent as the glue you use to make it. If you use white school glue, then your gak will be opaque. If you use translucent clear or blue glue gel (or another see-through color), then your slime will be translucent.
- **Are borax and boric acid interchangeable? Can I substitute one for the other?** Borax and boric acid are not the same chemical; borax [$Na_2B_4O_7 \cdot 10H_2O$ or $Na_2[B_4O_5(OH)_4] \cdot 8H_2$] is a salt of boric acid [$B(OH)_3$]. I haven't tried making slime using boric acid. (Feel free to post a comment if you can offer a more complete answer to this question.)
- **How do I color polymer?** It is easier to add the color to one of the ingredients before mixing the two ingredients together. If your glue is tinted, then your polymer will be colored. For non-edible polymer only, put on disposable gloves, break a highlighter pen, remove the ink stick, and place that into the glue solution and let the ink bleed. It fluoresces under black light. Add glow-in-the-dark paint (purchase at craft stores usually be tempera paint). Add glitter. You can also use any of the edible polymer coloring ideas with inedible polymers, but not vice versa. If you are making edible polymer, be sure that your color is also edible. Food color, jello, chocolate, and some candies will add color.
- **How long can I keep my slime?** Edible polymers are food, and they must be refrigerated, and either eaten or tossed within 7 days of making them. Inedible slime doesn't go 'bad', but you may want to toss it if it develops mold or if it dries out. Tightly sealed and refrigerated slime will last for a couple of weeks or longer.
- **How does slime work?** When you mix the glue and the borax a chemical change occurs in the polymer in the glue, polyvinyl acetate. Cross-linking bonds are formed, making the glue stick to you less and to itself more. You can experiment with the amount of glue, water, and borax that you use to make the slime more fluid or more stiff. The molecules in the polymer are not fixed in place, so you can stretch the slime.
- **Testing edible polymers:** You can easily modify this lesson plan to make three edible polymers, however there are many different changes between one recipe and the next. When reflecting on how the properties of polymers are different, you cannot specifically state which ingredient was the primary factor in that change. Instead, focus on how the texture is different and consider the "edibility" of each one in taste, texture, and visual appeal.
- **Sterilizing craft sticks:** To sterilize craft sticks place them in a single layer on a cookie sheet and baking them in the oven for 60 min. at 200°F. Allow them to cool completely. Invert a zip lock baggie by pushing the outside in, grasp the sticks with your hand inside the inverted baggie, and while holding them tightly, pull the baggie right side out, keeping the craft sticks inside. Seal.
- **Label baggies with markers:** You can use permanent markers to write "Slime," "Gak," and "Flubber" on the baggies, but have the youth label their polymer after they have completed making it, and before they start the next one. Ink will rub onto their hands.

Slime, Gak, and Flubber Formulae
Edible Polymers

Edible Slime
Most slime recipes are edible, but none that taste as good!

Time Required: 30 min
Materials:
- 14 oz. can sweetened condensed milk
- 1½ tablespoon cornstarch
- food coloring (or add a little unsweetened powdered drink mix)
- couple of drops vanilla or other flavoring, if desired
- Optional: Chocolate Edible Slime—in addition to the above, 2 tablespoons chocolate syrup or hot fudge sauce

Procedure:
1. In a saucepan over low heat, stir together the milk and cornstarch. Stir and heat until the mixture thickens. Remove from heat.
2. Stir in the coloring and any flavorings. Allow the slime to cool.
3. Enjoy! When you are finished playing with this slime, store it in a sealed plastic bag in the refrigerator.
4. Refrigerated slime is good for a day or two. You can clean up the edible slime with warm soapy water. If you added food coloring or drink mix, keep the slime away from surfaces which could be colored, such as carpet or upholstery.

Kool-aid Gak
This makes an edible, fruit-scented play-dough.

Time Required: 15 mins.
Materials:
- 1 c flour, sifted
- 1/2 c salt
- 3 T cooking oil
- 1 pkg Koolaid (unsweetened)
- 1 c boiling water

Procedure:
1. Mix together flour, salt, oil, and Kool-aid.
2. Add the cup of boiling water. Mix well.
3. Knead the mixture until it forms a soft dough.
4. Have fun!
5. Store in a sealed container in the refrigerator.

Tips:
1. Any unsweetened, powdered drink mix may be substituted.
2. Expect colored hands :-)
3. Non-toxic... could be eaten, but won't taste very good.

Electro-active Slime
This recipe makes cool, non-toxic slime that appears to have a life of its own!

Time Required: 30 minutes
Materials:
- 3/4 c cornstarch
- 2 c vegetable oil
- glass or tumbler
- refrigerator
- measuring cup
- 1x6x6 inch Styrofoam
- Sandwich size baggie

Procedure:
1. Mix the cornstarch and vegetable oil together in the glass.
2. Refrigerate the slime mixture until it is chilled.
3. Remove from the refrigerator and stir (separation is normal).
4. Allow the mixture to warm enough so that it can flow.
5. Take a block of Styrofoam and charge it by rubbing it on hair, wool, or a cat.
6. Tip the container of slime (which should flow slowly). Place the charged Styrofoam about an inch (2 cm) from the flowing slime. It should stop flowing and seem to gel!
7. If you wiggle the charged Styrofoam the slime may follow or pieces of it may even break off.
8. When the Styrofoam is removed the slime will continue to flow.
9. After use, refrigerate slime in a sealed container.

Ectoplasm Flubber for Halloween
Great for Halloween costumes, haunted houses, and parties.

Time Required: 15 min.
Materials:
- 1 teaspoon soluble fiber (e.g., Metamucil psyllium fiber)
- 8 ounces (1 cup) water
- large microwave safe bowl
- measuring cup
- measuring teaspoon
- microwave
- craft stick or stirring spoon
- coloring
- food coloring (edible) AND/OR
- (**non-edible**) phosphorescent zinc sulfide (ZnS) glowing paint
- sandwich size zip lock baggie

Procedure
1. Pour the water and fiber into a large microwave-safe bowl.
2. Microwave the ectoplasm on high power for 3 minutes.
3. Stir the ectoplasm. Return it to the microwave and heat it for another 3 minutes.
4. Stir the ectoplasm and check its consistency. If you want drier ectoplasm, microwave the ectoplasm another minute or two. Continue checking the ectoplasm and microwaving it until you achieve the desired consistency.
5. Add a drop of food coloring and/or glow paint. You'll get an interesting effect if you incompletely mix the coloring into the ectoplasm, such as multicolored ectoplasm or ectoplasm slime with glowing streaks.
6. Store the ectoplasm in a sealed baggie to prevent dehydration. The slime will last for a week or longer, as long as you keep it from drying out.

Edible Blood Flubber

This edible slime looks like blood and glows blue under a black light.

Materials:

- 1 teaspoon soluble fiber (e.g., Metamucil psyllium fiber)
- 8 ounces (1 cup) diet tonic water
- large microwave safe bowl
- measuring cup
- measuring teaspoon
- microwave
- craft stick or stirring spoon
- red food coloring
- sandwich size zip lock baggie

Procedure

1. Stir the fiber into the tonic water.
2. Add a drop or two of food coloring. The slime gets darker during preparation, so don't add too much food coloring.
3. Heat the liquid in a microwave-safe container until it boils. Depending on your microwave power this may be anywhere from 1 -4 minutes. When the mixture boils, pause the microwave and stir the slime.
4. Cook the microwave another 1-2 minutes. Stir it.
5. Repeat the cooking/stirring cycle a total of 4-5 times, until the slime develops a gelatinous consistency. Carefully remove the slime from the microwave. The container will be very hot!
6. Let the slime cool before you handle it. You can play with it, decorate with it, or even eat it. No matter what color you made your slime, it will glow blue-white under a black light or ultraviolet light. The glow is fluorescence from the quinine in the tonic water.
7. Store your slime in a plastic bag. If you are just decorating with it, it's fine at room temperature, but if you plan on putting the slime in your mouth, it's a good idea to refrigerate leftovers.

Slime, Gak, and Flubber Formulae

Inedible Polymers

Soap Slime

Soap slime is an easy-to-make type of slime that is fun to play with and makes clean-up fun.

Time Requirement: 5 min. and 2 days
Materials:

- leftover pieces from bars of soap
- water
- jar with tight lid

Procedure:

1. Place the soap pieces in a jar.
2. Cover the soap with water.
3. Let the jar sit for a day or two. You've got slime!

You can play with the slime or you can use it during bath time like you would ordinary soap. The soap slime will rinse away with water. Soap isn't edible, so don't eat this slime either. Also keep it out of your eyes. If you get some soap slime in your eyes, immediately rinse it out with water. Otherwise, have good clean fun!

Flubber

This is NOT a polymer, and can be used to compare/contrast with polymers. Called a non-Newtonian fluid, flubber hardens like a solid when you squeeze it, but flows like a liquid when you pour it. Instead of chemical reactions, the cornstarch particles remain suspended in the water. When compressed, the water is squeezed out between the particles, forming a solid. When left to flow, the water allows the particles to slip and slide past each other, and acting like a liquid.

Time Required: 5 min
Materials:

- 16-oz box cornstarch
- water
- food coloring
- bowl

Procedure:

1. Empty the box of cornstarch into a bowl.
2. Add 1-1/2 cups of water.
3. Add about 15 drops of food coloring. It's fine without color, too.
4. Mix the goo with your hands.
5. Have fun!

Floam

Floam™ is like slime with polystyrene beads in it, that kids can mold into shapes. You can sculpt with it or use it to coat other objects. You can store it to reuse it or allow it to dry, if you want permanent creations. It's a lot of fun, but not always easy to locate. I've seen it in some stores and online, but you can make a type of 'Floam' yourself. As with slime, it's very safe, though anything containing food coloring can stain surfaces. Don't eat 'Floam'. Polystyrene beads simply aren't food.

Time Required: 10 min
Materials:

- 4 oz. Elmer's brand white school (or alternatively, you can use Elmer gel glue instead)
- ¾ cup water
- 2 tsp. borax
- measuring tablespoon
- measuring cup
- 2 craft sticks
- 2 paper cups 6 oz
- either 12 ounce paper cup or jar with lid
- 1/2 cup water
- 1/4 cup white glue (e.g., Elmer's)
- 1/4 cup water
- food coloring
- gallon ziplock baggie
- 1 1/3 c. polystyrene beads

Procedure:

1. Dissolve 2 tsp. borax completely in 1/2 cup (4 oz.) water in the measuring cup. (2 tsp. of borax will produce a stiff product. If you want slimier, more flexible 'Floam', then try 1 tsp. borax.) Use craft stick to stir. Pour into the paper cup. Be sure that the measuring cup is completely clean before proceeding to step 2.

2. In the clean measuring cup, mix 1/4 cup (2 oz.) white glue and 1/4 cup (2 oz.) water. Stir with a clean craft stick and add food coloring. Pour into the other paper cup.
3. Pour the polystyrene beads into the quart size zip lock baggie.
4. Add the glue solution and mix well.
5. Add borax solution and knead it until it's well mixed. Use 1 T. of the borax solution for a very fluid Floam, 3 T. for average Floam, and the entire amount for stiff Floam.
6. To keep the Floam, store it in a sealed bag in the refrigerator (discourages mold). Otherwise, you can allow it to dry into whatever shape you have chosen.

Tips:

1. How it works: borax reacts to crosslink the polyvinyl acetate molecules in the glue. This forms a flexible polymer.
2. If you use a 4% solution of polyvinyl alcohol instead of glue, you will get a more transparent product that will hold shapes better.
3. Polystyrene beads can be found at craft stores (e.g., JoAnn Fabrics), usually as fillers for bean bags or dolls. You can grind Styrofoam™ cups using a cheese grater, if you like.

Bouncing Polymer Ball

You can use chemistry to make your own bouncing ball. Once you understand the basic technique, you can alter the recipe for the ball to see how the chemical composition affects the bounciness of the ball, as well as other characteristics. The bouncing ball in this activity is made from a polymer. Polymers are molecules made up of repeating chemical units. Glue contains the polymer polyvinyl acetate (PVA), which cross-links to itself when reacted with borax.

Time Requirements: 45 min
Materials:

- borax (found in the laundry section of the store)
- cornstarch (found in the baking section of the store)
- white glue (e.g., Elmer's glue - makes an opaque ball) or blue or clear school glue (makes a translucent ball)
- warm water
- food coloring (optional)
- measuring spoons
- spoon or craft stick to stir the mixture
- 2 small plastic cups or other containers for mixing
- marking pen
- watch with a second hand
- metric ruler
- zip-lock plastic baggie

Procedure

1. Label one cup 'Borax Solution' and the other cup 'Ball Mixture'.
2. Pour 2 tablespoons warm water and 1/2 teaspoon borax powder into the cup labeled 'Borax Solution'. Stir the mixture to dissolve the borax. Add food coloring, if desired.
3. Pour 1 tablespoon of glue into the cup labeled 'Ball Mixture'. Add 1/2 teaspoon of the borax solution you just made and 1 tablespoon of cornstarch. **Do not stir.** Allow the ingredients to interact on their own for 10-15 seconds and then stir them together to fully mix. Once the mixture becomes impossible to stir, take it out of the cup and start molding the ball with your hands.
4. The ball will start out sticky and messy, but will solidify as you knead it.
5. Once the ball is less sticky, go ahead and bounce it!
6. Store your plastic ball in a sealed zip lock bag when you are finished playing with it.
7. Don't eat the materials used to make the ball or the ball itself. Wash your work area, utensils, and hands when you have completed this activity.

Experiments:

- Experiment with the ratio between the amounts of glue, cornstarch, and borax. Adding more cornstarch will make a ball that stretches and bends. Using less borax will produce a 'goopier' type of ball. Add more glue for a slimier ball.
- Observations you can make and then compare as you change the composition of the ball include the diameter of the finished ball, how sticky it is, how long it takes to solidify into a ball, and how high it bounces.

Adapted from the American Chemical Society's "Meg A. Mole's Bouncing Ball"

Notes: